Enclosure 9

The 2020 ICRANet Newsletters

ICRANet Newsletter

November - December 2019 – January 2020

SUMMARY

1. ICRANet Press Release *"A New Paradigm of Black Hole Physics Leads to a New Quantum in Fundamental Physical Laws"*

A change of paradigm in black hole physics, leading to new perspectives in the role of the quantum in fundamental laws of physics, is finally reaching its most cogent confirmation by the introduction of the "inner engine" originating the GeV emission of GRB 130427A. This is explained in the new article [1], published today (22 November 2019) in The Astrophysical Journal, co-authored by R. Ruffini, R. Moradi, J. A. Rueda, L. Becerra, C. L. Bianco, C. Cherubini, Y. C. Chen, M. Karlica, N. Sahakyan, Y. Wang, and S. S. Xue. Remo Ruffini, Director of ICRANet, recalls that this a final step of a 49 years effort. In our joint article of 1971 with John Archibald Wheeler, "Introducing the black hole" [2], we pointed out how the concept of "continuous gravitational contraction", conceived by Oppenheimer and Snyder [3] for the Schwarzschild geometry, had profound modifications by introducing the Kerr metric describing the gravitational field of a spinning mass [4]. We there introduced an effective potential technique to address the particle trajectories around the Kerr black hole (BH), see Problem 12.2 in [5], that led to: 1) the determination of the last stable orbits around the Kerr BH amply applied to the study of gravitational accretion in a vast number of processes, from active galactic nuclei (AGNs), to accretion disk around the BH, to the emission of gravitational waves, see ch. 33 and 34 in [6]; 2) the mass-energy formula of a Kerr BH [7], of a Kerr-Newman BH [8] later confirmed by [9] (see Figure 1) and 3) the progressive change of the Oppenheimer paradigm, based on a Schwarzschild "dead" BH, to the new paradigm envisaging the Kerr "alive" BH indicating the BH as the "largest storehouse of energy in the Universe" [10]. Precisely, the "inner engine" extracting the rotational Christodoulou-Hawking-Ruffini energy of the Kerr BH, has been identified today, after 49 years, in GRB 130427A [1] and has been already successfully extended to GRB 190114C [11]. These results have been made possible thanks to the outstanding data of the GBM and LAT detectors of the Fermi satellite, the BAT and XRT detectors of the Neil Gehrels Swift Observatory, and the optical and the higher energy detectors on the ground.

Fig. 1. Prof. Remo Ruffini and Prof. Roy Kerr with his wife at Prof. Stephen Hawking's home in Cambridge for dinner on 20 June 2017, celebrating the Christodoulou-Hawking-Ruffini mass-energy formula of the Kerr metric.

Laura Beccera, who has been collaborating with the group of Los Alamos National Laboratory (LANL) in the simulation of these GRBs, notices that this "inner engine" naturally forms in the binary-driven hypernova (BdHN) scenario of GRBs [12–14] (see Figure 2).

Rahim Moradi recalls: an extremely efficient electrodynamical process of BH energy extraction occurs in the "inner engine", composed of a rotating BH in a background of very low density ionized plasma and a magnetic field, aligned and parallel with the rotation axis. These features are in contrast with the usual assumptions of a vacuum solution, of asymptotic flatness, and more important, the "inner engine" must be, necessarily, non-stationary. The electrons accelerate to ultrahigh-energies at expenses of the BH extractable energy: the mass and spin of the BH decrease in time keeping constant the BH irreducible mass. Jorge Rueda

comments: Quantitatively, we obtain for both GRB systems the three 'inner engine' parameters, the BH mass M, the spin α, and the magnetic field B_0, by requiring that the system satisfies three conditions: (1) the energetics of the GeV photon emission originates in the rotational energy of the BH; (2) the synchrotron radiation of the electrons in the magnetic field sets the timescale of the observed GeV luminosity; (3) the system is transparent to the emission of GeV photons. When applying this model to GRB 130427A, we find [1]: $\alpha = 0.5$, $M = 2.3$ solar masses, just above the critical mass for the gravitational collapse of a neutron star (NS), and $B_0 = 3x10^{10}$ G, sufficient to explain the GeV emission via synchrotron radiation. For GRB 190114C [11]: $\alpha = 0.4$, $M = 4.4$ solar masses, and $B_0 = 4x10^{10}$ G. This, for the first time, gives the clear evidence that BHs in BdHNe I form by hypercritical accretion onto a NS. Figure 3 shows how the 'inner engine' accelerates electrons away from the BH, emitting synchrotron radiation as a function of the pitch angle (angle between the electron motion and the magnetic field).

Ruffini adds: The 'inner engine' operates in a sequence of discrete 'quantized' steps, authentic electric discharges, emitting a 'blackholic quantum' of energy [15]: $\varepsilon=\hbar\Omega_{eff}$. Along the rotation axis, electrons gain the total potential energy: $\Delta\Phi=\hbar\omega_{eff}$. Here Ω_{eff} e ω_{eff} are effective frequencies that depend only on fundamental constants, the electron mass, charge, and the Planck mass; on the neutron mass, and on the three 'inner engine' parameters. We obtain for the 'blackholic quantum,' $\varepsilon\sim10^{37}$ erg, a maximum energy of electrons, $\Delta\Phi\sim10^{18}$ eV, and the emission timescale of the synchrotron radiation, 10^{-14} s, leading to a GeV photon luminosity of 10^{51} erg/s. Every quantized event takes away only 10^{-16} of the rotational energy of the BH, implying that the process can be long-lasting, providing ionized plasma to feed the BH be present.

C. L. Bianco and She-Sheng Xue also recall: All the above imply a full shift of paradigm from the traditional, gravitational accretion of high-density matter onto a BH. It seems to be too expensive for Nature to accelerate high-density matter in bulk, against the gravitational pull of the BH, to bring it to a distance of 10^{16}-10^{17} cm, where it becomes transparent to high-energy photons. Our 'inner engine,' instead, uses a more efficient process of electrodynamical accretion, acting on very low density ionized plasma of 10^{-14} g/cm^3[16], producing the observable high-energy emission directly close to the horizon of the BH, where the rotational energy of the Kerr BH is extracted.

Narek Sahakyan, Mile Karlica, Yen Chen Chen, and Yu Wang comment: We are eager to apply this model, successfully used for GRB 130427A [1] and GRB 190114C [11], to extract the energy of BHs of much larger masses in AGNs (e.g., the central BH of M87 of nearly 10^{10} solar masses), for which the 'inner engine' repetition timescale is of the order of hours [15].

Christian Cherubini and Simonetta Filippi comment: One of the most intriguing aspects of this result is that the emission of the blackholic quantum of 10^{37} erg, with a timescale of 10^{-14} s, occurs in the entire universe in view of the ubiquitous and homogenous cosmological presence of GRBs. It is interesting that scenario proposing a possible role of GRB in the evolution of life in our universe was introduced in [16] and may now be further quantitatively extended following the observation of GRB 130427A.

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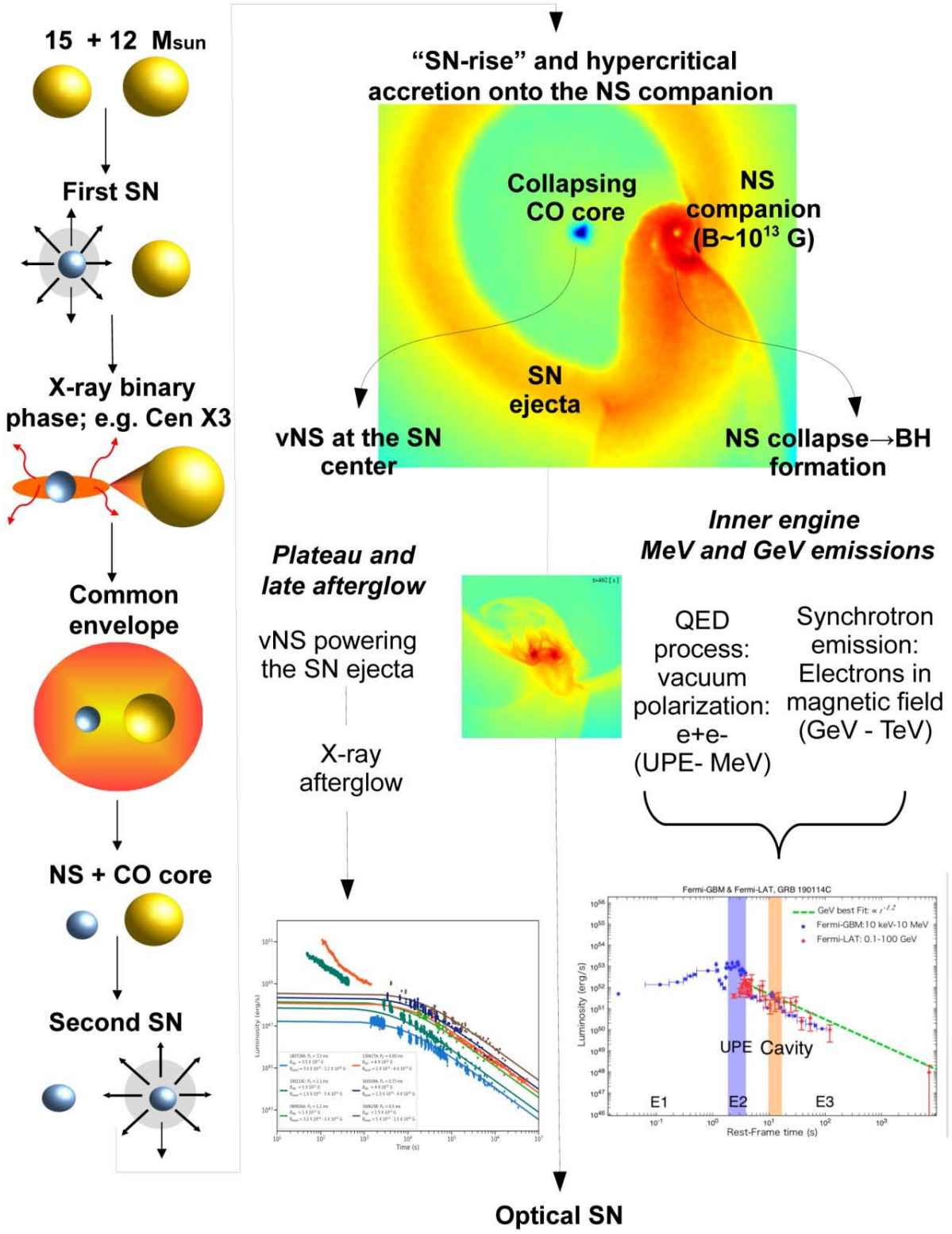

Fig. 2. The evolutionary path (left-hand side, from up to down) leading to the progenitor of a BdHN I, the carbon-oxygen star (COcore)-NS binary [18, 19]. The BdHN I starts with the second supernova (SN) explosion ("SN-rise"), leaving a newborn NS (vNS), and producing a hypercritical accretion process onto the NS companion [13]. As the NS reaches the critical mass, a BH is formed [14, 20], and a cavity is formed around it [16]. The newborn BH, the embedding magnetic field inherited from the collapsed NS, and the surrounding low-density ionized plasma, conform the "inner engine" of the GRB, which explains the high-energy GeV emission via synchrotron radiation.

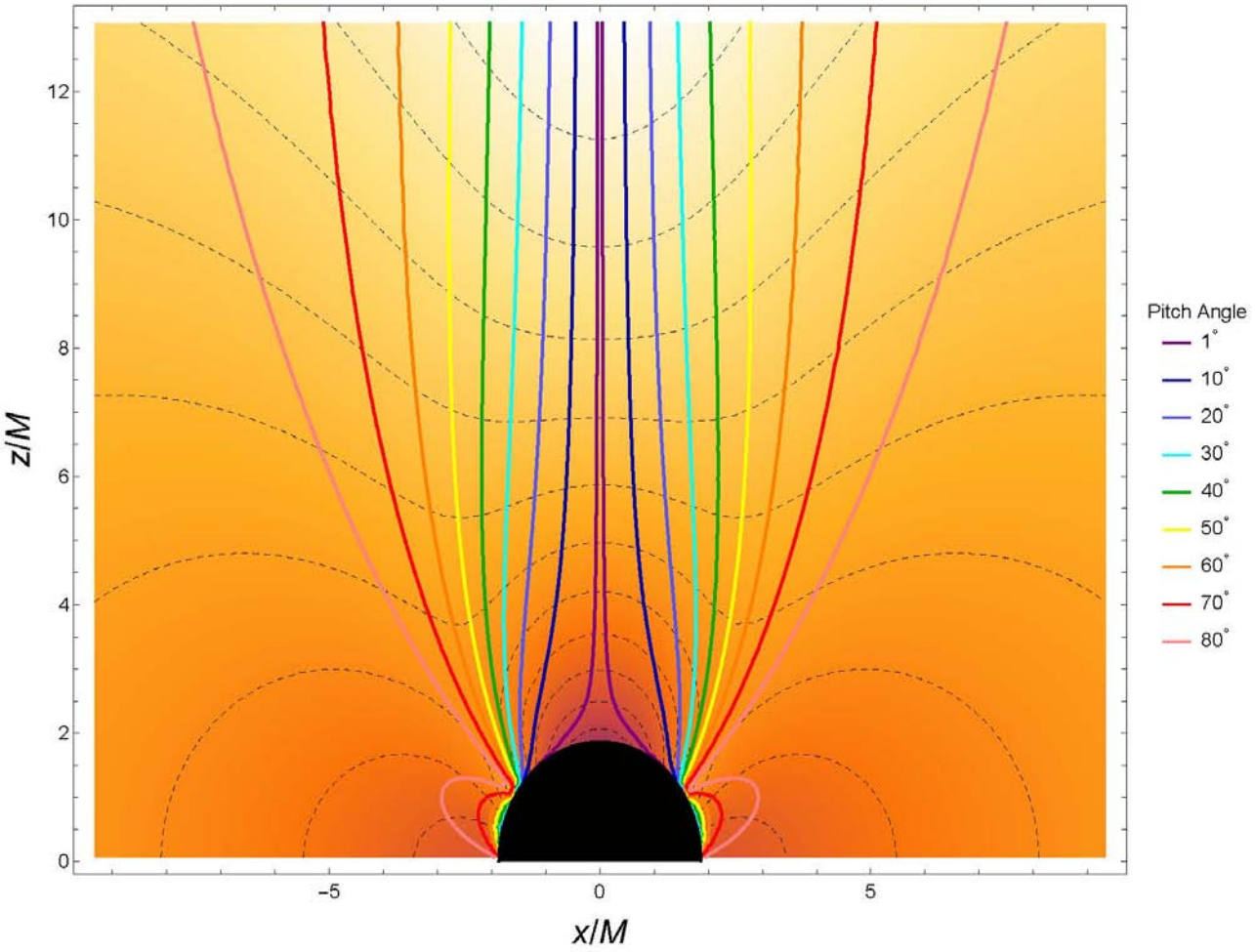

Fig. 3. Figure taken from [11] with the kind permission of the authors. Contours of constant pitch angle (colored curves from purple to pink) of electrons moving in the uniform magnetic field around the rotating BH (filled black disk). The black dashed curves represent contours of constant electric energy density, and the colored background shows how it decreases with distance. Compare and contrast these theoretical expectations with the recent observational data of M87 (see Figure 4 in [21]), which harbored a supermassive BH of nearly 1010 solar masses.

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2. ICRANet-Armenia has been provided by the law with offices for gratuitous use in prestigious Marshal Baghramyan Avenue area in Yerevan

The ICRANet Armenia center is established since 2014 after the approval of the Seat Agreement by the Government of the Republic of Armenia. The Seat Agreement has been signed in Rome on February 14, 2015, by the director of ICRANet, prof. Remo Ruffini and the Ambassador of Armenia in Italy, Mr. Sargis Ghazaryan which was then unanimously approved by the Parliament of the Republic of Armenia. In October 3, 2019, the Government of the Republic of Armenia passed a law (N 1343-A) signed by the Prime Minister N. Pashinyan to provide 270 square meters area of the main building of the Institute of Geological Sciences (address: 24 Marshal Baghramyan Avenue, Yerevan 0019, Kentron district) to ICRANET Armenia Center International Organization with the right of gratuitous use for an indefinite period of time. The area has a separate entrance in accordance with the Seat Agreement to provide extraterritoriality (diplomatic immunity) and includes six working rooms and a large seminar room (with a maximum capacity of 70 persons). The Seat is located in the prestigious Marshal Baghramyan Avenue neighboring the parliament of the Republic of Armenia and the President Palace. This opens a new perspective for the ICRANet activities in Armenia and now the Seat in Armenia can host scientists from other ICRANet member institutions as well as host international conferences and workshops.

Fig. 4: The President of the Republic of Armenia, H.E. Armen Sarkissian at his residence in Yerevan greeting Prof. Narek Sahakyan during the visit of the delegation from ICRANet led by prof. Remo Ruffini, in the occasion of the Armenian-Italian Science Day, Yerevan, April 15, 2019.

3. Renewal of the collaboration agreement ICRANet - CNR, December 23, 2019


Consiglio Nazionale delle Ricerche

ICRANet

ATTO DI RINNOVO DELL' ACCORDO - QUADRO

tra

il CONSIGLIO NAZIONALE DELLE RICERCHE (CNR)

e

l'INTERNATIONAL CENTERS FOR RELATIVISTIC ASTROPHYSICS NETWORK (ICRANet)

On December 23, 2019, the agreement between ICRANet and CNR (Consiglio Nazionale delle Ricerche - Italy) has been renewed. The renewal was signed by Prof. Massimo Inguscio (President of CNR) and by Prof. Remo Ruffini (Director of ICRANet).

This agreement will be valid for 3 years and the main joint activities to be developed under its framework include: the promotion of theoretical and observational activities within the field of Relativistic Astrophysics;

the joint collaboration of faculty members, researchers, post-doctorate fellows and students; the organization of training and teaching courses, seminars, conferences, workshops or short courses, and the joint work on scientific publications.

For the text of the agreement: http://www.icranet.org/index.php?option=com_content&task=view&id=892

4. Stakeholders' conference on the future of the Marie Sklodowska-Curie Actions, Brussels, December 3, 2019

Fig. 5: Prof. Ruffini during his speech at the Stakeholders' conference on the future of the Marie Sklodowska-Curie Actions, Brussels, December 3, 2019.

On December 3, 2019, Professor Ruffini took part in the *Stakeholders' Conference on the Future of the Marie Skłodowska-Curie Actions MSCA under Horizon Europe*, held in Brussels. This was an opportunity for him and for all other participants to present their ideas on the Marie Sklodowska-Curie Actions (MSCA) under the Horizon Europe program (2021-2027) and to share opinions on policy and implementation issues.

For more information about the MSCA Advisory Group, see the link:

http://ec.europa.eu/research/mariecurieactions/

5. Visit of the artist Michelangelo Pistoletto, ICRANet Pescara, January 14-15, 2020

On January 14 and 15, 2020 the famous Italian artist Michelangelo Pistoletto visited ICRANet center in Pescara. Pistoletto is an Italian painter, action and object artist, and art theorist. Pistoletto is acknowledged as one of the main representatives of the Italian Arte Povera. His work mainly deals with the subject matter of reflection and the unification of art and everyday life in terms of a Gesamtkunstwerk. His works are exhibited in the main Italian museums (the Museo Nazionale di Capodimonte – Naples, the Galleria Nazionale d'Arte Moderna – Rome, the Galleria degli Uffizi – Florence, the MAXXI – Rome, …) as well as worldwide (Musée du Louvre and Centre Georges Pompidou - Paris, the Metropolitan Museum of Art, the MoMA and the Solomon R. Guggenheim Museum - New York, ….).
Prof. Ruffini accompanied Pistoletto to visit ICRANet center, showing him all the fundamental documents and pictures collected there. He also showed him the exhibition *"Einstein, Fermi, Heisenberg and the birth of Relativistic Astrophysics"*, organized in ICRANet library. At the end of the tour, Michelangelo Pistoletto left his dates signature on the wall, next to those of other eminent personalities (scientists, politicians, artists,…) who visited the center. During his visit, Pistoletto had an important dialogue with Prof. Ruffini, on the important relationship and correlation between "art and science" and Prof. Ruffini illustrated him the most recent scientific results on which ICRANet scientist are working on.

Fig. 6: Michelangelo Pistoletto and Prof. Ruffini discussing about the correlation between art and science.

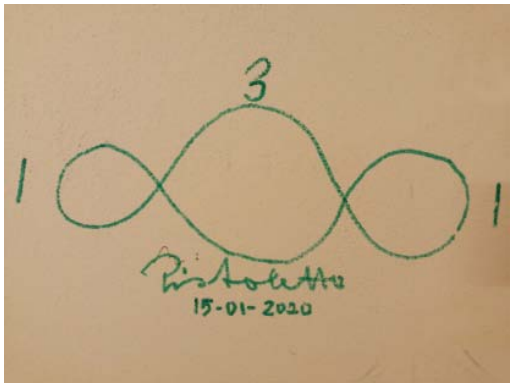


Fig. 7: dated signature of Michelangelo Pistoletto on the wall of ICRANet center in Pescara.

Fig. 8: Prof. Ruffini showing to Michelangelo Pistoletto and his wife, the important pictures collected in his office.

Fig. 9: Michelangelo Pistoletto and his wife meeting ICRANet Faculty Professor and research students.

On the morning of Wednesday, January 15, Pistoletto and Prof. Ruffini met the major of Pescara, Dr Carlo Masci, at the Municipality of Pescara. During that meeting, Pistoletto recalled the longstanding relationship with the city of Pescara, which he has often visited in the '70s, when the city attracted both the attention of the European Union and of several artists from all over the world. The Major Masci highlighted that this was a fruitful meeting, which could open the way to future collaborations, especially concerning the regeneration of run-down urban spaces. At the end of the meeting, he gave to Pistoletto a precious book where some postcards realized by Basilio Cascella are collected, as a gift.

Press releases on this meeting:

- Rete 8: http://www.rete8.it/cronaca/123pescara-masci-riceve-la-visita-del-maestro-pistoletto/
- Abruzzo news: https://www.abruzzonews.eu/michelangelo-pistoletto-e-remo-ruffini-ricevuti-da-sindaco-masci-foto-582313.html

Fig. 10 and 11: The Italian artist Michelangelo Pistoletto together with Prof. Remo Ruffini, during their meeting with the Major of Pescara, Dr Carlo Masci at the Municipality of Pescara, January 15, 2020.

6. *"Mercurio in sole visu"*. Second event of the project *"Alternanza scuola-lavoro"* with High School G. Galilei of Pescara at ICRANet center, November 11, 2019

On November 11, 2019, ICRANet center in Pescara hosted the second event of the project *"Alternanza scuola-lavoro"*, at the presence of the students from the classes 4°B, 4°D and 4°F from High School Galileo Galilei of Pescara, under the supervision of their tutor, Prof. Tiziana Pompa.

Chaired by Prof. Costantino Sigismondi, ICRANet collaborator, the morning session of the event started at 11 am with the opening remarks by Prof. Vladimir Belinski, ICRANet Faculty Professor, and went on with some plenary presentations in videoconference by Prof. Jay M. Pasachoff from the Williams College (*"Projects for the Mercury transit of 2019"*), by Prof. Sigismondi (*"SAROS, Transiti Eclissi e Occultazioni tra Collegio Romano e Minerva"*), by Prof. Terry Mahoney from the IAU (*"Kepler and Gassendi: the first observed transit"*) and by Prof. Lorenzo Ricciardi from the University of Roma Tre (*"La tecnologia e la società nel 2032"*).

Fig. 12: Prof. Costantino Sigismondi, chairman of the event, introducing Prof. Vladimir Belinski (ICRANet Faculty Professor).

Fig. 13: Participants to the second event of the project *"Alternanza scuola-lavoro"*.

From 1 pm to 3 pm, the students, guided by Prof. Sigismondi and by their tutors, observed the transit of Mercury on the Sun through an optical telescope in ICRANet garden. The afternoon session continued with some plenary presentations in videoconference by Prof. Wolfgang Beisker from IOTA/ES (*"The transit of Mercury and the asteroidal occultations"*), by Prof. Björn Kattendit from IOTA/ES (*"Observations of the transit f Mercury with a 28cm SC Telescope in 2016"*), by Prof. Hamed Altafi, Tehran Observatory (*"Il transito di Mercurio del 2016 e del 2019"*) and by Prof. Marcelo Emilio, Universidade de Ponta Grossa (*"Diametro solare con SOHO e SDO"*). Other contributions have been presented in videoconference also by Prof. Michele Bianda, Prof. Axel Wittmann, Prof. Marta Grabowska, Prof. Irene Sigismondi, Prof. Paolo Ochner, Prof. Francesco Berrilli, Prof. Lukasz Wieteska, Prof. Luigi M. Bordoni, Prof. Francesco Giannini, Prof. Rodolfo Calanca, Prof. Francesco Berrilli and Prof. Cesare Barbieri. The last part of the event has been dedicated to the concluding remarks by Prof. Ruffini.

Fig. 14: Professors and students preparing the optical telescope for the observations in ICRANet garden.

Fig. 15: Observation of the transit of Mercury on the Sun through the optical telescope.

For more information about the event: http://www.icranet.org/index.php?option=com_content&task=view&id=1264#2

For the videos of the event:
https://www.youtube.com/watch?v=kmKJ-Ppsftg&list=PLr5RLbSWSonviNqCXECM-5ahTACPb_JdY&index=4
https://www.youtube.com/watch?v=SUHVWsvE7G0&list=PLr5RLbSWSonviNqCXECM-5ahTACPb_JdY&index=5

7. *"Betelgeuse dimming: the state of the star"*, ICRANet workshop in Pescara, January 17, 2020

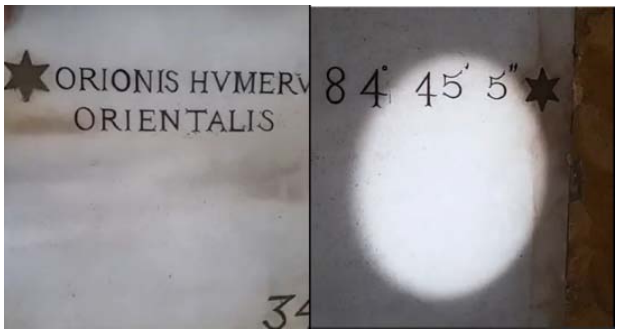


Fig. 16: Betelgeuse as in 1702, Clementine Gnomon – Rome.

On January 17, 2020, ICRANet center in Pescara hosted an international workshop titled *"Betelgeuse dimming: the state of the star"*, on the occasion of an epochal event, with some of the most prominent scientists in the field.

Betelgeuse, the alpha of Orion, has been classified as the brightest star of the constellation by Ptolemy around 150 AD. It is a semi-regular variable that in the top luminosity phases can be the brightest star of the northern hemisphere, with negative magnitude. Since October 2019, its luminosity is dimming and lost one whole magnitude, attaining the visual magnitude of 1.4, at the level of Regulus, the alpha of Leo. What is going on now? This is the main subject discussed during this event.

The workshop, chaired by Prof. Costantino Sigismondi, ICRANet collaborator, started with 2 Lectio magistralis: one by Prof. Ruffini, Director of ICRANet on *"Supernovae and Gamma-Ray bursts"* and the other by Prof. Sigismondi on *"The case of eta Carinae in 1843"*. The event went on with some plenary presentations in videoconference by Prof. Cersare Barbieri, University of Padova (*"Astronomy and media"*), by Prof. Margarita Karovska, Harvard CfA (*"Multiperiodicity in the Light Curve of Alpha Orionis"*), by Prof. Paolo Ochner, Asiago Astrophysical Observatory (*"Galactic SN classification"*), by Prof. Stella Kafka, AAVSO Director (*"AAVSO Mission and Database"*) and by Prof. Massimo Turatto, INAF/Padova Observatory (*"Supernova and variability from spectra and light curves"*).

Fig. 17: Prof. Ruffini and Prof. Sigismondi during their presentation at the workshop.

Fig. 18: Prof. Vereshchagin and Prof. Sigismondi during their presentation at the workshop.

For more information about the event: http://www.icranet.org/index.php?option=com_content&task=view&id=1281

8. Prof. Ruffini intervention at *"Science by Night"*, High School G. Galilei of Pescara, January 18, 2020

On January 18, 2020, the High School Galileo Galilei of Pescara organized an important event titled *"Science by Night"*. This event represented a nice occasion for discussion among students, citizens and researchers, and attracted a lot of people, offering to participants a unique opportunity to take part in science activities aiming to showcase both the fascination of research as a career and its significant societal impact.

On that occasion, Prof. Remo Ruffini, Director of ICRANet, and Prof. Costantino Sigismondi, ICRANet collaborator, were invited to participate. On that occasion, Prof. Ruffini deliver an important talk, titled "*Observing a newly-born Black Hole*".

For more information about the event and for the program:
http://galileipescara.it/blog/science-by-night-v-ed/

Fig. 19: Prof. Ruffini presenting his talk "*Observing a newly-born Black Hole*", on the occasion of the event Science by Night at High School G. Galilei of Pescara, January 18, 2020.

9. Visit of the Prefect of Pescara and the exhibition *"Einstein, Fermi, Heisenberg and the birth of Relativistic Astrophysics"*, ICRANet Pescara, January 25-February 29, 2020

ICRANet is pleased to announce the exhibition *"Einstein, Fermi, Heisenberg and the birth of Relativistic Astrophysics"* at ICRANet center in Pescara, which will be opened from January 25 to February 29, 2020 (from Monday to Friday, from 9:00 to 18:00). The exhibition has been organized on the occasion of the conferral of the honorary citizenship of Pescara to Liliana Segre, Life Senator of the Italian Republic, and to the Unione Comunità Ebraiche Italiane, to the Brigata Ebraica and to all the victims of Shoah by the Major Carlo Masci. Several eminent local institutional, military and religious authorities have been invited to visit the exhibition.

On Monday January 27, the Prefect of Pescara, H.E. Gerardina Basilicata, visited the exhibition. Prof. Ruffini accompanied her during the visit, explaining the birth of relativistic astrophysics thanks to the important role played by eminent personalities such as Albert Einstein, Enrico Fermi, Robert Oppenheimer, John Von Neumann and Werner Heisenberg.

Fig. 20 and 21: The Prefect of Pescara, H.E. Gerardina Basilicata, visiting the exhibition *"Einstein, Fermi, Heisenberg and the birth of Relativistic Astrophysics"* at ICRANet center in Pescara.

10.Scientific visits to ICRANet

- **Dr Seddigheh Tizchang** (Institute for Research in Fundamental Sciences IPM – Iran), November 6 – 19, 2019. Dr Tizchang visited ICRANet center in Pescara and had the opportunity to meet and discuss scientific issues with ICRANet scientists. On that occasion she also gave a seminar titled *"Probing the effect of background fields on the polarization of photons from CMB to lasers"*.
- **Dr Orchidea Maria Lecian** (University of Rome "La Sapienza" - Italy), November 7-8, 2019. During his visit, Dr Lecian had the opportunity to meet and discuss scientific issues with ICRANet scientists. On that occasion she also gave a seminar titled *"Quantum-systems investigations vs optical-systems ones"*.
- **Prof. Mathews Grant** (Center for Astrophysics at Notre Dame University – USA), November 19-20, 2019. Prof. Grant visited ICRANet center in Pescara and had the opportunity to meet and discuss scientific issues with ICRANet scientists from all over the world.
- **Academician Sergei Kilin** (National Academy of Sciences of Belarus), December 15-17, 2019. Academician Kilin participated in the 21° ICRANet Steering Committee meeting, held on December 16. He had, therefore, the possibility to visit ICRANet center in Pescara and to meet and discuss scientific issues with ICRANet scientists.
- **Prof. Johann Rafelski** (University of Arizona - USA), December 14-17, 2019. Prof. Rafelski participated in the 21° ICRANet Steering Committee meeting, held on December 16, as representative of the University of Arizona. He had, therefore, the possibility to visit ICRANet center in Pescara and meet and discuss scientific issues with ICRANet scientists.
- **Dr Yunlong Zheng** (University of Science and Technology of China), December 12-26, 2019. Dr Zheng visited ICRANet center in Pescara and had the opportunity to meet and discuss scientific issues with ICRANet scientists. Accompanied by Prof. Ruffini, Dr Zheng visited also the University Campus Bio-medico of Rome.

