Enclosure 9

The 2023 ICRANet Newsletters

ICRANet Newsletter

December 2022 – January 2023

SUMMARY

1. **Scientific highlights: N. Sahakyan, P. Giommi, P. Padovani, M. Petropoulou, D. Bégué, B. Boccardi, S. Gasparyan, *A multimessenger study of the blazar PKS 0735+178: a new major neutrino source candidate* , Monthly Notices of the Royal Astronomical Society, Volume 519, Issue 1**

The blazar PKS 0735+178 is possibly associated with multiple neutrino events observed by the IceCube, Baikal, Baksan, and KM3NeT neutrino telescopes. This remarkable combination of events and multi-wavelength coverage makes PKS 0735+178 one of the best candidate neutrino sources discovered so far. The multimessenger properties of PKS 0735+178 have been studied in a recent paper published in Monthly Notices of the Royal Astronomical Society coauthored by N. Sahakyan, P. Giommi, P. Padovani, M. Petropoulou, D. Bégué, B. Boccardi and S. Gasparyan.

The discovery of a flux of very high-energy (VHE; > 100 GeV) neutrinos of astrophysical origin by the IceCube South Pole observatory and the first reliable association of IceCube neutrinos with a cosmic source, the blazars TXS 0506+056, paved the way for the beginning of (extra-galactic) neutrino astronomy. Recently, several other possible associations between IceCube neutrinos and blazars have been observed, strengthening the connection between VHE neutrinos and blazars at varying levels of significance. Blazars, a rare type of powerful Active Galactic Nuclei (AGN) with a relativistic jet pointing at the Earth, are known to be efficient and powerful cosmic accelerators, and for this reason, have long been considered potential sources of astrophysical neutrinos.

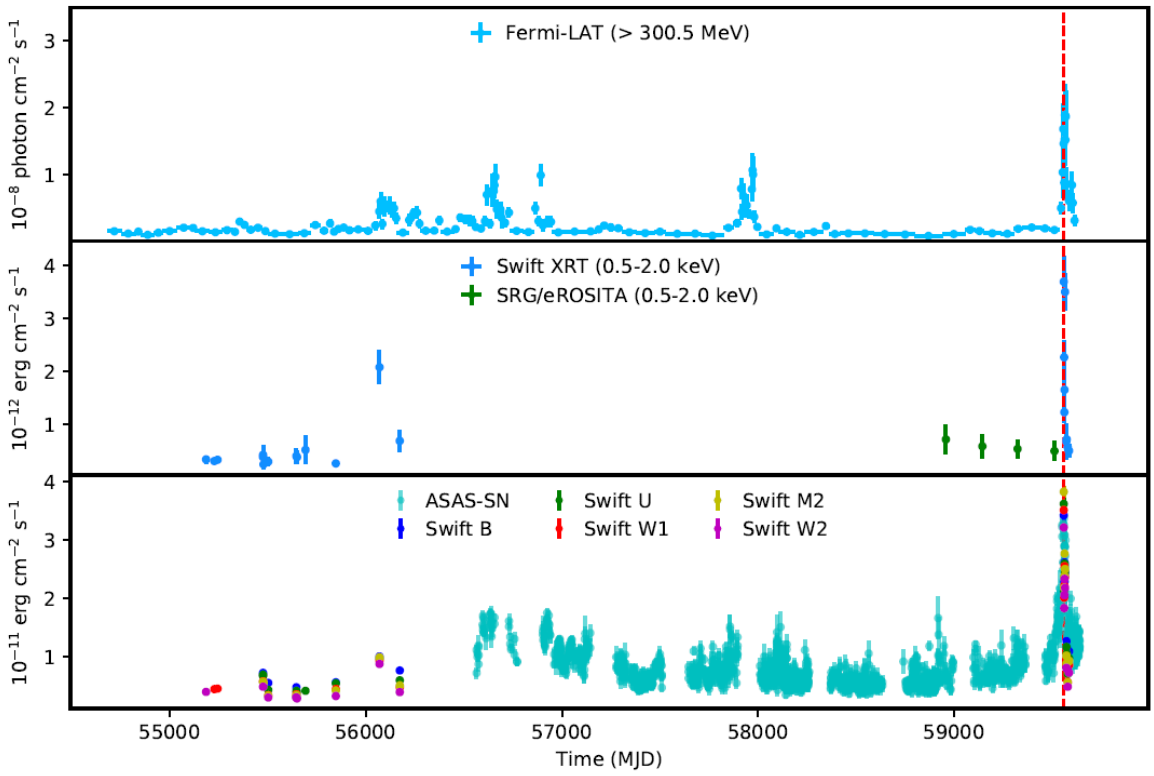


Figure 1

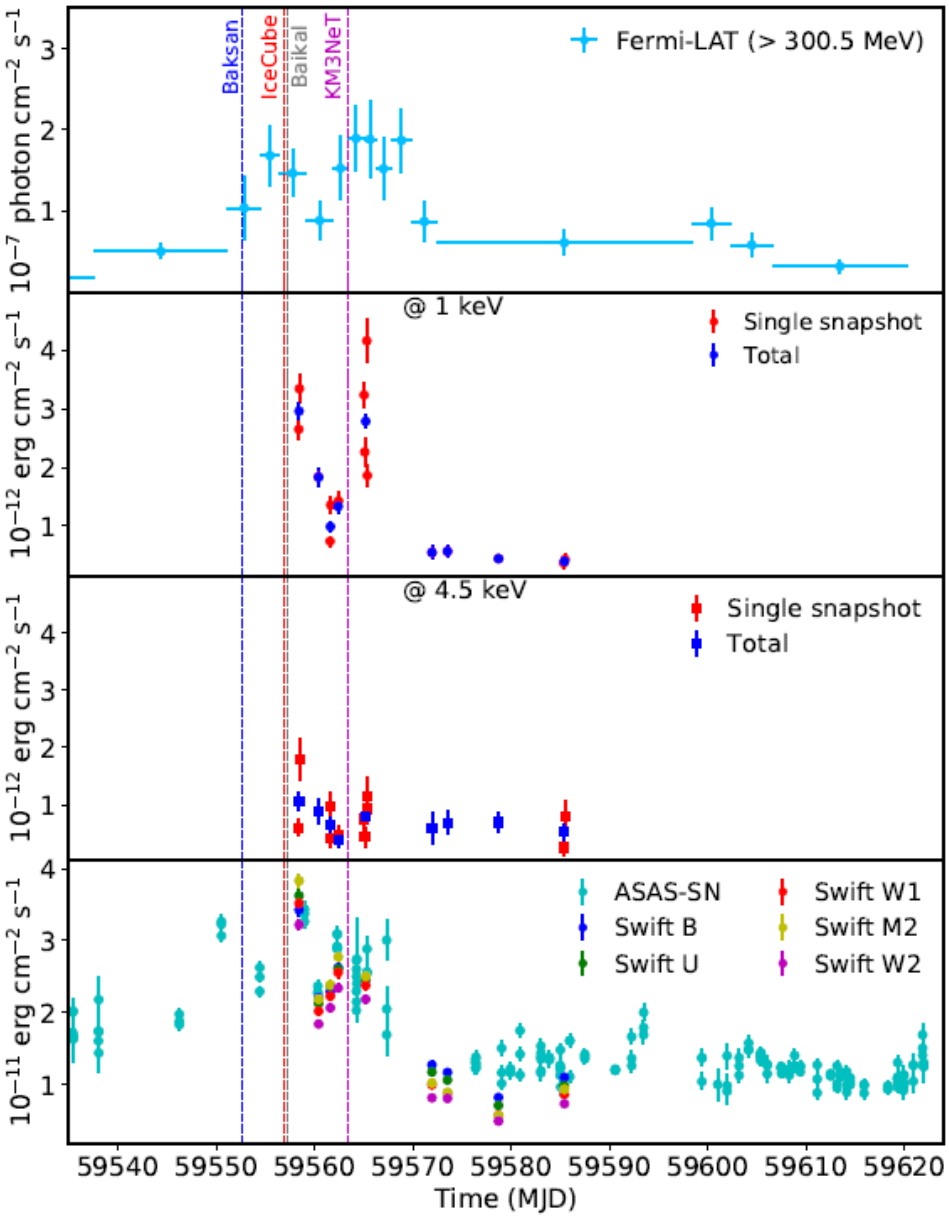


Figure 2

Figure 1 shows the multi-wavelength light curve of PKS 0735+178 from 2008 to 2022, while Figure 2 displays a composite multi-frequency light curve around the time of the neutrino arrival. The flux in all bands exhibits a similar behavior, with the largest flare since the launch of the Fermi satellite in 2008 occurring at the time of IceCube-211208A, marked on the figure by a red vertical dashed line. At the time of the arrival of the IceCube-211208A neutrino, PKS 0735+178 was undergoing the largest γ-ray, X-ray and optical flare observed since 2008. This further strengthens the possible association between PKS 0735+178 and IceCube-211208A and PKS 0735+178 should be considered one of the best VHE neutrino source candidates detected so far.

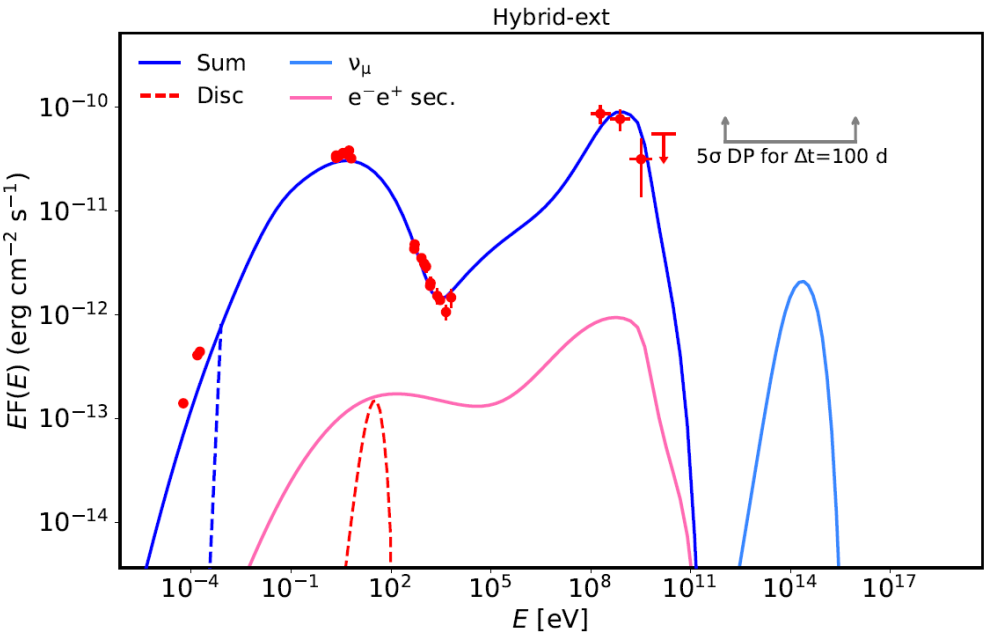
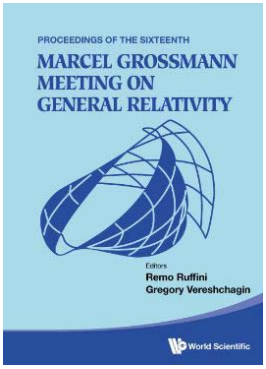


Figure 3

Thanks to the very good multiwavelength coverage from the optical to the HE band during the IceCube-211208A event, the available data set is very constraining allowing to perform comprehensive modelling of the multiwavelength emission from PKS 0735+178. In particular, the spectral energy distribution of PKS 0735+178 was modeled within one-zone lepto-hadronic models considering both internal and external photon fields and estimate the expected accompanying neutrino flux. The code SOPRANO was used to simulate the electromagnetic and neutrino emissions from PKS0735+178. The code has been developed to study the time-dependent γ-ray and neutrino emission from relativistic sources such as blazars and gamma-ray bursts, taking into account all relevant radiative processes. The most optimistic scenario invokes a jet with luminosity close to the Eddington value and the interactions of $\sim$ PeV protons with an external UV photon field. Broadband SED of PKS 0735+178 during the time of the arrival of IceCube-211208A modeled considering the presence of an external radiation field (broad line region photons) is shown in Figure 3. This scenario predicts $\sim$ 0.067 muon and antimuon neutrinos over the observed 3-week flare. The obtained results are consistent with the detection of one very-high-energy neutrino like IceCube-211208A.