Dr Seddigheh Tizchang

Dr Orchidea Maria Lecian

Prof. Mathews Grant

Academician Sergei Kilin

Prof. Johann Rafelski

Dr Yunlong Zheng

11.Seminars at ICRANet center in Pescara

Seminar of Dr Orchidea Maria Lecian

On Thursday, November 7, 2019, Dr Orchidea Maria Lecian (University of Rome "La Sapienza" - Italy), gave a seminar titled *"Quantum-systems investigations vs optical-systems ones"*. Here below is the abstract:

The features of quantum systems, quantum-optical-systems and optical systems can be outlined according to the possibility for the study of the properties of matter fields and of the gravitational field. Quantum properties of particles and of the background gravitational field at quantum scales, at the semi-classical regime and at the classical level are analyzed by quantum systems and optical-systems devices, for which the experimental features of the research are compared. Investigation in cosmology and in early cosmology can be envisaged. The features of quantum operators to be evaluated by these techniques are pointed out. The properties of relativistic objects are this way examined. The features of the Einstein field equations and of their initial conditions are defined. The degrees of freedom available for the Einstein field equations and their initial conditions are characterized.

The announcement of the seminar has also been published on ICRANet website:
http://www.icranet.org/index.php?option=com_content&task=blogcategory&id=89&Itemid=781

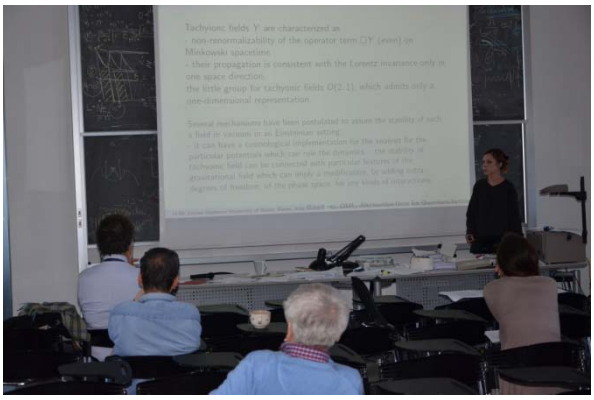


Fig. 22 and 23 : Dr Orchidea Maria Lecian giving her seminar at ICRANet center in Pescara, November 7, 2019.

Seminar of Dr Seddigheh Tizchang

On Friday, November 15, 2019, Dr Seddigheh Tizchang (Institute for Research in Fundamental Sciences IPM – Iran), gave a seminar titled *"Probing the effect of background fields on the polarization of photons from CMB to lasers"*. Here below is the abstract:

It is known that the polarization of photons can partly rotate and/or convert to circular polarization via forward Compton scattering in the presence of a background field. Based on this fact, we show that Compton scattering in presence of non-trivial background and scalar perturbation of metric, in addition to generate circularly polarized microwaves, can lead to a B-mode polarization for the CMB. Besides, we proposed an earth-based experiment in which the polarization of the laser photon convert to circular one via forward scattering by high energy charged lepton beam in presence of non-trivial background fields such as Non-commutative space-time and Lorentz violation.

The announcement of the seminar has also been published on ICRANet website:
http://www.icranet.org/index.php?option=com_content&task=blogcategory&id=89&Itemid=781

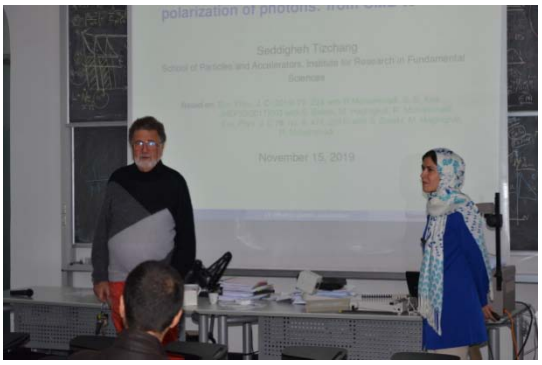


Fig. 24 and 25: Dr Seddigheh Tizchang giving her seminar at ICRANet center in Pescara, November 15, 2019.

12. Prof. Ruffini awarded the prize Rosone d'oro 2019, Pianella, Italy, December 21, 2019

On December 21, 2019, Prof. Ruffini, Director of ICRANet, was awarded the prize Rosone d'oro 2019 by the Municipality of Pianella. This award has been assigned to Prof. Ruffini in the section "Sciences" of the

Prize for Literature, Art and Sciences 'Città di Pianella', in sign of appreciation of his eminent personality and his scientific achievements both at the international and national levels.

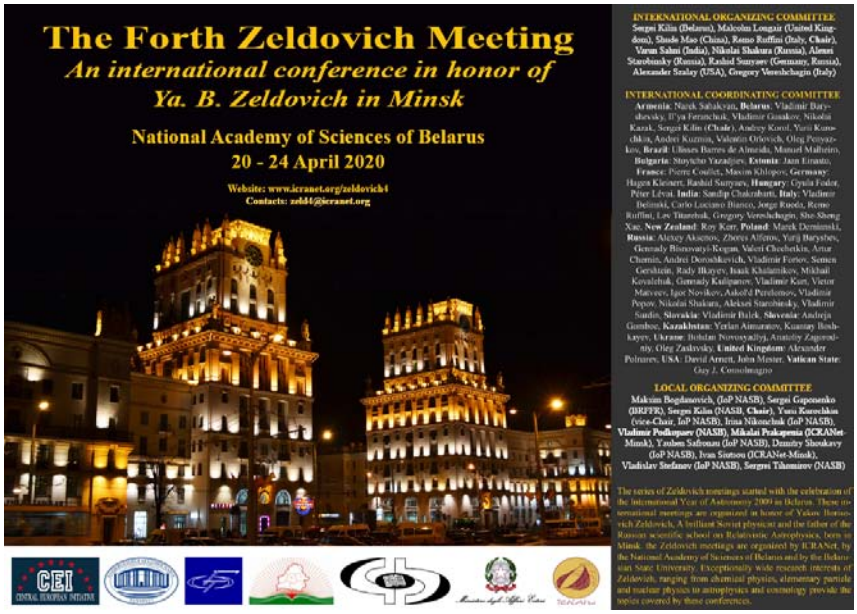
Fig. 26: Prof. Ruffini receiving his award.

Fig. 27: Prof. Ruffini attending the official ceremony with the others awardees.

Fig. 28: Prof. Ruffini together with some organizers of the official ceremony.

13. Upcoming meetings

The International Center for Relativistic Astrophysics Network (ICRANet) together with the National Academy of Sciences of Belarus is organizing an international conference to be held in Minsk, Belarus on April 20-24, 2020: the Fourth Zeldovich meeting. The participation from neighboring countries such as Estonia, Latvia, Lithuania, Poland, Russia and Ukraine as well as from Balkan countries, Eastern and Western Europe and the Americas is expected. Exceptionally wide research interests of Ya. B. Zeldovich, ranging from chemical physics, elementary particle and nuclear physics to astrophysics and cosmology, provide the topics to be covered at the conference.
Registration to this meeting is open until March 15, 2020 at the following link:
http://dbserver.icra.it:8080/meetings/registration_zeld4.htm



From October 30 until April 1, 2020, it is possible to submit an abstract through the following link: https://uploader.icranet.org/zeld4/.

The preliminary list of invited speakers includes:

- Abhay Ashtekar, Institute for Gravitation & the Cosmos, Penn State University, USA;

- Rong-Gen Cai, Institute of Theoretical Physics, Chinese Academy of Sciences, China;
- Jens Chluba, Jodrell Bank Centre for Astrophysics, University of Manchester, UK;
- Alexander Dolgov, Novosibirsk State University and ITEP, Russia;
- Jaan Einasto, Tartu Observatory, Estonia;
- Stefan Gillessen, Max Planck Institute for Extraterrestrial Physics, Germany;
- Claus Lämmerzahl, ZARM, Germany;
- Vladimir Lipunov, Moscow State University, Russia;
- Felix Mirabel, CEA Saclay, France;
- Slava Mukhanov, Ludwig-Maximilians-Universität München, Germany;
- Konstantin Postnov, Sternberg Astronomical Institute of the Moscow State University, Russia;
- Piero Rosati, University of Ferrara, Italy;
- Jorge Rueda, ICRANet, Italy;
- Remo Ruffini, ICRANet, Italy;
- Nikolay Shakura, Sternberg Astronomical Institute of the Moscow State University, Russia;
- Dmitry Sokoloff, Moscow State University, Russia;
- Alexey Starobinsky, Landau institute for theoretical physics, RAS, Russia.

For more information concerning the meeting, please consult the its official website:
http://www.icranet.org/zeldovich4

14. Recent publications

Sahakyan, N., *Investigation of the Gamma-ray Spectrum of CTA 102 During the Exceptional Flaring State in 2016-2017*, accepted for publication in Astronomy & Astrophysics, November 2019.

The flat spectrum radio quasar CTA 102 entered an extended period of activity from 2016 to 2017 during which several strong $\gamma\gamma$-ray flares were observed. Using Fermi large area telescope data a detailed investigation of \gray spectra of CTA 102 during the flaring period is performed. In several periods the \gray spectrum is not consistent with a simple power-law, having a hard photon index with an index of $\sim(1.8-2.0)\sim(1.8-2.0)$ that shows a spectral cutoff around an observed photon energy of $\sim(9-16)\sim(9-16)$ GeV. The internal $\gamma\gamma$-ray absorption via photon-photon pair production on the broad line-region-reflected photons cannot account for the observed cut-off/break even if the emitting region is very close to the central source. This cut-off/break is likely due to a similar intrinsic break in the energy distribution of emitting particles. The origin of the spectral break is investigated through the multiwavelength modeling of the spectral energy distribution, considering a different location for the emitting region. The observed X-ray and $\gamma\gamma$-ray data is modeled as inverse Compton scattering of synchrotron and/or external photons on the electron population that produce the radio-to-optical emission which allowed to constrain the power-law index and cut-off energy in the electron energy distribution. The obtained results are discussed in the context of a diffusive acceleration of electrons in the CTA 102 jet.

Link: https://ui.adsabs.harvard.edu/abs/2019arXiv191112087S/abstract

Acciari, V. A., et al. *Monitoring of the radio galaxy M 87 during a low emission state from 2012 to 2015 with MAGIC*, published in Monthly Notices of the Royal Astronomical Society, January 2020.

M 87 is one of the closest (z=0.00436) extragalactic sources emitting at very-high-energies (VHE, E > 100 GeV). The aim of this work is to locate the region of the VHE gamma-ray emission and to describe the observed broadband spectral energy distribution (SED) during the low VHE gamma-ray state. The data from M 87 collected between 2012 and 2015 as part of a MAGIC monitoring programme are analysed and

combined with multi-wavelength data from Fermi-LAT, Chandra, HST, EVN, VLBA and the Liverpool Telescope. The averaged VHE gamma-ray spectrum can be fitted from 100 GeV to 10 TeV with a simple power law with a photon index of (- 2.41 ± 0.07), while the integral flux above 300 GeV is (1.44 ± 0.13) × 10^{-12} cm^{-2} s^{-1}. During the campaign between 2012 and 2015, M 87 is generally found in a low emission state at all observed wavelengths. The VHE gamma-ray flux from the present 2012-2015 M 87 campaign is consistent with a constant flux with some hint of variability (3 σ) on a daily timescale in 2013. The low-state gamma-ray emission likely originates from the same region as the flare-state emission. Given the broadband SED, both a leptonic synchrotron self Compton and a hybrid photo-hadronic model reproduce the available data well, even if the latter is preferred. We note, however, that the energy stored in the magnetic field in the leptonic scenario is very low suggesting a matter dominated emission region.

Link: https://doi.org/10.1093/mnras/staa014

MAGIC Collaboration; Acciari, V. A. et al., *Testing emission models on the extreme blazar 2WHSP J073326.7+515354 detected at very high energies with the MAGIC telescopes,* published in Monthly Notices of the Royal Astronomical Society, Volume 490, Issue 2, p.2284-2299.

Extreme high-energy-peaked BL Lac objects (EHBLs) are an emerging class of blazars. Their typical two-hump-structured spectral energy distribution (SED) peaks at higher energies with respect to conventional blazars. Multiwavelength (MWL) observations constrain their synchrotron peak in the medium to hard X-ray band. Their gamma-ray SED peaks above the GeV band, and in some objects it extends up to several TeV. Up to now, only a few EHBLs have been detected in the TeV gamma-ray range. In this paper, we report the detection of the EHBL 2WHSP J073326.7+515354, observed and detected during 2018 in TeV gamma rays with the MAGIC telescopes. The broad-band SED is studied within an MWL context, including an analysis of the Fermi-LAT data over 10 yr of observation and with simultaneous Swift-XRT, Swift-UVOT, and KVA data. Our analysis results in a set of spectral parameters that confirms the classification of the source as an EHBL. In order to investigate the physical nature of this extreme emission, different theoretical frameworks were tested to model the broad-band SED. The hard TeV spectrum of 2WHSP J073326.7+515354 sets the SED far from the energy equipartition regime in the standard one-zone leptonic scenario of blazar emission. Conversely, more complex models of the jet, represented by either a two-zone spine-layer model or a hadronic emission model, better represent the broad-band SED.

Link: https://doi.org/10.1093/mnras/stz2725

MAGIC Collaboration; Acciari, V. A., et al., *Observation of inverse Compton emission from a long γ-ray burst,* published in Nature, Volume 575, Issue 7783, p.459-463.

Long-duration γ-ray bursts (GRBs) originate from ultra-relativistic jets launched from the collapsing cores of dying massive stars. They are characterized by an initial phase of bright and highly variable radiation in the kiloelectronvolt-to-megaelectronvolt band, which is probably produced within the jet and lasts from milliseconds to minutes, known as the prompt emission. Subsequently, the interaction of the jet with the surrounding medium generates shock waves that are responsible for the afterglow emission, which lasts from days to months and occurs over a broad energy range from the radio to the gigaelectronvolt bands. The afterglow emission is generally well explained as synchrotron radiation emitted by electrons accelerated by the external shock. Recently, intense long-lasting emission between 0.2 and 1 teraelectronvolts was observed from GRB 190114C. Here we report multi-frequency observations of GRB 190114C, and study the evolution in time of the GRB emission across 17 orders of magnitude in energy, from 5 × 10^{-6} to 10^{12} electronvolts. We find that the broadband spectral energy distribution is double-peaked, with the teraelectronvolt emission constituting a distinct spectral component with power comparable to the synchrotron component. This component is associated with the afterglow and is satisfactorily explained by inverse Compton up-scattering of synchrotron photons by high-energy electrons. We find that the conditions required to account for the observed teraelectronvolt component are typical for GRBs, supporting the possibility that inverse Compton emission is commonly produced in GRBs.

Link: https://ui.adsabs.harvard.edu/abs/2019Natur.575..459M/abstract

MAGIC Collaboration; Acciari, V. A. et al., *Teraelectronvolt emission from the γ-ray burst GRB 190114C*, published in Nature, Volume 575, Issue 7783, p.455-458.

Long-duration γ-ray bursts (GRBs) are the most luminous sources of electromagnetic radiation known in the Universe. They arise from outflows of plasma with velocities near the speed of light that are ejected by newly formed neutron stars or black holes (of stellar mass) at cosmological distances. Prompt flashes of megaelectronvolt-energy γ-rays are followed by a longer-lasting afterglow emission in a wide range of energies (from radio waves to gigaelectronvolt γ-rays), which originates from synchrotron radiation generated by energetic electrons in the accompanying shock waves. Although emission of γ-rays at even higher (teraelectronvolt) energies by other radiation mechanisms has been theoretically predicted, it has not been previously detected. Here we report observations of teraelectronvolt emission from the γ-ray burst GRB 190114C. γ-rays were observed in the energy range 0.2-1 teraelectronvolt from about one minute after the burst (at more than 50 standard deviations in the first 20 minutes), revealing a distinct emission component of the afterglow with power comparable to that of the synchrotron component. The observed similarity in the radiated power and temporal behaviour of the teraelectronvolt and X-ray bands points to processes such as inverse Compton upscattering as the mechanism of the teraelectronvolt emission. By contrast, processes such as synchrotron emission by ultrahigh-energy protons are not favoured because of their low radiative efficiency. These results are anticipated to be a step towards a deeper understanding of the physics of GRBs and relativistic shock waves.

Link: https://ui.adsabs.harvard.edu/abs/2019Natur.575..455M/abstract

Ruffini, R.; Moradi, R.; Rueda, J. A.; Becerra, L.; Bianco, C. L.; Cherubini, C.; Filippi, S.; Chen, Y. C.; Karlica, M.; Sahakyan, N.; Wang, Y.; Xue, S. S., *On the GeV Emission of the Type I BdHN GRB 130427A*, published in the Astrophysical Journal, Volume 886, Issue 2, article id. 82, 13 pp. (2019) on November 22, 2019.

We propose that the inner engine of a type I binary-driven hypernova (BdHN) is composed of Kerr black hole (BH) in a non-stationary state, embedded in a uniform magnetic field B_0 aligned with the BH rotation axis and surrounded by an ionized plasma of extremely low density of 10^{-14} g cm^{-3}. Using GRB 130427A as a prototype, we show that this inner engine acts in a sequence of elementary impulses. Electrons accelerate to ultrarelativistic energy near the BH horizon, propagating along the polar axis, $\theta = 0$, where they can reach energies of $\sim 10^{18}$ eV, partially contributing to ultrahigh-energy cosmic rays. When propagating with $\theta \neq 0$ through the magnetic field B_0, they produce GeV and TeV radiation through synchroton emission. The mass of BH, $M = 2.31 M_\odot$, its spin, $\alpha = 0.47$, and the value of magnetic field $B_0 = 3.48 \times 10^{10}$ G, are determined self consistently to fulfill the energetic and the transparency requirement. The repetition time of each elementary impulse of energy $\mathcal{E} \sim 10^{37}$ erg is $\sim 10^{-14}$ s at the beginning of the process, then slowly increases with time evolution. In principle, this "inner engine" can operate in a gamma-ray burst (GRB) for thousands of years. By scaling the BH mass and the magnetic field, the same inner engine can describe active galactic nuclei.

Journal link: https://iopscience.iop.org/article/10.3847/1538-4357/ab4ce6

arXiv link: https://arxiv.org/abs/1812.00354

De Lima, Rafael C. R.; Coelho, Jaziel G.; Pereira, Jonas P.; Rodrigues, Claudia V.; Rueda, J. A., *Evidence for a multipolar magnetic Field in SGR J1745-2900 from X-ray light-curve analysis*, accepted for publication in The Astrophysical Journal; in press.

SGR J1745-2900 was detected from its outburst activity in April 2013 and it was the first soft gamma repeater (SGR) detected near the center of the Galaxy (Sagittarius A∗). We use 3.5-year Chandra X-ray light-curve data to constrain some neutron star (NS) geometric parameters. We assume that the flux modulation comes from hot spots on the stellar surface. Our model includes the NS mass, radius, a maximum of three spots of any size, temperature and positions, and general relativistic effects. We find that the light-curve of SGR J1745-2900 could be described by either two or three hot spots. The ambiguity is due to the small

amount of data, but our analysis suggests that one should not disregard the possibility of multi-spots (due to a multipolar magnetic field) in highly magnetized stars. For the case of three hot spots, we find that they should be large and have angular semi-apertures ranging from 16-67 degrees. The large size found for the spots points to a magnetic field with a nontrivial poloidal and toroidal structure (in accordance with magnetohydrodynamics investigations and NICER's recent findings for PSR J0030+0451) and is consistent with the small characteristic age of the star. Finally, we also discuss possible constraints on the mass and radius of SGR J1745-2900 and briefly envisage possible scenarios accounting for the 3.5-year evolution of SGR J1745-2900 hot spots.

arXiv link: https://arxiv.org/abs/1912.12336

Ruiz-Baier R.,Gizzi A., Loppini A., Cherubini C. and Filippi S., *Modelling Thermo-Electro-Mechanical Effects in Orthotropic Cardiac Tissue*, published in Commun. Comput. Phys. Vol.27, No. 1, pp. 87-115 (January 2020).

In this paper we introduce a new mathematical model for the active contraction of cardiac muscle, featuring different thermo-electric and nonlinear conductivity properties. The passive hyperelastic response of the tissue is described by an orthotropic exponential model, whereas the ionic activity dictates active contraction incorporated through the concept of orthotropic active strain. We use a fully incompressible formulation, and the generated strain modifies directly the conductivity mechanisms in the medium through the pull-back transformation. We also investigate the influence of thermo-electric effects in the onset of multiphysics emergent spatiotemporal dynamics, using nonlinear diffusion. It turns out that these ingredients have a key role in reproducing pathological chaotic dynamics such as ventricular fibrillation during inflammatory events, for instance. The specific structure of the governing equations suggests to cast the problem in mixed-primal form and we write it in terms of Kirchhoff stress, displacements, solid pressure, dimensionless electric potential, activation generation, and ionic variables. We also advance a new mixed-primal finite element method for its numerical approximation, and we use it to explore the properties of the model and to assess the importance of coupling terms, by means of a few computational experiments in 3D.

Link: 10.4208/cicp.OA-2018-0253

M. A. Prakapenia and G. V. Vereshchagin, *Bose-Einstein condensation in relativistic plasma*, published in Europhysics Letters, Volume 128, Number 5 (2019) 50002 on 30 of January 2020.

The phenomenon of Bose-Einstein condensation is traditionally associated with and experimentally verified at low temperatures: either of the nano-Kelvin scale for alkali atoms, or room temperatures for quasi-particles or photons in two dimensions. Here we demonstrate out of first principles that for certain initial conditions nonequilibrium plasma at relativistic temperatures of billions of Kelvin undergoes condensation, as predicted by Zeldovich and Levich in their seminal work. We determine the necessary conditions for the onset of condensation and discuss the possibilities to observe such a phenomenon in laboratory and astrophysical conditions.

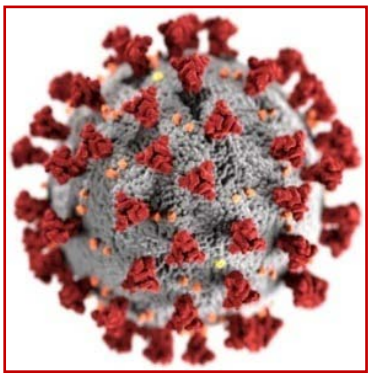
Link: https://iopscience.iop.org/article/10.1209/0295-5075/128/50002

ICRANet Newsletter

February–March 2020

SUMMARY

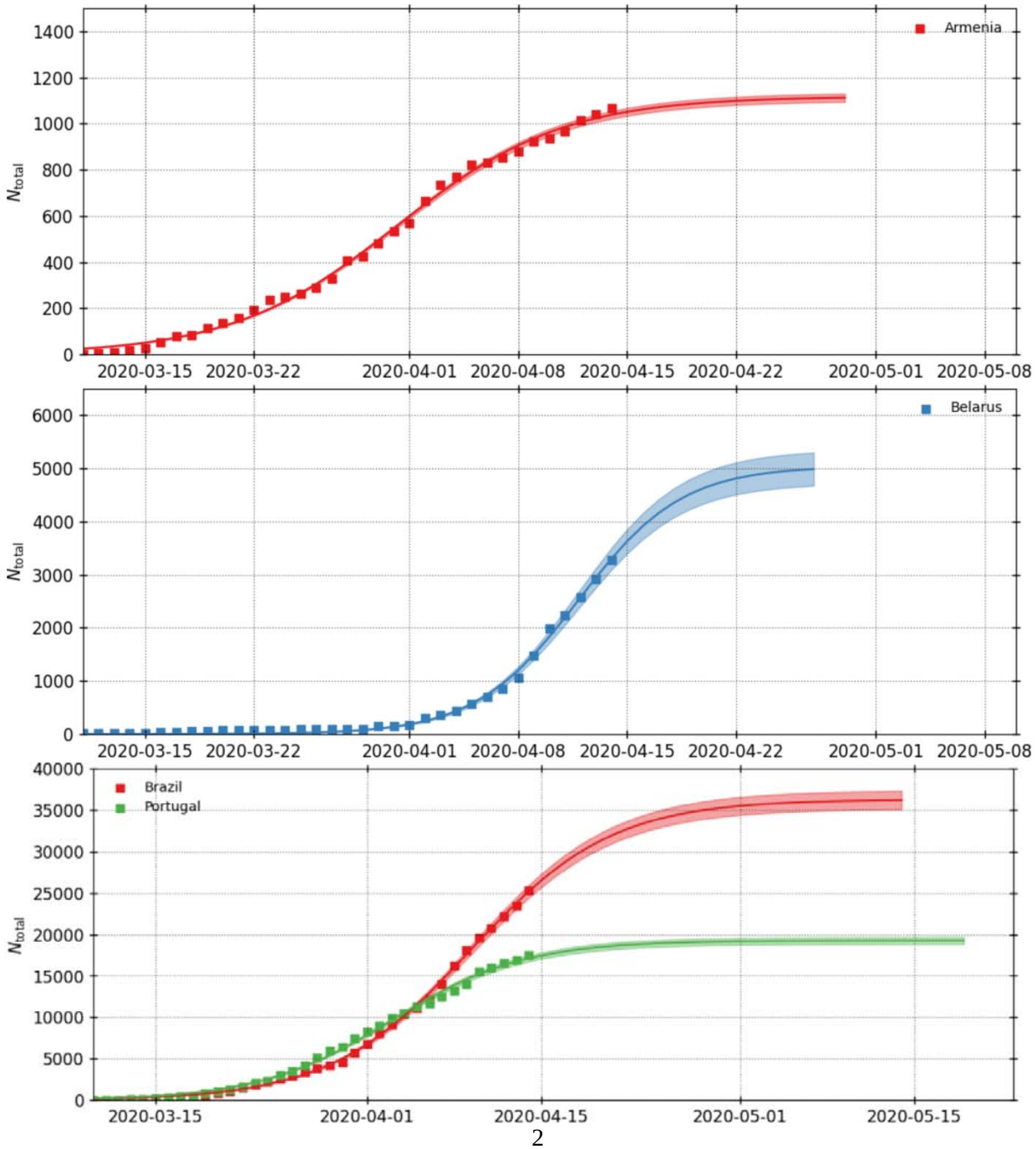
1. COVID-19 statistics

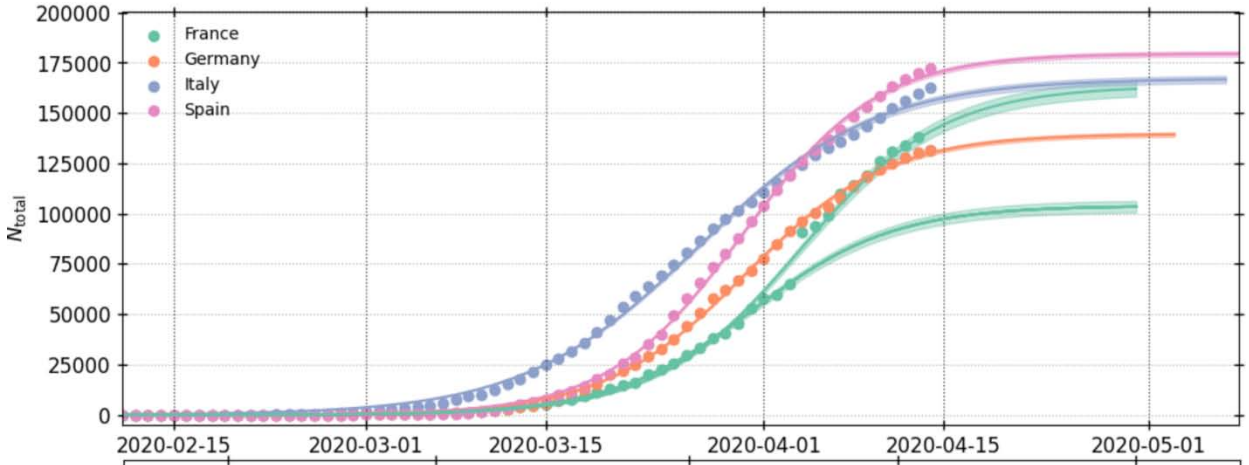


Starting from April 15, 2020, we are offering to all ICRANet members, our daily report on COVID-19. Please, click on the following link on ICRANet webpage: http://www.icranet.org/covid19-statistics

The phenomenological logistic function is used to model the evolution of the COVID-19 pandemic in different countries. The logistic model is mainly used in epidemiology and provides insights into the transmission dynamics of the virus. The data are from Johns Hopkins University. We note, however, to evaluate the dynamics of transmission of COVID-19, more refined models are needed, which take into account specific measures adopted in each country.

Total number of confirmed cases as a function of time: 15.04.2020

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Italy
Spain
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150000
125000
100000
75000
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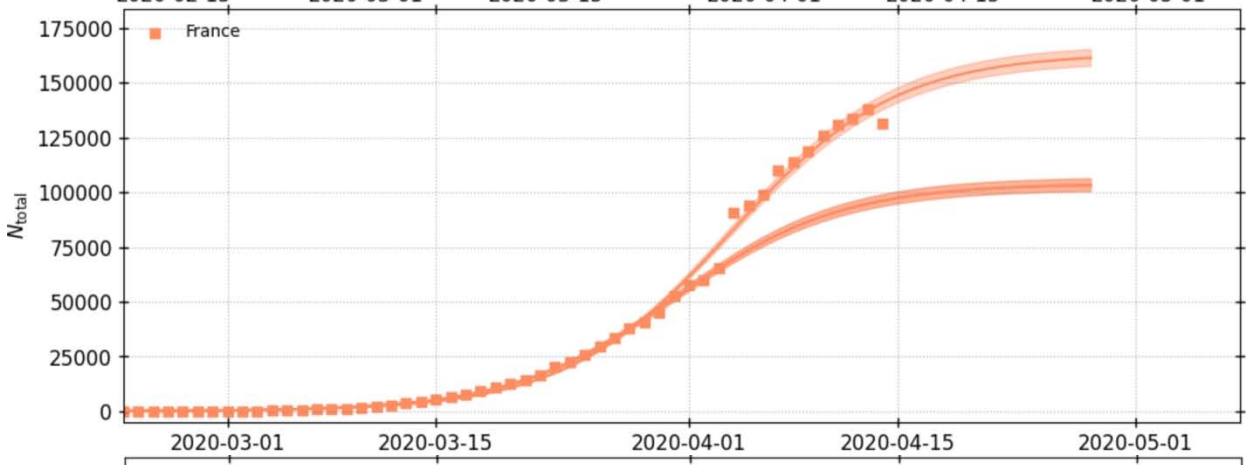
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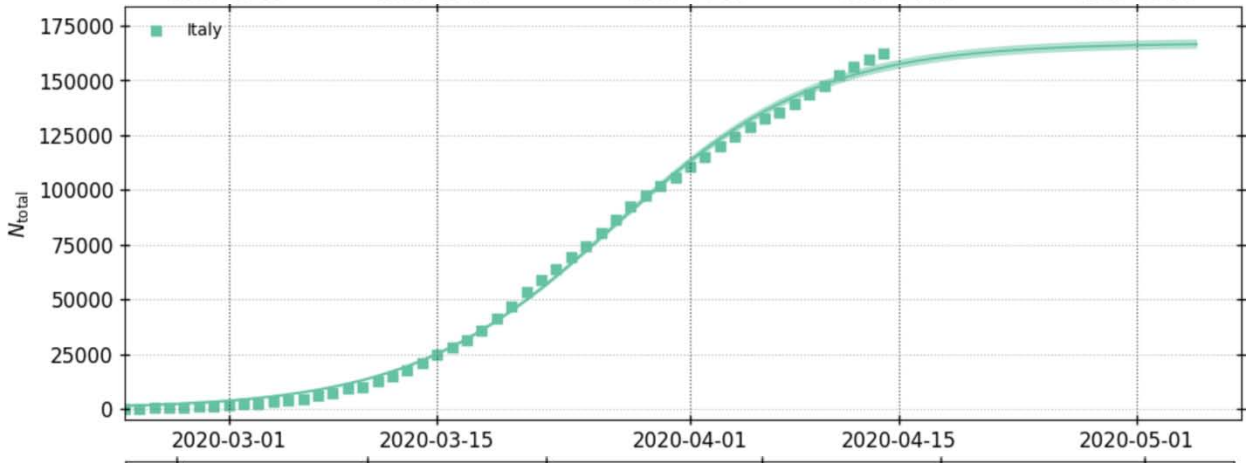
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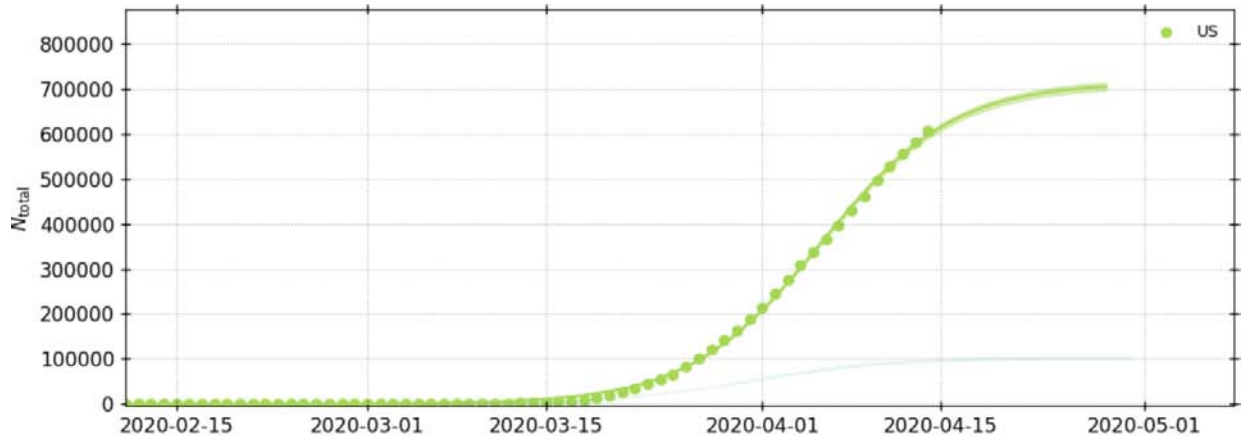
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2. The “Blackholic quantum”

Summary of paper “The blackholic quantum” by J. A. Rueda and R. Ruffini

Progress is being made at ICRANet towards a change of paradigm in black hole (BH) physics that explains how they can be the most powerful sources of energy emission in the Universe. The energy that can be “extracted” from a BH was established in a short period, from September 17, 1970, to March 11, 1971, in a series of papers published by D. Christodoulou, R. Ruffini and S.W. Hawking. Up to 29% of the BH mass-energy could be in principle extracted. This means that for a few solar masses, the amount of energy that it stores is of the order of 10^{53} erg, and up to billion times bigger for the supermassive black holes harbored in the cores of some galaxies. The former energetic could explain the most powerful astrophysical sources in the sky, the gamma-ray bursts (GRBs), while the latter might explain the active galactic nuclei (AGN). However, the determination of a physical process that efficiently extracts the BH energy, has remained elusive for decades.

The new article by J. A. Rueda and R. Ruffini, “The blackholic quantum”, published in The European Physical Journal C [1], makes a step forward the identification of such a physical process: it makes use of a rotating BH in presence of a magnetic field and ionized matter, conditions which are common in astrophysical environments. The rotation and the magnetic field induces an electric field (from which it is possible to define an effective BH charge) that accelerates the charged particles toward ultra-relativistic speeds in the BH surroundings, thence emitting high-energy radiation. In the article, the amount of energy of the BH that this acceleration process is able to take off, is established. The process is shown to occur in “elementary steps”, each one radiating off a part of the BH energy and angular momentum. Indeed, it is shown that, as in the case of the quantum of energy of quantum mechanics, each elementary process takes off a specific amount of the BH energy, say E, that is expressible in the “quantum” form, $E = \hbar^* \Omega_{\rm eff}$, where $\Omega_{\rm eff}$ is an effective angular frequency that depends on the BH mass, angular momentum, the magnetic field strength, and fundamental constants such as the Planck mass and length. The timescale in which the elementary process occurs leads to an estimate of the luminosity of the process, which is applicable and it is shown to be in agreement, to the observed luminosities not only for GRBs but also for AGN, by duly scaling of the BH mass (from solar mass BH to billion mass one) and the strength (from tens of giga Gauss to tens of Gauss) of the surrounding magnetic field. The table shown below, reproduced from the publication, shows the obtained astrophysical quantities derivedfrom the “energy quantum” and the characteristic time of the elementary process. This mechanism, already recently applied to the case of GRB 130427A (see Table and Ref. [2] for details), paves the way towards the explanation of the recently observed emission in GRB 190114C, which not only radiates at GeV energies but also in the most-extreme TeV energy domain, as well as to the high-emission of AGN, such as the one at the center of M87.

	GRB (130427-like)	AGN (M87*-like)
$\tau_{\rm el}$	2.21×10^{-5} s	0.49 day
ε_e (eV)	1.68×10^{18}	1.19×10^{19}
$\mathscr{E}$ (erg)	4.73×10^{36}	5.19×10^{47}
$\dot{\mathscr{E}}$ (erg/s)	2.21×10^{41}	1.22×10^{43}

Fig. 1: Table reproduced from Rueda & Ruffini (2020) [1]. Inner engine astrophysical quantities for GRBs and AGN. The reported power in the last row is the one to accelerate ultrahigh-energy particles. In both cases the parameters (mass, spin and magnetic field) have been fixed to explain the observed high-energy (~GeV) luminosity.

The analogy with the quantum world does not end here, it is also shown that, by properly introducing the concept of “BH magneton”, for the energy of the accelerated particles occurs an analogy with the Zeeman and Stark effects, scaled from microphysics to macrophysics. Furthermore, the application of the derived formulas to an electron, namely replacing the BH mass with the electron mass, it is shown that the effective BH charge, which depends on the magnetic moment of the exterior field and the BH angular momentum, becomes the electron’s charge. Further consequences on theoretical physics aspects of these intriguing analogies are currently under study.

For more details, we refer to the published article [1].

[1] Rueda, J.A., Ruffini, R., “The blackholic quantum”, Eur. Phys. J. C 80, 300 (2020). https://doi.org/10.1140/epjc/s10052-020-7868-z / ArXiv pre-print: https://arxiv.org/abs/1907.08066
[2] Ruffini, R., Rueda, J.A., Moradi, R., et al., “On teh GeV emission of the Type I BdHN GRB 130427A”, The Astrophysical Journal 886, 82 (2019).

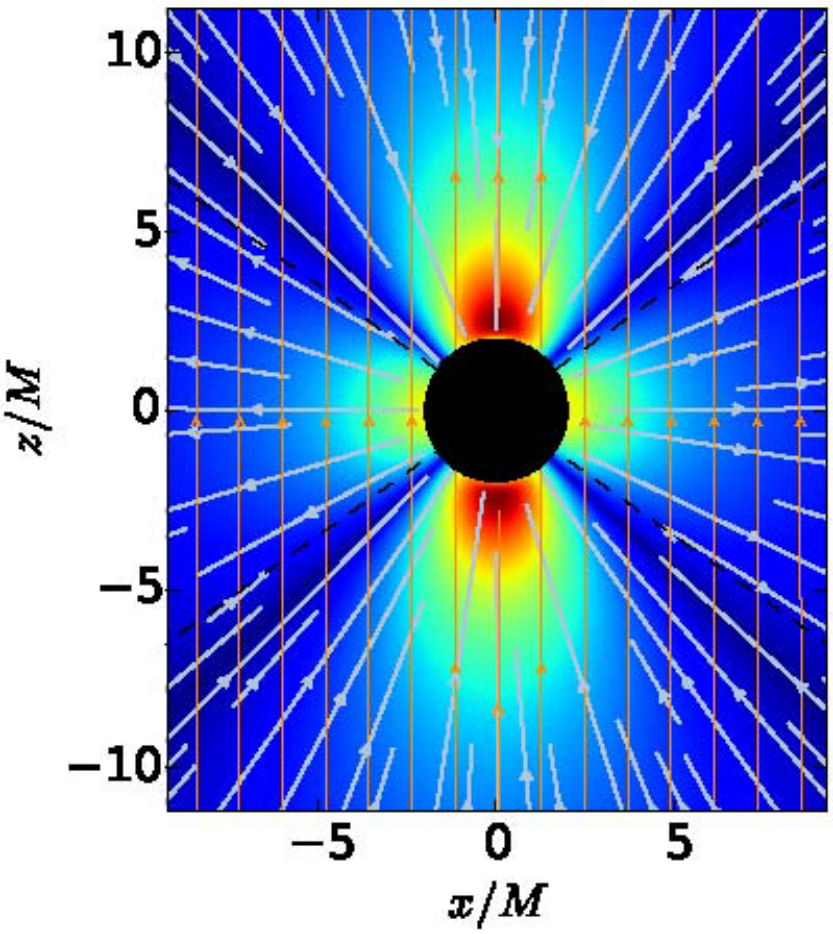

Fig. 2: Electric (light blue) and magnetic (orange) field lines around a Kerr black hole. The colored background shows the blackholic quantum of energy per unit volume; redder regions have more energy to accelerate charged particles than bluer ones.

3. The two papers by ICRANet scientists within MAGIC collaboration

The paper by MAGIC collaboration entitled "*Monitoring of the radio galaxy M 87 during a low-emission state from 2012 to 2015 with MAGIC"* has been published in Monthly Notices of the Royal Astronomical Society on 08 January 2020.

Fig. 3.: the MAGIC telescope.

M87 is a large elliptical galaxy located at about 50 million light years from Earth. It is a very interesting source for various reasons. First, at the center of M87 we can infer the presence of an object that contains a total mass about as large as 7 billion times the mass of the Sun. We think that such an object is a super massive black hole. Second, M87 is surrounded by a disk of matter that fuels the emission of particles/radiation, which we can detect from Earth. This radiations pans a large range of energy, going from radio waves (indeed, M87, is known as a radio galaxy) to very high energy. In particular, part of this emission is concentrated in a pair of narrow jets that, indeed, do accelerate particles up to very high energy. By studying this emission we can gain a better understanding of the physics that governs the evolution of M87, and other similar objects in the universe. Moreover, we can also test our understanding of physics in such an extreme scenario. Finally, since M87 is located relatively close to Earth (it is, indeed, the closest very high energy source), it is a convenient target for such challenging observations.

Objects like M87 often show a variable emission, which means that the amount of particles/radiation that they emit changes with time. Sometimes they are in a "high state" (more particles/energy emitted),other times in a "low" one. Moreover, such a change in the emission may appear at some energies, but not at others (e.g., we could see an enhanced radio emission, but a constant emission at very high energies, and so on).

The MAGIC telescopes, a pair of Cherenkov telescopes located at the Canary Island of La Palma, are an ideal instrument to study the very high energy emission of M87. MAGIC uses the Earth's atmosphere as a huge detector: when high-energy particles reach Earth, they interact with the atmosphere, and produce fluorescence light, that is collected by MAGIC17 meters wide mirrors, and focused on a camera. The data acquired in this way is thoroughly analyzed, to extract as much information as possible about the original particle. It proves extremely effective to combine the very high energy information obtained by MAGIC, with the observations of other instruments at different energies, as different energies are usually related to different fundamental processes.

This is why, between 2012 and 2015, MAGIC joined forces with other instruments (Fermi-LAT, Chandra, HST, EVN, VERA, VLBA, and the Liverpool Telescope) to regularly monitor the emission of M87 over its entire energy spectrum (from radio to very high energy). Another goal of MAGIC observations has been to pinpoint the region where VHE are emitted. These combined observations, together with, e.g., the more recent results of the Event Horizon Telescope, give us a more complete picture of M87

and of the processes that it harbors, and helps us in developing and refining our models of this fascinating astrophysical object. More details and technical results, are reported in a paper that has been recently published in the Monthly Notices of the Royal Astronomical Society.

Links: https://arxiv.org/abs/2001.01643, https://doi.org/10.1093/mnras/staa014

The paper "*New Hard-TeV Extreme Blazars Detected with the MAGIC Telescopes*" has been published in the Astrophysical Journal on 20 February 2020.

Extreme high-frequency-peaked BL Lac objects (EHBLs) are blazars that exhibit extremely energetic synchrotron emission. They also feature non thermal gamma-ray emission whose peak lies in the very high-energy (VHE, E > 100 GeV) range, and in some sources exceeds 1 TeV: this is the case for hard-TeV EHBLs such as 1ES 0229+200. With the aim of increasing the EHBL population, 10 targets were observed with the MAGIC telescopes from 2010 to 2017, for a total of 265 hr of good-quality data. The data were complemented by coordinated Swift observations. The X-ray data analysis confirms that all but two sources are EHBLs. The sources show only a modest variability and a harder-when-brighter behavior, typical for this class of objects. At VHE gamma-rays, three new sources were detected and a hint of a signal was found for another new source. In each case, the intrinsic spectrum is compatible with the hypothesis of a hard-TeV nature of these EHBLs. The broadband spectral energy distributions (SEDs) of all sources are built and modeled in the framework of a single-zone, purely leptonic model. The VHE gamma-ray-detected sources were also interpreted with a spine-layer model and a proton synchrotron model. The three models provide a good description of the SEDs. However, the resulting parameters differ substantially in the three scenarios, in particular the magnetization parameter. This work presents the first mini catalog of VHE gamma-ray and multi wave length observations of EHBLs.

Link: https://doi.org/doi:10.3847/1538-4365/ab5b98

4. The "fall and raise" of Betelgeuse of 2020

C. Sigismondi, ICRA/Sapienza

Introduction

Betelgeuse, the supergiant star alpha of Orion is a semi-regular variable star, ranging normally between 0 and 0.9 magnitude. In 2019/2020 it reached a visual minimum of 1.45 mag around February 11, and by April 12, it is already at mag 0.45. The attention of the astronomical world on this phenomenon was relevant, but none of the media dedicated were able to evidence the unproper quoting of a supposed pre-supernova stage.

A meeting on January 17, 2020 in ICRANet seat in Pescara was organized in order to comment these news and the last observations show a rapid restoring of the usual luminosity of the star, please see: http://www.icranet.org/index.php?option=com_content&task=view&id=1281

Fig. 4: Prof. Costantino Sigismondi during his seminar at ICRANet seat in Pescara.

Visual observations of Variable stars since 1997 with Mira Ceti
On December 6th 2019, after more than one month of cloudy nights over Rome, Betelgeuse was estimated by me as 1.1 visual magnitude, getting the lowest value of AAVSO records. AAVSO is the American Association of variable Stars Observers and it has thousands affiliated.

During a science visit as ICRA member in Fermilab and ESO/Chile in 1999, I had the first possibility to observe Eta Carinae, the supergiant star that had a outburst in 1843, to negative magnitude, becoming the second star of the night sky, only inferior to Sirius and Canopus. This observation was done in Santiago de Chile at ESO headquarters where I gave a talk on Fermions in the Early Universe, the subject of my first PhD, and it was the occasion to become an AAVSO contributing observer, with the code SGQ. The enrollment on the internet was done in the bureaus of prof. Teitelboim, I was visiting.

In July of the same year (1999), when the Nova Aquilae 1999 was measured from Pescara ICRANet seat, we obtained an acknowledging diploma from Janet Mattei, the former director of AAVSO, untimely dead in 2004. My research project in variable stars begun in 1997 with my history of science studies about the Bethlehem star, made for the master's degree in Theology at Lateran University (Rome, 1998). I explored the hypothesis that Mira Ceti could have been that star.

Mira is close to the position where in the year 6-7 b.C. Jupiter and Saturn had the triple conjunction calculated already from Kepler in 1611. Kepler added that this conjunction could have been the cause of the new star, which should have been the Bethlehem star. The connection between Mira and the Bethlehem star was possible because of my series of observations of Mira in 1997, made for understanding the appearance of a variable star, and the method of observing with naked eyes (Argelander's method and airmass correction). This is for presenting my 23-years experience in observing variable stars.

On the occasion of the XIV Marcel Grossmann Meeting (MG14) in 2015 and of the XV Marcel Grossmann Meeting (MG15) in 2018, I have presented two talks dedicated to 1) the first 1000 observations; and 2) Betelgeuse visual observations compared to V-band digital data realized in Wien by Wolfgang Vollmann for the same time period: from 2011.

The historical minimum
On December 8, E. Guinan of Villanova University started a series of Astronomer's Telegrams dedicated to the unusual fading of Betelgeuse. I attended it on December 29, 2019 to prepare a communication to arxiv.org appeared on January 1, 2020, dealing with the Historical minimum of Betelgeuse, about to end. The date of the minimum was predicted "by February" simply by analyzing the last 8 years of homogeneous observations made by me and Vollmann (SGQ and VOL) already published in MGM XIV and updated to the end 2019.

The ICRANet meeting on Betelgeuse dimming
Another occasion to study the behavior of Betelgeuse was created by the interaction held with Margarita Karovska of Harvard CfA who read my arxiv and commented it via e-mail: we decided to organize a virtual meeting with the most prominent italian experts of Supernovae and Observational Astronomy and the AAVSO director Stella Kafka. The Meeting was held in Pescara, ICRANet seat on January 17.

My first goal was to remind the public opinion that a Supernova is the result of a core collapse in a free-fall time, that for a 12 solar mass star does not excess some tens of minutes, not months, as the news from several media were diffusing.

Cesare Barbieri, Massimo Turatto and Paolo Ochner of Padova University and Asiago Astrophysical Observatory, the major in Italy added their contribution to that successful meeting, chaired by prof. Ruffini and me.

On February 2, on AGB newsletter of the IAU division on Red Giant Variable stars, I sent my contribution for the Question of the Month "When Betelgeuse will explode? And it has been reported in full detail, with the aforementioned goal of the ICRANet meeting of January 17.

Rapid rising of the light curve of Betelgeuse in March-April 2020
On March 31, I have published the Astronomer's Telegram #13601 regarding the rapid rising of the light curve of Betelgeuse, attaining already 0.02 magnitudes/day and 0.9 visual magnitude, with an increase of 0.55 magnitudes since February 11, 2020, when the minimum was reached, with 1.45 visual magnitude. I

wrote that if this will be the fastest rate it would have been reasonable a maximum around magnitude 0.4, with a very simple kinematic model: the largest speed is found at the center of an oscillation.

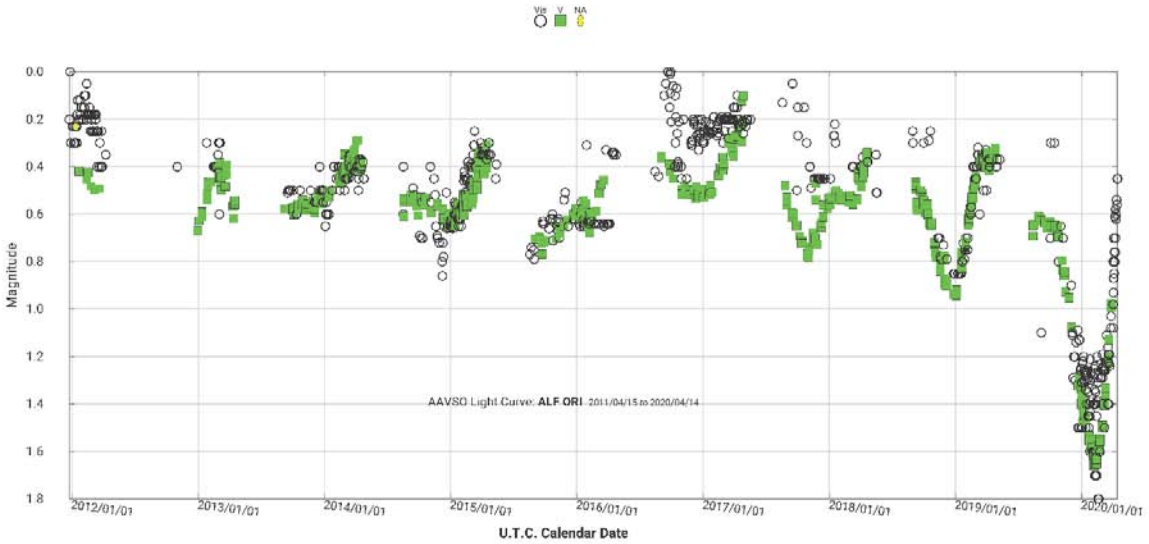

Fig. 5. Betelgeuse light curve in visible light. Data from www.aavso.org. Black points (VIS): Costantino Sigismondi, green squares (VOL): Wolfgang Vollmann (Vienna), V-band.

Now, April 12, 2020, the magnitude is reaching already 0.45 visual magnitude with an average rising velocity of 0.45 mag/12 days or 0.0375 mag/day during the last two weeks, see Fig. 2. A simple extension of the kinematic model would consider this one as the new center of the oscillation, but it cannot be, implying a negative magnitude maximum, which would be really unprecedented.

The basic idea proposed since 1984 by Margarita Karovska and treated once again during our ICRANet meeting of January 17, is that there are dust clouds around the star which can either dim the light from the photosphere, either diffuse it through backward scattering when the cloud is behind the star. The observations to be realized in these days by the ESO VLT interferometer can confirm this hypothesis. The last published ones, available in the Astronomer's Telegram references in my #13601, show Betelgeuse at minimum, as consisting in a photosphere divided in two regions, one of which is much darker than the other, because behind the aforementioned cloud of ejecta. Now this cloud is possibly moving to the back of the stellar photosphere, contributing to a maximum even brighter than usual values and approaching to magnitude 0. We have to expect new data to complete this noteworthy cycle of Betelgeuse.

Conclusions

The last one data on which I based the ATel #13601 have been taken from Rome, near the Vatican, by using the naked eye technique developed in these last two decades to solve the problem of lack of nearby comparison stars for such bright variable star. Differential photometry is impossible and the different altitude of the comparison stars has to be measured to compute the air mass contributions for each star (Betelgeuse, compared with Pollux and Castor during the minimum phase and compared with Procyon and Aldebaran during the present phase, or Procyon and Rigel during maxima).
This technique is a basic one in photometry, but it is not mentioned in visual observations. I have done it with several high school students of Rome and Pescara and through specialized publications.

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5. VII Leopoldo García-Colín Mexican Meeting on Mathematical and Experimental Physics, Mexico City, February 15-18, 2020

From February 15 to 18, Professor Ruffini, Director of ICRANet, visited El Colegio Nacional in Mexico City (Mexico) since he was invited to deliver a super plenary lecture on the occasion of the VII Leopoldo García-Colín Mexican Meeting on Mathematical and Experimental Physics. On Monday, February 17, Prof. Ruffini presented his talk, titled"*Discovery of energy extraction by discrete "Black-Holic" quanta from a Kerr Black Hole in GRB 190114C"*.

Here is the abstract: Almost fifty years after the paper "Introducing the Black Hole" by Ruffini and Wheeler and the Black Hole (BH) mass energy formula by Christodoulou Ruffini and Hawking, we can finally assert that we have been observing the moment of creation of a BH in the BdHN I GRB 190114C with corresponding rotational energy extraction process. The predicted properties of the BdHN I have been now observed: both in this source and in GRB 130427A, in GRB 160509A and in GRB 160625B. The first appearance of the Supernova the SN rise triggering the BdHN has been identified and followed all the way to the appearance of the optical SN. The onset of the GeV radiation coinciding with the BH formation has revealed self similar structures in the time resolved spectral analysis of all sources. Consequently, we find evidence for quantized-discrete-emissions in all sources, with energy quanta of 1037 ergs with repetition time of 10-14 sec. GRBs are the most complex systems ever successfully analyzed in physics and astrophysics, and they may well have a role in the appearance of life in the Cosmos. These results have been made possible by a long-lasting theoretical activity, a comprehensive unprecedented high quality data analysis, an observational multi-messenger effort by the astronomical, the physical and the space research communities. This observational effort is well epitomized by the original Vela Satellites, the NASA Compton space mission (CGRO), the Italo-Dutch Beppo SAX satellite, The Russian Konus Wind Satellite, the NASA Niels-Gehrels SWIFT satellite, the Italian AGILE satellite, the NASA FERMI mission and most recently the Chinese satellite HXMT. These space missions have been assisted by radio and optical equally outstanding observational facilities from the ground.

Fig. 6: Prof. Ruffini during his super plenary lecture at the VII Leopoldo García-Colín Mexican Meeting on Mathematical and Experimental Physics, in Mexico City (Mexico), February 17, 2020.

Fig. 7: Prof. Alfredo Macias introducing Prof. Ruffini at El Colegio Nacional.

For the video of Prof. Ruffini presentation: https://www.youtube.com/watch?v=m532c7iFE60

6. Postponement of the Fourth Zeldovich meeting, Minsk, Belarus

In view of the current worldwide situation caused by Coronavirus COVID-19, the 4thZeldovich meeting Organizing Committee decided to postpone the conference, previously scheduled from April 20-24, 2020 in Minsk (Belarus). The new tentative dates for the meeting are September 7-11, 2020. We hope that invited speakers as well as other participants, will be available also in these new dates.

More details will be communicated through the conference website: www.icranet.org/zeldovich4

7. Congratulations to Prof. Narek Sahakyan, Director of ICRANet Armenia, included in the top 100 Armenian researchers' list, March 6, 2020

It is a pleasure to announce that Professor Narek Sahakyan, Director of ICRANet Armenia, has been included in the list of the top 100 researchers in Armenia. On March 6, 2020, the Ministry of Education, Science, Culture and Sport of Armenia has published, as every year, a list of the most active and productive 100 Armenian researchers in all disciplines (called *"Top 100"*), based on the publications of the previous 10 years, citations, etc. Prof. Sahakyan was included in this list.

For the official announcement, see the link (in Armenian): http://scs.am/am/06-03-2020

8. Recent publications

J. A. Rueda and R. Ruffini, *The blackholic quantum*, European Physical Journal C, 80, 300 (2020).

We show that the high-energy emission of GRBs originates in the "inner engine": a Kerr black hole (BH) surrounded by matter and a magnetic field B0. It radiates a sequence of discrete events of particle acceleration, each of energy $\varepsilon=\hbar\Omega_{eff}$, the "blackholic quantum", where $\Omega_{eff}=4(m_{Pl}/m_n)^8(ca/GM)(B^2_0/\rho_{Pl})\Omega_+$. Here M, $a=J/M$, $\Omega_+=c^2\partial M/\partial J=(c^2/G)a/(2Mr_+)$ and r_+ are the BH mass, angular momentum per unit mass, angular velocity and horizon; m_n is the neutron mass, m_{Pl}, $\lambda_{Pl}=\hbar/(m_{Pl}c)$ and $\rho_{Pl}=m_{Pl}c^2/\lambda^3_{Pl}$, are the Planck mass, length and energy density. The timescale of each process is $\tau el\sim\Omega^{-1}_+$. We show an analogy with the Zeeman and Stark effects, properly scaled from microphysics to macrophysics, that allows us to define the "BH magneton", $\mu_{BH}=(m_{Pl}/m_n)^4(ca/GM)e\hbar/(Mc)$. We give quantitative estimates for GRB 130427A adopting $M=2.3M_\odot$, $ca/(GM)=0.3$ and $B_0=2.9\times10^{14}$ G. Each emitted "quantum", $\varepsilon\sim10^{44}$ erg, extracts only 10^{-9} times the BH rotational energy, guaranteeing that the process can be repeated for thousands of years. The "inner engine" can also work in AGN as we here exemplified for the supermassive BH at the center of M87.

Links: https://arxiv.org/abs/1907.08066, https://doi.org/10.1140/epjc/s10052-020-7868-z.

J. A. Rueda, R. Ruffini, M. Karlica, R. Moradi, Y. Wang, *Magnetic Fields and Afterglows of BdHNe: Inferences from GRB 130427A, GRB 160509A, GRB 160625B, GRB 180728A and GRB 190114C*, accepted for publication in The Astrophysical Journal.

GRB 190114C is the first binary-driven hypernova (BdHN) fully observed from the initial supernova appearance to the final emergence of the optical SN signal. It offers an unprecedented testing ground for the BdHN theory and it is here determined and further extended to additional gamma-ray bursts (GRBs). BdHNe comprise two subclasses of long GRBs with progenitors a binary system composed of a carbon-oxygen star (CO_{core}) and a neutron star (NS) companion. The CO_{core} explodes as a SN leaving at its center a newborn NS (νNS). The SN ejecta hypercritically accretes both on the νNS and the NS companion. BdHNe I are the tightest binaries where the accretion leads the companion NS to gravitational collapse into a black hole (BH). In BdHN II the accretion onto the NS is lower, so there is no BH formation. We observe the same structure of the afterglow for GRB 190114C and other selected examples of BdHNe I (GRB 130427A, GRB 160509A, GRB 160625B) and for BdHN II (GRB 180728A). In all the cases the explanation of the afterglow is reached via the synchrotron emission powered by the νNS: their magnetic fields structures and their spin are determined. For BdHNe I, we discuss the properties of the magnetic field embedding the newborn BH, inherited from the collapsed NS and amplified during the gravitational collapse process, and surrounded by the SN ejecta.

Link: https://arxiv.org/abs/1905.11339

De Lima, Rafael C. R.; Coelho, Jaziel G.; Pereira, Jonas P.; Rodrigues, Claudia V.; Rueda, Jorge A., *Evidence for a Multipolar Magnetic Field in SGR J1745-2900 from X-Ray Light-curve Analysis*, published in The Astrophysical Journal, Volume 889, Issue 2, id.165, on February 4, 2020.

SGR J1745-2900 was detected from its outburst activity in April 2013 and it was the first soft gamma repeater (SGR) detected near the center of the Galaxy (Sagittarius A*). We use 3.5-year Chandra X-ray light-curve data to constrain some neutron star (NS) geometric parameters. We assume that the flux modulation comes from hot spots on the stellar surface. Our model includes the NS mass, radius, a maximum of three spots of any size, temperature and positions, and general relativistic effects. We find that the light-curve of SGR J1745-2900 could be described by either two or three hot spots. The ambiguity is due to the small amount of data, but our analysis suggests that one should not disregard the possibility of multi-spots (due to a multipolar magnetic field) in highly magnetized stars. For the case of three hot spots, we find that they should be large and have angular semi-apertures ranging from 16-67 degrees. The large size found for the spots points to a magnetic field with a nontrivial poloidal and toroidal structure (in accordance with magnetohydrodynamics investigations and NICER's recent findings for PSR J0030+0451) and is consistent

with the small characteristic age of the star. Finally, we also discuss possible constraints on the mass and radius of SGR J1745-2900 and briefly envisage possible scenarios accounting for the 3.5-year evolution of SGR J1745-2900 hot spots.

Link: https://arxiv.org/abs/1912.12336

Loppini A, Cherubini C, Bertolaso M, Filippi S., *Breaking down calcium timing in heterogenous cells populations*, published in BIOSYSTEMS, vol. 191-192, p. 1-7, ISSN: 0303-2647.

Calcium controls a large number of cellular processes at different scales. Decades of studies have pointed out the importance of calcium signaling in regulating differentiation, apoptosis, mitosis and functions such as secretion, muscle contraction and memory. The space-time structure of calcium signaling is central to this complex regulation. In particular, cells within organisms behave as clocks beating their own biological time, although in several cases they can synchronize across long distances leading to an emergent space-time dynamics which is central for single cell and organ functioning. We use a mathematical model built on published experimental data of hepatic non-excitable cells, analyzing emerging calcium dynamics of cells clusters composed both of normally functioning cells and pathological aggregates. Calcium oscillations are investigated by varying the severity of dysfunction and size of pathological aggregate. We show how strong and localized heterogeneity in cellular properties can profoundly alter organized calcium dynamics leading to sub-populations of cells which create their own coordinated dynamical organization. Our simulations of Ca^{2+} signals reveal how cell behaviors differ and are related to intrinsic time signals. Such different cells clusters dynamically influence each other so that non-physiological although organized calcium patterns are generated. This new reorganization of calcium activity may possibly be a precursor of cancer initiation.