2. Publication of MG16 e-proceedings, January 25, 2023



It is our great pleasure to inform you that the proceedings of the MG16 meeting, held online from July 5 to 10, 2021, have been just published by the World Scientific as open access document. Here is the link to the 4 Volumes (A, B, C and D) on the World Scientific website dedicated page:

https://www.worldscientific.com/worldscibooks/10.1142/13149#t=aboutBook

These proceedings include about 400 papers resulting in 4880 pages of printed volumes covering virtually all topics of astrophysics, gravity and cosmology, traditionally discussed at MG meetings.

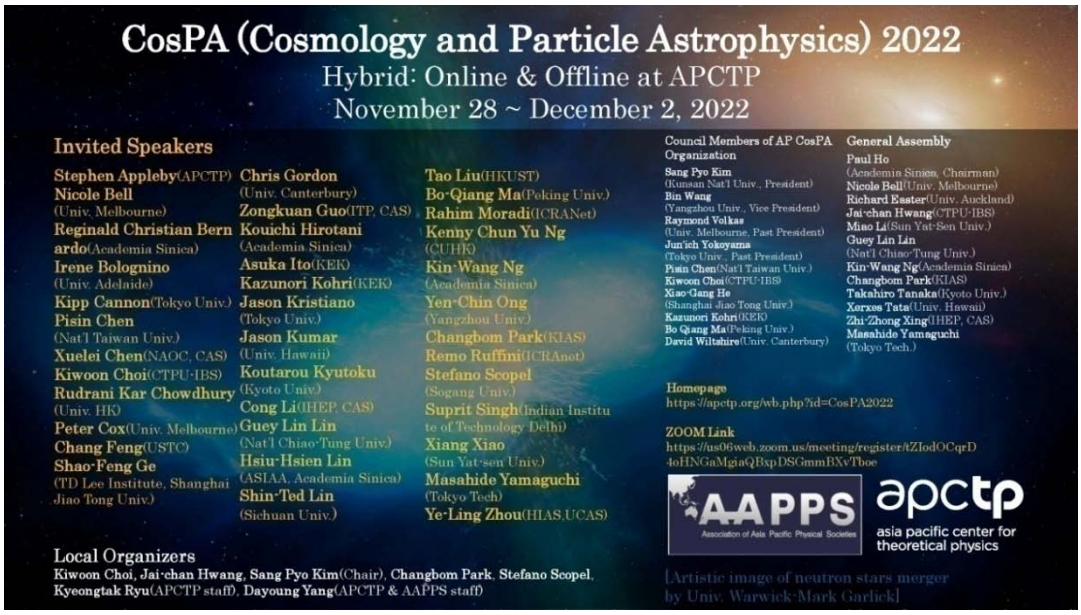
We recall that MG16 has been a record breaking meeting with over 1200 participants from more than 50 nations.

The editors of this proceedings are Remo Ruffini and Gregory Vereshchagin.

3. ICRANet participation at the International Symposium on Cosmology and Particle Astrophysics in 2022 (CosPA 2022), November 27 - December 2, 2022, APCTP (South Korea) and online

FromNovember 27 to December 2, 2022, Prof. Remo Ruffini (Director of ICRANet) and Prof. Rahim Moradi (ICRANet Faculty Professor), have been invited to present a lecture on the occasion of International Symposium on Cosmology and Particle Astrophysics in 2022 (CosPA 2022), held both at APCTP (South Korea) and online.

The CosPA is a series of conferences, initiated in Taiwan and organized in the Asia Pacific region annually as an activity of the Asia Pacific Organization of Cosmology and Particle Astrophysics (APCosPA). This edition took place after 2 years of postponement, due to the spreading Covid-19 pandemic. The main topics addressed during the conference have been astrophysics, particle physics, cosmology and gravitation.



On Wednesday, November 30, Prof. Ruffini presented a lecture titled*"GRB-Supernova Association within the Binary-Driven Hypernova Model"*. Here below the abstract:

The association of supernova with GRBs was heralded by the Beppo SAX and the optical observation of SN1998bw associated with GRB980425. Since the beginning, the problem was to face the different conceptual origins of these components and their energetics. Today this field has been developed in the Binary driven Hypernova (BdHN model) and has grown as the most extended topic in relativistic astrophysics. The role of the progenitor CO core and a binary neutron star has recently become central in the BdHN model's development. In this work, the BdHN I, BdHN II, and BdHN III families, and the role of supernova, newborn neutron star, and companion NS (BH in BdHN I) are described in detail.

On Thursday, December 1, Prof. Rahim Moradi presented a lecture titled*"GRB 221009A: A type I BdHN of exceptional energetics"*. Here below the abstract:

GRB 221009A, the most intense and fluent GRB detected by Fermi GBM, presents a rare opportunity to test various GRB models. In this research, we examine the characteristics of GRB 221009A using the Binary Driven Hypernova (BdHN) model. GRB221009A categorized as a type I BdHN, originates from the collapse of a carbon-oxygen core (CO-core) in presence of a companion neutron star (NS). In this research we first examine the characteristics of the inner engine of this GRB which powers the GeV radiation observed by Fermi-LAT. We also demonstrate that the X-ray afterglow emission is powered by the release of rotational energy of the newborn neutron star evolving as a Maclaurin spheroid, starting from the bifurcation point of the Jacobi ellipsoid sequence.

For the website of the meeting: https://indicocquest.sogang.ac.kr/event/19/

4. 2nd Italian Knowledge leaders meeting, Milan (Italy), December 5, 2022

On December 5, 2022, Prof. Remo Ruffini, Director of ICRANet, has been invited to participate to the 2nd Italian Knowledge Leaders meeting as one of the awarded Italian knowledge leaders.

This project, organized under the aegis of the Italian Ministry of tourism, aimed to start a path which brings together the support of the Italian Institutions and firms as well as the scientific and cultural competences of the most relevant "knowledge leaders" of our country. This meeting was attended by relevant representatives of the national and local Institutions, as well as by a delegation of the main 'Italian Knowledge Leaders', prominent members from international scientific and professional Institutions.

This is the second event of a series of meetings, which will provide a nice occasion to organize networking activities, training courses and conferences aiming at improving the awareness of the scientific and cultural development at national and international level. The main goal of the project is to give the right recognition to these "intellectual leaders" as ambassadors of the Italian intellectual capital, involving them in the promotion of Italy as a "destination of knowledge" and encouraging the opinion leaders to be even more active at international level, in order to promote the scientific and cultural knowledge of our country.

5. Prof. Rahim Moradi awarded the Prize Lucio Colletti, Rome (Italy), December 7, 2022

It is our pleasure to announce that on December 7, 2022 Prof. Rahim Moradi, ICRANet Faculty Professor, has been awarded the Prize "Lucio Colletti" by the Lucio Colletti Foundation. The ceremony took place in the "Sala Laudatosì" of the Senatorial Palace at Camipoglio, the seat of Rome Municipality.

Fig. 4: Prof. Rahim Moradi during the Prize Lucio Colletti awards' ceremony on December 7, 2022.

This award, in memory of the philosopher Lucio Colletti, is attributed every year to eminent personalities who, in their relevant field of study, stand out for their courage, freedom and accuracy.

In the 2022 edition, the prize has been also attributed to Marco Taradash (politician), Lorenzo Infantino (philosopher), DianoraTinti (writer), Alessandra Giovannoni (painter), Giovanna Botteri (journalist), GiseldaVagnoni (journalist), Valerio Rossi Albertini (physicist), Silvio Perrella (writer) and Antonio Bonfilio (musicologist).

Prof. Moradi was very grateful to receive this important recognition for his research and thanked all the organization for its kindness and regard.

6. Special Issue Universe *"Kinetic Processes in Relativistic Domain"*, edited by Prof. Gregory Vereshchagin

The journal Universe has publishedin 2022 a Special Issue titled *"Kinetic processes in relativistic domain"*, edited by Prof. Gregory Vereshchagin (ICRANet Faculty Professor).

The goal of this Special Issue is to cover the recent developments in kinetic theory, with particular attention to relativistic plasma, neutrino transport, self-gravitating systems and dark matter, radiative transfer in

relativistic flows and other new and emergent topics in kinetic theory. The contributions to this issue include:

- *"A Multidimensional Multi-component Gas Dynamic with the Neutrino Transfer in Gravitational Collapse"* by Alexey G. Aksenov;
- *"Field-Theoretical Representation of Interactions between Particles: Classical Relativistic Probability-Free Kinetic Theory"* by Anatoly Yu.Zakharov and Victor V. Zubkov;
- *"Post-Newtonian Jeans Equation for Stationary and Spherically Symmetrical Self-Gravitating Systems"* by Gilberto Medeiros Kremer;
- *"The Principle of Maximum Entropy and the Distribution of Mass in Galaxies"* by Jorge Sanchez Almeida;
- *"The secular dressed diffusion equation"* by Pierre-Henri Chavanis;
- *"Kinetics of Degenerate Electron--Positron Plasmas"* by GregoryVereshchagin and MikalaiPrakapenia.

All papers are published in open access format and can be downloaded from the Universe website: https://www.mdpi.com/journal/universe/special_issues/KPRD

7. Scientific visits to ICRANet

- Mikalai Prakapenia (ICRANet-Minsk and Belarusian State University), December 5 – 16, 2022
- Shurui Zhang (University of Science and Technology of China), December 15, 2022 – ongoing
- Prof. Seyed Mohammad Taghi Mirtorabi (Alzahra University - Iran), January 26, 2023 - ongoing

Dr Mikalai Prakapenia

Shurui Zhang

Prof. Seyed Mohammad Taghi Mirtorabi

During their visit, those scientists had an opportunity to discuss their scientific research and to have fruitful exchange of ideas with other researchers from ICRANet and from different parts of the world.

8. Recent publications

Shesheng Xue, *Massive particle pair production and oscillation in Friedman Universe: its effect on inflation*, to be published in The European Physical Journal C.

We study the classical Friedman equations for the time-varying cosmological term $\Lambda\sim$ and Hubble function H, together with quantised field equations for the production of massive $M\gg H$ particles, namely, the $\Lambda\sim$CDM scenario of dark energy and matter interactions. Classical slow components

$O(H^{-1})$ are separated from quantum fast components $O(M^{-1})$. The former obeys the Friedman equations, and the latter obeys a set of nonlinear differential equations. Numerically solving equations for quantum fast components, we find the production and oscillation of massive particle-antiparticle pairs in microscopic time scale $O(M^{-1})$. Their density and pressure averages over microscopic time do not vanish. It implies the formation of a massive pair plasma state in macroscopic time scale $O(H^{-1})$, whose effective density and pressure contribute to the Friedman equations. Considering the inflation driven by the time-varying cosmological term and slowed down by the massive pair plasma state, we obtain the relation of spectral index and tensor-to-scalar ratio in agreement with recent observations. We discuss the singularity-free pre-inflation, the CMB large-scale anomaly, and dark-matter density perturbations imprinting on power spectra.

DOI: https://doi.org/10.1140/epjc/s10052-023-11195-6

M. F. Sousa, J. G. Coelho, J. C. N. de Araujo, S. O. Kepler and J. A. Rueda, *The Double White Dwarf Merger Progenitors of SDSS J2211+1136 and ZTF J1901+1458*, published on December 9, 2022 in The Astrophysical Journal, Volume 941, Number 1.