Link: https://doi.org/10.1016/j.biosystems.2020.104117

MAGIC Collaboration; Acciari, V. A.; Ansoldi, S.; Antonelli, L. A.; Arbet Engels, A.; Arcaro, C.; Baack, D.; Babić, A.; Banerjee, B.; Bangale, P.; Barres de Almeida, U.; Barrio, J. A.; Becerra González, J.; Bednarek, W.; Bellizzi, L.; Bernardini, E.; Berti, A.; Besenrieder, J.; Bhattacharyya, W.; Bigongiari, C. Biland, A.; Blanch, O.; Bonnoli, G.; Bošnjak, Ž.; Busetto, G.; Carosi, R.; Ceribella, G.; Chai, Y.; Chilingaryan, A.; Cikota, S.; Colak, S. M.; Colin, U.; Colombo, E.; Contreras, J. L.; Cortina, J.; Covino, S.; D'Elia, V.; da Vela, P.; Dazzi, F.; de Angelis, A.; de Lotto, B.; Delfino, M.; Delgado, J.; Depaoli, D.; di Pierro, F.; di Venere, L.; Do SoutoEspiñeira, E.; Dominis Prester, D.; Donini, A.; Dorner, D.; Doro, M.; Elsaesser, D.; Fallah Ramazani, V.; Fattorini, A.; Fernández-Barral, A.; Ferrara, G.; Fidalgo, D.; Foffano, L.; Fonseca, M. V.; Font, L.; Fruck, C.; Fukami, S.; García López, R. J.; Garczarczyk, M.; Gasparyan, S.; Gaug, M.; Giglietto, N.; Giordano, F.; Godinović, N.; Green, D.; Guberman, D.; Hadasch, D.; Hahn, A.; Herrera, J.; Hoang, J.; Hrupec, D.; Hütten, M.; Inada, T.; Inoue, S.; Ishio, K.; Iwamura, Y.; Jouvin, L.; Kerszberg, D.; Kubo, H.; Kushida, J.; Lamastra, A.; Lelas, D.; Leone, F.; Lindfors, E.; Lombardi, S.; Longo, F.; López, M.; López-Coto, R.; López-Oramas, A.; Loporchio, S.; Machado de Oliveira Fraga, B.; Maggio, C.; Majumdar, P.; Makariev, M.; Mallamaci, M.; Maneva, G.; Manganaro, M.; Mannheim, K.; Maraschi, L.; Mariotti, M.; Martínez, M.; Masuda, S.; Mazin, D.; Mićanović, S.; Miceli, D.; Minev, M.; Miranda, J. M.; Mirzoyan, R.; Molina, E.; Moralejo, A.; Morcuende, D.; Moreno, V.; Moretti, E.; Munar-Adrover, P.; Neustroev, V.; Nigro, C.; Nilsson, K.; Ninci, D.; Nishijima, K.; Noda, K.; Nogués, L.; Nöthe, M.; Nozaki, S.; Paiano, S.; Palacio, J.; Palatiello, M.; Paneque, D.; Paoletti, R.; Paredes, J. M.; Peñil, P.; Peresano, M.; Persic, M.; Prada Moroni, P. G.; Prandini, E.; Puljak, I.; Rhode, W.; Ribó, M.; Rico, J.; Righi, C.; Rugliancich, A.; Saha, L.; Sahakyan, N.; Saito, T.; Sakurai, S.; Satalecka, K.; Schmidt, K.; Schweizer, T.; Sitarek, J.; Šnidarić, I.; Sobczynska, D.; Somero, A.; Stamerra, A.; Strom, D.; Strzys, M.; Suda, Y.; Surić, T.; Takahashi, M.; Tavecchio, F.; Temnikov, P.; Terzić, T.; Teshima, M.; Torres-Albà, N.; Tosti, L.; Tsujimoto, S.; Vagelli, V.; van Scherpenberg, J.; Vanzo, G.; Acosta, M. Vazquez; Vigorito, C. F.; Vitale, V.; Vovk, I.; Will, M.; Zarić, D.; Asano, K.; Hada, K.; Harris, D. E.; Giroletti, M.; Jermak, H. E.; Madrid, J. P.; Massaro, F.; Richter, S.; Spanier, F.; Steele, I. A.; Walker, R. C., *Monitoring of the radio galaxy M 87 during a low-emission state from 2012 to 2015 with MAGIC*, published on Monthly Notices of the Royal Astronomical Society, Volume 492, Issue 4, p.5354-5365.

M 87 is one of the closest (z = 0.004 36) extragalactic sources emitting at very high energies (VHE, E > 100 GeV). The aim of this work is to locate the region of the VHE gamma-ray emission and to describe the observed broad-band spectral energy distribution (SED) during the low VHE gamma-ray state. The data from M 87 collected between 2012 and 2015 as part of a MAGIC monitoring programme are analysed and combined with multiwavelength data from Fermi-LAT, Chandra, HST, EVN, VLBA, and the Liverpool Telescope. The averaged VHE gamma-ray spectrum can be fitted from ∼100 GeV to ∼10 TeV with a simple power law with a photon index of (-2.41 ± 0.07), while the integral flux above 300 GeV is (1.44± 0.13)× 10^{-12} cm^{-2} s^{-1}. During the campaign between 2012 and 2015, M 87 is generally found in a low-emission state at all observed wavelengths. The VHE gamma-ray flux from the present 2012-2015M 87 campaign is consistent with a constant flux with some hint of variability (∼ 3 σ) on a daily time-scale in 2013. The low-state gamma-ray emission likely originates from the same region as the flare-state emission. Given the broad-band SED, both a leptonic synchrotron self-Compton and a hybrid photohadronic model reproduce the available data well, even if the latter is preferred. We note, however, that the energy stored in the magnetic field in the leptonic scenario is very low, suggesting a matter-dominated emission region.

Link: https://doi.org/10.1093/mnras/staa014

Acciari, V. A.; Ansoldi, S.; Antonelli, L. A.; Engels, A. Arbet; Asano, K.; Baack, D.; Babić, A.; Banerjee, B.; de Almeida, U. Barres; Barrio, J. A.; González, J. Becerra; Bednarek, W.; Bellizzi, L.; Bernardini, E.; Berti, A.; Besenrieder, J.; Bhattacharyya, W.; Bigongiari, C.; Biland, A.; Blanch, O. Bonnoli, G.; Bošnjak, Ž.; Busetto, G.; Carosi, R.; Ceribella, G.; Cerruti, M.; Chai, Y.; Chilingaryan, A.; Cikota, S.; Colak, S. M.; Colin, U.; Colombo, E.; Contreras, J. L.; Cortina, J.; Covino, S.; D'Elia, V.; Vela, P. Da; Dazzi, F.; Angelis, A. De; Lotto, B. De; Delfino, M.; Delgado, J.; Depaoli, D.; Pierro, F. Di; Venere, L. Di; SoutoEspiñeira, E. Do; Prester, D. Dominis; Donini, A.; Dorner, D.; Doro, M.; Elsaesser, D.; Ramazani, V. Fallah; Fattorini, A.; Ferrara, G.; Fidalgo, D.; Foffano, L.; Fonseca, M. V.; Font, L.; Fruck, C.; Fukami, S.; López, R. J. García; Garczarczyk, M.; Gasparyan, S.; Gaug, M.; Giglietto, N.; Giordano, F.; Godinović, N.; Green, D.; Guberman, D.; Hadasch, D.; Hahn, A.; Herrera, J.; Hoang, J.; Hrupec, D.; Hütten, M.; Inada, T.; Inoue, S.; Ishio, K.; Iwamura, Y.; Jouvin, L.; Kerszberg, D.; Kubo, H.; Kushida, J.; Lamastra, A.; Lelas, D.; Leone, F.; Lindfors, E.; Lombardi, S.; Longo, F.; López, M.; López-Coto, R.; López-Oramas, A.; Loporchio, S.; de Oliveira Fraga, B. Machado; Maggio, C.; Majumdar, P.; Makariev, M.; Mallamaci, M.; Maneva, G.; Manganaro, M.; Mannheim, K.; Maraschi, L.; Mariotti, M.; Martínez, M.; Mazin, D.; Mićanović, S.; Miceli, D.; Minev, M.; Miranda, J. M.; Mirzoyan, R.; Molina, E.; Moralejo, A.; Morcuende, D.; Moreno, V.; Moretti, E.; Munar-Adrover, P.; Neustroev, V.; Nigro, C.; Nilsson, K.; Ninci, D.; Nishijima, K.; Noda, K.; Nogués, L.; Nozaki, S.; Paiano, S.; Palatiello, M.; Paneque, D.; Paoletti, R.; Paredes, J. M.; Peñil, P.; Peresano, M.; Persic, M.; Moroni, P. G. Prada; Prandini, E.; Puljak, I.; Rhode, W.; Ribó, M.; Rico, J.; Righi, C.; Rugliancich, A.; Saha, L.; Sahakyan, N.; Saito, T.; Sakurai, S.; Satalecka, K.; Schmidt, K.; Schweizer, T.; Sitarek, J.; Šnidarić, I.; Sobczynska, D.; Somero, A.; Stamerra, A.; Strom, D.; Strzys, M.; Suda, Y.; Surić, T.; Takahashi, M.; Tavecchio, F.; Temnikov, P.; Terzić, T.; Teshima, M.; Torres-Albà, N.; Tosti, L.; Vagelli, V.; Scherpenberg, J. van; Vanzo, G.; Acosta, M. Vazquez; Vigorito, C. F.; Vitale, V.; Vovk, I.; Will, M.; Zarić, D.; Arcaro, C.; Carosi, A.; D'Ammando, F.; Tombesi, F.; Lohfink, A., *New Hard-TeV Extreme Blazars Detected with the MAGIC Telescopes*, published on The Astrophysical Journal Supplement Series, Volume 247, Issue 1, id.16.

Extreme high-frequency-peaked BL Lac objects (EHBLs) are blazars that exhibit extremely energetic synchrotron emission. They also feature nonthermal gamma-ray emission whose peak lies in the very high-energy (VHE, E > 100 GeV) range, and in some sources exceeds 1 TeV: this is the case for hard-TeV EHBLs such as 1ES 0229+200. With the aim of increasing the EHBL population, 10 targets were observed with the MAGIC telescopes from 2010 to 2017, for a total of 265 hr of good-quality data. The data were complemented by coordinated Swift observations. The X-ray data analysis confirms that all but two sources are EHBLs. The sources show only a modest variability and a harder-when-brighter behavior, typical for this class of objects. At VHE gamma-rays, three new sources were detected and a hint of a signal was found for another new source. In each case, the intrinsic spectrum is compatible with the hypothesis of a hard-TeV nature of these EHBLs. The broadband spectral energy distributions (SEDs) of all sources are built and modeled in the framework of a single-zone, purely leptonic model. The VHE gamma-ray-detected sources were also interpreted with a spine-layer model and a proton synchrotron model. The three models provide a

good description of the SEDs. However, the resulting parameters differ substantially in the three scenarios, in particular the magnetization parameter. This work presents the first mini catalog of VHE gamma-ray and multiwavelength observations of EHBLs.

Link: https://doi.org/10.3847/1538-4365/ab5b98

Paiani et al., The redshift and the host galaxy of the neutrino candidate 4FGL J0955.1+3551 (3HSP J095507.9+355101), accepted by MNRAS.

The BL Lac object 4FGLJ0955.1+3551 has been suggested as a possible source of ultra energetic neutrinos detected by the Icecube observatory. The target was observed in January 2020 at the Large Binocular Telescope. Our spectroscopy (4100-8500 Ang) yields a firm redshift z = 0.557 as deduced by the absorption lines of the host galaxy. The upper limit of the minimum equivalent width on emission lines is 0.3 Ang. From the source image we are able to resolve the host galaxy for which we measure an absolute magnitude M(R) = -22.9 and Re = 8 kpc, that is values which are typical of the host galaxies of BL Lacs.

Link: https://arxiv.org/abs/2003.03634

She-Sheng Xue,*Cosmological constant, matter, cosmic inflation and coincidence*, Modern Physics Letters A (2020), 2050123 (13 pages).

We present a possible understanding to the issues of cosmological constant, inflation, dark matter and coincidence problems based only on the Einstein equation and Hawking particle production. The inflation appears and results agree to observations. The CMB large-scale anomaly can be explained and the dark-matter acoustic wave is speculated. The entropy and reheating are discussed. The cosmological term Ω_Λ tracks down the matter Ω_M until the radiation-matter equilibrium, then slowly varies, thus the cosmic coincidence problem can be avoided. The relation between $\Omega_\Lambda$and Ω_M is shown and can be examined at large redshifts.

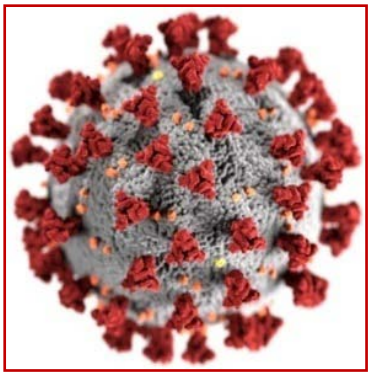
Link: https://doi.org/10.1142/S0217732320501230

ICRANet Newsletter

April–May2020

SUMMARY

1. COVID-19 statistics



Starting from April 15, 2020, we are offering to all ICRANet members, our daily report on COVID-19. Please, click on the following link on ICRANet webpage: http://www.icranet.org/covid19-statistics

The phenomenological logistic function is used to model the evolution of the COVID-19 pandemic in different countries. The logistic model is mainly used in epidemiology and provides insights into the transmission dynamics of the virus. The data are from Johns Hopkins University. We note, however, to evaluate the dynamics of transmission of COVID-19, more refined models are needed, which take into account specific measures adopted in each country.

2. *Magnetic field and rotation of the newborn neutron star in binary-driven hypernovae inferred from the X-ray afterglow of long gamma-ray bursts*

The new article coauthored by Rueda, J. A., Ruffini R., Karlica M., Moradi R., Wang Y.,*Magnetic Fields and Afterglows of BdHNe Inferences from GRB 130427A, GRB 160509A, GRB 160625B, GRB 180728A and GRB 190114C,* has been published by The Astrophysical Journal, 893:148 on April 20, 2020. On that occasion, ICRA and ICRANet released a press release titled *"Magnetic field and rotation of the newborn neutron star in binary-driven hypernovae inferred from the X-ray afterglow of long gamma-ray bursts"*.

This press release, available on ICRANet website (http://www.icranet.org/communication/18052020/eng.pdf), has been circulated by the American Astronomical Society AAS on May 18, 2020 (in English) as well as by INAF (http://www.inaf.it/it/notizie-inaf/campo-magnetico-e-rotazione-della-stella-di-neutroni-neonata-nelle-ipernove-binary-driven-derivato-dall2019afterglow-x-dei-lampi-di-raggi-gamma-lunghi) on May 25, 2020 (in Italian).

Below follows the ICRA-ICRANet press release.

The change of paradigm in gamma-ray burst (GRBs) physics and astrophysics introduced by the binary driven hypernova (BdHN) model, proposed and applied by the ICRA-ICRANet-INAF members in collaboration with the University of Ferrara and the University of Côte d'Azur, has gained further observational support from the X-ray emission in long GRBs. These novel results are presented in the new article [1], published on April 20, 2020, in The Astrophysical Journal, co-authored by J. A. Rueda, Remo Ruffini, Mile Karlica, Rahim Moradi, and Yu Wang.

The GRB emission is composed by episodes: from the hard X-ray trigger and the gamma-ray prompt emission, to the high-energy emission in GeV, recently observed also in TeV energies in GRB 190114C, to the X-ray afterglow. The traditional model of GRBs attempts to explain the entire GRB emissions from a single-component progenitor, i.e. from the emission of a relativistic jet originating from a rotating black hole (BH). Differently, the BdHN scenario proposes GRBs originate from a cataclysmic event in the last evolutionary stage of a binary system composed of a carbon-oxygen (CO) star and a neutron star (NS) companion in close orbit. The gravitational collapse of the iron core of the CO star produces a supernova (SN) explosion ejecting the outermost layers of the star, and at the same time, a newborn NS (νNS) at its center. The SN ejecta trigger a hypercritical accretion process onto the NS companion and onto the νNS. Depending on the size of the orbit, the NS may reach, in the case of short orbital periods of the order of minutes, the critical mass for gravitational collapse, hence forming a newborn BH. These systems where a BH is formed are called BdHN of type I. For longer periods, the NS gets more massive but it does not form a BH. These systems are BdHNe II. Three-dimensional simulations of all this process showing the feasibility of its occurrence, from the SN explosion to the formation of the BH, has been recently made possible by the collaboration between ICRANet and the group of Los Alamos National Laboratory (LANL) guided by Prof. C. L. Fryer, see Figure 1 and [2].

The role of the BH for the formation of the high-energy GeV emission has been recently presented in The Astrophysical Journal in [3]. There, the“engine” composed of a Kerr BH, with a magnetic field aligned with the BH rotation axis immersed in a low-density ionised plasma, gives origin, by synchrotron radiation, to the beamed emission in the MeV, GeV, and TeV, currently observed only in some BdHN I, by the Fermi-LAT and MAGIC instruments. In the new publication [1], the ICRA-ICRANet team addresses the interaction of the νNS with the SN due to hypercritical accretion and pulsar-like emission. They show that the fingerprint of the νNS appears in the X-ray afterglow of long GRBs observed by the XRT detector on board the Niels Gehrels Swift observatory. Therefore, the νNS and the BH have well distinct and different roles in the long GRB observed emission.

The emission from the magnetized νNS and the hypercritical accretion of the SN ejecta into it, gives origin to the afterglow observed in all BdHN I and II subclasses. The early (~few hours) X-ray emission during the afterglow phase is explained by the injection of ultra-relativistic electrons from the νNS into the expanding ejecta, producing synchrotron radiation; see Figure 2. The magnetic field inferred from the synchrotron analysis agrees with the expected toroidal/longitudinal magnetic field component of the νNS. Furthermore, from the analysis of the XRT data of these GRBs at times $t>10^4$ s, it has been shown that the power-law decaying luminosity is powered by the νNS rotational energy loss by the torque acted upon it by its dipole+quadrupole magnetic. From this, it has been inferred that the νNS possesses a magnetic field of strength ~ 1012 -1013 G, and a rotation period of the order of a millisecond; see Figure 3. It is shown in [1], that the inferred millisecond rotation period of the νNS agrees with the conservation of angular momentum in the gravitational collapse of the iron core of the CO star which the νNS came from.

The inferred structure of the magnetic field of the “inner engine”' agrees with a scenario in which, along the rotational axis of the BH, it is rooted in the magnetosphere left by the NS that collapsed into a BH. On the equatorial plane, the field is magnified by magnetic flux conservation.

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[1] J. A. Rueda, R. Ruffini, M. Karlica, R. Moradi, and Y. Wang, Astroph. J. 893, 148 (2020), 1905.11339.

[2] L. Becerra, C. L. Ellinger, C. L. Fryer, J. A. Rueda, and R. Ruffini, Astroph. J. 871, 14 (2019), 1803.04356.

[3] R. Ruffini, R. Moradi, J. A. Rueda, L. Becerra, C. L. Bianco, C. Cherubini, S. Filippi, Y. C. Chen, M. Karlica, N. Sahakyan,et al., Astroph. J. 886, 82 (2019).

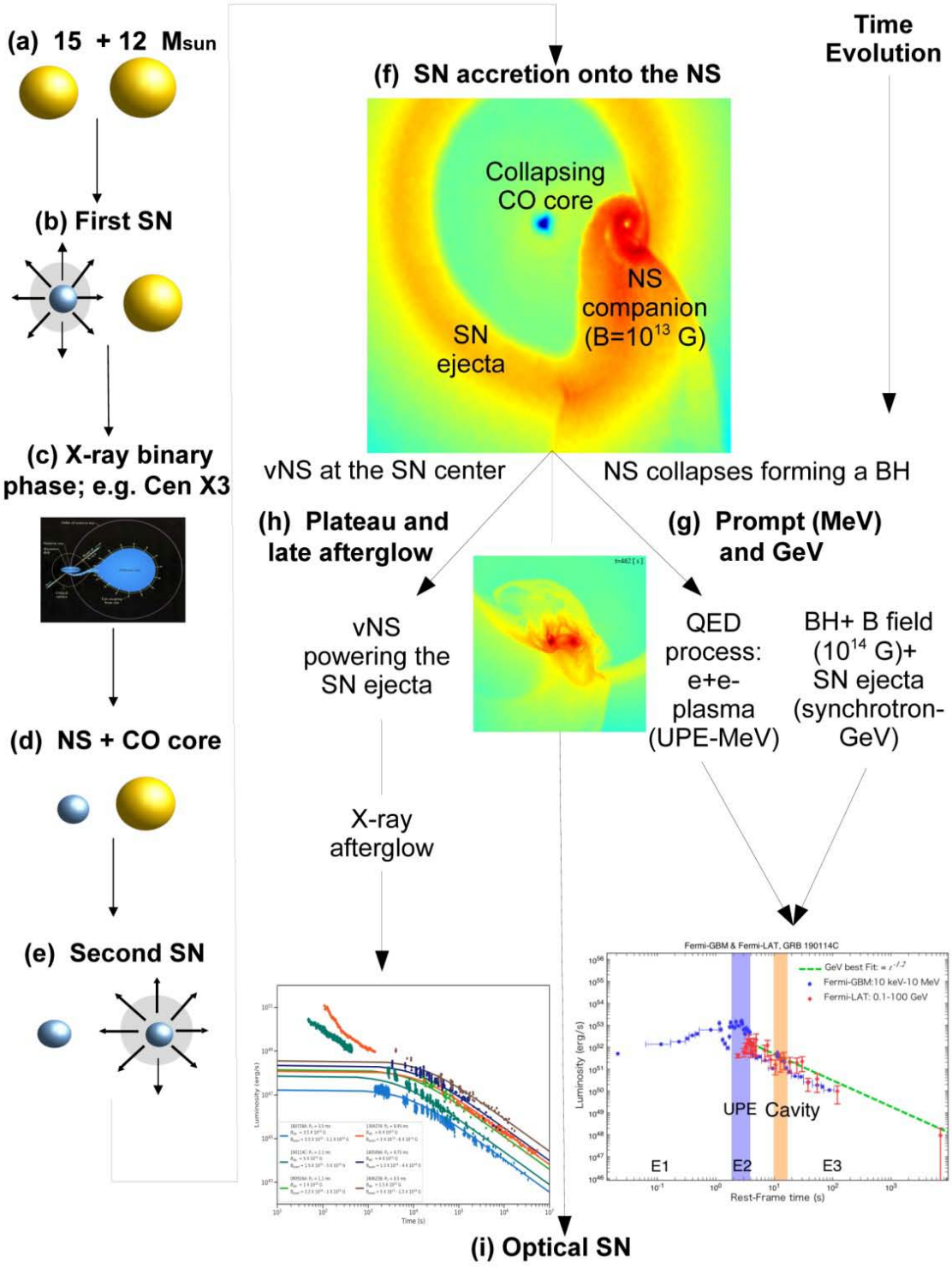


Figure 1. Taken from [1]. Schematic evolutionary path of a massive binary up to the emission of a BdHN. (a) Binary system composed of two main-sequence stars, say 15 and 12 solar masses, respectively. (b) At a given time, the more massive star undergoes the core-collapse SN and forms a NS (which might have a magnetic field B~10^{13} G). (c) The system enters the X-ray binary phase. (d) The core of the remaining evolved star, rich in carbon and oxygen, for short CO star, is left exposed since the hydrogen and helium envelope have been striped by binary interactions and possibly multiple common-envelope phases (not shown in this diagram). The system is, at this stage, a CO-NS binary, which is taken as the initial configuration of the BdHN model [2]. (e) The CO star explodes as SN when the binary period is of the order of few minutes, the SN ejecta of a few solar masses start to expand and a fast rotating, newborn NS, for short *ν*NS, is left in the center. (f) The SN ejecta accrete onto the NS companion, forming a massive NS (BdHN II) or a BH (BdHN I; this example), depending on the initial NS mass and the binary separation. Conservation of magnetic flux and possibly additional MHD processes amplify the magnetic field from the NS value to B~10^{14} G around the newborn BH. At this stage the system is a *ν*NS-BH binary surrounded by ionized matter of the expanding ejecta. (g) The accretion, the formation and the activities of the BH contribute to the GRB prompt gamma-ray emission and GeV emission.

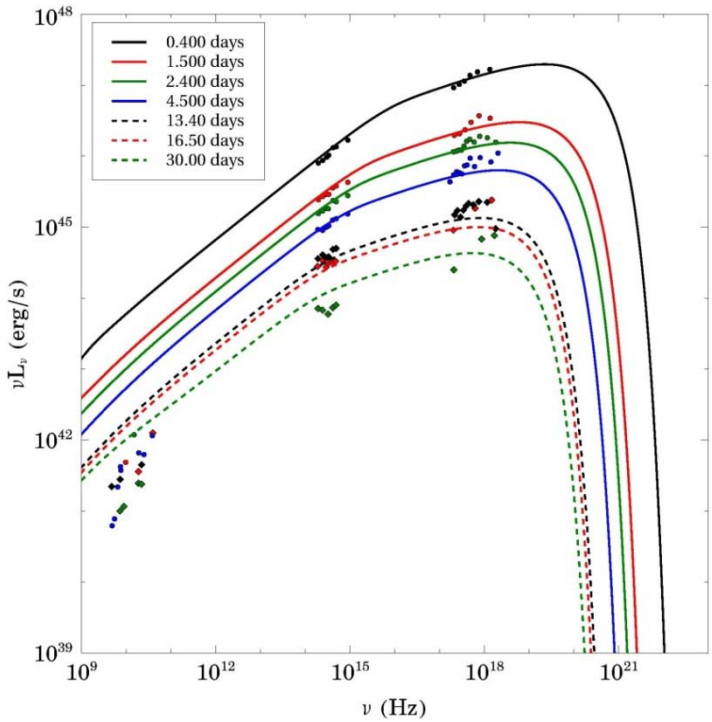


Figure 2. Taken from [1]. Model evolution of synchrotron spectral luminosity at various times compared with measurements in various spectral bands for GRB 160625B.

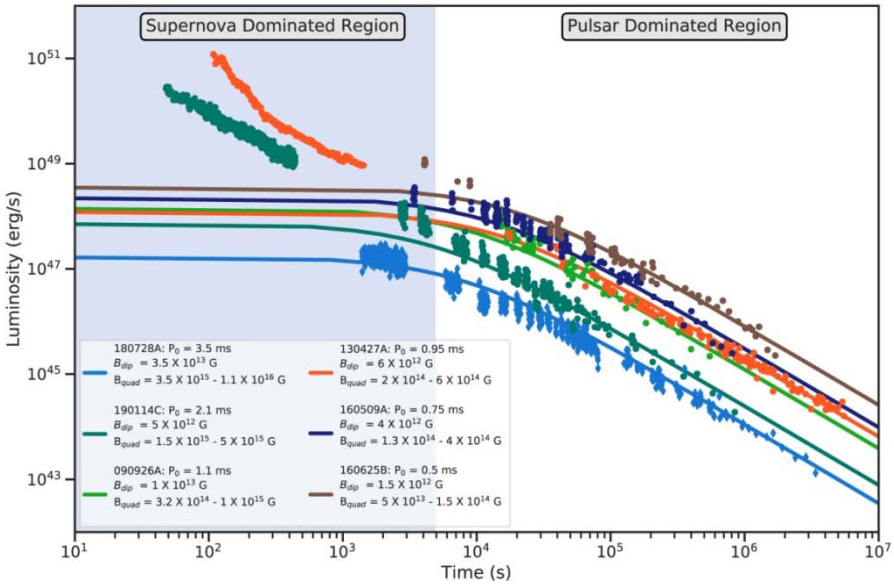


Figure 3. Taken from [1]. The brown, deep blue, orange, green and bright blue points correspond to the bolometric (about ~ 5 times brighter than the soft X-ray observed by Swift-XRT data) light-curves of GRB 160625B, 160509A, 130427A, 190114C and 180728A, respectively. The solid lines are theoretical light-curves obtained from the rotational energy loss of the νNS powering the late afterglow ($t \geq 5 \times 10^3$ s, white background), while in the earlier times ($3 \times 10^2 \leq t \leq 5 \times 10^3$ s, blue background), the kinetic energy of the SN ejecta plays also an important role. Because of the necessity of having a significant sample to extract the physical properties of the νNS (magnetic field and rotation rate), the analysis was limited to late part of the afterglow, say at times $t \geq 3 \times 10^2$ s, where data are more available. At earlier times, only GRB 130427A and GRB 190114C in this same have available data.

Link to the article in ApJ: https://doi.org/10.3847/1538-4357/ab80b9

ICRA-ICRANet press release: http://www.icranet.org/communication/18052020/eng.pdf

INAF press release: http://www.inaf.it/it/notizie-inaf/campo-magnetico-e-rotazione-della-stella-di-neutroni-neonata-nelle-ipernove-binary-driven-derivato-dall2019afterglow-x-dei-lampi-di-raggi-gamma-lunghi#null

3. *Armenian Government assigns a Ph.D. fellowship to ICRANet Armenia, May 21, 2020*

On May 21, 2020 the Government of the Republic of Armenia approved Ph.D. positions for the academic year 2020-2021. ICRANet Armenia center obtained one Ph.D. position. An additional one will be provided in June. The final exam and admission will be at the end of June.

The news is available (in Armenian) through the Armenian legal information system website here: http://www.arlis.am/DocumentView.aspx?DocID=142700

4. *"Gerbertus 2020 – Scientific Rationale"*, podcast meeting, May 7, 2020

C. Sigismondi, ICRA/Sapienza

Figure 4: Silvestro II (1854, Turin).

The annual congress in honor of Gerbert of Aurillac, scientist, scholastic astronomer and Pope, has been inaugurated on Thursday, May 7, 2020. This event has been coordinated, as the two previous ones on November 2019 and January 2020, by and in the ICRANet center in Pescara at international level.

The program of the 2020 meeting is centered on the Moon: how it was seen 1000 years ago... the Moon of Gerbert, with the idea of reflecting on a great part of the history of astronomy and cultural heritage. Students fromHigh School Galileo Galilei in Pescara as well as students from the Technical Industrial Institute Galileo Ferraris in Rome, participating in European Programs of Didactic Empowerment (PON projects), are working on the main subjects of the program.

Among the motivations to study Gerbert I propose a selection:*"Why Gerbert has not a crater on the Moon, being the first to spread a treatise on the Astrolabe before the year 1000?"*

He taught Astronomy among the Quadrivium in the Cathedral of Reims in France and was considered as a scientific reference for many centuries after his death in Mathematical Computus, having also been the first man using Arabic numbers and an abacus,as well as in Music. He left to the literature a treatise in Geometry and 220 letters epistolary (Patrologia Latina volume 90): a unique case of preservation of this medieval culture. Hermann of Reichenau, half a century later, was supposed to be the author of that treatise of the astrolabe, but it has been proved that the original author was Gerbert. Hermann has his own crater and Gerbert not...moreover,Gerbert built the first documented equatorial mount described in his epistolarium (to Constantine, 980 AD on which I wrote a book, *La Sfera da Gerberto al Sacrobosco*, Athenaeum Regina Apostolorum, Roma 2009).

The standard of astronomical names commission avoid religious leaders, but in this case Gerbert was respected in all Europe as the most known man of his time, when he was elected Pope by Otto III in 999, according to the uses of the time, and Gerbert chose the name Sylvester II.A late medieval legend (in Wilhelm of Malmesbury and in Benno of Osnabruck), transformed him into a magician, who built a head (a Golem) able to say "yes"or"no" through which Gerbert knew that he would not die unless going to Jerusalem. On May 3, 1003, he went to celebrate Mass in the roman church of the Holy Cross, named today S. Croce in Jerusalem and at his time "Basilica Hierusalem" built by Constantine's mother Helen, bringing the ground of Jerusalem there after having found the relic of the Cross.During this Mass, Gerbert felt ill and understood that the end was approaching, so that the Golem's prediction was satisfied. He died on May 12, 1003 and that's the reason why we celebrate the congress in the first part of May, after 2003, a millennium after his death. He was buried in the Lateran's Roman Cathedral.

The slow process of Gerbert's rehabilitation happened in 1620 with a Polish Dominican Bzovsky and following the publication of his epistolarium and textbooks in the Patrologia Latina around 1700 (now in

wikipedia, Latin section). In the second part of the 19° century, Nicolay Bubnov published, in Russia, his mathematical works (1899) now available as google books. In 1970, Klaus Jurgen Sachs founded a manuscript in Madrid on the musical treatise De Mensura Fistularum, of the 11° century with the attribution to Gerbert, further proving that he was the real center of the contemporary culture before and after 1000. Clyde Brockett in 1995 and Flavio G. Nuvolone (1942-2019) have deeply studiedthe encrypted composition *"Carme Figuratum"* (980) written by Gerbert to Otto II, including the Arabic numbers he first introduced in latin Europe.The approach to Gerbert's study is necessarily inter-multi disciplinary and the surprises are not over. Our duties are to maintain those studies and promoting their development through the web also by using the vehicle of the academic Journal Gerbertus, founded in 2010 in the Paris Observatory with three ISSN: paper, CD e online.The 2020 edition acknowledges the immense contribution to Gerbert's studies, carried on by Professor Flavio Giuseppe Nuvolone (September 2, 1942 - December 11, 2019) who published several books on Gerbert and guided numerous meetings since 1983, when he started to collaborate with Michele Tosi at Bobbio's journal ArchivumBobiense.His primary activity was in Freiburg University as chair of Pathrology, but he become amultidisciplinary investigator trying to encompass the figure of Gerbert.Talking with him was a way to enter in direct contact with the spirit and the milieu in which Gerbert acted. The resilience of Gerbert's life, and his solid Catholic faith, were shared by Professor Nuvolone with great discretion and depth.

The lossof George V. Coyne (January 19, 1933- February 11,2020), former director of SpecolaVaticana, is, for the scientific community, the loss of a person who naturally conducted a life of synergy between science and faith, similarly as Gerbert did. Both are remembered on this occasion.

The arguments belonging to bothany, philosophy, didactic, optics, Solar physics, always intend to invite young students to approach the study of sciences, as Gerbert first let possible in his Cathedral School of Reims, with the teaching of quadrivium (mathematics, geometry, astronomy and music) along with the classical trivium (grammar, rethoric, dialectic), which he interpreted as studying also profaneLatin writers and Aristotle.The musical contribution prepared by Stefano Carciofalo Parisse is an homage to the great master Gerbert, author either of the music and of a theoretical treatise on it in 980, De Mensura Fistularum.A crater on the Moon should be dedicated to Gerbert, at least, and in the Earth side face.

For more information about the event, its program and the downloadable material, please see: http://www.icranet.org/index.php?option=com_content&task=view&id=1317

The academic journal dedicated to Gerbert, the history of medieval science and to the didactic is available at the following link: http://www.icra.it/gerbertus

5. COVID webinar, Tucson USA, May 19,2020

On May 19, Prof. Ruffini was invited to join the COVID webinar, organized in Tucson (Arizona, USA) by Prof. Johan Rafelski. The webinar started with the opening remarks made by Prof. Rafelski, followed by the presentation ofProf. Giorgio Torrieri (in collaboration with Prof.AlessioNotari) about the COVID-19 transmission risk factors. Then, Prof. Ruffini, in collaboration with Prof. Narek Sahakyan (Director of ICRANet Armenia), presented his talk “Real danger: critical COVID-triggers seen in statistical analysis”, Prof. Berndt Muller presented his talk on reliable COVID-19 analysis and outcomes,and finally Prof. John W. Clark gave his contribution.

Figure 5: Prof. Ruffini joining the COVID webinar, organized by Prof. Johan Rafelski in Tucson on May 19, 2020.

This event has been recorded and can be viewed on:

- ICRANet website: http://www.icranet.org/index.php?option=com_content&task=view&id=1321
- the University of Arizona website: https://arizona.hosted.panopto.com/Panopto/Pages/Viewer.aspx?tid=26f8fd43-c2a2-43ac-802d-abc0015fee02
- the Zoom playback: https://arizona.zoom.us/rec/share/yuJxcqv-rD9Oc5Hv9ESFS598HJriT6a8gCYarvsNmEhEopGz7QhSImdAteDITbBw

6. The Fourth Zeldovich meeting goes virtual

In view of the COVID-19 pandemic, the 4th Zeldovich meeting will be held virtually, on September 7 – 11, 2020, in collaboration with ICRANet and the National Academy of Sciences of Belarus as organizers and hosts. All participants who have registered so far are confirmed.

The participation will be free of charge, the registration deadline has been extended until July 31, 2020 as well as the abstract submission deadline has been extended until August 15, 2020.

The proceedings of the meeting will be published in Astronomy Reports journal.

For more information, please see: http://icranet.org/zeldovich4

7. Call for Proposals "BRFFR – ICRANet 2020"

In April 2020, the Belarusian Republican Foundation for Fundamental Research (BRFFR) and ICRANet announced a call for proposals for joint basic research projects in relativistic astrophysics. The scientific areas covered by the call are relativistic astrophysics, cosmology and gravitation. Joint applications from international research teams, including Belarusian scientists, must be submitted simultaneously using agreed application forms to both organizations: Belarusian teams apply to the BRFFR, international ones apply to ICRANet. The duration of the projects is up to 2 years, and the deadline for applications is September 15, 2020.

For more information about the call and to download the application form, please use the link: http://www.icranet.org/index.php?option=com_content&task=view&id=1311

8. Recent publications

Rueda, J. A., Ruffini R., Karlica M., Moradi R., Wang Y., *Magnetic Fields and Afterglows of BdHNe Inferences from GRB 130427A, GRB 160509A, GRB 160625B, GRB 180728A and GRB 190114C*, 893:148 (13pp), 2020 April 20.

GRB 190114C is the first binary-driven hypernova (BdHN) fully observed from initial supernova (SN) appearance to the final emergence of the optical SN signal. It offers an unprecedented testing ground for the BdHN theory, which is here determined and further extended to additional gamma-ray bursts (GRBs). BdHNe comprise two subclasses of long GRBs, with progenitors a binary system composed of a carbon–oxygen star (CO_{core}) and a neutron star (NS) companion. The CO_{core} explodes as an SN, leaving at its center a newborn NS (*ν*NS). The SN ejecta hypercritically accretes on both the νNS and the NS companion. BdHNe I arevery tight binaries, where the accretion leads the companion NS to gravitationally collapse into a black hole (BH). In

BdHN II, the accretion rate onto the NS is lower, so there is no BH formation. We observe the same afterglow structure for GRB 190114C and other selected examples of BdHNe I (GRB 130427A, GRB 160509A, GRB 160625B) and for BdHN II (GRB 180728A). In all cases, the afterglows are explained via the synchrotron emission powered by the νNS, and their magnetic field structures and their spin are determined. For BdHNe I, we discuss the properties of the magnetic field embedding the newborn BH, which was inherited from the collapsed NS and amplified during the gravitational collapse process, and surrounded by the SN ejecta.

Link: https://doi.org/10.3847/1538-4357/ab80b9

Li, Liang, *Thermal Components in Gamma-Ray Bursts. II. Constraining the Hybrid Jet Model*, The Astrophysical Journal, Volume 894, Issue 2, id.100.

In explaining the physical origin of the jet composition of gamma-ray bursts (GRBs), a more general picture, i.e., the hybrid jet model (which introduced another magnetization parameter σ_0 on the basis of the traditional fireball model), has been well studied in Gao & Zhang. However, it still has not yet been applied to a large GRB sample. Here, we first employ the "top-down" approach of Gao & Zhang to diagnose the photosphere properties at the central engine to see how the hybrid model can account for the observed data as well, through applying a Fermi GRB sample (eight bursts) with the detected photosphere component, as presented in Li (our Paper I). We infer all physical parameters of a hybrid problem with three typical values of the radius of the jet base ($r_0 = 10^7$, 10^8, and 10^9 cm). We find that the dimensionless entropy for all the bursts shows $\eta \gg 1$ while the derived $(1+\sigma_0)$ for five bursts (GRB 081224, GRB 110721A, GRB 090719, GRB 100707, and GRB 100724) is larger than unity, indicating that in addition to a hot fireball component, another cold Poynting-flux component may also play an important role. Our analysis also shows that in a few time bins for all r_0 in GRB 081224 and GRB 110721A, the magnetization parameter at $\sim 10^{15}$ cm $(1+\sigma_{r15})$ is greater than unity, which implies that internal-collision-induced magnetic reconnection and turbulence may be the mechanism to power the nonthermal emission, rather than internal shocks. We conclude that the majority of bursts (probably all) can be well explained by the hybrid jet problem.

Link: https://iopscience.iop.org/article/10.3847/1538-4357/ab8014

Vereshchagin, G. V.; Siutsou, I. A., *Diffusive photospheres in gamma-ray bursts*, Monthly Notices of the Royal Astronomical Society, Volume 494, Issue 1, pp.1463-1469, April 2020.

Photospheric emission may originate from relativistic outflows in two qualitatively different regimes: last scattering of photons inside the outflow at the photospheric radius or radiative diffusion to the boundary of the outflow. In this work, the measurement of temperature and flux of the thermal component in the early afterglows of several gamma-ray bursts along with the total flux in the prompt phase is used to determine initial radii of the outflow as well as its Lorentz factors. Results indicate that in some cases the outflow has relatively low Lorentz factors ($\Gamma < 10$), favouring cocoon interpretation, while in other cases Lorentz factors are larger ($\Gamma > 10$), indicating diffusive photospheric origin of the thermal component, associated with an ultra relativistic outflow.

Link: https://doi.org/10.1093/mnras/staa868

Cheng-Jun Xia, She-Sheng Xue, Ren-Xin Xu, and Shan-Gui Zhou, *"Supercritically charged objects and electron-positron pair creation"*, Phys. Rev. D, Vol. 101, Iss. 10 — 15 May 2020.

We investigate the stability and e^+e^- pair creation of supercritically charged superheavy nuclei, *udQM* nuggets, strangelets, and strangeon nuggets based on the Thomas-Fermi approximation. The model parameters are fixed by reproducing masses and charge properties of these supercritically charged objects reported in earlier publications. It is found that *udQM* nuggets, strangelets, and strangeon nuggets may be more stable than ^{56}Fe at the baryon number $A \gtrsim 315$, 5×10^4, and 1.2×10^8, respectively. For those stable against neutron emission, the most massive superheavy element has a baryon number ~ 965, while *udQM* nuggets, strangelets, and strangeon nuggets need to have baryon numbers larger than 39, 433, and 2.7×10^5. The e^+e^- pair creation will inevitably start for superheavy nuclei with charge numbers $Z \gtrsim 177$, for *udQM* nuggets with $Z \gtrsim 163$, for strangelets with $Z \gtrsim 192$, and for strangeon nuggets with $Z \gtrsim 212$. A universal relation $Q/Re = (m_e - \bar{\mu}_e)/\alpha$ is obtained at a given electron chemical potential $\bar{\mu}_e$, where Q is the total charge

and R_e the radius of electron cloud. The maximum number of Q without causing e^+e^- pair creation is then fixed by taking $\bar{\mu}_e=-m_e$. For supercritically charged objects with $\bar{\mu}_e<-m_e$, the decay rate for e^+e^- pair production is estimated based on the Jeffreys-Wentzel-Kramers-Brillouin (JWKB) approximation. It is found that most positrons are emitted at $t\lesssim 10^{-15}$ s, while a long lasting positron emission can be observed for large objects with $R\gtrsim 1000$ fm. The emission of positrons and electron-positron annihilation from supercritically charged objects may be partially responsible for the short γ-ray burst during the merger of binary compact stars, the 511 keV continuum emission, as well as the narrow faint emission lines in x-ray spectra from galaxies and galaxy clusters.

Link: https://doi.org/10.1103/PhysRevD.101.103031

9. Internal assessment on the paper of Dr Liang Li "*Thermal Components in Gamma-Ray Bursts. II. Constraining the Hybrid Jet Model*" published in ApJS

Since the early days, the standard model for Gamma-Ray Bursts (GRBs) attempted to explain all the different phases of the GRB event (precursor, prompt emission, afterglow, high-energy GeV emission, ecc.) as originating from a single ultrarelativistically expanding jet. Also within ICRANet it was initially followed a similar approach. However, after twenty years of observations, and thanks to the much better observational data provided by the new satellites, it became increasingly difficult to deal with the unveiling richness of the GRB phenomenon within this simple traditional approach. Therefore, ICRANet scientists started to follow a completely alternative approach in which all the different phases of the GRB event come from different physical processes occurring in the progenitor binary system, without involving necessarily ultrarelativistic dynamics. It is therefore important at this stage to have papers analyzing GRB observations within the two different approaches, the traditional and the alternative one, to present the corresponding possible strengths and weaknesses.

The paper by Liang Li *"Thermal Components in Gamma-Ray Bursts. II. Constraining the Hybrid Jet Model"* published in The Astrophysical Journal Supplement Series, 242:16, 2019, uses the traditional approach and follows the previous work on identification of thermal emission in GRBs and its interpretation as the photospheric emission in the fireball model. This work follows the idea introduced in the paper by Zhang et al. [Nature Astronomy, 2 (2018) 69], who interpreted emission in GRB 160625B as transition from unmagnetized to magnetized fireball. This work was extended by Liang Li in the paper published previously in The Astrophysical Journal Supplement Series, 242:16, 2019. The physical model behind this picture is developed by Gao and Zhang [ApJ, 801 (2015) 103]. There, in addition to the dimensionless entropy eta they introduce a magnetization parameter sigma. It was shown in the paper by Meszaros and Rees, ApJ 733:40 2011 that strongly magnetized outflows accelerate slowly, compared to unmagnetized ones. This is the main difference, causing the dependence of the observed photospheric emission on the degree of magnetization. Gao and Zhang provide analytic formula which connect the observed parameters such as luminosity, flux and temperature to the physical parameters of the underlying outflow, namely the Lorentz factor, photospheric radius, nozzle radius and magnetization parameter. The nonthermal component is not explained, it is assumed that a fraction of the jet luminosity is transformed into nonthermal radiation with a given spectrum. The top-down approach, introduced in this work based on the work of Pe'er, et al., ApJL, 664, 1, 2007, and used also by Liang Li, allows to infer physical parameters of the outflow directly from the observed quantities.

The paper mentions two major shortcomings of the analysis:

1. The underlying theoretical model is based on the key assumption that both the GRB prompt emission and the x-ray afterglow originate from an ultrarelativistic jet with a Lorentz Gamma factor 10^2--10^3. Such a jetted emission was introduced since the very early days of GRB modelling to reduce the GRB energy budget, and was justified with the purported presence of "achromatic jet breaks" in the x-ray afterglow light curves. However, after 20 years of observations, no real achromatic jet break has been observed in any x-ray afterglow light curve [see e.g. Pisani et al., ApJ, 833 (2016) 159]. Only some chromatic jet breaks have actually been observed, whose explanation is currently the subject of active research but

which cannot be connected to an ultrarelativistic jet dynamics. Moreover, in Ruffini et al. [ApJ, 852 (2018) 53] it has been shown, in a model independent way, that in the early phases of the x-ray afterglow light curves there are clear signatures of the presence of a thermal emitter which expands with a Lorentz Gamma factor less than 4, and no evidence of an ultrarelativistic expansion. The key assumption of the presence of an ultrarelatvistic jet is therefore not supported by the X-ray afterglow data.

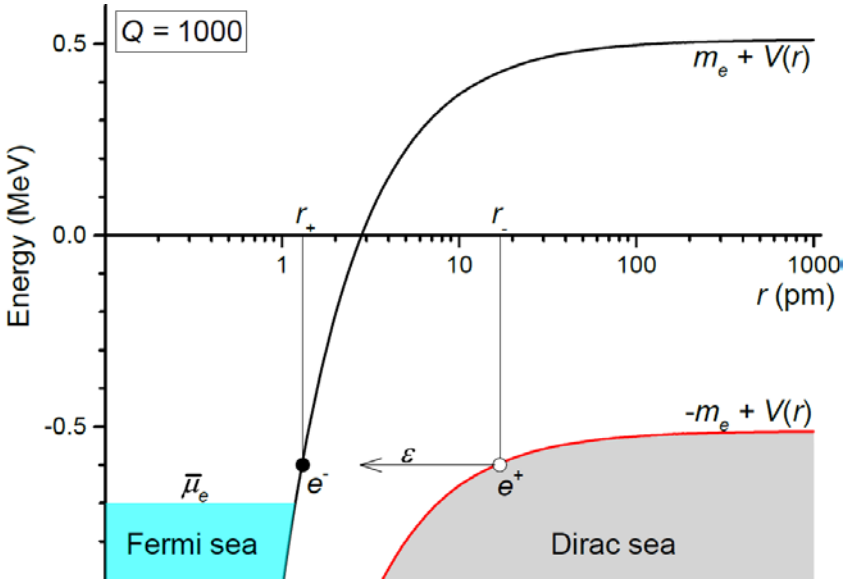
2. More than half of the analysed GRBs have no measured cosmological redshift. Therefore, for these sources it is not possible to define the precise cosmological rest frame. In Ruffini et al. [ApJ, 852 (2018) 53] it was shown that many of the common features of the GRB light curves become evident only when the data are analysed in the cosmological rest frame of each source but are hidden when data are seen in the observer frame.

In the conclusions of the paper it is recalled that the alternative theoretical approach to GRBs developed within ICRANet, the Induced Gravitational Collapse scenario [see e.g. Ruffini et al., ApJ, 832 (2016) 136, and references therein], does not present these shortcomings and may well account for the observations. Within this theoretical model long GRBs originate in binary systems composed by an FeCO core and a companion neutron star, named "Binary Driven Hypernovae" (BdHNe). At the basis of the phenomenon there is not a single ultrarelativistic jet, but each phase of the GRB emission (prompt gamma-ray emission, early X-ray afterglow emission, late x-ray afterglow emission, GeV emission, etc.) comes from a different physical process occurring in the progenitor binary system. The entire photospheric emission is currently being reconsidered within this new approach, overcoming the above shortcomings 1 and 2. In the meantime, we can already say that this new approach gives an answer about the late X-ray afterglow emission: it is due to the newly born neutron star which remains after the explosion of the FeCO core, and no ultrarelativistic dynamics is involved in this process [see e.g. Ruffini et al., ApJ, 869 (2016) 101; Rueda et al., ApJ, 893 (2020) 148].

Link to the paper: https://iopscience.iop.org/article/10.3847/1538-4357/ab8014

10. Internal assessment of the paper published co-authored by Prof. Shesheng Xue *"Supercritically charged objects and electron-positron pair creation"* and published in Physical Review D

In astrophysical systems, there can possibly exist the strong coupling between nucleons and quark matters of large charge number Z and atomic number A, such as udQM nuggets, strangelets, and strangeon nuggets. In order to further understand electron-positron production in such strong coupling matter in connection with the observed phenomena, the authors of this paper study supercritically charged matter by applying the Thomas-Fermi model of chemical potential equilibrium for highly degenerate electrons and the Schwinger model of vacuum polarisation for electron-positron pair production. This research, as shown by the references below, has been well developed for years in ICRANet to understand the physical relevance of electron-positron pair production and annihilation for the astrophysical phenomena of Gamma-Ray Bursts, the 511 keV continuum emission and the narrow ~ 4 keV faint emission lines from galaxies and galaxy clusters.



To understand how the Coulomb energy raised in such a strong

coupling matter is balanced, Authors from China use their expertise on the empirical model of Fermi type describing such a strong coupling matter. They make both analytical and numerical analyses of chemical potentials to examine the stability of strong coupling matter against pair production and to obtain the critical values of large charge number Z and atomic number A, as well as the size of strong coupling matter, see Figure. Instead, in the case of Coulomb energy being released, they make numerical calculations by using the pair-production rate in an electron degenerate system, developed within ICRANet, to approximately obtain the time scale and rate of electron-positron pair production as functions of charge number Z and atomic number A, and to give an insight into their relevance for the observations.

This work has been completed by remote collaborations via internet between: Professors Cheng-Jun Xia of Zhejiang University Ningbo Institute of Technology, Ren-Xin Xu of Peking University and Shan-Gui Zhou of Institute of Theoretical Physics, and ICRANet faculty member She-Sheng Xue. Chinese colleagues Xia, Xu and Zhou are experts on the nuclear physics and astro-nuclear physics, in particular the properties of nuclear and quark matter that composes compact stars in our Universe. They are very active in the field and have published many articles in international high impact scientific journals worldwide.

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- J. Rueda, R. Ruffini, Y. Wang, Y. Aimuratov, U. B. de Almeida, C. Bianco, Y. Chen, R. Lobato, C. Maia, D. Primorac, R. Moradi, and J. Rodriguez, J. Cosmol. Astropart. P. 2018, 006 (2018).

Link to the paper: https://doi.org/10.1103/PhysRevD.101.103031

ICRANet Newsletter

June–July 2020

SUMMARY

1. Press Release ICRA-ICRANet-UNLP-UIS: Geodesic motion of S2 and G2 as a test of the fermionic dark matter nature of our Galactic core

The anomalous perihelion precession of Mercury around our Sun led to the greatest change of paradigm of physics thanks to the conception of General Relativity by Albert Einstein. The multi-year, high-quality data recording the motion of the closest objects around the compact source at the Galactic center, Sgr A*, led to the verification of the predicted gravitational redshift, to the anomalous precession of S2, as well as to the anomalous fly-by of G2. This heralds a fermionic dark matter dense core interpretation of the nature of Sgr A*, traditionally interpreted as a black hole. A new neutral fermion of 56 keV, a dark matter *"ino"*, for short a *"darkino"*, is basic to this alternative approach. New perspectives are open 1) to the understanding of the predominance of dark matter in our Galaxy and in the large scale of the Universe, 2) to formulate a new paradigm for identifying the seed for the formation of ten-billion-solar-masses black holes in active galactic nuclei, and 3) to address the fundamental physics of the *darkinos* which, together with the *neutrinos*, appear to have a fundamental role in accounting for a large portion of the Universe mass-energy. These results are presented in the new article appearing on 9 September 2020, in Astronomy & Astrophysics, co-authored by E.A. Becerra-Vergara, C.R. Arg¨uelles, A. Krut, J.A. Rueda, and R. Ruffini [1].

Harvesting the detailed analysis made possible by the Einstein Theory of General Relativity, the article shows that the motion of the S2 star and the G2 cloud around Sgr A*, traditionally interpreted as due to a black hole of about 4 million solar masses, is instead better explained by the fermionic dark matter dense core of nearly the same mass (see Figs. 1–4 on pages 2–5). The core is composed of *darkinos* of 56 keV rest mass-energy, roughly 9 times lighter than electrons. This dark matter component extends, from the core, to the entire Galaxy, creating the stable gravitational cradle where all the stars rotate. The dense core formed of these *"darkinos"* becomes unstable giving origin to a black hole when it reaches a mass of about 100 million solar masses. This represents the lowest black hole seed mass for the growth of supermassive ten-billion-solar-masses black holes in active galactic nuclei.

This discovery has been made possible thanks to some of the largest observational facilities ever achieved in the history of our planet. The data of S2 (see Fig. 1 on page 2 and Fig. 3 on page 4) are taken from the SINFONI (http://www.icranet.org/telescopes/SINFONI-VLT.jpg) and NACO (http://www.icranet.org/telescopes/NaCo-VLT.jpg) instruments of the Very Large Telescope (VLT) (http://www.icranet.org/telescopes/VLT.jpg), operated by the European Southern Observatory (ESO) located on Cerro Paranal in the Atacama Desert in Chile (http://www.icranet.org/telescopes/potw2023a.jpg), the Keck I (http://www.icranet.org/telescopes/Keck_I.jpg) and Keck II (http://www.icranet.org/telescopes/Keck_II.jpg) Telescopes, operated by the W. M. Keck Observatory located in Hawaii (http://www.icranet.org/telescopes/Keck_ext.jpg), the Gemini North Telescope (http://www.icranet.org/telescopes/Gemini_int.jpg), operated by the Gemini Observatory located in Hawaii (http://www.icranet.org/telescopes/Gemini_ext.jpg), as well as from the Subaru Telescope (http://www.icranet.org/telescopes/Subaru_int.jpg), operated by the National Astronomical Observatory of Japan at the Mauna Kea Observatory on Hawaii (http://www.icranet.org/telescopes/Subaru_ext.jpg). The observational data of G2 (see Fig. 2 on page 3 and Fig. 4 on page 5) are taken from the SINFONI and NACO instruments of the VLT.

This approach is rooted in the work of Enrico Fermi who introduced the fermions in particle physics. Remo Ruffini recalls: "Eugene Wigner, Nobel laureate colleague of Einstein and Fermi, often stated: *the Thomas-Fermi model works better than it should.* This model has been leading for 93 years the description of all atoms: a gas of electrons, negatively-charged fermions, attracted electromagnetically by a positively-charged nucleus. In 1973, in Princeton, I addressed the gravitational analog of a Thomas-Fermi atom. Many neutral self-gravitating fermions characterized by their mass and spin, kept in equilibrium by their collective self-gravitation [2]. This idea was developed for years in ICRA and ICRANet, leading to a new approach to neutron stars (see [3] and references therein), and to the dark matter distribution in galaxies in the RAR model [4, 5], here applied to the dark matter galactic cores".

[1] https://doi.org/10.1051/0004-6361/201935990 (A&A forthcoming article).
[2] R. Ruffini and S. Bonazzola, Physical Review 187, 1767 (1969).
[3] J. A. Rueda, R. Ruffini, and S. S. Xue, Nucl. Phys. A 872, 286 (2011), 1104.4062.
[4] C. R. Arg¨uelles, A. Krut, J. A. Rueda, and R. Ruffini, Phys. Dark Universe 21, 82 (2018), 1810.00405.
[5] C. R. Arg¨uelles, A. Krut, J. A. Rueda, and R. Ruffini, Phys. Dark Universe 24, 100278 (2019).

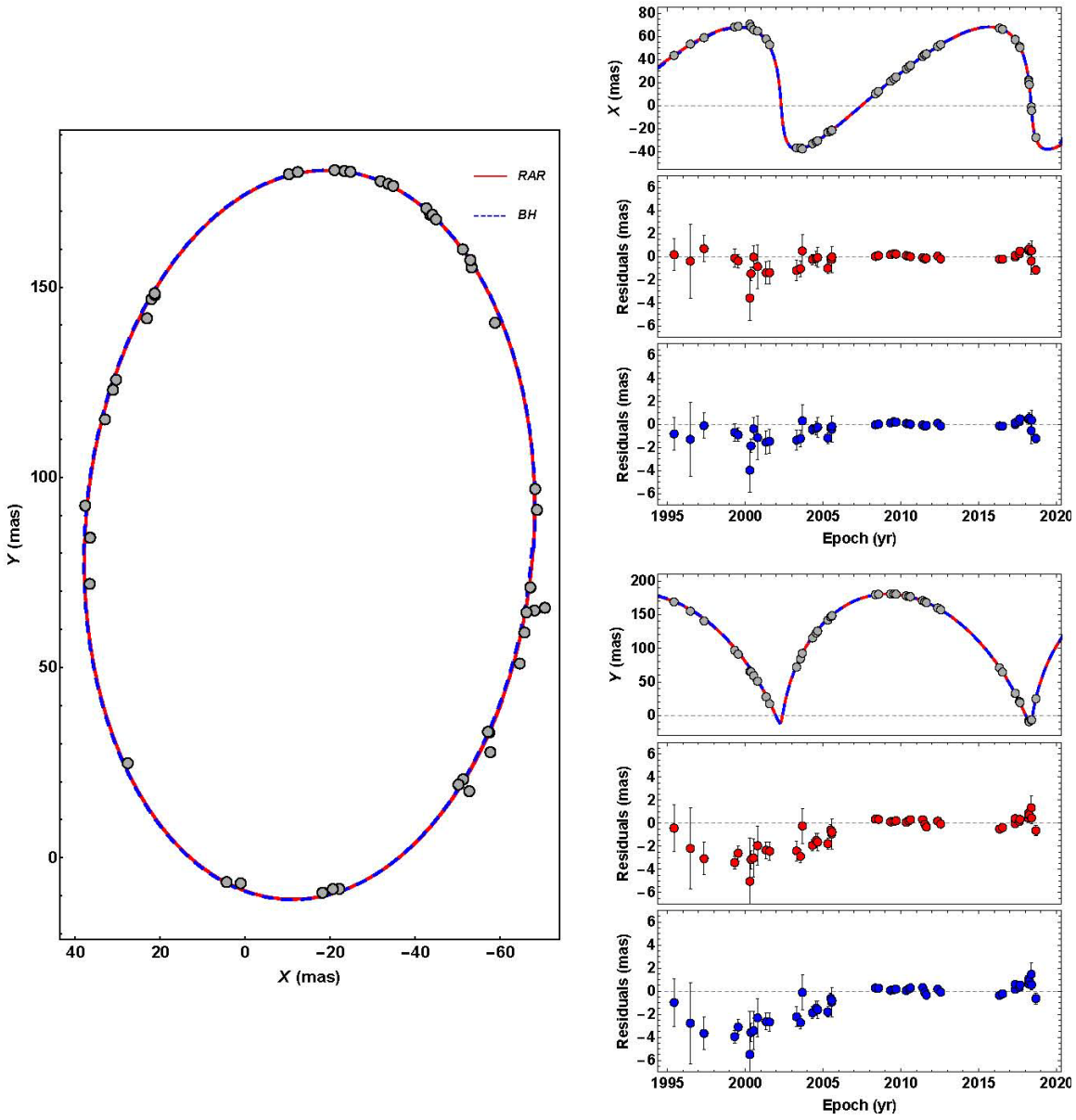


FIG. 1. Taken from [1]. Theoretical (central BH and RAR models) and observed orbit of S2 around Sgr A*. The left panel shows the orbit, i.e. the right ascension (X) vs. declination (Y) angular positions, and the right panel shows the X and Y positions as a function of the observation time, and the corresponding residuals of the best-fit for the BH (blue) and the RAR (red) models. The theoretical models are calculated by solving the equations of motion of a test particle in the gravitational field of: 1) a Schwarzschild BH of 4.075 million solar masses (blue-dashed curves), and 2) the DM distribution obtained from the extended RAR model for 56 keV-fermions (red curves). The mass of the quantum core in the RAR model is 3.5 million solar masses. Figure available at: http://www.icranet.org/orbitS2.pdf