Double white dwarf (DWD) mergers are possibly the leading formation channel of massive, rapidly rotating, high-field magnetic white dwarfs (HFMWDs). However, a direct link connecting a DWD merger to any observed HFMWD is still missing. We here show that the HFMWDs SDSS J221141.80+113604.4 (hereafter J2211+1136) and ZTF J190132.9+145808.7 (hereafter J1901+1458) might be DWD merger products. J2211+1136 is a 1.27 $M_{\odot}$ white dwarf (WD) with a rotation period of 70.32 s and a surface magnetic field of 15 MG. J1901+1458 is a 1.327–1.365 $M_{\odot}$ WD with a rotation period of 416.20 s, and a surface magnetic field in the range 600–900 MG. With the assumption of single-star evolution and the currently measured WD masses and surface temperatures, the cooling ages of J2211+1136 and J1901+1458 are, respectively, 2.61–2.85 Gyr and 10–100 Myr. We hypothesize that these WDs are DWD merger products and compute the evolution of the postmerged configuration formed by a central WD surrounded by a disk. We show that the postmerger system evolves through three phases depending on whether accretion, mass ejection (propeller), or magnetic braking dominates the torque onto the central WD. We calculate the time the WD spends in each of these phases and obtain the accretion rate and disk mass for which the WD rotational age, i.e., the total time elapsed since the merger to the instant where the WD central remnant reaches the current measured rotation period, agrees with the estimated WD cooling age. We infer the mass values of the primary and secondary WD components of the DWD merger that lead to a postmerger evolution consistent with the observations.

DOI: https://doi.org/10.3847/1538-4357/aca015

Liang Li, *Standard GRB Spectral Models "Misused"?*, published on December 9, 2022 in the Astrophysical Journal, Volume 941, Number 1.

The standard model characterizing the gamma-ray burst (GRB) spectrum invokes a four-parameter empirical function, the so-called the BAND model. An alternative model named cutoff power law (COMP) implements a power law with an exponential cutoff. These functions achieve almost equally good fits on observed spectra, and are adopted in nearly all of the GRB literature. Here, we reanalyze the sample defined in Li et al. (39 bursts including 944 spectra). We classify the spectra by two methods: (1) checking their corner–corner plots of the posteriors to determine well-constrained β (BAND-better) and unconstrained β (COMP-better) categories; and (2) defining the four groups by difference of the deviance information criterion (DIC). We find inconsistent peaks of the parameter distributions between the BAND-better spectra ($\alpha = -0.64 \pm 0.28$ and $\log_{10}(E_{\rm p}) = \log_{10}(191) \pm 0.41$) and the COMP-better spectra ($\alpha = -0.96 \pm 0.33$ and $\log_{10}(E_{\rm p}) = \log_{10}(249) \pm 0.40$). With the *statistically preferred* model and vice versa

the *misused* model defined based on DIC statistics, we also find that the fitted parameters obtained by the *misused* model (COMP) significantly deviate from those obtained by the statistically preferred model (BAND). This means that if a spectrum is statistically preferred, described as the BAND, applying COMP to derive the spectral parameters will prominently deviate from their intrinsic shape, therefore affecting the physical interpretation. Our analysis indicates that the *better* or statistically preferred model should be duly examined during GRB spectral analysis. In addition, the β distribution exhibits a bimodal structure containing the BAND-better and COMP-better spectra, respectively, implying that BAND and COMP both may have physical origin.

DOI: https://doi.org/10.3847/1538-4357/ac3d89

N. Sahakyan, P. Giommi, P. Padovani, M. Petropoulou, D. Bégué, B. Boccardi, S. Gasparyan, *A multimessenger study of the blazar PKS 0735+178: a new major neutrino source candidate* , Monthly Notices of the Royal Astronomical Society, Volume 519, Issue 1.

The blazar PKS 0735+178 is possibly associated with multiple neutrino events observed by the IceCube, Baikal, Baksan, and KM3NeT neutrino telescopes while it was flaring in the γ-ray, X-ray, ultraviolet, and optical bands. We present a detailed study of this peculiar blazar to investigate the temporal and spectral changes in the multiwavelength emission when the neutrino events were observed. The analysis of Swift-XRT snapshots reveal a flux variability of more than a factor 2 in about 5×10^3 s during the observation on 2021 December 17. In the γ-ray band, the source was in its historical highest flux level at the time of the arrival of the neutrinos. The observational comparison between PKS 0735+178 and other neutrino source candidates, such as TXS 0506+056, PKS 1424+240, and GB6 J1542+6129, shows that all these sources share similar spectral energy distributions, very high radio and γ-ray powers, and parsec scale jet properties. Moreover, we present strong supporting evidence for PKS 0735+178 to be, like all the others, a masquerading BL Lac. We perform comprehensive modelling of the multiwavelength emission from PKS 0735+178 within one-zone lepto-hadronic models considering both internal and external photon fields and estimate the expected accompanying neutrino flux. The most optimistic scenario invokes a jet with luminosity close to the Eddington value and the interactions of ∼PeV protons with an external UV photon field. This scenario predicts ∼0.067 muon and anti-muon neutrinos over the observed 3-week flare. Our results are consistent with the detection of one very high-energy neutrino like IceCube-211208A.

DOI: https://doi.org/10.1093/mnras/stac3607

N. Sahakyan, V. Vardanyan, M. Khachatryan, *Gradient boosting decision trees classification of blazars of uncertain type in the fourth Fermi-LAT catalogue*, to be published on Monthly Notices of the Royal Astronomical Society, Volume 519, Issue 2.

The deepest all-sky survey available in the γ-ray band – the last release of the Fermi-LAT catalogue (4FGL-DR3) based on the data accumulated in 12 years contains more than 6600 sources. The largest population among the sources is blazar subclass – 3743, 60.1 per cent of which are classified as BL Lacertae objects (BL Lacs) or Flat Spectrum Radio Quasars (FSRQs), while the rest are listed as blazar candidates of uncertain type (BCU) as their firm optical classification is lacking. The goal of this study is to classify BCUs using different machine learning algorithms, which are trained on the spectral and temporal properties of already classified BL Lacs and FSRQs. Artificial Neural Networks, XGBOOST, and LIGHTGBM algorithms are employed to construct predictive models for BCU classification. Using 18 input parameters of 2219 BL Lacs and FSRQs, we train (80 per cent of the sample) and test (20 per cent) these algorithms and find that LIGHTGBM model, state-of-the-art classification algorithm based on gradient boosting decision trees, provides the highest performance. Based on our best model, we classify 825 BCUs as BL Lac candidates and

405 as FSRQ candidates, however, 190 remain without a clear prediction, but the percentage of BCUs in 4FGL is reduced to 5.1 percent. The γ -ray photon index, synchrotron peak frequency, and high-energy peak frequency of a large sample are used to investigate the relationship between FSRQs and BL Lacs (LBLs, IBLs, and HBLs).

DOI: https://doi.org/10.1093/mnras/stac3701

MAGIC collaboration, *Gamma-ray observations of MAXI J1820+070 during the 2018 outburst,* published on December 2022 in Monthly Notices of the Royal Astronomical Society, Volume 517, Issue 4.

MAXI J1820+070 is a low-mass X-ray binary with a black hole (BH) as a compact object. This binary underwent an exceptionally bright X-ray outburst from 2018 March to October, showing evidence of a non-thermal particle population through its radio emission during this whole period. The combined results of 59.5 h of observations of the MAXI J1820+070 outburst with the H.E.S.S., MAGIC and VERITAS experiments at energies above 200 GeV are presented, together with Fermi-LAT data between 0.1 and 500 GeV, and multiwavelength observations from radio to X-rays. Gamma-ray emission is not detected from MAXI J1820+070, but the obtained upper limits and the multiwavelength data allow us to put meaningful constraints on the source properties under reasonable assumptions regarding the non-thermal particle population and the jet synchrotron spectrum. In particular, it is possible to show that, if a high-energy (HE) gamma-ray emitting region is present during the hard state of the source, its predicted flux should be at most a factor of 20 below the obtained Fermi-LAT upper limits, and closer to them for magnetic fields significantly below equipartition. During the state transitions, under the plausible assumption that electrons are accelerated up to ∼500 GeV, the multiwavelength data and the gamma-ray upper limits lead consistently to the conclusion that a potential HE and very-HE gamma-ray emitting region should be located at a distance from the BH ranging between 10^{11} and 10^{13} cm. Similar outbursts from low-mass X-ray binaries might be detectable in the near future with upcoming instruments such as CTA.

DOI: https://doi.org/10.1093/mnras/stac2686

MAGIC collaboration, *Search for Gamma-ray Spectral Lines from Dark Matter Annihilation up to 100 TeV towards the Galactic Center with MAGIC,* accepted for publication in Phys. Rev. Letters.

Line-like features in TeV γ-rays constitute a "smoking gun" for TeV-scale particle dark matter and new physics. Probing the Galactic Center region with ground-based Cherenkov telescopes enables the search for TeV spectral features in immediate association with a dense dark matter reservoir at a sensitivity out of reach for satellite γ-ray detectors, and direct detection and collider experiments. We report on 223 hours of observations of the Galactic Center region with the MAGIC stereoscopic telescope system reaching γ-ray energies up to 100 TeV. We improved the sensitivity to spectral lines at high energies using large-zenith-angle observations and a novel background modeling method within a maximum-likelihood analysis in the energy domain. No line-like spectral feature is found in our analysis. Therefore, we constrain the cross section for dark matter annihilation into two photons to $\langle\sigma v\rangle \lesssim 5\times10^{-28}\mathrm{cm}^3\mathrm{s}^{-1}$ at 1 TeV and $\langle\sigma v\rangle \lesssim 1\times10^{-25}\mathrm{cm}^3\mathrm{s}^{-1}$ at 100 TeV, achieving the best limits to date for a dark matter mass above 20 TeV and a cuspy dark matter profile at the Galactic Center. Finally, we use the derived limits for both cuspy and cored dark matter profiles to constrain supersymmetric wino models.

ArXiv: https://doi.org/10.48550/arXiv.2212.10527

S. H. Hendi, Kh. Jafarzade, and B. EslamPanah, *Black holes in dRGT massive gravity with the signature of EHT observations of M87, accepted for publication in Journal of Cosmology and Astroparticle Physics.**

The recent Event Horizon Telescope (EHT) observations of the M87* have led to a surge of interest in studying the shadow of black holes. Besides, investigation of time evolution and lifetime of black holes helps us to veto/restrict some theoretical models in gravitating systems. Motivated by such exciting properties, we study optical features of black holes, such as the shadow geometrical shape and the energy emission rate in modified gravity. We consider a charged AdS black hole in dRGT massive gravity and look for criteria to restrict the free parameters of the theory. The main goal of this paper is to compare the shadow of the mentioned black hole in a rotating case with the EHT data to obtain the allowed regions of the model parameters. Therefore, we employ the Newman-Janis algorithm to build the rotating counterpart of static solution in dRGT massive gravity. We also calculate the energy emission rate for the rotating case and discuss how the rotation factor and other parameters affect the emission of particles around the black holes.

ArXiv: https://arxiv.org/abs/2206.05132

ICRANet Newsletter

February – March 2023

SUMMARY

1. Chinese scientist Yu Wang appointed President of the International Centre for Relativistic Astrophysics (ICRA), February 28, 2023

It is our great pleasure to announce that Prof. Yu Wang has been appointed as the new President of the International Center for Relativistic Astrophysics (ICRA) on the occasion of the ICRA Assembly Meeting, held on February 28, 2023, after voting and deliberation.

On this occasion, Prof. Massimo Della Valle, Chairperson of the ICRANet Scientific Committee, delivered a speech in support of the nomination of Prof. Yu Wang, as well as a scientific presentation on ICRA titled "*From the birth of Relativistic Astrophysics to the discovery and comprehension of Gamma-Ray Bursts to the new era of Black Hole physics and Artificial Intelligence*". The text of the speech can be read at the following link: www.icranet.org/documents/presentationDellaValle.pdf.

ICRA (International Centre for Relativistic Astrophysics) was founded in 1985by Prof. Remo Ruffini together with Riccardo Giacconi (Nobel Prize for Physics 2002), Abdus Salam (Nobel Prize for Physics 1979), Paul Boyton (University of Washington), George Coyne (former director of the Vatican observatory), Francis Everitt (Stanford University), Fang Li-Zhi (University of Science and Technology of China). It became a legal entity in 1991 with the Ministerial Decree 22/11/1991 from the Ministry of Education, Universities and Research. Members of ICRA are Stanford University, the University of Science and Technology of China,The World Academy of Sciences (TWAS), the Specola Vaticana, the Space Telescope Institute, the Abdus Salam International Center for Theoretical Physics (ICTP), the University of Washington, the University Campus Bio-Medico of Rome, the University of Insubria and the University of Udine. The main mission of ICRA is to promote the exchange and development of astrophysics in all countries.

After his appointment, Prof. Wang made a presentation to the assembly of his scientific career and publications, which can be found at the following link: www.icranet.org/documents/presentationWang.pdf.

Prof. Yu Wang is a native of Suzhou, Jiangsu Province, born in 1985. He has a BSc in Physics from Southeast University, an MSc in Astrophysics from the Purple Mountain Observatory, Chinese Academy of Sciences, and a PhD in Astrophysics from the University of Rome, Italy. He has been working in astrophysics at ICRANet (International Center for Relativistic Astrophysics Network) since 2015 and at the National Astronomical Observatory of Italy (INAF) since 2019, and has been appointed the President of ICRA in 2023.

The ICRA Assembly congratulated Prof. Yu Wang on his appointment as the new President of ICRA, fostering his research on Black Holes, Gamma-Ray Bursts and promoting the application of new technologies such as deep learning in astronomy and astrophysics. It looked forward that Prof. Yu Wang would further expand ICRA's exchanges and collaborations with universities and institutes around the world.

For the press release on ICRANet website:
http://www.icranet.org/index.php?option=com_content&task=view&id=1032&Itemid=920

For the press releases on:

- Tencent news (QQ news): https://new.qq.com/rain/a/20230311A083OV00 / https://new.qq.com/rain/a/20230316A0AH0B00
- Purple Mountain Observatory, Chinese academy of sciences: http://www.pmo.cas.cn/dqyd2019/djdt2019/cxzy2019/202303/t20230312_6696396.html
- Southeast University: https://physics.seu.edu.cn/2023/0313/c23142a437955/pagem.htm
- University of Science and Technology of China: https://qybx.ustc.edu.cn/2023/0318/c20985a595585/pagem.htm
- China Association for Education Development Strategy: https://hr.edu.cn/huiyuan/zzgl/202210/t20221027_2252455.shtml

- Kunshan Government: http://www.ks.gov.cn/kss/ksyw/202303/0afdbe6426ac40feb6cce8120ef8cca6.shtml
- Suzhou Government: https://kjj.suzhou.gov.cn/szkj/sxdt/202303/1b02f0dd7b7b42a5a3357d37f0be4fc2.shtml
- Kunshan Daily: http://epaper.ksrmtzx.com/html/2023-03/18/content_480_15916130.htm
- Kunshan School: https://kz.ksecloud.cn/newsinfo/5618011.html
- First Kunshan: https://www.ksrmtzx.com/news/detail/152319
- Jiangsu TV: http://news.jstv.com/a/20230315/1678864417568.shtml
- Our Jiangsu: https://www.ourjiangsu.com/a/20230315/1678846110996.shtml
- Science Net: https://news.sciencenet.cn/htmlnews/2023/3/496130.shtm
- Chinese News Service (Youtube Video): https://www.youtube.com/watch?v=69iIF0J5SSc
- China News: https://www.chinanews.com.cn/shipin/cns-d/2023/03-15/news953922.shtml
- Global People: https://www.globalpeople.com.cn/index.php?m=content&c=index&a=show&catid=2&id=73402
- Global Times: https://m.huanqiu.com/article/4C5Iz4TYXqv
- Overseas China: https://www.chinaqw.com/m/sp/2023/03-15/354219.shtml
- The Paper: https://www.thepaper.cn/newsDetail_forward_22302924
- Netease (163): https://www.163.com/dy/article/HVS878V10514R9OJ.html
- Sina: https://k.sina.com.cn/article_2760296044_a486c66c0190192qt.html
- Sohu: https://www.sohu.com/a/655323738_121386817
- Phoenix Net: http://js.ifeng.com/c/8O9J1XjVSTB
- Hua Xin News: https://www.newmediamax.com.tw/article/1is3d9izdvay0.html
- Wanwei Literature and Periodicals Network: https://www.eshukan.com/academic/show.aspx?id=96124&cid=23
- Headlines of Chinese: https://www.52hrtt.com/global/n/w/info/F1678954840193

2. Seminar of Prof. Remo Ruffini at INAF IAPS, March 15, 2023, Rome (Italy)

On March 15, 2023, Prof. Ruffini, Director of ICRANet, has been invited to give a seminar at the Institute for Space Astrophysics and Planetology (IAPS) of INAF in Rome (Italy). This seminar has been inserted in the series of the *"Rome Joint Astrophysics Colloquia (Rome JAC)"*, co organized by IAPS, the Astronomical Observatory of Rome and the Physics department of the University of Rome Tor Vergata and regularly held every third Wednesday of the month.

Fig. 1: Prof. Ruffini on the occasion of his seminar at the IAPS INAF on March 15, 2023 together with INAF members and part of the ICRANet group.

Fig. 2: From the left to the right: Prof. Rahim Moradi (ICRANet Faculty Professor), Prof. Ruffini, Prof. Enrico Costa (INAF), Dr Fatemeh Rastegar Nia (ICRANet researcher), Prof. Carlo Luciano Bianco (ICRANet Faculty Professor), Prof. Wang Yu (ICRANet Faculty Professor) and Shurui Zhang (ICRANet visiting student from USCT – China).

On that occasion, Prof. Ruffini presented a talk titled *"New Physics and Astrophysics from GRBs"*, chaired by Prof. Enrico Costa; here it is the abstract:

The observations of Ic supernovae (Ic/SNe) occurring after the prompt emission of long gamma-ray bursts (GRBs) are addressed within the binary-driven hypernova (BdHN) model. Here, the GRBs originate from a binary composed of a $\sim 10 M_{\odot}$ *carbon-oxygen (CO) star and a companion neutron star (NS). We assume these same progenitors originate the Ic/SN. The binary evolution depends strongly on the binary period,* P_{bin}*. The trigger, given by the CO core collapse, for* P_{bin} *of up to a few hours leads to an Ic/SN with a fast-spinning NS (vNS) at its center. For Pbin* $\sim$ *4–5 min, BdHN I occur with 37 energies* 10^{52}*–*10^{54} *erg, a contribution by the black hole (BH) created by the NS companion collapse, originates the Mev/GeV radiations. The* $\sim$ *1 millisecond vNS originates, by synchrotron radiation, the X-ray afterglow. For* P_{bin} $\sim$ *10 min, BdHN II occurs with energies of* 10^{50}*–*10^{52} *erg. For* P_{bin} $\sim$ *hours, BdHN III occurs with energies below* 10^{50} *erg. The 1–1000 ms vNS, in all BdHNe, originates the X-ray afterglow by synchrotron emission. The SN Ic follows an independent evolution, becoming observable by the nickel decay after the GRB prompt emission. We report 24 Ic/SNe associated with BdHNe, their optical peak luminosity and their time of occurrence are similar and independent of the associated GRBs. We give four examples of BdHNe and their associated hypernovae. We approach, for the first time, new physical processes in BdHNe; we identify seven episodes and their signatures in their spectra.*

As soon as available, the video of the seminar will be published on the ICRANet YouTube channel at the following link: https://www.youtube.com/channel/UCU19scWRGvlIiKBcN1QXCRQ

3. ICRANet participation at the "*Conference for scientific and space attachés: scientific diplomacy for the growth of Italy*", March 6-7, 2023, Padua (Italy)

On March 6-7, 2023, Prof. Ruffini, Director of ICRANet, together with Prof. Yu Wang, ICRANet Faculty Professor, took part at the "*Conference for scientific and space attachés: scientific*

diplomacy for the growth of Italy", organized by the Italian Ministry of Foreign Affairs and International Cooperation (MAECI) and held at the University of Padua (Italy).

After the opening ceremony, the first day of the meeting saw the participation and intervention of eminent Italian personalities, such as the Italian Minister of Foreign Affairs and International Cooperation H. E. Antonio Tajani, the Italian Minister for Business and Made in Italy H.E. Adolfo Urso, the Rector of the University of Padua Prof. Daniela Mapelli and the astronaut Luca Parmitano. The first day ended with a roundtable on the subject "Space: the new frontier of internationalization", with a relevant intervention of the Edmondo Cirielli, Italian Deputy Minister of Foreign Affairs with appointment to Space, and the participation, among others, of Prof. Giorgio Saccoccia, president of ASI as well as of Prof. Marco Tavani, President of INAF.

During the second day of the meeting, two roundtables have been held. The first one on the subject *"Research as the engine of the competitiveness of the country system"* saw the participation of the Italian Minister of University and ResearchH.E. Anna Maria Bernini as well as of the former Italian Minister of Education, University and Research, now President of CNR Dr Maria Chiara Carrozza. The second roundtable was on the subject *"The reply of Italian innovation to the new global challenges"*.

On the occasion of that meeting, Prof. Ruffini and Prof. Wang met the Min. Plen. Shen Jianlei (Ministry Counselor for Science and Technology of the Chinese Embassy in Italy), Dr Francesco Ubertini (President of Cineca), Dr Maria Chiara Carrozza (former Italian Minister of Education, University and Research, now President of CNR) and H.E. Min. Anna Maria Bernini (Italian Minister of University and Research).

Fig. 3 from the left to the right: Min. Plen. Shen Jianlei (Ministry Counselor for Science and Technology of the Chinese Embassy in Italy), Dr Francesco Ubertini (President of Cineca), Dr Maria Chiara Carrozza (former Italian Minister of Education, University and Research, now President of CNR), H.E. Min. Anna Maria Bernini (Italian Minister of University and Research), prof. Remo Ruffini (Director of ICRANet) and Prof. Yu Wang (ICRANet faculty Professor and new President of ICRA).

For more information about the meeting: https://innovitalia.esteri.it/notizia/conferenza-delle-addette-e-degli--addetti-scientifici-e-spaziali-2023

4. Nicolaus Copernicus and Gregory III, online meeting, February 24, 2023

On February 24, 2023, Prof. Costantino Sigismondi, organized the online meeting *"Nicolaus Copernicus and Gregory III"* at the Ateneo Pontificio Regina Apostolorum, Istituto Scienza e Fede in Rome, in collaboration with ICRANet and the Astrophysical Observatory of Asiago. The meeting has also been broadcasted via Zoom and Youtubewith the opening remarks by Prof. Remo Ruffini, Director of ICRANet, as well as by Prof. Rafael Pascual, Director of ISF.

Fig. 4: Prof. Remo Ruffini delivering his opening speech at the meeting *"Nicolaus Copernicus and Gregory III"*, chaired by Prof. Costantino Sigismondi and held on February 24, 2023 both at the Ateneo Pontificio Regina Apostolorum, Istituto Scienza e Fede in Rome and online.

Members of the Organizing Committee of the meeting have been Cesare Barbieri (University of Padua), Giuseppe Giudice (University of Neaples Federico II), Paolo Ochner (Astrophysical Observatory of Asiago and University of Padua), Cosimo Palagiano (Accademia dei Lincei), Rafael Pascual (APRA/ISF), Elena Piccoli (High School Antonio Scarpa Motta di Livenza), Tiziana Pompa (High School Galilei in Pescara), Remo Ruffini (Director of ICRANet) and Costantino Sigismondi (APRA and ICRANet).