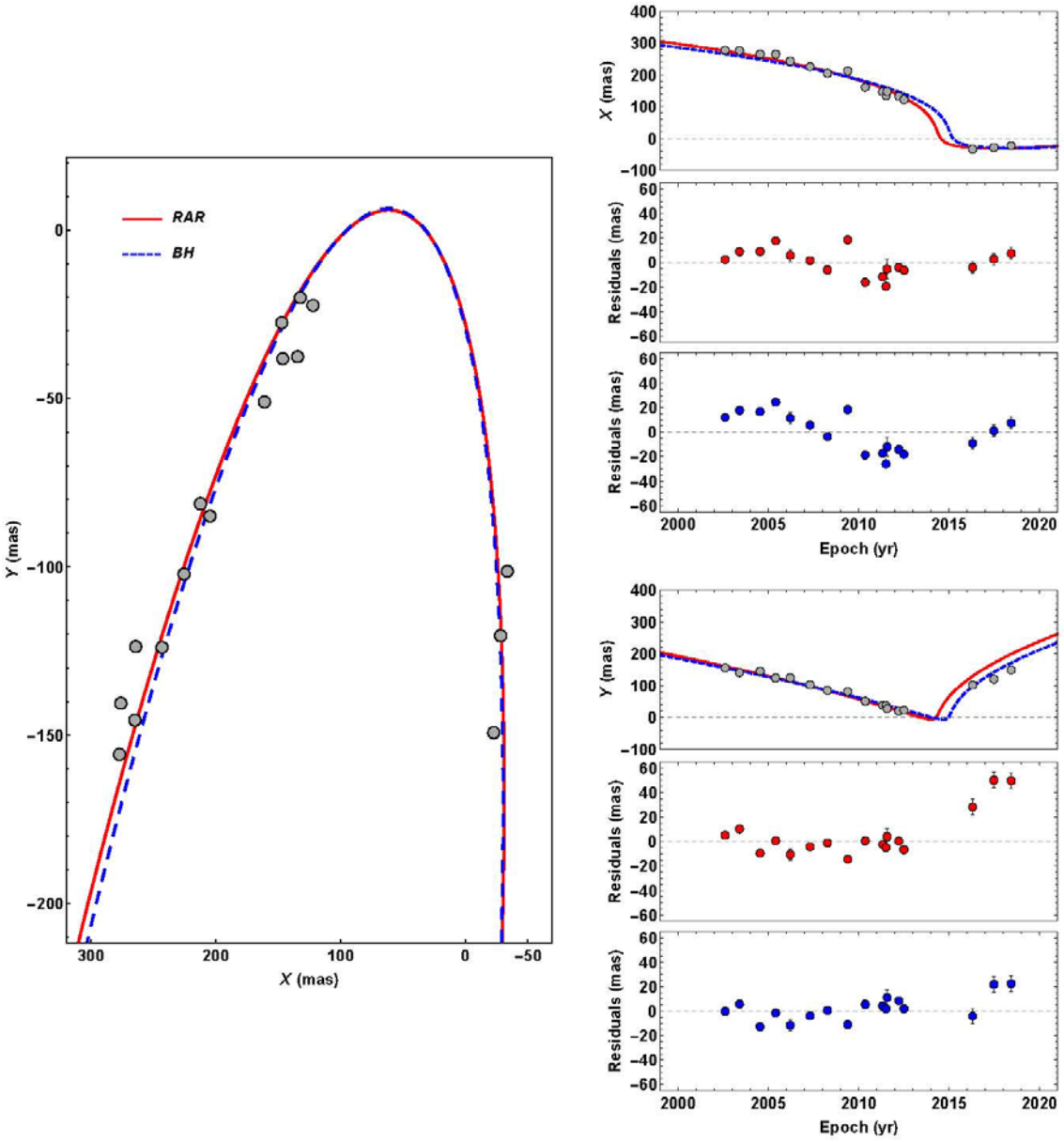


FIG. 2. Taken from [1]. Same as Fig. 1, but for G2. Figure available at: http://www.icranet.org/orbitG2.pdf

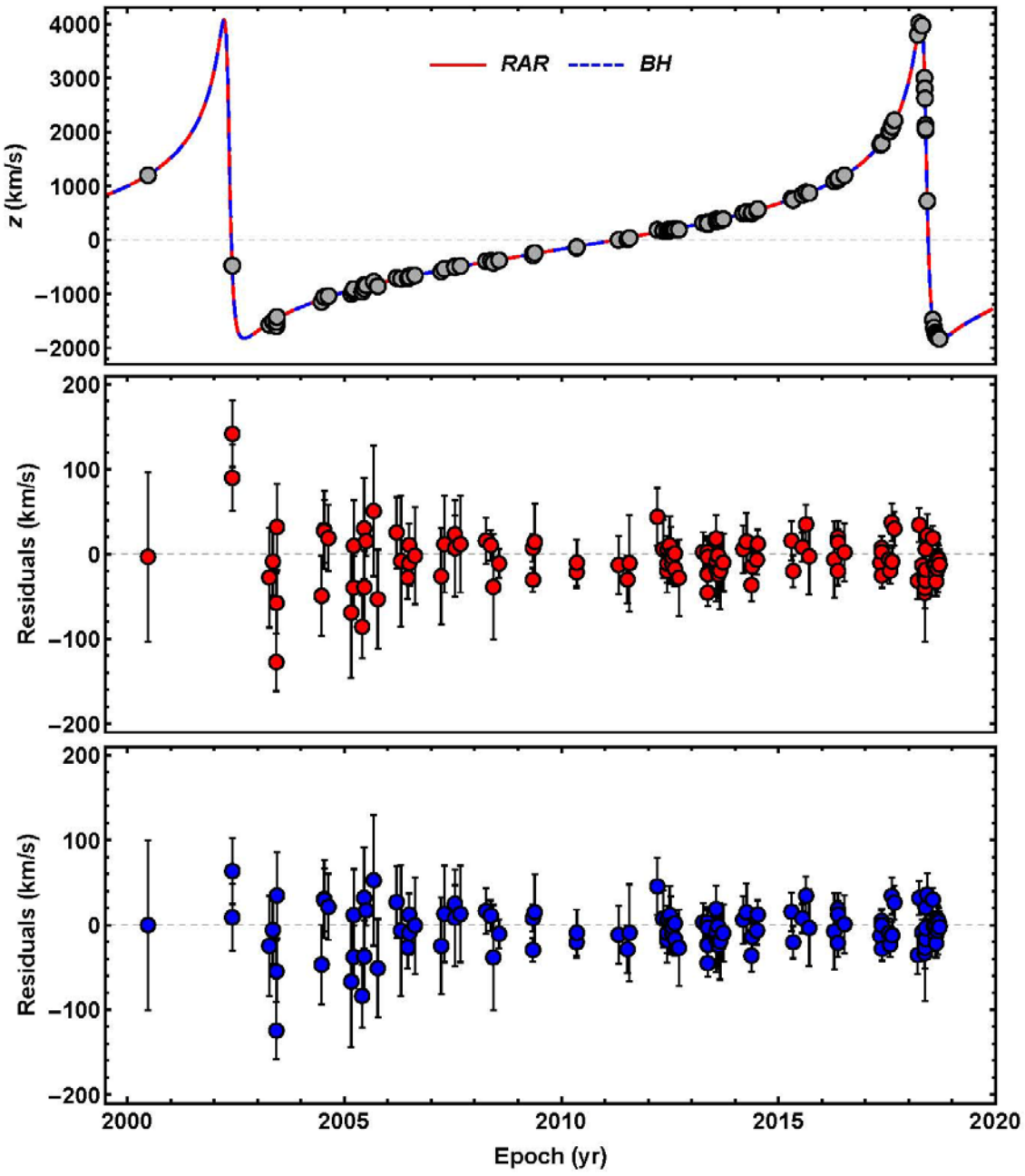


FIG. 3. Taken from [1]. Same as Fig. 1, but for the line-of-sight radial velocity of S2 (i.e. the redshift function z). Figure available at: http://www.icranet.org/velS2.pdf

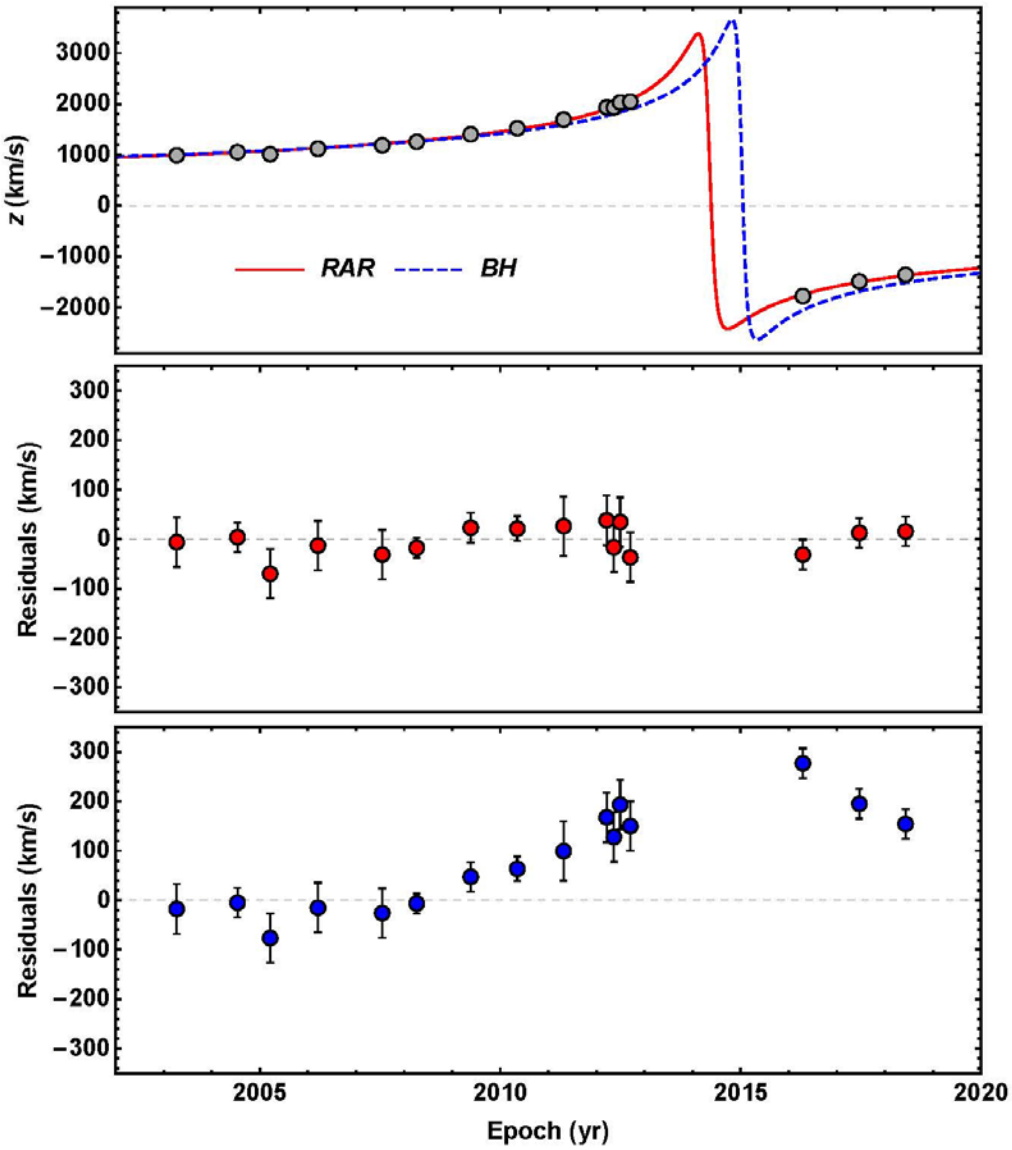


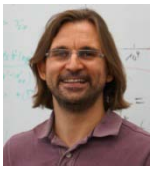
FIG. 4. Taken from [1]. Same as Fig. 3, but for G2. Figure available at: http://www.icranet.org/velG2.pdf

- Link press release on ICRANet website: http://www.icranet.org/communication/28072020/eng.pdf
- Link press release on A&A website: https://www.aanda.org/2020-press-releases
- Link press release on CONICET website: https://www.conicet.gov.ar/materia-oscura-proponen-una-nueva-manera-de-entender-su-distribucion-en-el-universo/
- Link press release on INAF website: http://www.inaf.it/en/inaf-news/fermionic-dark-matter-in-our-galactic-core

2. News about the 4° Zeldovich virtual meeting, September 7-11, 2020

We are happy to announce the final list of invited speakers at the 4° Zeldovich virtual meeting.

For more information, please consult our conference website: http://www.icranet.org/zeldovich4

	Marika Asgari Royal Observatory Edinburgh, UK Talk: *"Weak lensing and the Kilo-Degree Survey"*
	Abhay Ashtekar Institute for Gravitation & the Cosmos, Penn State University, USA Talk: *"Loop Quantum Cosmology"*
	Artem Burdanov Massachusetts Institute of Technology, USA Talk: *"Search for exoplanets in ultracold dwarfs"*
	Rong-Gen Cai Institute of Theoretical Physics, Chinese Academy of Sciences, China Talk: *"Gravitational waves from the early Universe"*
	Daniela Calzetti University of Massachusetts Amherst, USA Talk: *"The astrophysical implications of the Starburst Attenuation Curve"*
	Jens Chluba Jodrell Bank Centre for Astrophysics, University of Manchester, UK Talk: *"CMB spectral distortions"*
	Alexander Dolgov Novosibirsk State University and ITEP, Russia Talk: *"Primordial black holes and modification of Zeldovich-Novikov mechanism"*
	Jaan Einasto Tartu Observatory, Estonia Talk: *"The biasing phenomenon"*

	Katherine Freese University of Texas, Austin, USA
	Chris Fryer Los Alamos National Laboratories, USA Talk: *"Supernova explosions"*
	Stefan Gillessen Max Planck Institute for Extraterrestrial Physics, Germany Talk: *"GRAVITY scientific results"*
	Luca Izzo DARK - Niels Bohr Institute, Denmark Talk: *"Recent progresses on the connection between GRBs and type-Ic broad-lined supernovae"*
	Joanna Kiryluk Stony Brook University, USA Talk: *"Results from ICECube"*
	Claus Lämmerzahl ZARM, Germany Talk: *"Tests of general relativity"*
	Vladimir Lipunov Moscow State University, Russia Talk: *"Central GRB Engine from Early Multimessanger observations"*
	Andrea Merloni Max-Planck Institute fuer Extraterrestrische Physik, Garching, Germany Talk: *"Mapping the hot Universe: the first year of operations of eROSITA on SRG"*
	Felix Mirabel CEA Saclay, France Talk: *"Black holes in the universe"*
	Razmik Mirzoyan Max Planck Institute for Physics, Germany
	Slava Mukhanov Ludwig-Maximilians-Universität München, Germany Talk: *"The final state of nonsigular evaporating black hole"*
	Piero Rosati University of Ferrara, Italy Talk: *"Cosmography and tests of the LCDM paradigm with high-precision strong lensing modelling of galaxy clusters"*

	Jorge Rueda ICRANet, Italy Talk: *"An update of the binary-driven hypernova scenario"*
	Remo Ruffini ICRANet, Italy Talk: *"The discovery of the moment of formation of the black hole in GRB 190114C"*
	Nikolay Shakura Sternberg Astronomical Institute of the Moscow State University, Russia Talk: *"On the nature of 35-day cycle in Her X1/HZ Her"*
	Joseph Silk Oxford University, UK
	Ignas Snellen University of Leiden, Netherlands Talk: *"Exoplanets and the search for extraterretrial life"*
	Dmitry Sokoloff Moscow State University, Russia Talk: *"Dynamo in accretion discs"*
	Alexey Starobinsky Landau institute for theoretical physics, RAS, Russia Talk: *"Inflation"*
	Rashid Sunyaev Max Planck Institute for Astrophysics, Germany Talk: *"Results of SRG Orbital Observatory with eRosita and ART-XC X-Ray telescopes aboard"*
	Amaury Triaud University of Birmingham, UK Talk: *"Exoplanet atmospheres"*
	Ye-Fei Yuan Univ. of Sci. and Tech. of China, China Talk: *"Probes of strong gravity: SgrA* and M87*"*
	Shuang Nan Zhang Institute of High Energy Physics, Chinese Academy of Sciences, China Talk: *"HSTC mission"*

3. Recent publications

M. Haghighat, S. Mahmoudi, R.Mohammadi, S. Tizchang, S.S Xue, *Circular polarization of cosmic photons due to their interactions with Sterile neutrino dark matter*, submitted for publication on Phys. Rev. D 101, 123016 (2020).

In this paper, we explore the possibility of the polarization conversion of a wide energy range of cosmic photons to the circular polarization through their interactions with right handed Sterile neutrinos as a candidate for dark matter. By considering the Sterile neutrino in the seesaw mechanism framework and right-handed current model, we examine the Faraday conversion $\Delta_{\phi\tiny{FC}}$ of gamma ray burst (GRB) photons at both the prompt and afterglow emission levels as well as the radio photons emitted from our galaxy and extra-galactic sources interacting with the Sterile neutrinos. Consequently, for the Sterile neutrino with mixing angle $\theta^2 \lesssim 10^{-2}$ motivated by models with a hidden sector coupled to the sterile neutrino, the Faraday conversion can be estimated as $\Delta_{\phi\tiny{FC}} \lesssim 10^{-3}-10^{-18}$ rad for GRB, $\Delta_{\phi\tiny{FC}} \lesssim 10^{-6}-10^{-11}$ rad for radio emission source from our galaxy and $\Delta_{\phi\tiny{FC}} \lesssim 10^{-6}-10^{-15}$ rad for extra-galactic sources. We also examine the V-mode power spectrum C_{Vl} of the cosmic microwave background (CMB) at the last scattering surface. We show that the circular polarization power spectrum at the leading order is proportional to the linear polarization power spectrum C_{pl} and the mixing angle where for $\theta^2 \lesssim 10^{-2}$ leads to $C_{Vl} \lesssim 0.01$ Nano-Kelvin squared.

Link: https://arxiv.org/abs/1909.03883

Becerra-Vergara, E. A.; Arguelles, C. R.; Krut, A.; Rueda, J. A.; Ruffini, R., *The geodesic motion of S2 and G2 as a test of the fermionic dark matter nature of our galactic core*, accepted for publication on July 22, 2020 in Astronomy & Astrophysics.

[Abridged] The S-stars motion around the Galactic center (Sgr A*) implies the existence of a compact source with a mass of about $4\times10^6 M_\odot$, traditionally assumed to be a massive black hole (BH). Important for any model is the explanation of the multiyear, accurate astrometric data of S2 and the challenging G2: its post-pericenter velocity decelerates faster than expected from a Keplerian orbit around the putative BH. This has been reconciled in the literature by acting on G2 a drag force by an accretion flow. Alternatively, we show that the S2 and G2 motion is explained by the "core-halo" fermionic dark matter (DM) profile of the fully-relativistic Ruffini-Argüelles-Rueda (RAR) model. It has been already shown that for 48-345 keV fermions, it accurately fits the rotation curves of the Milky-Way halo. We here show that, for a fermion mass of 56 keV, it explains the time-dependent data of the position (orbit) and light-of-sight radial velocity (redshift function z) of S2 and G2, the latter without a drag force. We find the RAR model fits better the data: the mean of reduced chi-squares of the orbit and z data are, for S2, $\langle\bar{\chi}^2\rangle_{\rm S2,RAR}\approx3.1$ and $\langle\bar{\chi}^2\rangle_{\rm S2,BH}\approx3.3$ while, for G2, $\langle\bar{\chi}^2\rangle_{\rm G2,RAR}\approx20$ and $\langle\bar{\chi}^2\rangle_{\rm G2,BH}\approx41$. For S2 the fits of the z data are comparable, $\bar{\chi}^2_{\rm z,RAR}\approx1.28$ and $\bar{\chi}^2_{\rm z,BH}\approx1.04$, for G2 only the RAR model fits, $\bar{\chi}^2_{\rm z,RAR}\approx1.0$ and $\bar{\chi}^2_{\rm z,BH}\approx26$. In addition, the critical mass for the gravitational collapse of a degenerate 56 keV-fermion DM core into a BH is $\sim10^8 M_\odot$, which may be the initial seed for the formation of the observed central supermassive BH in active galaxies, such as M87.

Link: https://arxiv.org/abs/2007.11478

M. A. Prakapenia, G.V.Vereshchagin, *Pauli blocking effects in thermalization of relativistic plasma,* accepted for publication on June 14,2020 in Physics Letters A.

We investigate the effects of Pauli blocking on thermalization process of relativistic plasma by solving relativistic Uehling-Uhlenbeck equations with QED collision integral for all binary and triple processes. With this purpose we consider nonequilibrium initial state of plasma to be strongly degenerate. We found that when electron-positron annihilation is efficient, initial plasma degeneracy is quickly destroyed. As a result in a wide range of final temperatures ranging from nonrelativistic to mildly relativistic $0.1m_ec^2 \leq k_BT \leq 10m_ec^2$ thermalization is not affected by Pauli blocking. Conversely, when electron-positron annihilation process is inefficient, thermalization process in such degenerate plasma is strongly affected by Pauli blocking. This is possible either in a nonrelativistic plasma, with equilibrium temperature $k_BT \leq 0.3m_ec^2$, or in photon-electron plasma. In these cases all reaction rates are strongly suppressed by Pauli blocking and thermalization does not occur until electrons can populate energy states above the Fermi energy. Soon after this happens thermalization proceeds suddenly in an avalanche-like process. Such rapid thermalization can be a unique footprint of strongly degenerate plasma.

Link: https://doi.org/10.1016/j.physleta.2020.126679

N. Sahakyan, *Broadband Study of High-Synchrotron-Peaked BL Lac Object 1ES 1218+304,* accepted for publication in MNRAS on July 2020.

The origin of the multiwavelength emission from the high-synchrotron-peaked BL Lac 1ES 1218+304 is studied using the data from Swift UVOT/XRT, NuSTAR and Fermi-LAT. A detailed temporal and spectral analysis of the data observed during 2008-2020 in the γ-ray (>100 MeV), X-ray (0.3-70 keV), and optical/UV bands is performed. The γ-ray spectrum is hard with a photon index of 1.71 ± 0.02 above 100 MeV. The Swift UVOT/XRT data show a flux increase in the UV/optical and X-ray bands; the highest 0.3 - 3 keV X-ray flux was $(1.13 \pm 0.02) \times 10^{-10}$erg cm^{-2} s^{-1}. In the 0.3-10 keV range the averaged X-ray photon index is >2.0 which softens to 2.56 ± 0.028 in the 3-50 keV band. However, in some periods, the X-ray photon index became extremely hard (<1.8), indicating that the peak of the synchrotron component was above 1 keV, and so 1ES 1218+304 behaved like an extreme synchrotron BL Lac. The hardest X-ray photon index of 1ES 1218+304 was 1.60 ± 0.05 on MJD 58489. The time-averaged multiwavelength spectral energy distribution is modeled within a one-zone synchrotron self-Compton leptonic model using a broken power-law and power-law with an exponential cutoff electron energy distributions. The data are well explained when the electron energy distribution is E−2.1eEe−2.1 extending up to $\gamma_{br/cut} \simeq (1.7 - 4.3) \times 10^5$, and the magnetic field is weak ($B \sim 1.5 \times 10^{-2}$ G). By solving the kinetic equation for electron evolution in the emitting region, the obtained electron energy distributions are discussed considering particle injection, cooling, and escape.

Link: https://doi.org/10.1093/mnras/staa1893
https://ui.adsabs.harvard.edu/abs/2020MNRAS.tmp.2023S/abstract

MAGIC Collaboration, *Studying the nature of the unidentified gamma-ray source HESS J1841-055 with the MAGIC telescopes*, accepted for publication in MNRAS on July 2020.

We investigate the physical nature and origin of the gamma-ray emission from the extended source HESS J1841-055 observed at TeV and GeV energies. We observed HESS J1841-055 at TeV energies for a total effective time of 43 hours with the MAGIC telescopes, in 2012 and 2013. Additionally, we analysed the GeV counterpart making use of about 10 years of Fermi-LAT data. Using both Fermi-LAT and MAGIC, we study both the spectral and energy-dependent morphology of the source for almost four decades of energy. The origin of the gamma-ray emission from this region is investigated using multi-waveband information on sources present in this region, suggested to be associated with this unidentified gamma-ray source. We find that the extended emission at GeV-TeV energies is best described by more than one source model. We also perform the first energy-dependent analysis of the HESS J1841-055 region at GeV-TeV. We find that the emission at lower energies comes from a diffuse or extended component, while the major contribution of gamma rays above 1 TeV arises from the southern part of the source. Moreover, we find that a significant curvature is present in the combined observed spectrum of MAGIC and Fermi-LAT. The first multi-wavelength spectral energy distribution of this unidentified source shows that the emission at GeV-TeV energies can be well explained with both leptonic and hadronic models. For the leptonic scenario, bremsstrahlung is the dominant emission compared to inverse Compton. On the other hand, for the hadronic model, gamma-ray resulting from the decay of neutral pions (π^0) can explain the observed spectrum. The presence of dense molecular clouds overlapping with HESS J1841-055 makes both bremsstrahlung and π^0-decay processes the dominant emission mechanisms for the source.

Link: https://ui.adsabs.harvard.edu/abs/2020arXiv200709321M/abstract

MAGIC Collaboration, *An intermittent extreme BL Lac: MWL study of 1ES 2344+514 in an enhanced state*, in MNRAS, Volume 496, Issue 3, pp.3912-3928.

Extreme high-frequency BL Lacs (EHBL) feature their synchrotron peak of the broad-band spectral energy distribution (SED) at $\nu_s \geq 10^{17}$ Hz. The BL Lac object 1ES 2344+514 was included in the EHBL family because of its impressive shift of the synchrotron peak in 1996. During the following years, the source appeared to be in a low state without showing any extreme behaviours. In 2016 August, 1ES 2344+514 was detected with the ground-based γ-ray telescope FACT during a high γ-ray state, triggering multiwavelength (MWL) observations. We studied the MWL light curves of 1ES 2344+514 during the 2016 flaring state, using data from radio to very-high-energy (VHE) γ-rays taken with OVRO, KAIT, KVA, NOT, some telescopes of the GASP-WEBT collaboration at the Teide, Crimean, and St. Petersburg observatories, Swift-UVOT, Swift-XRT, Fermi-LAT, FACT, and MAGIC. With simultaneous observations of the flare, we built the broad-band SED and studied it in the framework of a leptonic and a hadronic model. The VHE γ-ray observations show a flux level of 55 per cent of the Crab Nebula flux above 300 GeV, similar to the historical maximum of 1995. The combination of MAGIC and Fermi-LAT spectra provides an unprecedented characterization of the inverse-Compton peak for this object during a flaring episode. The Γ index of the intrinsic spectrum in the VHE γ-ray band is $2.04 \pm 0.12_{stat} \pm 0.15_{sys}$. We find the source in an extreme state with a shift of the position of the synchrotron peak to frequencies above or equal to 10^{18} Hz.

Link: https://ui.adsabs.harvard.edu/abs/2020MNRAS.496.3912M/abstract

MAGIC Collaboration, *Testing two-component models on very-high-energy gamma-ray emitting BL Lac objects,* accepted for publication in A&A on June 2020.

Context. It has become evident that one-zone synchrotron self-Compton models are not always adequate for very-high-energy (VHE) gamma-ray emitting blazars. While two-component models are performing better, they are difficult to constrain due to the large number of free parameters. Aims. In this work, we make a first attempt to take into account the observational constraints from Very Long Baseline Interferometry (VLBI) data, long-term light curves (radio, optical, and X-rays) and optical polarisation to limit the parameter space for a two-component model and test if it can still reproduce the observed spectral energy distribution (SED) of the blazars. Methods. We selected five TeV BL Lac objects based on the availability of VHE gamma-ray and optical polarisation data. We collected constraints for the jet parameters from VLBI observations. We evaluated the contributions of the two components to the optical flux by means of decomposition of long-term radio and optical light curves as well as modeling of the optical polarisation variability of the objects. We selected eight epochs for these five objects, based on the variability observed at VHE gamma rays, for which we constructed the SEDs that we then modeled with a two-component model. Results. We found parameter sets which can reproduce the broadband SED of the sources in the framework of two-component models considering all available observational constraints from VLBI observations. Moreover, the constraints obtained from the long-term behavior of the sources in the lower energy bands could be used to determine the region where the emission in each band originates. Finally, we attempted to use optical polarisation data to shed new light on the behavior of the two components in the optical band. Our observationally constrained two zone model allows explanation of the entire SED from radio to VHE with two co-located emission regions.

Link: https://ui.adsabs.harvard.edu/abs/2020arXiv200604493M/abstract

MAGIC Collaboration, *Unraveling the Complex Behavior of Mrk 421 with Simultaneous X-Ray and VHE Observations during an Extreme Flaring Activity in 2013 April,* in APJ Supplement Series, Volume 248, Issue 2, id.29.

We report on a multiband variability and correlation study of the TeV blazar Mrk 421 during an exceptional flaring activity observed from 2013 April 11 to 19. The study uses, among others, data from GLAST-AGILE Support Program (GASP) of the Whole Earth Blazar Telescope (WEBT), Swift, Nuclear Spectroscopic Telescope Array (NuSTAR), Fermi Large Area Telescope, Very Energetic Radiation Imaging Telescope Array System (VERITAS), and Major Atmospheric Gamma Imaging Cherenkov (MAGIC). The large blazar activity and the 43 hr of simultaneous NuSTAR and MAGIC/VERITAS observations permitted variability studies on 15 minute time bins over three X-ray bands (3-7 keV, 7-30 keV, and 30-80 keV) and three very-high-energy (VHE; >0.1 TeV) gamma-ray bands (0.2-0.4 TeV, 0.4-0.8 TeV, and >0.8 TeV). We detected substantial flux variations on multi-hour and sub-hour timescales in all of the X-ray and VHE gamma-ray bands. The characteristics of the sub-hour flux variations are essentially energy independent, while the multi-hour flux variations can have a strong dependence on the energy of the X-rays and the VHE gamma-rays. The three VHE bands and the three X-ray bands are positively correlated with no time lag, but the strength and characteristics of the correlation change substantially over time and across energy bands. Our findings favor multi-zone scenarios for explaining the achromatic/chromatic variability of the fast/slow components of the light curves, as well as the changes in the flux-flux correlation on day-long timescales. We interpret these results within a magnetic reconnection scenario, where the multi-hour flux variations are dominated by the combined emission from various plasmoids of different sizes and velocities, while the sub-hour flux variations are dominated by the emission from a single small plasmoid moving across the magnetic

reconnection layer. * Contact MAGIC Collaboration (contact.magic@mpp.mpg.de) for queries. Corresponding authors are D. Paneque, A. Babic, J. Finke, T. Hassan, and M. Petropoulou.

Link: https://ui.adsabs.harvard.edu/abs/2020ApJS..248...29A/abstract

MAGIC Collaboration, *Broadband characterization of the very intense TeV flares of the blazar 1ES 1959+650 in 2016*, in Astronomy & Astrophysics, Volume 638, id.A14, 16 pp.

1ES 1959+650 is a bright TeV high-frequency-peaked BL Lac object exhibiting interesting features like "orphan" TeV flares and broad emission in the high-energy regime that are difficult to interpret using conventional one-zone Synchrotron Self-Compton (SSC) scenarios. We report the results from the Major Atmospheric Gamma Imaging Cherenkov (MAGIC) observations in 2016 along with the multi-wavelength data from the Fermi Large Area Telescope (LAT) and Swift instruments. MAGIC observed 1ES 1959+650 with different emission levels in the very-high-energy (VHE, E > 100 GeV) γ-ray band during 2016. In the long-term data, the X-ray spectrum becomes harder with increasing flux and a hint of a similar trend is also visible in the VHE band. An exceptionally high VHE flux reaching ∼3 times the Crab Nebula flux was measured by MAGIC on the 13 and 14 of June, and 1 July 2016 (the highest flux observed since 2002). During these flares, the high-energy peak of the spectral energy distribution (SED) lies in the VHE domain and extends up to several TeV. The spectrum in the γ-ray (both Fermi-LAT and VHE bands) and the X-ray bands are quite hard. On 13 June and 1 July 2016, the source showed rapid variations in the VHE flux within timescales of less than an hour. A simple one-zone SSC model can describe the data during the flares requiring moderate to large values of the Doppler factors ($\delta \geq 30$-60). Alternatively, the high-energy peak of the SED can be explained by a purely hadronic model attributed to proton-synchrotron radiation with jet power $L_{jet} \sim 10^{46}$ erg s^{-1} and under high values of the magnetic field strength (∼100 G) and maximum proton energy (∼few EeV). Mixed lepto-hadronic models require super-Eddington values of the jet power. We conclude that it is difficult to get detectable neutrino emission from the source during the extreme VHE flaring period of 2016.

Link: https://ui.adsabs.harvard.edu/abs/2020A%26A...638A..14M/abstract

Giommi P., Glauch T., Padovani P., Resconi E., Turcati A., Chang Y.L., *Dissecting the regions around IceCube high-energy neutrinos: growing evidence for the blazar connection*, published on July 16, 2020 in MNRAS.