Nicolaus Copernicus was born on February 19, 1473 in Torun (Poland) and, with the publication of "De Revolutionibus Orbium Coelestium" he became the most influent astronomer of the modern history. 50 years ago, the University of Padua dedicated to him the biggest telescope (still today) in Italy, namely the Cima Ekar telescope.

The cosmogony was changing its reference system, abandoning the geocentric viewpoint. Astronomy was still based on the meridian positional and topocentric observations and for additional two centuries continued to prefer the pinhole to the telescope for the solar astrometry. An experiment jointly performed in Rome and Motta di Livenza on the angular measurement of the meridian arc shows us how the pinhole is still valid. The entrance of the Sun in the sign of Pisces on February 18, 2023 at h 23:34 is a geocentric phenomenon, concerning the ecliptic reference system, which has the vernal equinox as zero and the orbit belonging to the Sun as axis of the longitudes.

Julius Caesar promulgated the reform of the Calendar in 46 b.c., taking as value for the tropical year 365 days and 6 hours, under which the Sun comes back to the vernal equinox. In 325, the vernal equinox retreated on March 21 and this date has been fixed as ecclesiastical equinox by the fathers of the Council of Nicaea. The retreat of the equinox date continued to the rhythm of 3 days every 4 centuries and, at the times of Copernicus, anticipated of 10 days. The astronomers measured the equinoxes and the zodiac signs timing the meridian passages of the Sun in comparison with the stars. They knew since Ipparco (150 b. C.) that the equinox retreated compared to the direction that the Sun has on the background of the starry sky.If the Sun goes from Aquarius to Pisces, the

equinox goes in the opposite sense but much more slowly, making a full circle in 26.000 years and covering an entire sign in around 2.000 years. Astronomically, the birth date of Copernicus fell 10 days closer to the spring equinox, so in the sign of Pisces and in the zodiac constellation of Aquarius, the last one visible only in case of total eclipse.

The Reformation of the Calendar was issued on February 24, 1582 by the Pope Gregory XIII, because the real equinox was occurring on March 11, instead of March 21 according to Nicaea's Council prescriptions of 325 AD on the Easter Computus. The Gregorian Reform solved the real equinox date problem, known by all scholarly people (e.g. Dante Alighieri). Enacted on February 24, 1582 from Villa Mondragone in Frascati with the "Bolla Inter Gravissimas" the precession continues but the vernal equinox date (from Ver = spring in Latin) remained fixed on March 21, according to the Nicaenian tradition for the computation of the Easter date. Therefore, the precession continues to change the constellations on which the Sun is projected on a fixed date: 4.000 years ago it should have been on the background of Pisces, 2.000 years ago retreated in the constellation of Aquarius, and in few centuries it will be in Capricorn, but the zodiacal signs remain those of the Greek-Babylonian tradition to which Ptolemy wanted to conform. It's just a change in the reference system, as happens for the compass which, when looks at North-East is Grecale but from Rome to North-East we don't go to Greece: the original reference was to Malta.

In that meeting, Prof. Sigismondi presented how could the effectiveness of the Reform could be seen measuring the entry of the Sun in Pisces this year 2023 by using the historical meridian lines of Saint Peter's square in Vatican (1586-1817) and of Santa Maria degli Angeli (1702), using also the meridian passage of Sirius, as already done by the Egyptians more than 4.000 years ago.. With the latter instrument, it has also been taken the angular measure of the meridian arc from Rome to Motta di Livenza, repeating the Eratosthenes experiment with the Cassini corrections for the atmospheric refraction, obtaining the Earth's circumference within 1%, and showing why the giant pinhole meridian lines have been preferred for solar astrometry up to two centuries after the invention of the telescope.

Several talks have been presented during the meeting, namely on the *"Copernican conference in Santa Maria Deglia Angeli on February 18, 2023"*, on *"The entrance in the Pisces at the sundial in Saint Peter Square on February 18, 2023"*, on "*The transit of Sirius to the sundial in Saint Peter Square on February 18, 2023"*, on "*The passage of the Sun to the Clementine meridian line on Sunday February 19, 2023"*, on *"The Bolla Inter Gravissimas translated in Italian"*, on *"The astronomer Copernicus by Jan Matejko (1873)"* and on *"The lunar algorithm of the Gregorian calendar"*. Prof. Sigismondi also illustrated the positional data of the solar image on the Clementine meridian line on February 18 – 19, 2023and the linear interpolation for the entrance in Pisces.

Fig. 5: the Sun projected on the marble marquetry of the Pisces of Francesco Tedeschi in Santa Maria degli Angeli in Rome on February 18, 2023. The center of this frame is at 5198 mm from the reference 160.

Fig. 6: Sirius on the left of the Vatican obelisk on February 18, 2023 at h 20:57:15, observed from the meridian line.

For more information on the meeting, including the videos, the scientific rationale and the podcast material: http://www.icranet.org/index.php?option=com_content&task=view&id=1487

5. Announcement of the 18th Italian- Korean Symposium (IK18), June 19 – 23, 2023, Pescara (Italy)

It gives us great pleasure to announce the 18th Italian-Korean Symposium on Relativistic Astrophysics that will be held from June19 to 23, 2023 in person at ICRANet center in Pescara (Italy) and online. The meeting has been co organized by Kunsan National University, CQUeST and Sogang University (on the Korean side) and, on the italian side, by ICRANet. Members of IK18 Italian Committee are Remo Ruffini (Director of ICRANet, ICRA), Carlo Luciano Bianco (ICRA, ICRANet), Massimo Della Valle (Capodimonte Astronomical Observatory, INAF, ICRANet), Luca Izzo (Capodimonte Astronomical Observatory, INAF), Paolo Giommi (ASI), Roy Patrick Kerr (ICRANet), Liang Li (ICRANet), Rahim Moradi (ICRANet), Jorge A. Rueda H. (ICRANet, University of Ferrara), Narek Sahakyan (Director of ICRANet center in Armenia), Gregory Vereshchagin (ICRANet), Yu Wang (ICRANet) and Shesheng Xue (ICRANet). Members of IK18 Korean Committee are Stefano Scopel (CQUeST, Sogang University), Bum-Hoon Lee (CQUeST, Sogang University), Wontae Kim (CQUeST, Sogang University), Jeong-Hyuck Park (CQUeST, Sogang University), Wonwoo Lee (CQUeST, Sogang University), Sang Pyo Kim (Kunsan National University), Bogeun Gwak (Dongguk University), Imtak Jeon (APCTP), Hyungwon Lee (Inje University), Changhwan Lee (Pusan National University) and Hyeong Chan Kim (Korea National university of Transportation).

The Italian-Korean Symposia on Relativistic Astrophysics is a series of biannual meetings, alternatively organized in Italy and in Korea since 1987, with support from Korea Science and Engineering Foundation (KOSEF), Consiglio Nazionale delle Ricerche (CNR), ICRANet and hosting institutes. The main purpose of this symposium is to accelerate the exchange between Italian and Korean scientists, especially young researchers.

In addition to the topics in Relativistic Astrophysics traditionally discussed at the IK meetings (e.g.Gamma-Ray bursts and compact stars, high energy cosmic rays, dark energy and dark matter, general relativity, black holes and new physics related to cosmology), particular attention will be

given in this IK18 meeting to the energy extraction processes from the Kerr black hole by fission of massive particles (Penrose process), by classical electrodynamic processes and by quantum processes. In all cases, the role of the irreducible mass will be evidenced in characterizing the efficiency of the emission processes. Examples from active galactic nuclei and Gamma-Ray bursts will be illustrated.

The scientific program of the meeting is in preparation and more details about the event will be posted on its webpage:https://indico.icranet.org/event/7/.

6. Third announcement of the 5th Zeldovich meeting, June 12-17, 2023, Yerevan (Armenia)

We are very happy to inform that the list of confirmed invited talks for the 5th Zeldovich meeting, which will be held from June 12 – 17, 2023 in Yerevan (Armenia) now includes:

- *"Fermionic dark matter: theory & phenomenology"* by Carlos Raúl Argüelles, Universidad Nacional de La Plata, Argentina;
- *"Hubble Tension challenge in the modern cosmology: possible solutions"* by Gennady Bisnovatyi-Kogan, Space Research Institute (IKI), Russia;
- *"Pair-balance model for relativistic shocks and its application to astrophysical sources"* by Evgeny Derishev, Institute of Applied Physics, Russia;
- *"Quantum sensing – the key technology for further gravitational experiments in space*" by Hansjoerg Dittus, University of Bremen, Germany;
- *"Neutrino Telescope Baikal-GVD: Status and Nearest Future"* by Zhan-Arys Dzhilkibaev, Institute for Nuclear Research of the Russian Academy of Sciences, Russia;
- *"SRG/eROSITA all-sky survey: from solar flares and neutrino sources to cosmology"* by Marat Gilfanov, Max-Planck Institute for Astrophysics, Germany and IKI, Russia;
- *"Neutron Stars as Strong Field QED Laboratory"* by Sang Pyo Kim, Kunsan National University, South Korea;
- *"New quantum technologies and gravity"* by Claus Laemmerzahl, University Bremen, Germany;
- *"Discoveries from FAST"* by Di Li, National Astronomical Observatories of China, China;
- *"Black hole induced star formation in the early universe"* by Felix Mirabel, CEA Saclay, France;
- *"Selected Studies of Cosmic and Gamma Rays with the MAGIC telescopes"* by Razmik Mirzoyan, Max-Planck-Institute for Physics, Germany;
- *"Influence of a plasma on the shadow of black holes"* by Volker Perlick, ZARM, University Bremen, Germany;
- *"An electrodynamic process to extract the rotational energy of a Kerr black hole"* by Jorge Armando Rueda Hernandez, ICRANet, Italy;
- *"The Imaging X-ray Polarimetry Explorer (IXPE) results from the first 1.5 years of observation"* by Paolo Soffitta, IAPS, INAF, Rome, Italy;

– *"New developments in the inflationary scenario"* by Alexei Starobinsky, Landau Institute for Theoretical Physics, Russia;

– *"The spectral signatures of BHs versus NSs"* by Lev Titarchuk, University di Ferrara, Italy and Astro Space Center, Lebedev Physical Institute, Russia;

– *"Highlights of the Insight-HXMT X-ray Astronomy Satellite"* by Shuang-Nan Zhang, Institute of High Energy Physics, China,

The early bird registration fee is 300 euro (100 euro for students) and it ends up on 1 of May 2023. Starting from that date, the registration fee will be 400 euro (150 euro for students).

For the website of the meeting: http://www.icranet.org/zeldovich5

For the poster of the meeting: https://indico.icranet.org/event/6/attachments/382/560/poster.pdf

7. Scientific visits to ICRANet

- Antonio Enea Romano (Universidad de Antioquia UDEA), February 2 – 6, 2023
- Narek Sahakyan (Director of ICRANet Armenia), February 6 – 12, 2023
- Soroush Shakeri (Isfahan University of Technology), March 28, 2023 - ongoing

During their visit, those scientists had an opportunity to discuss their scientific research and to have fruitful exchange of ideas with other researchers from ICRANet and from different parts of the world.

8. Recent publications

Liang Li, Yu Wang, Felix Ryde, Asaf Pe'er, Bing Zhang, Sylvain Guiriec, Alberto J. Castro-Tirado, D. Alexander Kann, Magnus Axelsson, Kim Page, *A Cosmological Fireball with 16% Gamma-Ray Radiative Efficiency*, published in The Astrophysical Journal Letters, Volume 944, Number 2 on February 23, 2023.

Gamma-ray bursts (GRBs) are the most powerful explosions in the universe. How efficiently the jet converts its energy to radiation is a long-standing problem, which is poorly constrained. The standard model invokes a relativistic fireball with a bright photosphere emission component. A definitive diagnosis of GRB radiation components and the measurement of GRB radiative efficiency require prompt emission and afterglow data, with high resolution and wide band coverage in time and energy. Here, we present a comprehensive temporal and spectral analysis of the TeV-emitting bright GRB 190114C. Its fluence is one of the highest for all the GRBs that have been detected so far, which allows us to perform a high-resolution study of the prompt emission spectral properties and their temporal evolutions, down to a timescale of about 0.1 s. We observe that each of the initial pulses has a thermal component contributing ∼20% of the total energy and that the corresponding temperature and inferred Lorentz factor of the photosphere evolve following broken power-law shapes. From the observation of the nonthermal spectra and the light curve, the onset of the afterglow corresponding to the deceleration of the fireball is considered to start at ∼6 s. By incorporating the thermal and nonthermal observations, as well as the photosphere and synchrotron radiative mechanisms, we can directly derive the fireball energy budget with little dependence on hypothetical parameters, measuring a ∼16% radiative efficiency for this GRB. With

the fireball energy budget derived, the afterglow microphysics parameters can also be constrained directly from the data.

DOI: https://doi.org/10.3847/2041-8213/acb99d

Liang Li, J. A. Rueda, R. Moradi, Y. Wang, S. S. Xue, and R. Ruffini, *Self-similarities and Power Laws in the Time-resolved Spectra of GRB 190114C, GRB 130427A, GRB 160509A, and GRB 160625B*, published in The Astrophysical Journal, Volume 945, Number 1 on March 1, 2023.

Binary-driven hypernova (BdHN) models have been adopted to explain the observed properties of long gamma-ray bursts (GRBs). Here, we perform a comprehensive data analysis (temporal and spectral analysis, GeV emission, and afterglow) on GRB 130427A, GRB 160509A, and GRB 160625B. We identify three specific episodes characterized by different observational signatures and show that these episodes can be explained and predicted to occur within the framework of the BdHNe I model, as first observed in GRB 190114C and reported in an accompanying paper. Episode 1 includes the "SN-rise" with the characteristic cutoff power-law spectrum; Episode 2 is initiated by the moment of formation of the black hole, coincident with the onset of the GeV emission and the ultrarelativistic prompt emission phase, and is characterized by a cutoff power law and blackbody spectra; Episode 3 is the "cavity," with its characteristic featureless spectrum.

DOI: https://doi.org/10.3847/1538-4357/acb20b

Liang Li, *Revisiting the Spectral-Energy Correlations of GRBs with Fermi Data I: Model-wise Properties*, accepted for publication in The Astrophysical Journal Supplement Series.

Gamma-ray bursts (GRBs) exhibit a diversity of spectra. Several spectral models (e.g., Band, cutoff power-law, and blackbody) and their hybrid versions (e.g., Band+blackbody) have been widely used to fit the observed GRB spectra. Here, we attempt to collect all the bursts detected by Fermi-GBM with known redshifts from July 2008 to May 2022, motivated to (i) provide a parameter catalog independent from the official Fermi/GBM team and (ii) achieve a "clean" model-based GRB spectral- energy correlation analysis. A nearly complete GRB sample was created, containing 153 such bursts (136 long gamma-ray bursts and 17 short gamma-ray bursts). Using the sample and by performing detailed spectral analysis and model comparisons, we investigate two GRB spectral-energy correlations: the cosmological rest-frame peak energy ($E_{p,z}$) of the νF_νprompt emission spectrum correlated with (i) the isotropic-bolometric-equivalent emission energy $E_{\gamma,\mathrm{iso}}$ (the Amati relation), and (ii) the isotropic- bolometric-equivalent peak luminosity $L_{p,\mathrm{iso}}$ (the Yonetoku relation). From a linear regression analysis, a tight correlation between $E_{p,z}$ and $E_{\gamma,\mathrm{iso}}$ (and $L_{\gamma,\mathrm{iso}}$) is found for both the Band-like and CPL-like bursts. More interestingly, the CPL-like bursts do not fall on the Band-like burst Amati and Yonetoku correlations, suggesting distinct radiation processes, and pointing towards the fact that these spectral-energy correlations are tightly reliant on the model-wise properties.

DOI: https://doi.org/10.48550/arXiv.2211.12187

Sahakyan, N., Harutyunyan, G., Israyelyan, D., *Origin of multiwavelength emission from flaring high redshift blazar PKS 0537-286*, published on Monthly Notices of the Royal Astronomical Society, Volume 521, Issue 1, May 2023 on February 20, 2023.

The high redshift blazars powered by supermassive black holes with masses exceeding $10^9\,M_\odot$ have the highest jet power and luminosity and are important probes to test the physics of relativistic jets at the early epochs of the Universe. We present a multifrequency spectral and temporal study of

high redshift blazar PKS 0537−286 by analyzing data from Fermi-LAT, NuSTAR Swift XRT, and UVOT. Although the time averaged γ-ray spectrum of the source is relatively soft (indicating the high-energy emission peak is below the GeV range), several prominent flares were observed when the spectrum hardened and the luminosity increased above 10^{49} erg s^{-1}. The X-ray emission of the source varies in different observations and is characterized by a hard spectrum with a luminosity of $>10^{47}$ erg s^{-1}. The broad-band spectral energy distribution in the quiescent and flaring periods was modelled within a one-zone leptonic scenario assuming different locations of the emission region and considering both internal (synchrotron radiation) and external (from the disc, broad-line region, and dusty torus) photon fields for the inverse Compton scattering. The modeling shows that the most optimistic scenario, from the energy requirement point of view, is when the jet energy dissipation occurs within the broad-line region. The comparison of the model parameters obtained for the quiescent and flaring periods suggests that the flaring activities are most likely caused by the hardening of the emitting electron spectral index and shifting of the cut-off energy to higher values.

DOI: https://doi.org/10.1093/mnras/stad517

MAGIC Collaboration, *MAGIC observations provide compelling evidence of hadronic multi-TeV emission from the putative PeVatron SNR G106.3+2.7*, published in Astronomy & Astrophysics, Volume 671, March 2023 on February 28, 2023.

Context. Certain types of supernova remnants (SNRs) in our Galaxy are assumed to be PeVatrons, capable of accelerating cosmic rays (CRs) to ~ PeV energies. However, conclusive observational evidence for this has not yet been found. The SNR G106.3+2.7, detected at 1–100 TeV energies by different γ-ray facilities, is one of the most promising PeVatron candidates. This SNR has a cometary shape, which can be divided into a head and a tail region with different physical conditions. However, in which region the 100 TeV emission is produced has not yet been identified because of the limited position accuracy and/or angular resolution of existing observational data. Additionally, it remains unclear as to whether the origin of the γ-ray emission is leptonic or hadronic.

Aims. With the better angular resolution provided by new MAGIC data compared to earlier γ-ray datasets, we aim to reveal the acceleration site of PeV particles and the emission mechanism by resolving the SNR G106.3+2.7 with 0.1° resolution at TeV energies.

Methods. We observed the SNR G106.3+2.7 using the MAGIC telescopes for 121.7 h in total – after quality cuts – between May 2017 and August 2019. The analysis energy threshold is ~0.2 TeV, and the angular resolution is 0.07–0.1°. We examined the γ-ray spectra of different parts of the emission, whilst benefitting from the unprecedented statistics and angular resolution at these energies provided by our new data. We also used measurements at other wavelengths such as radio, X-rays, GeV γ-rays, and 10 TeV γ-rays to model the emission mechanism precisely.

Results. We detect extended γ-ray emission spatially coincident with the radio continuum emission at the head and tail of SNR G106.3+2.7. The fact that we detect a significant γ-ray emission with energies above 6.0 TeV from only the tail region suggests that the emissions above 10 TeV detected with air shower experiments (Milagro, HAWC, Tibet ASγ and LHAASO) are emitted only from the SNR tail. Under this assumption, the multi-wavelength spectrum of the head region can be explained with either hadronic or leptonic models, while the leptonic model for the tail region is in contradiction with the emission above 10 TeV and X-rays. In contrast, the hadronic model could reproduce the observed spectrum at the tail by assuming a proton spectrum with a cutoff energy of ~1 PeV for that region. Such high-energy emission in this middle-aged SNR (4–10 kyr) can be explained by considering a scenario where protons escaping from the SNR in the past interact with surrounding dense gases at present.

Conclusions. The γ-ray emission region detected with the MAGIC telescopes in the SNR G106.3+2.7 is extended and spatially coincident with the radio continuum morphology. The multi-wavelength spectrum of the emission from the tail region suggests proton acceleration up to ~PeV, while the emission mechanism of the head region could either be hadronic or leptonic.

DOI: https://doi.org/10.1051/0004-6361/202244931

S. Campion, J. D. Uribe-Suárez, J. D. Melon Fuksman, J. A. Rueda, *MeV, GeV and TeV Neutrinos from Binary-Driven Hypernovae*, published in Symmetry, 15, 412 on February 3, 2023.

We analyze neutrino emission channels in energetic ($\gtrsim 10^{52}$ erg) long gamma-ray bursts within the binary-driven hypernova model. The binary-driven hypernova progenitor is a binary system composed of a carbon-oxygen star and a neutron star (NS) companion. The gravitational collapse leads to a type Ic supernova (SN) explosion and triggers an accretion process onto the NS. For orbital periods of a few minutes, the NS reaches the critical mass and forms a black hole (BH). Two physical situations produce MeV neutrinos. First, during the accretion, the NS surface emits neutrino–antineutrino pairs by thermal production. We calculate the properties of such a neutrino emission, including flavor evolution. Second, if the angular momentum of the SN ejecta is high enough, an accretion disk might form around the BH. The disk's high density and temperature are ideal for MeV-neutrino production. We estimate the flavor evolution of electron and non-electron neutrinos and find that neutrino oscillation inside the disk leads to flavor equipartition. This effect reduces (compared to assuming frozen flavor content) the energy deposition rate of neutrino–antineutrino annihilation into electron–positron (e^+e^-) pairs in the BH vicinity. We then analyze the production of GeV-TeV neutrinos around the newborn black hole. The magnetic field surrounding the BH interacts with the BH gravitomagnetic field producing an electric field that leads to spontaneous e^+e^- pairs by vacuum breakdown. The e^+e^- plasma self-accelerates due to its internal pressure and engulfs protons during the expansion. The hadronic interaction of the protons in the expanding plasma with the ambient protons leads to neutrino emission via the decay chain of π-meson and μ-lepton, around and far from the black hole, along different directions. These neutrinos have energies in the GeV-TeV regime, and we calculate their spectrum and luminosity. We also outline the detection probability by some current and future neutrino detectors.

DOI: https://doi.org/10.3390/sym15020412

Wang, Yu, Becerra, L. M., Fryer, C. L., Rueda, J. A., Ruffini, R., *GRB 171205A: Hypernova and Newborn Neutron Star*, published in The Astrophysical Journal, Volume 945, Issue 2 on March 9, 2023.

GRB 171205A is a low-luminosity, long-duration gamma-ray burst (GRB) associated with SN 2017iuk, a broad-line type Ic supernova (SN). It is consistent with having been formed in the core collapse of a widely separated binary, which we have called the binary-driven hypernova of type III. The core collapse of the CO star forms a newborn NS (νNS) and the SN explosion. Fallback accretion transfers mass and angular momentum to the νNS, here assumed to be born non-rotating. The accretion energy injected into the expanding stellar layers powers the prompt emission. The multiwavelength power-law afterglow is explained by the synchrotron radiation of electrons in the SN ejecta, powered by energy injected by the spinning νNS. We calculate the amount of mass and angular momentum gained by the νNS, as well as the νNS rotational evolution. The νNS spins up to a period of 47 ms, then releases its rotational energy powering the synchrotron emission of the afterglow. The paucity of the νNS spin explains the low-luminosity characteristic and that the optical emission of the SN from the nickel radioactive decay outshines the optical emission from the synchrotron radiation. From the νNS evolution, we infer that the SN explosion had to occur at

most 7.36 h before the GRB trigger. Therefore, for the first time, the analysis of the GRB data leads to the time of occurrence of the CO core collapse leading to the SN explosion and the electromagnetic emission of the GRB event.