The association of two IceCube detections, the IceCube-170922A event and a neutrino flare, with the blazar TXS 0506+056, has paved the way for the multimessenger quest for cosmic accelerators. IceCube has observed many other neutrinos but their origin remains unknown. To better understand the reason for the apparent lack of neutrino counterparts we have extended the comprehensive dissection of the sky area performed for the IceCube-170922A event to all 70 public IceCube high-energy neutrinos that are well reconstructed and off the Galactic plane. Using the multi-frequency data available through the Open Universe platform, we have identified numerous candidate counterparts of IceCube events. We report here the classification of all the γ-ray blazars found and the results of subsequent statistical tests. In addition, we have checked the 4LAC, 3FHL and 3HSP catalogues for potential counterparts. Following the dissection of all areas associated with IceCube neutrinos, we evaluate the data using a likelihood-ratio test and find a 3.23 σ (post-trial) excess of HBLs and IBLs with a best-fit of 15 ± 3.6 signal sources. This result, together with previous findings, consistently points to a growing evidence for a connection between IceCube neutrinos and blazars, the most energetic particle accelerators known in the Universe.

Link: https://doi.org/10.1093/mnras/staa2082

Giommi P., Padovani P., Oikonomou F., Glauch T., Paiano S., Resconi E., *3HSP J095507.9+355101: a flaring extreme blazar coincident in space and time with IceCube-200107A*, accepted for publication in A&A Letters.

The uncertainty region of the highly energetic neutrino IceCube200107A includes 3HSP J095507.9+355101 (z~=~0.557), an extreme blazar, which was detected in a high, very hard, and variable X-ray state shortly after the neutrino arrival. Following a detailed multi-wavelength investigation, we confirm that the source is a genuine BL Lac, contrary to TXS 0506+056, the first source so far associated with IceCube neutrinos, which is a "masquerading" BL Lac. As in the case of TXS0506+056, 3HSP J095507.9+355101 is also way off the so-called "blazar sequence". We consider 3HSP J095507.9+355101 a possible counterpart to the IceCube neutrino. Finally, we discuss some theoretical implications in terms of neutrino production.

Link: https://arxiv.org/abs/2003.06405

Giommi P., Chang Y.~L., Turriziani S., Glauch T., Leto C., Verrecchia F., Padovani P., et al., *The Open Universe survey of Swift-XRT GRB fields: a complete sample of HBL blazars*, accepted for publication in A&A Letters.

We have analysed all the X-ray images centred on Gamma Ray Bursts generated by Swift over the last 15 years using automatic tools that do not require any expertise in X-ray astronomy, producing results in excellent agreement with previous findings. This work, besides presenting the largest medium-deep survey of the X-ray sky and a complete sample of blazars, wishes to be a step in the direction of achieving the ultimate goal of the Open Universe Initiative, that is to enable non expert people to fully benefit of space science data, possibly extending the potential for scientific discovery, currently confined within a small number of highly specialised teams, to a much larger population. We have used the Swift_deepsky Docker container encapsulated pipeline to build the largest existing flux-limited and unbiased sample of serendipitous X-ray sources. Swift_deepsky runs on any laptop or desktop computer with a modern operating system. The tool automatically downloads the data and the calibration files from the archives, runs the official Swift analysis software and produces a number of results including images, the list of detected sources, X-ray fluxes, SED data, and spectral slope estimations. We used our source list to build the LogN-LogS of extra-galactic sources, which perfectly matches that estimated by other satellites. Combining our survey with multi-frequency data we selected a complete radio flux-density limited sample of High Energy Peaked (HBL) blazars.

Link: https://arxiv.org/abs/2003.05153

Petropoulou M., Oikonomou F., Mastichiadis A., Murase K., Padovani P., Vasilopoulos G., Giommi P., *Comprehensive Multimessenger Modeling of the Extreme Blazar 3HSP J095507.9+355101 and Predictions for IceCube*, accepted for publication in ApJ.

3HSP J095507.9+355101 is an extreme blazar which has been possibly associated with a high-energy neutrino (IceCube-200107A) detected one day before the blazar was found to undergo a hard X-ray flare. We perform a comprehensive study of the predicted multimessenger emission from 3HSP J095507.9+355101 during its recent X-ray flare, but also in the long term. We focus on one-zone leptohadronic models, but we also explore alternative scenarios: (i) a blazar-core model, which considers neutrino production in the inner jet, close to the supermassive black hole; (ii) a hidden external-photon model, which considers neutrino production in the jet through interactions with photons from a weak broad line region; (iii) a proton

synchrotron model, where high-energy protons in the jet produce γ-rays via synchrotron; and (iv) an intergalactic cascade scenario, where neutrinos are produced in the intergalactic medium by interactions of a high-energy cosmic-ray beam escaping the jet. The Poisson probability to detect one muon neutrino in ten years from 3HSP J095507.9+355101 with the real-time IceCube alert analysis is ∼1% (3%) for the most optimistic one-zone leptohadronic model (the multi-zone blazar-core model). Meanwhile, detection of one neutrino during the 44-day-long high X-ray flux-state period following the neutrino detection is 0.06%, according to our most optimistic leptohadronic model. The most promising scenarios for neutrino production also predict strong intra-source γ-ray attenuation above ∼100 GeV. If the association is real, then IceCube-Gen2 and other future detectors should be able to provide additional evidence for neutrino production in 3HSP J095507.9+355101 and other extreme blazars.

Link: https://arxiv.org/abs/2005.07218

Paiano S., Falomo R., Padovani P., Giommi P., Gargiulo A., Uslenghi M., Rossi A., et al., *The redshift and the host galaxy of the neutrino candidate 4FGL J0955.1+3551 (3HSP J095507.9+355101)* in MNRAS, 495, L108.

The BL Lac object 4FGL J0955.1+3551 has been suggested as a possible source of ultra-energetic neutrinos detected by the IceCube observatory. The target was observed in 2020 January at the Large Binocular Telescope. Our spectroscopy (4100–8500 Å) yields a firm redshift $z = 0.557$ as deduced by the absorption lines of the host galaxy. The upper limit of the minimum equivalent width on emission lines is ∼0.3 Å. From the source image, we are able to resolve the host galaxy for which we measure an absolute magnitude $M(R) = -22.9$ and $R_e = 8$ kpc, which are values which are typical of the host galaxies of BL Lacs.

Link: https://doi.org/10.1093/mnrasl/slaa056

Fermi collaboration. Abdollahi S., Acero F., Ackermann M., Ajello M., Atwood W. B.,Axelsson M., Baldini L., et al., *Fermi Large Area Telescope Fourth Source Catalog*, in ApJS, 247, 33.

We present the fourth Fermi Large Area Telescope catalog (4FGL) of γ-ray sources. Based on the first eight years of science data from the Fermi Gamma-ray Space Telescope mission in the energy range from 50 MeV to 1 TeV, it is the deepest yet in this energy range. Relative to the 3FGL catalog, the 4FGL catalog has twice as much exposure as well as a number of analysis improvements, including an updated model for the Galactic diffuse γ-ray emission, and two sets of light curves (one-year and two-month intervals). The 4FGL catalog includes 5064 sources above 4σ significance, for which we provide localization and spectral properties. Seventy-five sources are modeled explicitly as spatially extended, and overall, 358 sources are considered as identified based on angular extent, periodicity, or correlated variability observed at other wavelengths. For 1336 sources, we have not found plausible counterparts at other wavelengths. More than 3130 of the identified or associated sources are active galaxies of the blazar class, and 239 are pulsars.

Link: https://doi.org/10.3847/1538-4365/ab6bcb

ICRANet Newsletter

August - September 2020

SUMMARY

1. Videos of recent talks given by ICRANet faculty members

Talk of Prof. Remo Ruffini at IWARA 2020 meeting

Talk of Prof. Jorge Rueda at IWARA 2020 meeting

Talk of Prof. Remo Ruffini at The Fourth Zeldovich virtual meeting

Talk of Prof. Gregory Vereshchagin at The Fourth Zeldovich virtual meeting

Talk of Prof. Jorge Rueda at The Fourth Zeldovich virtual meeting

Talk of Prof. Remo Ruffini at the 14th International Conference on Gravitation, Astrophysics and Cosmology

2. Multiwavelength Study of High-Redshift Blazars

The new article coauthored by N. Sahakyan, D. Israyelyan, G. Harutyunyan, M. Khachatryan and S. Gasparyan "Multiwavelength Study of High-Redshift Blazars", is published in Monthly Notices of the Royal Astronomical Society on 17 August 2020.

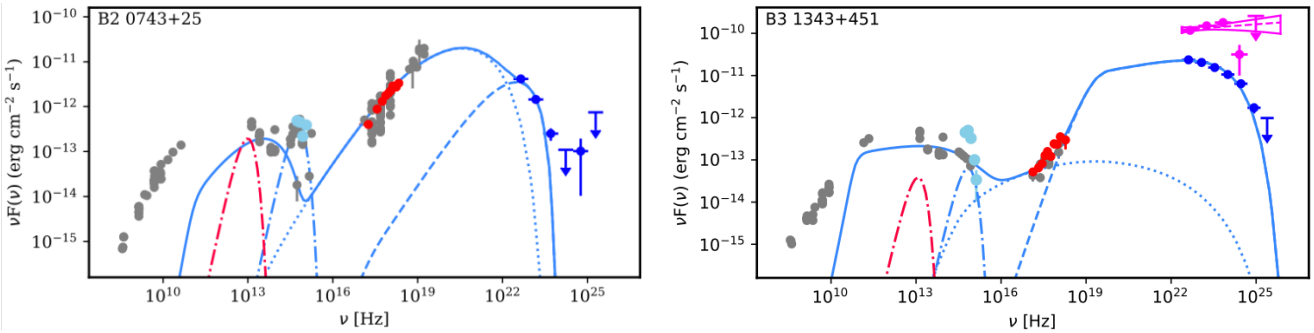


Figure 1. Spectra of some blazars.

Blazars harboring supermassive black holes are valuable sources for studying the relativistic outflows and formation and propagation of relativistic jets. In this context, the high redshift blazars (z>2.5) are of particular interest; they are among the most powerful non- explosive astrophysical sources in the Universe. Their study can shed light on the further understanding of the cosmological evolution of blazars and supermassive black holes and also on the evolution of relativistic jets across different cosmic epochs. Motivated by the large number of detected high redshift γ-ray emitting blazars, with the aim to characterize their multiwavelength emission properties, an intense broadband study of all the thirty-three known γ-ray blazars beyond redshift 2.5 is performed. In order to characterize the physical properties of the considered sources, Fermi Large Area Telescope γ-ray data accumulated during 2008-2018, as well as X-ray and optical/UV data from the observations with both Swift X-ray Telescope and Ultraviolet and Optical Telescope in the previous fifteen years are analyzed. This allowed collecting unprecedented data in the optical/UV, X-ray, and γ-ray bands, which is used to constrain the multiwavelength spectral energy distributions (SEDs), see Fig. 1. Then, through modeling of these SEDs within a one-zone leptonic scenario (assuming that the X-ray and γ-ray emissions are produced from inverse Compton scattering of synchrotron and dusty torus photons), the physical parameters characterizing the sources (disc luminosity, black hole mass, etc.) and their jets (e.g., the distribution of underlying electrons, magnetic field, power, etc.) are derived, allowing a quantitative discussion and investigation of the state of plasma in these powerful jets.

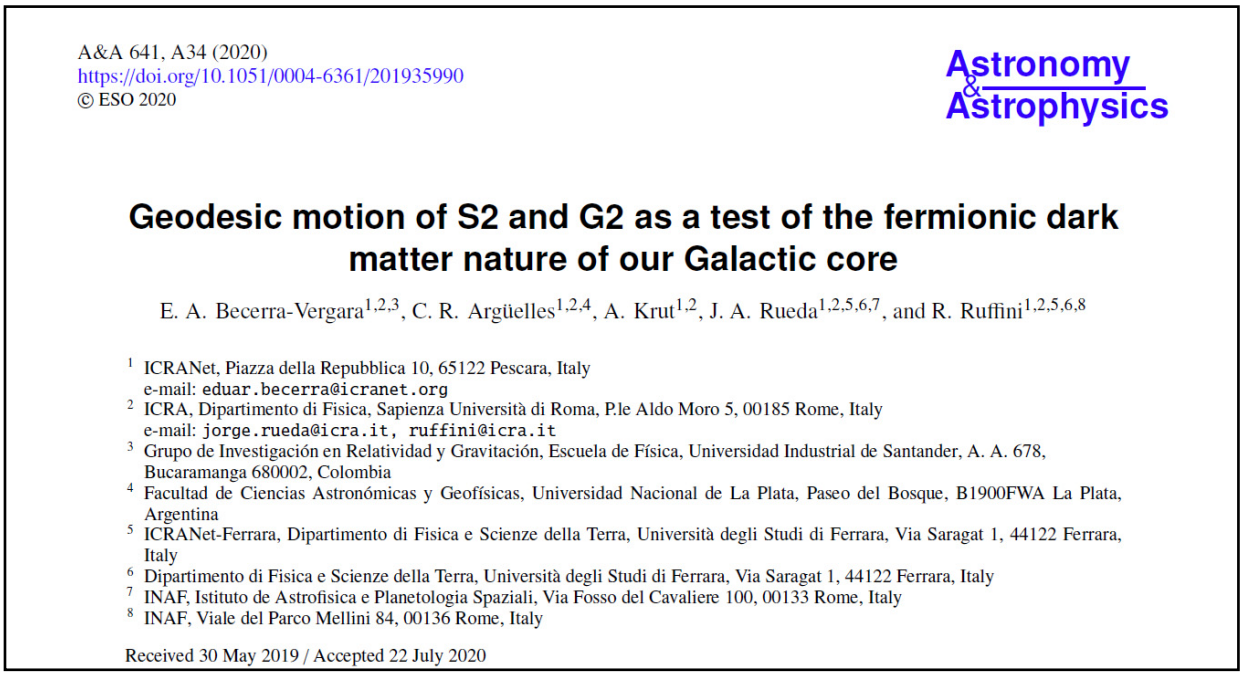
Time variability in different energy bands is particularly important. In the X-ray band, only the emission of PKS 0438-43, B2 0743+25 and TXS 0222+185 is found to vary in different Swift XRT observations whereas in the γ-ray band, the emission is variable for fourteen sources: the flux of B3 1343+451 and PKS 0537-286 changes in sub-day scales, that of PKS 0347-211 and PKS 0451-28 in day scales, while the γ-ray variability of the others is in week or month scales. Such rapid variability in high energy band is in agreement with recently proposed model for the inner engine of AGNs by Rueda, J.A., Ruffini, R., "The blackholic quantum", Eur. Phys. J. C 80, 300 (2020), see https://doi.org/10.1140/epjc/s10052-020-7868-z.

The article is available here: https://doi.org/10.1093/mnras/staa2477

ArXiv e-print: https://arxiv.org/abs/2008.09675

3. Geodesic motion of S2 and G2 as a test of the fermionic dark matter nature of our Galactic core

The paper "Geodesic motion of S2 and G2 as a test of the fermionic dark matter nature of our Galactic core", co-authored by E.A. Becerra-Vergara, C.R. Argüelles, A. Krut, J.A. Rueda, and R. Ruffini has been published by Astronomy & Astrophysics on September 4, 2020. In this paper, the evidence is given on the possibility of different interpretation of observational data of the motion of S2 and G2 objects near the Galactic center. Within this interpretation, which is perfectly consistent with General Relativity, the compact object is not a black hole but a condensation of dark matter.



A&A 641, A34 (2020)
https://doi.org/10.1051/0004-6361/201935990

Astronomy & Astrophysics

Geodesic motion of S2 and G2 as a test of the fermionic dark matter nature of our Galactic core

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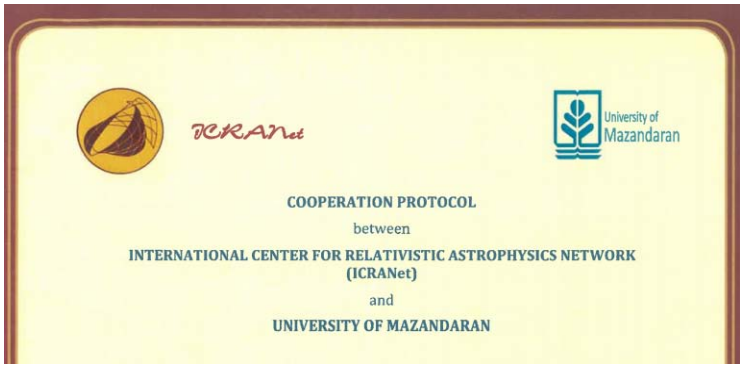
Link to the paper: https://www.aanda.org/articles/aa/abs/2020/09/aa35990-19/aa35990-19.html

Link to ArXiv e-print: https://arxiv.org/abs/2007.11478

4. New collaboration Agreement between University of Mazandaran and ICRANet, August 24, 2020



On August 24, a cooperation agreement between ICRANet and the University of Mazandaran (Iran) was signed by Prof. Kourosh Nozari (President of the University of Mazandaran), Prof. Mahmoud Azizi (Director of the Office of International and Scientific Cooperation – University of Mazandaran) and by Prof. Remo Ruffini (Director of ICRANet). The main joint activities to be developed under the framework of this agreement include: the promotion of theoretical and observational activities within the

field of Relativistic Astrophysics; the institutional exchange of faculty members, researchers, post-doctorate fellows and students; the promotion of technological developments; the development of Data Centers for Astrophysical data in all wavebands; the organization of training and teaching courses, seminars, conferences, workshops or short courses, and the development of inter-institutional research areas associated to local graduate programs; and joint publications. The agreement will be valid for 5 years.

For the text of the agreement: http://www.icranet.org/index.php?option=com_content&task=view&id=1341

5. The 14th International Conference on Gravitation, Astrophysics and Cosmology (ICGAC 14), August 17 – 21, 2020

The 2020 edition of the ICGAC 14 meeting has been held virtually from August 17 to 21 at the National Central University, Jhongli, in Taiwan. Prof. Ruffini, Director of ICRANet, gave a lecture titled *"The geodesic motion of S2 and G2 as a test of the fermionic dark matter nature of our galactic core"*, while Prof. Gregory Vereshchagin, ICRANet Faculty Professor, gave a lecture titled *"Diffusive photospheres and thermal emission in early afterglows of gamma-ray bursts"*. ICGAC14 is the series of biennial conferences on Gravitation, Astrophysics and Cosmology which take place in the Asia-Pacific region, with the goals to promote cooperation among the member countries and within an international context, high level studies on hot topics and to encourage young physicists on these fields.

The website of the meeting: https://icgac14.phy.ncu.edu.tw

6. IWARA 2020 video conference. From Quarks to Cosmo, September 6 – 12, 2020

Prof. Remo Ruffini was invited to give a plenary lecture on the occasion of the IWARA 2020 video conference, held from September 6-12 in Mexico City. On Sunday September 6, Prof. Ruffini presented his lecture on the *"Discovery of energy extraction from a Kerr Black Hole by discrete Black-Holic quanta in GRB 190114C, GRB 130427A, GRB 160509A and GRB 160625B"*.

Abstract: Almost fifty years after the paper "Introducing the Black Hole" by Ruffini and Wheeler and the Black Hole (BH) mass energy formula by Christodoulou, Ruffini and Hawking, we can finally assert that we have been observing the moment of creation of a BH in the BdHN I in GRB 190114C, GRB 130427A, GRB 160509A and GRB 160625B, with the corresponding rotational energy extraction process. The first appearance of the

Supernova, the SN-rise, triggering the BdHN has been identified. The hypercritical accretion on the SN ejecta on the new NS (νNS) created in the SN, is shown to originate the X-ray afterglow observed by the NASA Neil-Gehrels SWIFT satellite (SWIFT). The hypercritical accretion of the SN on the NS binary companion in the BdHN I model leads to the formation of the newly formed BH. The onset of the GeV radiation coinciding with the BH formation has revealed self similar structures in the time resolved spectral analysis of all sources. Consequently, we find evidence for quantized-discrete-emissions in all sources, with energy quanta of 1037 ergs with repetition time of 10-14 sec. GRBs are the most complex systems ever successfully analyzed in Physics and Astrophysics, and they may well have a role in the appearance of life in the Cosmos. These results have been made possible by a long-lasting theoretical activity, a comprehensive unprecedented high quality data analysis, an observational multi-messenger effort by the astronomical, the physical and the space research communities. This observational effort is well epitomized by the original Vela Satellites, the NASA Compton space mission (CGRO), the Italo-Dutch Beppo SAX satellite, the Russian Konus Wind Satellite, the SWIFT satellite, the Italian AGILE satellite, the NASA FERMI mission and most recently the Chinese satellite HXMT. These space missions have been assisted by radio and optical equally outstanding observational facilities from the ground.

The website of the conference: https://indico.cern.ch/event/822124/

7. The 4th Zeldovich virtual meeting, September 7 - 11, 2020

The Fourth Zeldovich virtual meeting has been organized by ICRANet and by the National Academy of Sciences of Belarus. It was held virtually from 7 to 11 of September, 2020.

Fig. 2. Final greetings at the end of the meeting.

The number of registered participants, about 150, was record breaking for Zeldovich meetings. Participants from all the continents and time zones were present. Every day, three sessions were organized: two in the morning in European Central Summer Time (CEST), and one in the afternoon. In the morning sessions mostly Asian, African and European speakers were present while in the afternoon session American participants, both from the North and the South were joining the meeting. The sessions included the following topics: Gravity, Gamma-Ray Bursts, General Relativity And The Quantum, The Space Missions, Magnetic Fields, General Relativity And Alternative Theories, Early Universe, Black Hole Horizons, Multi-Messenger Astrophysics, Gravity, Astrophysics And Elementary Particles, Large Scale Structure Of The Universe, Starburst and Dark Matter in the Universe, Exoplanets and Astrobiology, Dark Matter and Dark Energy, Supernovae and Gravity. In total, 89 talks have been presented, among them 30 were invited. Many exciting observational results were discussed, in particular: the first results from SRG Orbital Observatory and HXMT mission, the ground based observations of Neutrinos by ICECube Observatory, the high energy Gamma-Rays by MAGIC telescopes, and prompt optical observations by the MASTER network, the observations of Galactic Center by GRAVITY collaboration and Black Hole Shadow in M87*, the new observations and data analysis of Gamma-Ray Bursts, Exoplanets and large scale structure of the Universe. In addition, theoretical progress in Gamma-Ray Burst theory and Supernovae mechanisms, Magnetic Dynamo in Galaxies, Quantum Gravity,

alternative gravity theories, Neutrino Physics, origin of Dark Matter, CMB spectral distortions and many other topics were amply discussed.

The concluding remarks, summarizing the new and important scientific results presented along the meeting, have been made by Academician Sergei Kilin, Deputy Chairman of the National Academy of Sciences of Belarus NASB, by Prof. Remo Ruffini, Director of ICRANet and by Prof. Gregory Vereshchagin.

The proceedings of the 4th Zeldovich meeting will be published in the refereed journal Astronomy Reports, the leading Russian journal on Astronomy and Astrophysics. The website of the journal: https://www.springer.com/journal/11444.

This celebration was the forth international conference dedicated to Ya. B. Zeldovich. The previous meetings were held on April 23-27, 2018 in Minsk, on April 20-23, 2009 in Minsk (jointly organized by ICRANet and the Belarusian State University BSU, celebrating also the 2009 Year of Astronomy) and on March 11-14, 2014, celebrating 100th anniversary of Ya. B. Zeldovich.

The videos of the sessions are available on ICRANet YouTube channel:
https://www.youtube.com/playlist?list=PLr5RLbSWSonutlLDMpO1OnGV97rnCEdum

The speakers' presentations are available on the conference webpage:
http://www.icranet.org/index.php?option=com_content&task=view&id=1339

The website of the meeting: http://www.icranet.org/zeldovich4

8. 106th SIF National Congress, September 14 – 18, 2020

From September 14 - 18, the Italian Physical Society (Società Italiana di Fisica, SIF) held its 106th National Congress (virtually). Prof. Remo Ruffini, Director of ICRANet, Prof. Jorge Rueda, ICRANet Faculty Professor, and Prof. Costantino Sigismondi, ICRANet collaborator, were invited to participate and present their talk through a video presentation reporting on their latest scientific results. Prof. Ruffini presented a talk titled *"Magnetic fields and afterglows of BdHNe: Inferences from GRB 130427A, GRB 160509A, GRB 160625B, GRB 180728A and GRB 190114C"*, Prof. Rueda presented a talk titled "*On the inner engine of the high-energy (GeV) emission of gamma-ray bursts"* and Prof. Sigismondi presented a talk on "*The Eclipses of Betelgeuse"* (this red supergiant is now at magnitude 0.65, nearly at its maximum, after the second dimming due to dust cloud expulsions in the last few months).

For more information, please check the conference website: https://www.sif.it/attivita/congresso/106

9. *"Dante e l'Astronomia"* podcast meeting, September 13, 2020

C. Sigismondi, ICRA/Sapienza

The fame of Dante is international, as the Poet was at his own times. Remembering of his passage at the University of Paris are still visible. His pilgrimages, for political and professional reasons, are framed in the verses of the Divine Comedy. His poetry has been able to include all cultural, artistic, theological as well as scientific and religious aspects of his times.

The podcast meeting inaugurated on September 13, 2020 is expressly dedicated Dante and Astronomy. It started the seventh centennial celebrations of the death of Dante, occurred in Ravenna on the night of

September 13-14, 1321. Dante is an icon of the medieval culture, where science and faith were deeply united.

Fig. 3. Dante Alighieri (1265-1321)

"e nove Muse mi dimostran l'Orse" (Par. II, 9)

is the verse chosen for the title of the event: nine muses, all arts, contribute to show the Ursae, to maintain the North, the correct direction, in the extraordinary trip that Dante (not Aeneas, a classical hero, nor St. Paul, the Apostle...as he wrote) was able to perform. But not only a figurative North, an ideal Compass in the hard sea of human life... Dante shows several pictures of genuine observations of physical phenomena, and the awe of astronomical events as himself indeed experienced.

Astronomy as codified language, astronomical observations filled by nostalgic sensations, astronomical bodies as silent testimonies of the phases of the human life, before and after the passage into the Other World, of which Dante is the cantor par excellence.

Contributions of scientists and dantists were included in this meeting dedicated especially to the young students, and to all estimators of Dante. The podcast was hosted by ICRANet in Pescara with the participation of the Astrophysical Observatory of Asiago and of the Academy of Lincei. The patrocinium to the IAU Commission III of History of Astronomy has been requested.

For more information about the meeting: http://www.icranet.org/index.php?option=com_content&task=view&id=1334

For a press release (in Italian) on regional tv channel Rete 8: https://www.rete8.it/cronaca/icranet-dante-e-lasrtronomia/

10.Recent publications

N. Sahakyan, D. Israyelyan, G. Harutyunyan, M. Khachatryan and S. Gasparyan, *Multiwavelength Study of High-Redshift Blazars*, accepted for publication in MNRAS.

High-redshift blazars are among the most powerful objects in the Universe. The spectral and temporal properties of thirty-three distant blazars ($z > 2.5$) detected in the high energy γ-ray band are investigated by analyzing the *Fermi*-LAT and *Swift* UVOT/ XRT data. The considered sources have soft time averaged γ-ray spectra ($\Gamma_\gamma \geq 2.2$) whereas those that have been observed in the X-ray band have hard X-ray spectra ($\Gamma_X = 1.01 - 1.86$). The γ-ray flux of high-redshift blazars ranges from 4.84×10^{-10} to 1.50×10^{-7} photon $cm^{-2}\,s^{-1}$ and the luminosity is within $(0.10 - 5.54) \times 10^{48}$ erg s^{-1} which during the γ-ray flares increases up to $(0.1 - 1) \times 10^{50}$ erg s^{-1}. In the X-ray band, only the emission of PKS 0438-43, B2 0743+25 and TXS 0222+185 is found to vary in different Swift XRT observations whereas in the γ-ray band, the emission is variable for fourteen sources: the flux of B3 1343+451 and PKS 0537-286 changes in sub-day scales, that of PKS 0347-211 and PKS 0451-28 in day scales, while the γ-ray variability of the others is in week or month scales. The properties of distant blazar jets are derived by modeling the multiwavelength spectral energy distributions within a one-zone leptonic scenario assuming that the X-ray and γ-ray emissions are produced from inverse Compton scattering of synchrotron and dusty torus photons. From the fitting, the emission region size is found to be ≤ 0.05 pc and the magnetic field and the Doppler factor are correspondingly within $0.10 - 1.74$ G and $10.0 - 27.4$. By modeling the optical -UV excess, we found that the central black hole masses and accretion disk luminosities are within $L_d \simeq (1.09 - 10.94) \times 10^{46}$ erg s^{-1} and $(1.69 - 5.35) \times 10^9 M_\odot$, respectively.

DOI: https://doi.org/10.1093/mnras/staa2477
Link:https://ui.adsabs.harvard.edu/abs/2020arXiv200809675S/abstract

N. Sahakyan, G. Harutyunyan, D. Israyelyan and M. Khachatryan, *Exploring the Origin of Multiwavelength Emission from High-Redshift Blazar B3 1343 + 451*, published in Astrophysics, Volume 63, Issue 3, p.334-348, 2020.

B3 1343 + 451 is a distant (z = 2.534) and bright flat-spectrum radio quasar observed in the γ -ray band. The results from the multiwavelength observations of B3 1343 + 451 with Fermi-LAT and Swift are reported. In the γ -ray band, strong flares were observed on 05 December 2011 and on 13 December 2009 when the flux increased up to $(8.78 \pm 0.83).10^{-7}$ photon cm^{-2} s^{-1}. The hardest photon index $\Gamma = 1.73 \pm 0.24$ has been observed on MJD 58089 which is not common for flat-spectrum radio quasars. The analysis of Swift XRT data shows that in 2014 the X-ray flux of the source increased ~2 times as compared to 2009, but in both periods the X-ray emission is characterized by a hard photon index of $\Gamma_{X\text{-}ray}$ = 1.2-1.3. During the γ -ray flares, the shortest flux halving timescale was ~2.34 days, implying the emission had been produced in a very compact region, $R \leq \delta$ ct $/(1 + z) = 3.43.10^{16}$ cm (when $\delta = 20$). The spectral energy distribution of B3 1343 + 451 is modeled during the quiescent and flaring periods assuming a compact emitting region outside the BLR. It is found that the flares can be explained by only changing the bulk Lorentz factor of the emitting region without significant modification of the emitting electron parameters and luminosity of the jet.

DOI: https://doi.org/10.1007/s10511-020-09638-z
Link: https://ui.adsabs.harvard.edu/abs/2020Ap.....63..334S/abstract

MAGIC collaboration, *Testing two-component models on very high-energy gamma-ray-emitting BL Lac objects*, Astronomy & Astrophysics, Volume 640, id.A132, 29 pp., 2020.

Context. It has become evident that one-zone synchrotron self-Compton models are not always adequate for very high-energy (VHE) gamma-ray-emitting blazars. While two-component models perform better, they are difficult to constrain due to the large number of free parameters.
Aims: In this work, we make a first attempt at taking into account the observational constraints from very long baseline interferometry (VLBI) data, long-term light curves (radio, optical, and X-rays), and optical polarization to limit the parameter space for a two-component model and test whether or not it can still reproduce the observed spectral energy distribution (SED) of the blazars.
Methods: We selected five TeV BL Lac objects based on the availability of VHE gamma-ray and optical polarization data. We collected constraints for the jet parameters from VLBI observations. We evaluated the contributions of the two components to the optical flux by means of decomposition of long-term radio and optical light curves as well as modeling of the optical polarization variability of the objects. We selected eight epochs for these five objects based on the variability observed at VHE gamma rays, for which we constructed the SEDs that we then modeled with a two-component model.
Results: We found parameter sets which can reproduce the broadband SED of the sources in the framework of two-component models considering all available observational constraints from VLBI observations. Moreover, the constraints obtained from the long-term behavior of the sources in the lower energy bands could be used to determine the region where the emission in each band originates. Finally, we attempt to use optical polarization data to shed new light on the behavior of the two components in the optical band. Our observationally constrained two-component model allows explanation of the entire SED from radio to VHE with two co-located emission regions.