DOI: https://doi.org/10.3847/1538-4357/acb771

Krut, A., Argüelles, C. R., Chavanis, P. -H., Rueda, J. A., Ruffini, R., *Galaxy Rotation Curves and Universal Scaling Relations: Comparison between Phenomenological and Fermionic Dark Matter Profiles*, published in The Astrophysical Journal, Volume 945, Issue 1,onMarch 1, 2023.

Galaxies show different halo scaling relations such as the radial acceleration relation, the mass discrepancy acceleration relation (MDAR), or the dark matter (DM) surface density relation. At difference with traditional studies using phenomenological ΛCDM halos, we analyze the above relations assuming that DM halos are formed through a maximum entropy principle (MEP) in which the fermionic (quantum) nature of the DM particles is dully accounted for. For the first time, a competitive DM model based on first physical principles, such as (quantum) statistical-mechanics and thermodynamics, is tested against a large data set of galactic observables. In particular, we compare the fermionic DM model with empirical DM profiles: the Navarro–Frenk–White (NFW) model, a generalized NFW model accounting for baryonic feedback, the Einasto model, and the Burkert model. For this task, we use a large sample of 120 galaxies taken from the Spitzer Photometry and Accurate Rotation Curves data set, from which we infer the DM content to compare with the models. We find that the radial acceleration relation and MDAR are well explained by all the models with comparable accuracy, while the fits to the individual rotation curves, in contrast, show that cored DM halos are statistically preferred with respect to the cuspy NFW profile. However, very different physical principles justify the flat inner-halo slope in the most-favored DM profiles: while generalized NFW or Einasto models rely on complex baryonic feedback processes, the MEP scenario involves a quasi-thermodynamic equilibrium of the DM particles.

DOI: https://doi.org/10.3847/1538-4357/acb8bd

H. Barzegar, M. Bigdeli, G. H. Bordbar, and B. Eslam Panah, *Stable three-dimensional (un)charged AdS gravastars in gravity's rainbow*, published in European Physical Journal C 83, 151 on February 16, 2023.

In this work, we study the three-dimensional AdS gravitational vacuum stars (gravastars) in the context of gravity's rainbow theory. Then we extend it by adding the Maxwell electromagnetic field. We compute the physical features of gravastars, such as proper length, energy, entropy, and junction conditions. Our results show that the physical parameters for charged and uncharged states depend significantly on rainbow functions. Besides from charged state, they also depend on the electric field. Finally, we explore the stability of thin shell of three-dimensional (un)charged AdS gravastars in gravity's rainbow. We show that the structure of thin shell of these gravastars may be stable and is independent of the type of matter.

DOI: https://doi.org/10.1140/epjc/s10052-023-11295-3

B. Eslam Panah and M. E. Rodrigues, *Topological phantom AdS black holes in F(R) gravity*,accepted for publication in European Physical Journal C (March 2023).

In this paper, we obtain exact phantom (A)dS black hole solutions in the context of F(R) gravity with topological spacetime in four dimensions. Then, we study the effects of different parameters

on the event horizon. In the following, we calculate the conserved and thermodynamic quantities of the system and check the first law of thermodynamics for these kinds of black holes. Next, we evaluate the local stability of the topological phantom (A)dS black holes in F(R) gravity by studying the heat capacity and the geometrothemodynamic, where we show that the two approaches agree. We extend our study and investigate global stability by employing the Gibbs potential and the Helmholtz free energy. In addition, the effects of different parameters on local and global stabilities will be highlighted.

DOI: https://doi.org/10.1140/epjc/s10052-023-11402-4

ICRANet Newsletter

April – May 2023

SUMMARY

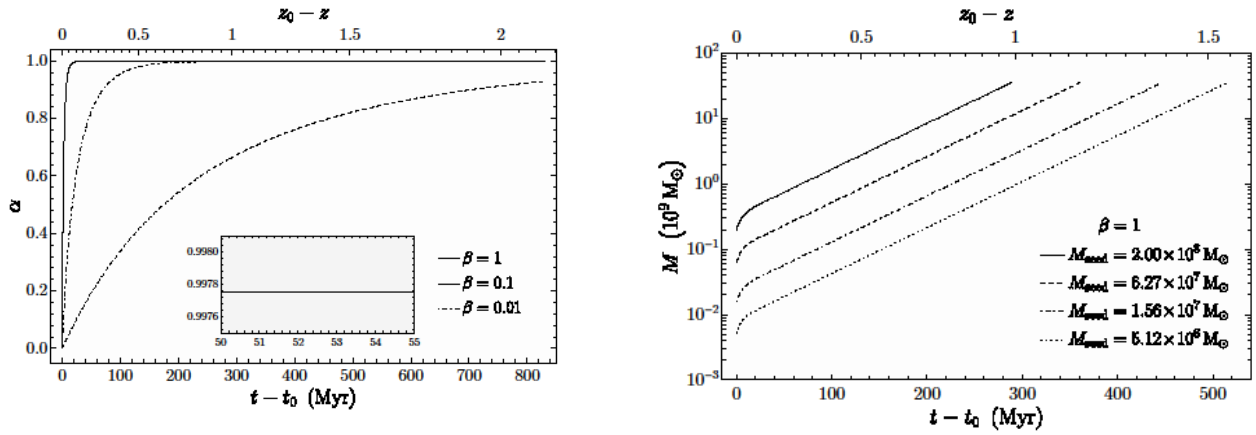
1. Scientific highlights: ICRA – ICRANet Press release - Supermassive black holes formation from fermionic dark matter core collapse

Fundamental questions about the origin and growth of supermassive black holes in the earliest stages of the Universe's life, up to about 800 million years after the Big Bang, challenge the scientific community. An international team of ICRANet, in collaboration with researchers from the University of La Plata (Argentina), Universidad Santiago de Cali (Colombia), and Al-Farabi Kazakh University (Kazakhstan), has made a crucial contribution by proposing a new mechanism that explains how these supermassive giants arise and grow so much, so quickly. The novelty was published on May 31, 2023, by the prestigious journal Monthly Notices of the Royal Astronomical Society: (https://doi.org/10.1093/mnras/stad1380 .

The observations from the central regions of active galaxies, those that are larger and more massive than the Milky Way and have very intense radiation, suggest supermassive black holes are responsible for generating the emission of energy through jets of matter shooting out from the center of these galaxies. However, contrary to the case of black holes of stellar origin that are formed from the death of a star with a mass similar to that of the Sun, there is still a strong debate about what are the origin and main channel of formation of the progenitors (or seeds) of these supermassive giants formed in the early universe.

In the article, the team proposes a new formation mechanism to form supermassive black holes in the early universe, completely different from existing models associated with the gravitational collapse of primordial gas or hypothetical massive stars. The new model shows supermassive black holes originate from the gravitational collapse of dense nuclei of dark matter that arise in the center of the galactic halos at the time of their formation, according to the model of fermionic dark matter halos proposed by the same experts in previous researches.

The relevance of this new result is both observational and theoretical. With respect to observations, it is shown that these seeds or progenitors of black holes formed from dark matter would be born with masses of millions to hundreds of millions of times the mass of the Sun and then, once formed, grow by accretion (or incorporation) of conventional matter up to the values inferred by the observations made by large telescopes. In Fig. 1 it is shown the evolution of black hole mass for different seeds (right pannel) in the novel formation channel, and for a range of fermionic dark matter particles or *darkino* masses. As clearly shown in the figure, the black hole seeds formed from the gravitational collapse of the dense dark matter cores, can grow up to 10^9-10^{10} $M_\odot$ in a fraction of the first Gyr of life of the Universe. In left panel of Fig. 1 we show the evolution of normalized black hole spin for different efficiencies β.



Black hole mass evolution in time for different black hole seeds with maximum efficiency β=1 (right panel), and normalized black hole spin α evolution for different efficiencies (left panel). Initial conditions are α_i=0 and darkino masses 56keV, 100keV, 200keV, and 350keV. The spin parameter does not depend on the black hole mass. The initial redshift is z_0=5.5 with t_0=1022 Myr for a halo mass M_{vir}=5x$10^{11}M_\odot$.

From the theoretical viewpoint, a new solution to Einstein's General Relativity equations was found for the first time, leading to a distribution of dark matter whose nucleus is on the verge of gravitational collapse towards a massive black hole. This solution implies that the same dark matter that forms the dense nucleus is surrounded by a more diluted halo that explains the galactic rotation curves, all in a realistic and unified picture.

For more details:

On the growth of supermassive black holes formed from the gravitational collapse of fermionic dark matter cores, C. R. Argüelles, K. Boshkayev, A. Krut, G. Nurbakhyt, J. A. Rueda, R. Ruffini, R., J. D. Uribe-Suarez, R. Yunis, Monthly Notices of the Royal Astronomical Society, Volume 523, Issue 2, August 2023, Pages 2209–2218.

Link to the journal's site:https://doi.org/10.1093/mnras/stad1380

Link to the ArXiv:https://arxiv.org/abs/2305.02430

Link to ICRA-ICRANet press release: http://icranet.org/communication/31052023/eng.pdf

Link to the press release on CONICET-Argentina website: https://laplata.conicet.gov.ar/proponen-una-posible-explicacion-a-como-se-formaron-los-agujeros-negros-supermasivos-en-el-universo-temprano/

Other press releases and contact information: Tweets by Royal Astronomical Society (RAS) Journals in https://twitter.com/RAS$_$Journals/status/1664678764356435969

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2. Visit of Prof. Ruffini to the USA, May 18-23, 2023

From May 18 to 23, 2023 Prof. Remo Ruffini, Director of ICRANet, visited the USA. In particular, until Saturday May 20, he visited Princeton University as well as the Institute for Advanced Study (IAS) in Princeton, since he was invited to take part in the *"IAS Founders Day 2023"*.

Since its foundation, the IAS has always been an incubator and accelerator for groundbreaking ideas and scholarship. Every year, the Institute organizes an annual event in honor of Louis Bamberger and Caroline Bamberger Fuld, the sibling philanthropists who founded and endowed IAS on May 20, 1930, providing for its lasting and essential independence. The annual event, organized this year on May 19, wanted to celebrate their vision as well as that of Faculty, Board, Members, and Staff, who together ensure that the work of the Institute is as vital today as it ever has been. During this festivity, attendees were invited to explore displays focused on Institute history, followed by the IAS Libraries and Archives. The archivists also provided scholars with the opportunity to view and sign their name in the IAS Registry, an autographed record of Faculty and Members that has been kept since the Institute's inception. Original signatories include Einstein and

many other famous names, such as John von Neumann, Kurt Gödel, and Anna Stafford. Also the name of Prof. Ruffini was present in this IAS Registry.

Fig. 1: Prof. Remo Ruffini looking at his signature in the IAS Registry, while attending the IAS Founders Day 2023 in Princeton on May 19, 2023.

For more information about the program of the meeting: https://www.ias.edu/founders-day-2023

For a recorded summary of the event (Prof. Ruffini is visible at Minute 1:00): https://www.youtube.com/watch?v=focxomx7t3w&t=1s

Soon after this meeting in Princeton, Prof. Ruffini flew to San Francisco in order to visit Stanford University and, in particular, the Hansen Experimental Physics Laboratory (HEPL). During this visit, he met Prof. Kent Irwin (Director of HEPL), Prof. Giorgio Gratta, Risa Wechsler (Director of theKavli Institute for Particle Astrophysics and Cosmology - KIPAC) and Prof. Francis Everitt (Emeritus Professor at Stanford University, representative of Stanford University in ICRA Assembly as well as Chairman of the ICRANet Steering Committee). On this occasion, Prof. Yu Wang, ICRA President and ICRANet Faculty Professor, joined all the others via GoToMeeting on Monday May 22, in order to make a presentation on the recent scientific results and the ongoing researches of ICRA and ICRANet. This meeting served also as a good opportunity to reinforce the ongoing joint research on the mission Gravity Probe B as well as the recent astrophysical developments and the collaborations with Prof. Peter Michelson, responsible of the FERMI program.