DOI: https://doi.org/10.1051/0004-6361/202037811
Link: https://ui.adsabs.harvard.edu/abs/2020A%26A...640A.132M/abstract

D. Maričić, B. Vršnak, A. M. Veronig, M. Dumbović, F. Šterc, D. Roša, M. Karlica, D. Hržina & I. Romštajn, *Sun-to-Earth Observations and Characteristics of Isolated Earth-Impacting Interplanetary Coronal Mass Ejections During 2008-2014*, published in Sol Phys 295, 91 (2020).

A sample of isolated Earth-impacting interplanetary coronal mass ejections (ICMEs) that occurred in the period January 2008 to August 2014 is analyzed to study in detail the ICME in situ signatures, with respect to the type of filament eruption related to the corresponding CME. Observations from different vantage points provided by the Solar and Heliospheric Observatory (SOHO) and the Solar Terrestrial Relations Observatory Ahead and Behind (STEREO-A and B) are used to determine whether each CME under study is Earth directed or not. For Earth-directed CMEs, a kinematical study was performed using the STEREO-A and B COR1 and COR2 coronagraphs and the Heliospheric Imagers (HI1), to estimate the CME arrival time at 1 AU and to link the CMEs with the corresponding in situ solar wind counterparts. Based on the extrapolated CME kinematics, we identified interacting CMEs, which were excluded from further analysis. Applying this approach, a set of 31 isolated Earth-impacting CMEs was unambiguously identified and related to the in situ measurements recorded by the Wind spacecraft. We classified the events into subsets with respect to the CME source location, as well as with respect to the type of the associated filament eruption. Hence, the events are divided into three subsamples: active region (AR) CMEs, disappearing filament (DSF) CMEs, and stealthy CMEs. The related three groups of ICMEs were further divided into two subsets: magnetic obstacle (MO) events (out of which four were stealthy), covering ICMEs that at least partly showed characteristics of flux ropes, and ejecta (EJ) events, not showing such characteristics. In this way, 14 MO-ICMEs and 17 EJ-ICMES were identified. The solar source regions of the non-stealthy MO-ICMEs are found to be located predominantly (9/10, 90%) within ±30∘±30∘ from the solar central meridian, whereas EJ-ICMEs originate predominantly (16/17, 94%) from source regions that are outside ±30∘±30∘. In the next step, MO-events were analyzed in more detail, considering the magnetic field strength and the plasma characteristics in three different segments, defined as the turbulent sheath (TS), the frontal region (FR), and the MO itself. The analysis revealed various well-defined correlations for AR, DSF, and stealthy ICMEs, which we interpreted considering basic physical concepts. Our results support the hypothesis that ICMEs show different signatures depending on the in situ spacecraft trajectory, in terms of apex versus flank hits.

DOI: https://doi.org/10.1007/s11207-020-01658-4
Link: https://link.springer.com/article/10.1007/s11207-020-01658-4

ICRANet Newsletter

October -November 2020

SUMMARY

1. Open Universe survey of Swift-XRT GRB fields: Flux-limited sample of HBL blazars

A new paper co-authored by Paolo Giommi and another 24 co-authors with this title has been published on the 13 of October 2020 in Astronomy and Astrophysics journal.

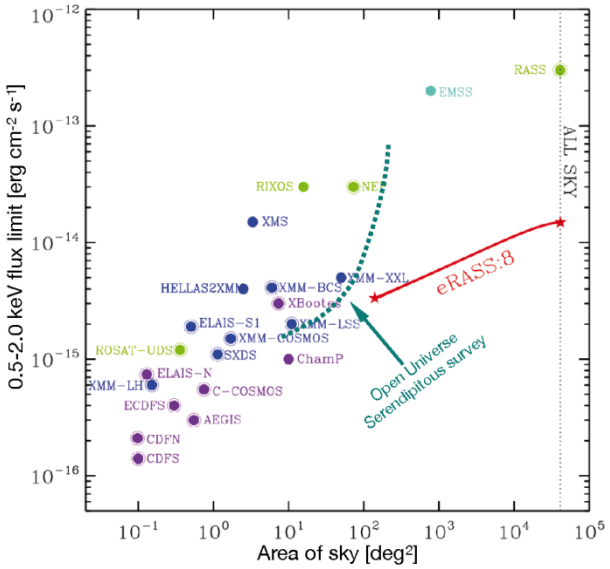


Fig. 1. Sky coverage of the Swift GRB serendipitous survey (dotted line) compared to all the major existing and upcoming surveys of X-ray point-like sources.

Open Universe is an initiative under the auspices of the United Nations Office for Outer Space Affairs (UNOOSA) with the objective of making astronomy and space science data more openly available, easily discoverable, free of bureaucratic, administrative or technical barriers, and therefore usable by the widest possible community, from professional researchers to all people interested in space science and astronomy, including students, non-professionals, and amateur scholars of the subject.

In this new paper Giommi et al. present for the first time an X-ray survey that is large and deep enough to allow the selection of a statistically complete flux-limited sample of blazars of this type with radio flux-densities .20 mJy. This work also demonstrates that complex data analysis projects can in principle be carried out by non-experts, one of the main goals of the United Nations Open Universe initiative.

The deepest fields, obtained investing several megaseconds of exposure time of the largest operating X-ray observatories like Chandra and XMM, reach sensitivities well below 10^{-15} erg cm^{-2} s^{-1} but cover very small areas of sky. The Rosat All Sky Survey still the only available all sky survey, is relatively shallow, only reaching a flux limit of a few times 10^{-13} erg cm^{-2} s^{-1} in the 0.5–2.0 keV band. Therefore, as can be seen from Fig. 1, the Open Universe survey of Swift-XRT GRB fields (OUSXG) represented by the dashed green line is currently the largest survey available.

Link to the paper: https://doi.org/10.1051/0004-6361/202037921

2. Numerical scheme for evaluating the collision integrals for triple interactions in relativistic plasma

A new paper co-authored by Mikalai Prakapenia, Ivan Siutsou and Gregory Vereshchagin with this title has been published in November issue of the journal Physics of Plasmas.

Relativistic plasmas are of interest in astrophysics and in laboratory experiments. Kinetics of relativistic plasma has been studied in ICRANet in the last decade with application to thermalization of electron-positron-photon plasma in gamma-ray bursts. In particular, the role of direct and inverse triple processes has been clarified in thermalization process.

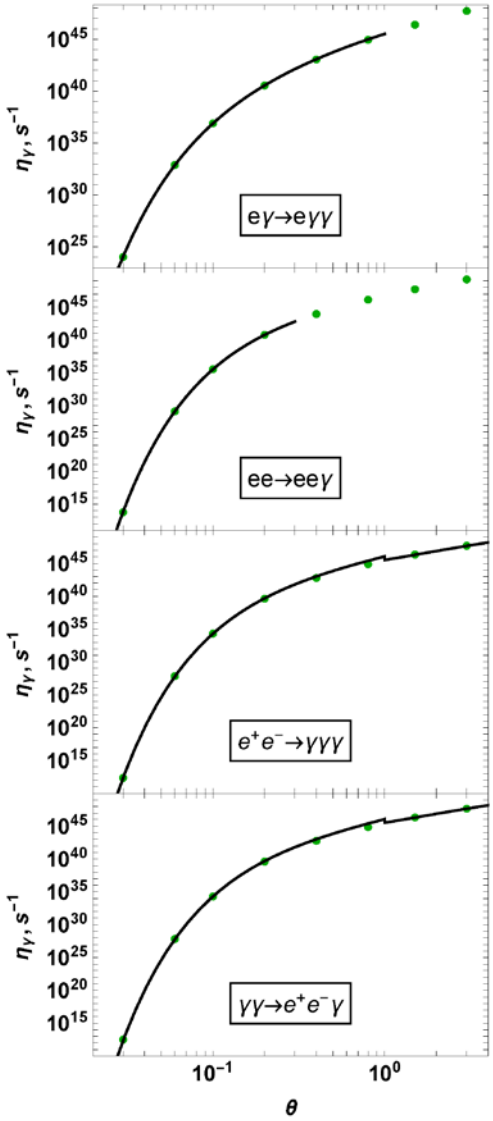


Fig. 2. Photon emissivity is presented as a function of temperature with fixed energy 0.05 kT/m_ec^2.

The new paper [1] co-authored by Mikalai Prakapenia (PhD student of the Belarusian State University and IRAP PhD program), Ivan Siutsou (researcher at the B.I. Stepanov Institute of Physics of the National Academy of Sciences of Belarus) and Gregory Vereshchagin (ICRANet professor) deals with first principles calculation of collision integrals for three particle processes in relativistic plasmas. Existing numerical codes treated these processes approximately, using thermal rates or various approximations such as nonrelativistic/ultrarelativistic or soft/hard photon limits. The new kinetic code developed in ICRANet [2] performs direct numerical integration of matrix elements of Quantum Electrodynamics over the phase space of interacting particles. In 2018 a numerical scheme for binary processes was developed [3]. The code takes into account quantum statistics of particles, so that quantum condensation of photons [4] as well as Pauli blocking in degenerate electron-positron plasma [5] can be studied as well. This year a new scheme was proposed and successfully implemented for calculation of triple interactions. The results were confronted with known analytic expressions obtained assuming thermal equilibrium. As an example, in Figure 1 photon emissivity is presented as a function of temperature with fixed energy 0.05 kT/m_ec^2 is presented (from top to bottom) for double Compton scattering, relativistic bremsstrahlung, three-photon annihilation, and radiative pair production. Overall, excellent agreement with known expressions was found.

This work was supported within the joint BRFFR-ICRANet-2018 funding programme under Grant No. F19ICR-001.

Mikalai Prakapenia defended his PhD thesis under the supervision of Prof. Vereshchagin on 27 of November 2020 in the National Academy of Sciences of Belarus.

The ICRANet seminar with discussion of recent results obtained in this work will be organized on the 10 of December 2020 by ICRANet via the Gotomeeting platform. The link to follow this meeting on the ICRANet Youtube channel event will be sent separately.

Links to the paper:

Journal: https://aip.scitation.org/doi/10.1063/5.0022931

Arxiv: https://arxiv.org/abs/2010.14348

References:

[1] M. A. Prakapenia, I. A. Siutsou and G. V. Vereshchagin, *Numerical scheme for evaluating the collision integrals for triple interactions in relativistic plasma*, Phys. Plasmas 27, 113302 (2020) pp. 1-10.

[2] G.V. Vereshchagin and A.G. Aksenov, *Relativistic Kinetic Theory With Applications in Astrophysics and Cosmology*, Cambridge University Press, 2017.

[3] M. A. Prakapenia, I. A. Siutsou, and G. V. Vereshchagin, *Numerical scheme for treatment of Uehling–Uhlenbeck equation for two-particle interactions in relativistic plasma*, Journal of Computational Physics, Volume 373 (2018), pp. 533–544.

[4] M. A. Prakapenia and G. V. Vereshchagin, *Bose-Einstein condensation in relativistic plasma*, EPL 128 (2019) 50002.

[5] M. A. Prakapenia and G. V. Vereshchagin, *Pauli blocking effects in thermalization of relativistic plasma*, Phys. Lett. A, Vol. 384 (2020) 126679.

3. The Extreme Red Excess in Blazar Ultraviolet Broad Emission Lines

The new article coauthored by Brian Punsly, Paola Marziani, Marco Berton and Preeti Kharb *"The Extreme Red Excess in Blazar Ultraviolet Broad Emission Lines"*, has been published in The Astrophysical Journal, Volume 903, Number 44 on October 30, 2020.

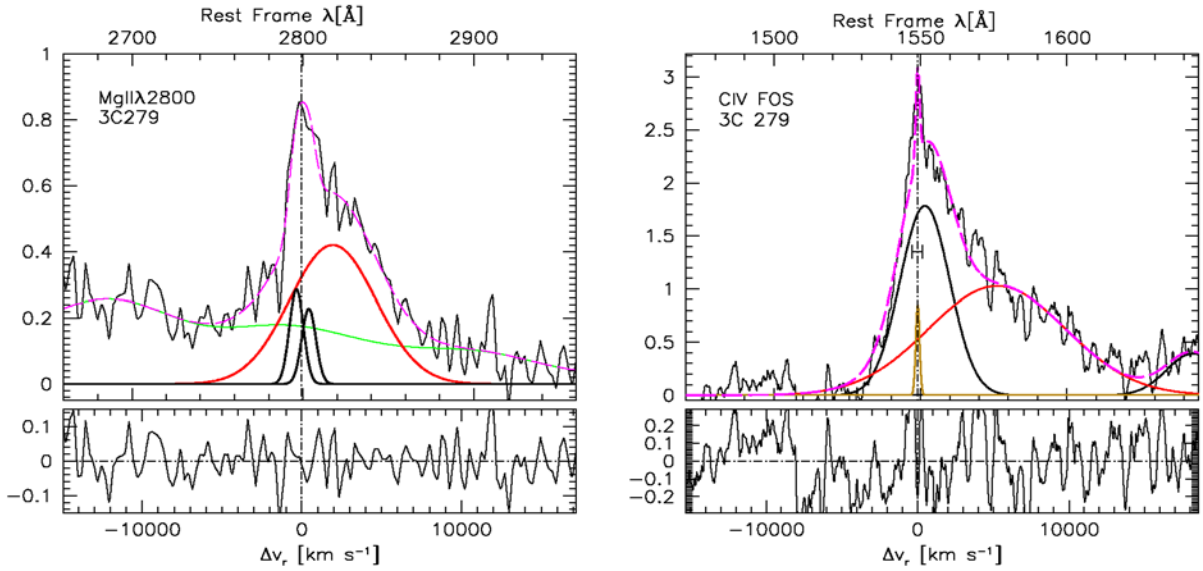


Fig. 3. Simultaneous observations of 3C 279 MgII (left) and CIV (right). Notice that the VBC is the source of the large redward asymmetry.

We present a study of quasars with very redward asymmetric (RA) ultraviolet (UV) broad emission lines (BELs). An excess of redshifted emission has been previously shown to occur in the BELs of radio-loud quasars and is most extreme in certain blazars. Paradoxically, blazars are objects that are characterized by a highly relativistic blueshifted outflow toward Earth. We show that the red emitting gas, see Fig. 3, resides in a very broad component (VBC) that is typical of Population B quasars that are defined by a wide *Hβ* BEL profile. Empirically, we find that RA BEL blazars have both low Eddington rates ($\leq 1\%$) and an inordinately large (order unity) ratio of long-term time-averaged jet power to accretion luminosity. The latter circumstance has been previously shown to be associated with a depressed extreme UV ionizing continuum. Both properties conspire to produce a low flux of ionizing photons, two orders of magnitude less than typical Population B quasars. We use CLOUDY models to demonstrate that a weak ionizing flux is required for gas near the central black hole to be optimally ionized to radiate BELs with high efficiency (most quasars overionize nearby gas, resulting in low radiative efficiency). The large gravitational redshift and transverse Doppler shift result in a VBC that is redshifted by ~2000–5000 km s^{-1} with a correspondingly large line width. The RA BELs result from an enhanced efficiency (relative to typical Population B quasars) to produce a luminous, redshifted VBC near the central black hole.

The article is available here: https://doi.org/10.3847/1538-4357/abb950

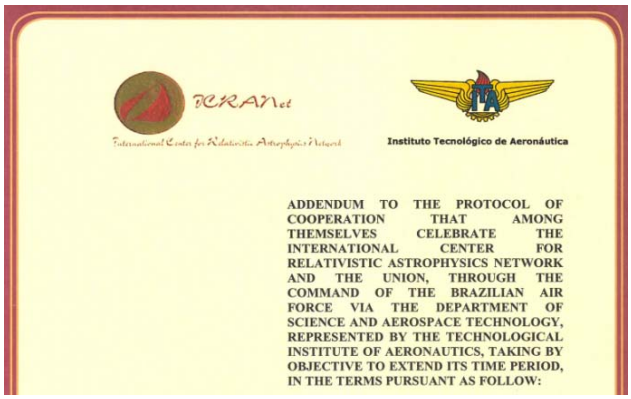
ArXiv e-print: https://arxiv.org/abs/2009.05082

4. Congratulations to Prof. Carlos Arguelles, ICRANet collaborator, awarded the Prize Estímulo in Astronomy by the National Academy of Science of Argentina, October 2020

It is our pleasure to announce that on October 5, 2020, Prof. Carlos Arguelles, ICRANet collaborator, was awarded the Prize Estimulo in Astronomy "Dr. Jorge Sahade" by the National Academy of Science of Argentina. Prof. Arguelles is a researchers at CONICET La Plata and at the Department of Astronomical Sciences and Geophysics of the Universidad Nacional de La Plata (FCAG, UNLP) in Buenos Aires, Argentina. The prize has been officially assigned virtually on November 2020. He received this prize for his studies on the Dark Matter and for a recent work presenting an alternative mathematical model which questioned the existence of a Black Hole at the centre of the Milky Way. Time ago, Prof. Arguelles has also been awarded by the Gravity Research Foundation (GRF) with a prize which has previously been assigned, starting from 1949, to eminent scientists such as, for example, Stephen Hawking.

For the news (in Spanish): https://laplata.conicet.gov.ar/la-academia-nacional-de-ciencias-exactas-fisicas-y-naturales-distingue-a-un-investigador-del-conicet-la-plata/

5. Renewal of the collaboration agreement ICRANet – ITA, September 2020


ICRANet

International Center for Relativistic Astrophysics Network

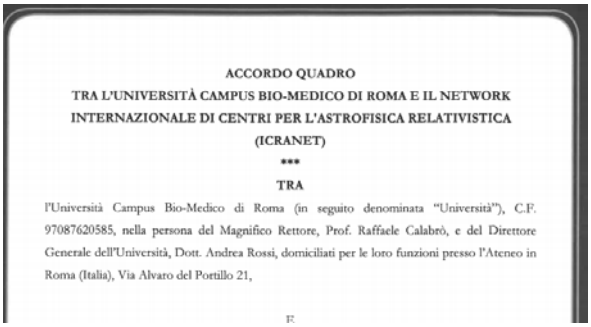
Instituto Tecnológico de Aeronáutica

ADDENDUM TO THE PROTOCOL OF COOPERATION THAT AMONG THEMSELVES CELEBRATE THE INTERNATIONAL CENTER FOR RELATIVISTIC ASTROPHYSICS NETWORK AND THE UNION, THROUGH THE COMMAND OF THE BRAZILIAN AIR FORCE VIA THE DEPARTMENT OF SCIENCE AND AEROSPACE TECHNOLOGY, REPRESENTED BY THE TECHNOLOGICAL INSTITUTE OF AERONAUTICS, TAKING BY OBJECTIVE TO EXTEND ITS TIME PERIOD, IN THE TERMS PURSUANT AS FOLLOW:

On November 2020 ICRANet has received the official confirmation that the agreement between ICRANet and ITA was renewed. The renewal was signed on September 22, 2020 by Prof. Dr. Anderson Ribeiro Correia (Rector of ITA) and by Prof. Remo Ruffini (Director of ICRANet), and will be valid for 3 years starting from April 2020. The main joint activities to be developed under its framework include: the promotion of theoretical and observational activities within the field of Relativistic Astrophysics; the joint collaboration of faculty members, researchers, post-doctorate fellows and students; the organization of training and teaching courses, seminars, conferences, workshops or short courses, and the joint work on scientific publications.

For the text of the agreement: http://www.icranet.org/index.php?option=com_content&task=view&id=844.

6. Renewal of the collaboration agreement ICRANet – Campus Bio-medico University of Rome, October 2020



ACCORDO QUADRO
TRA L'UNIVERSITÀ CAMPUS BIO-MEDICO DI ROMA E IL NETWORK INTERNAZIONALE DI CENTRI PER L'ASTROFISICA RELATIVISTICA (ICRANET)
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TRA
l'Università Campus Bio-Medico di Roma (in seguito denominata "Università"), C.F. 97087620585, nella persona del Magnifico Rettore, Prof. Raffaele Calabrò, e del Direttore Generale dell'Università, Dott. Andrea Rossi, domiciliati per le loro funzioni presso l'Ateneo in Roma (Italia), Via Alvaro del Portillo 21,

On October 2020, the agreement between ICRANet and the Campus Bio-medico University of Rome has been renewed. This agreement will be valid for 2 years and the main joint activities to be developed under its framework include: the promotion of theoretical and observational activities within the field of Relativistic Astrophysics; the joint collaboration of faculty members, researchers, post-doctorate fellows and students; the organization of training and teaching courses, seminars, conferences, workshops or short courses, and the joint work on scientific publications.

For the text of the agreement: http://www.icranet.org/index.php?option=com_content&task=view&id=1219.

7. ICRANet-Armenia received additional funding from the Ministry of Education, Science, Culture and Sports of Armenia, October 19, 2020

On October 19, 2020, the Ministry of Education, Science, Culture and Sports of the Republic of Armenia announced the results of the grant application. We are happy to announce that the ICRANet-Armenia center has been included among the 11 scientific groups that would receive a grant of about 100.000 € for three years (so, around 33.000 € per year). The grant will be used to strengthen the scientific groups, e.g., update the infrastructure, host the international collaborators, etc.

8. European Researchers' Night 2020

This year, due to the spreading on the Covid-19 pandemic, the European Researchers Night was held virtually on November 27, 2020. On that occasion, Prof. Costantino Sigismondi, ICRANet collaborator and chair of the event, organized a virtual meeting as well as a podcast meeting in order to create a nice occasion for discussion among students and researchers. This event attracted a lot of students and professors, as every year, and offered them a unique opportunity to take part in science activities aiming to showcase both the fascination of research as a career and its significant societal impact.

The virtual meeting started at 4:30 PM on Friday November 27, with the opening remarks made by Prof. Sigismondi and went on with presentations on the "*refraction at the sunrise and sunset from the Adriatic Sea to the Tyrrhenian Sea*", on "*The Sun in the sign of the Sagittarius and in the Scorpio constellation*" and on "*Betelgeuse, the dimming supergiant*". Then was the turn of Prof. Gregory Vereshchagin, ICRANet Faculty Professor, which gave a lecture on the Nobel Prize for Physics in 2020. This theoretical section was also integrated with the

podcast materials prepared by Prof. Sigismondi as well as by Prof. Paolo Ochner (University of Padova), available on the webpage of the meeting: http://www.icranet.org/index.php?option=com_content&task=view&id=1346

Following these discussions, 4 students from Liceo Scientifico Galileo Galilei of Pescara and from the IIS Federio Caffé of Rome, have been officially awarded the prize Mersenne, sponsored by the IAU C3 Commission for History and Astronomy of the International Union for Astronomy.

For the 2019 edition of the Prize, Roberta Chiacchiaretta (Liceo Scientifico Galileo Galilei of Pescara) and Gabriele Becagli (IIS Federio Caffé of Rome) have been awarded.

For the 2020 edition of the Prize, Francesco Di Iacovo (IIS Federio Caffé of Rome) and Christian Genghini (IIS Federio Caffé of Rome) have been awarded.

The program of the event and all the relevant podcast materials, can be found at the following link: http://www.icranet.org/index.php?option=com_content&task=view&id=1346

9. Recent publications

P. Giommi, Y. L. Chang, S. Turriziani, T. Glauch, C. Leto, F. Verrecchia, P. Padovani, A. V. Penacchioni, F. Arneodo, U. Barres de Almeida, C. H. Brandt, M. Capalbi, O. Civitarese, V. D'Elia, A. Di Giovanni, M. De Angelis, J. Del Rio Vera, S. Di Pippo, R. Middei, M. Perri, A. M. T. Pollock, S. Puccetti, N. Ricard, R. Ruffini and N. Sahakyan, *Open Universe survey of Swift-XRT GRB fields: Flux-limited sample of HBL blazars*, published in A&A 642, A141 (2020).

Aims. The sample of serendipitous sources detected in all *Swift*-XRT images pointing at gamma ray bursts (GRBs) constitutes the largest existing medium-deep survey of the X-ray sky. To build such dataset we analysed all *Swift* X-ray images centred on GRBs and observed over a period of 15 years using automatic tools that do not require any expertise in X-ray astronomy. Besides presenting a new large X-ray survey and a complete sample of blazars, this work aims to be a step in the direction of achieving the ultimate goal of the Open Universe Initiative, which is to enable non-expert people to benefit fully from space science data, possibly extending the potential for scientific discovery, which is currently confined within a small number of highly specialised teams, to a much larger population.

Methods. We used the *Swift*_deepsky Docker container encapsulated pipeline to build the largest existing flux-limited and unbiased sample of serendipitous X-ray sources. *Swift*_deepsky runs on any laptop or desktop computer with a modern operating system. The tool automatically downloads the data and the calibration files from the archives, runs the official *Swift* analysis software, and produces a number of results including images, the list of detected sources, X-ray fluxes, spectral energy distribution data, and spectral slope estimations.

Results. We used our source list to build the LogN-LogS of extra-galactic sources, which perfectly matches that estimated by other satellites. Combining our survey with multi-frequency data, we selected a complete radio-flux-density-limited sample of high energy peaked blazars (HBL). The LogN-LogS built with this data set confirms that previous samples are incomplete below ∼20 mJy.

The article is available here: https://doi.org/10.1051/0004-6361/202037921

M. A. Prakapenia, I. A. Siutsou and G. V. Vereshchagin, *Numerical scheme for evaluating the collision integrals for triple interactions in relativistic plasma*, published in Physics of Plasmas 27, 113302 (2020).
Binary interactions in relativistic plasma, such as Coulomb and Compton scattering as well as pair creation and annihilation are well known and studied in detail. Triple interactions, namely, relativistic bremsstrahlung, double Compton scattering, radiative pair production, and triple pair production and their inverse processes, are usually considered as emission processes in astrophysical problems, as well as in laboratory plasmas. Their role in plasma kinetics is fundamental [A. G. Aksenov et al., Phys. Rev. Lett. 99, 125003 (2007)]. We present a new conservative scheme for computation of the Uehling–Uhlenbeck collision integral for all triple interactions in relativistic plasma based on direct integration of exact QED matrix elements. Reaction rates for thermal distributions are compared, where possible, with the corresponding analytic expressions, showing good agreement. Our results are relevant for quantitative description of relativistic plasmas out of equilibrium, both under astrophysical and laboratory conditions.

The article is available here: https://aip.scitation.org/doi/10.1063/5.0022931

Sahakyan, N., Israyelyan, D. & Harutyunyan, G., *A Multiwavelength Study of Distant Blazar PKS 0537-286*, published in Astrophysics (2020).
We report the results of broadband observations of distant blazar PKS 0537-286 (z = 3.1) using data spanning more than ten years from the Fermi Large Area Telescope together with Swift UVOT/XRT archival data taken between 2005 and 2017. In the γ -ray band, the peak flux above 100 MeV, $F_\gamma = (6\ 23 \pm 0\ 56) \cdot 10^{-7}$ photon $cm^{-2}\ s^{-1}$ observed on MJD 57874 within one week, corresponds to $L_\gamma = 2\ 46 \cdot 10^{49}$ erg s^{-1} isotropic γ -ray luminosity. The Swift XRT data analyses show that the X-ray emission is characterized by a significantly hard photon index, $\Gamma_{X\text{-}ray} \leq 1.3$, and an X-ray flux of $4 \cdot 10^{-12}$ erg $cm^{-2}\ s^{-1}$, which is almost constant over twelve years. The spectral energy distribution is modeled within one-zone leptonic models assuming the emission region is within the broad-line region. The observed X-ray and γ -ray data are modeled as inverse Compton scattering of (i) only synchrotron photons and (ii) synchrotron and external photons on the electron population that produces the radioto-optical emission. The modeling shows that the nonthermal electrons in the jet of PKS 0537-286 have a hard power-law index (<1.9) and that the jet should be particle dominated with a luminosity within 10^{45}-10^{46} erg s^{-1}.

The article is available here: https://doi.org/10.1007/s10511-020-09650-3

MAGIC collaboration, *Study of the GeV to TeV morphology of the γ-Cygni SNR (G78.2+2.1) with MAGIC and Fermi-LAT*, accepted for publication in A&A in October 2020.
Context. Diffusive shock acceleration (DSA) is the most promising mechanism to accelerate Galactic cosmic rays (CRs) in the shocks of supernova remnants (SNRs). The turbulence upstream is supposedly generated by the CRs, but this process is not well understood. The dominant mechanism may depend on the evolutionary state of the shock and can be studied via the CRs escaping upstream into the interstellar medium (ISM). Aims. Previous observations of the γ-Cygni SNR showed a difference in morphology between GeV and TeV energies. Since this SNR has the right age and is at the evolutionary stage for a significant fraction of CRs to escape, we aim to understand γ-ray emission in the vicinity of the γ-Cygni SNR. Methods. We observed the region of the γ-Cygni SNR with the MAGIC Imaging Atmospheric Cherenkov telescopes between May 2015 and September 2017 recording 87 h of good-quality data. Additionally we analysed Fermi-LAT data to study the energy dependence of the morphology as well as the energy spectrum in the GeV to TeV range. The energy spectra and morphology were compared against theoretical predictions, which include a detailed derivation of the CR escape process and their γ-ray generation. Results. The MAGIC and Fermi-LAT data allowed us to identify three emission regions, which can be associated with the SNR and dominate at different energies. Our hadronic emission model accounts

well for the morphology and energy spectrum of all source components. It constrains the time-dependence of the maximum energy of the CRs at the shock, the time-dependence of the level of turbulence, and the diffusion coefficient immediately outside the SNR shock. While in agreement with the standard picture of DSA, the time-dependence of the maximum energy was found to be steeper than predicted and the level of turbulence was found to change over the lifetime of the SNR.

The article is available here: https://arxiv.org/abs/2010.15854

MAGIC collaboration, *Detection of the Geminga pulsar with MAGIC hints at a power-law tail emission beyond 15 GeV*, published in A&A 643, L14 (2020).

We report the detection of pulsed gamma-ray emission from the Geminga pulsar (PSR J0633+1746) between 15 GeV and 75 GeV. This is the first time a middle-aged pulsar has been detected up to these energies. Observations were carried out with the MAGIC telescopes between 2017 and 2019 using the low-energy threshold Sum-Trigger-II system. After quality selection cuts, ~80 h of observational data were used for this analysis. To compare with the emission at lower energies below the sensitivity range of MAGIC, 11 years of *Fermi*-LAT data above 100MeV were also analysed. From the two pulses per rotation seen by *Fermi*-LAT, only the second one, *P*2, is detected in the MAGIC energy range, with a significance of 6.3σ. The spectrum measured by MAGIC is well-represented by a simple power law of spectral index $\Gamma = 5.62 \pm 0.54$, which smoothly extends the *Fermi*-LAT spectrum. A joint fit to MAGIC and *Fermi*-LAT data rules out the existence of a sub-exponential cut-off in the combined energy range at the 3.6σ significance level. The power-law tail emission detected by MAGIC is interpreted as the transition from curvature radiation to Inverse Compton Scattering of particles accelerated in the northern outer gap.

The article is available here: https://doi.org/10.1051/0004-6361/202039131

Soroush Shakeri, Fazlollah Hajkarim, She-Sheng Xue, *Shedding New Light on Sterile Neutrinos from XENON1T Experiment*, accepted for publication in JHEP in November 2020.

The XENON1T collaboration recently reported the excess of events from recoil electrons, possibly giving an insight into new area beyond the Standard Model (SM) of particle physics. We try to explain this excess by considering effective interactions between the sterile neutrinos and the SM particles. In this paper, we present an effective model based on one-particle-irreducible interaction vertices at low energies that are induced from the SM gauge symmetric four-fermion operators at high energies. The effective interaction strength is constrained by the SM precision measurements, astrophysical and cosmological observations. We introduce a novel effective electromagnetic interaction between sterile neutrinos and SM neutrinos, which can successfully explain the XENON1T event rate through inelastic scattering of the sterile neutrino dark matter from Xenon electrons. We find that sterile neutrinos with masses around 90 keV and specific effective coupling can fit well with the XENON1T data where the best fit points preserving DM constraints and possibly describe the anomalies in other experiments.

The article is available here: https://arxiv.org/abs/2008.05029