Fig. 2: From the left to the right: Prof. Kent Irwin (Director of the Hansen Experimental Physics Laboratory HEPL), Prof. Peter Michaelson, Prof. Francis Everitt and Prof. Remo Ruffini at Stanford University.

Fig. 3: From the left to the right: Prof. Risa Wechsler (Director, Kavli Institute for Particle Astrophysics and Cosmology KIPAC at Stanford University, Prof. Francis Everitt and Prof. Remo Ruffini in front of the Gravity Probe B in the Hansen Experimental Physics Laboratory (HEPL).

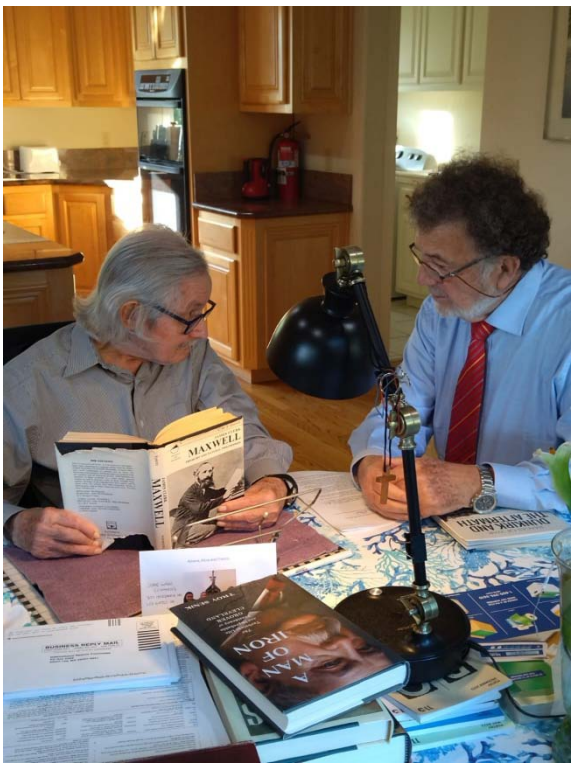


Fig. 4: Prof. Remo Ruffini with Prof. Francis Everitt in his apartment.

3. ICRANet GCN 33723, May 4, 2023

TITLE: GCN CIRCULAR
NUMBER: 33723
SUBJECT: GRB 230430A: A short GRB from a neutron star merger
DATE: 23/05/04 08:30:05 GMT
FROM: Remo Ruffini at ICRA <ruffini@icra.it>

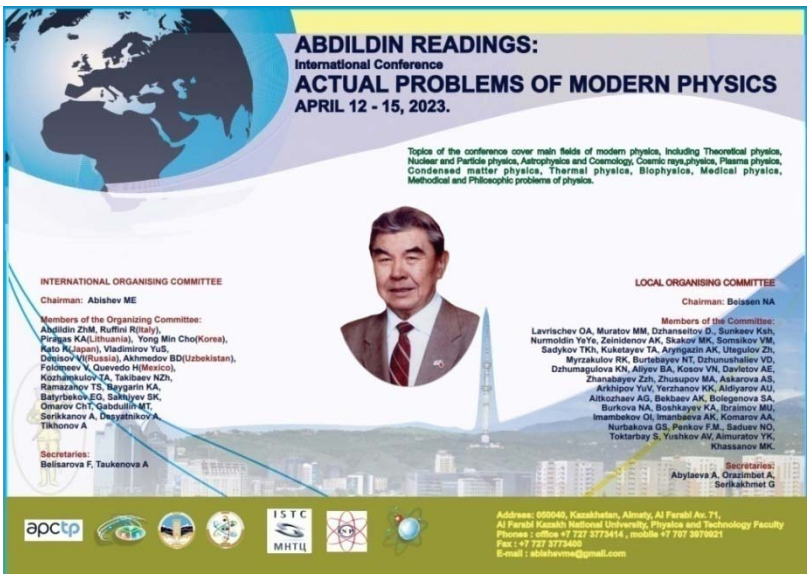
R. Ruffini, Y. Aimuratov, L. Becerra, C.L. Bianco, C. Cherubini, S. Filippi, M. Karlica, Liang Li, R. Moradi, F. Rastegar Nia, J.A. Rueda, N. Sahakyan, Y. Wang, S.S. Xue, on behalf of the ICRANet team, report:

GRB 230430A appears to have strong similarities with GRB 090510 originating from merging binary neutron stars (Ruffini et al., 2016). Also in this case no supernova is expected. Attention should be given to the determination of the temporal slope of the late X-ray luminosity which for long GRBs coincide with the common value of the power-law index -1.48+/-0.32 of the afterglow, and for short GRBs appears to have a different power law, to be confirmed (see Fig. 5 in Ruffini et al., 2016). The GeV luminosity for long GRBs has a temporal power-law index -1.19+/-0.04 and for short GRBs it has a temporal power-law index -1.29+/-0.06 (Ruffini et al., 2021). Confirmation of the values of both slopes in GRB 230430A is highly recommended to differentiate short GRBs from long GRBs. We encourage monitoring for the possible appearance of a kilonova signal.

References:
Ruffini, R.; Muccino, M.; Aimuratov, Y.; et al.; ApJ, 831 (2016) 178.
Ruffini, R.; Moradi, R.; Rueda, J.A; et al.; MNRAS, 504 (2021) 5301.

4. ICRANet participation at the International Conference Abdildin Readings. Actual problems of modern physics, April 12 – 15, 2023 Almaty (Kazakhstan)

From April 12 to 15, 2023, Prof. Remo Ruffini (Director of ICRANet) and Shurui Zhang (ICRANet visiting scientist from USTC – China) have been invited to present a lecture on the occasion of the International Conference Abdildin Readings. Actual problems of modern physics, held both at Al Farabi Kazakh National University in Almaty (Kazakhstan) and online.



The first meeting of this series has been organized in 2013 on the occasion of the 75thanniversary of the Academician MeirkhanAbdildin, and this year, of course, the conference has been organized on the occasion of his 85th anniversary. The main topics of the conference coveredthe main fields of modern physics, including theoretical physics, nuclear and particle physics, astrophysics and cosmology, cosmic rays physics, plasma physics, condensed matter physics, thermal physics, biophysics, medical physics, methodical and philosophic problems of physics. The main goal of the conference was to promote cooperation among Central Asia and key partner countries of the region, as well as to coordinate high-level studies on hot topics in physics at international level and to encourage fruitful collaboration among active researchers and gifted representatives of younger generation.

On Wednesday April 12, Prof. Ruffini presented a lecture titled*"New Physics and Astrophysicsfrom GRBs"*; here below the abstract:

The observations of Ic supernovae (Ic/SNe) occurring after the prompt emission of long gamma ray bursts (GRBs) are addressed within the binary-driven hypernova (BdHN) model. Here, the GRBs originate from a binary composed of a ∼ 10 $M_{\odot}$ carbon-oxygen (CO) star and a companion neutron star (NS). We assume these same progenitors originate the Ic/SN. The binary evolution depends strongly on the binary period, Pbin. The trigger, given by the CO core collapse, for P_{bin} of up to a few hours leads to an Ic/SN with a fast-spinning NS (vNS) at its center. For P_{bin}∼ 4–5 min, BdHN I occur with energies 10^{52} – 10^{54} erg, a contribution by the black hole (BH) created by the NS companion collapse, originates the Mev/GeV radiations. The ∼ 1 millisecond vNS originates, by synchrotron radiation, the X-ray afterglow. For P_{bin}∼ 10 min, BdHN II occurs with energies of 10^{50}–10^{52}erg. For Pbin∼ hours, BdHN III occurs with energies below 10^{50} erg. The 1–1000 ms vNS, in all BdHNe, originates the X-ray afterglow by synchrotron emission. The SN Ic follows an independent evolution, becoming observable by the nickel decay after the GRB prompt emission. We report 24 Ic/SNe associated with BdHNe, their optical peak luminosity and their time of occurrence are similar and independent of the associated GRBs. We give four examples of BdHNe and their associated hypernovae. We approach, for the first time, new physical processes in BdHNe; we identify seven episodes and their signatures in their spectra.

On the same day, Shurui Zhang presented a talk titled *"The transformation of the rotational energy of a Kerr BH"*.

For the website of the meeting:http://kazps.kz/index.php?page=conferences/AR

5. ICRANet participation at the Second international conference of the National Institute of Physics (NIP), April 28-29, 2023, Tirana (Albania)

From April 28 to 29, 2023, Prof. Remo Ruffini (Director of ICRANet) and Shurui Zhang (ICRANet visiting scientist from USTC – China) have been invited to present a lecture on the occasion of the second International Conference of the National Institute of Physics (NIP), which has been held at the Academy of Sciences of Albania in Tirana.

The NIP aims to promote modern knowledge and excellence in physics within Albania and internationally. The key goals of the conference included the dissemination of research accomplishments in the context of the latest developments in physics (including teaching), the consolidation of a cooperation network between Albanian and foreign physicists, as well as the expansion of NIP through new memberships.

Fig. 5: Prof. Ruffini presenting his talk on the occasion of the Second international conference of the National Institute of Physics (NIP), April 28, 2023.

Fig. 6: Shurui Zhang presenting his talk on the occasion of the Second international conference of the National Institute of Physics (NIP), April 28, 2023.

On Friday April 28, Prof. Ruffini presented a lecture titled *"New Physics and Astrophysics from GRBs"*; here below the abstract:

The observations of Ic supernovae (Ic/SNe) occurring after the prompt emission of long gamma ray bursts (GRBs) are addressed within the binary-driven hypernova (BdHN) model. Here, the GRBs originate from a binary composed of a ∼ 10 $M_{\odot}$ carbon-oxygen (CO) star and a companion neutron star (NS). We assume these same progenitors originate the Ic/SN. The binary evolution depends strongly on the binary period, Pbin. The trigger, given by the CO core collapse, for P_{bin} of up to a few hours leads to an Ic/SN with a fast-spinning NS (vNS) at its center. For P_{bin}∼ 4–5 min, BdHN I occur with energies 10^{52} – 10^{54} erg, a contribution by the black hole (BH) created by the NS companion collapse, originates the Mev/GeV radiations. The ∼ 1 millisecond vNS originates, by synchrotron radiation, the X-ray afterglow. For P_{bin}∼ 10 min, BdHN II occurs with energies of 10^{50}–10^{52}erg. For Pbin∼ hours, BdHN III occurs with energies below 10^{50} erg. The 1–1000 ms vNS, in all BdHNe, originates the X-ray afterglow by synchrotron emission. The SN Ic follows an independent evolution, becoming observable by the nickel decay after the GRB prompt emission. We report 24 Ic/SNe associated with BdHNe, their optical peak luminosity and their time of occurrence are similar and independent of the associated GRBs. We give four examples of BdHNe and their associated hypernovae. We approach, for the first time, new physical processes in BdHNe; we identify seven episodes and their signatures in their spectra.

On the same day, Shurui Zhang presented a talk titled *"The transformation of the rotational energy of a Kerr BH"*.

For the website of the meeting:https://ikf-akad.al/english/

6. Measuring the Sun with the Moon: the annular total solar eclipse from 1567 until today. *Gerbertian days* from April 20 to May 17, 2023, online meetings

The annual congress in honor of Gerbert of Aurillac, scientist, scholastic astronomer and Pope, took place from April 20 to May 17, 2023 and has been coordinated, as the previous ones, by Prof. Costantino Sigismondi, ICRANet collaborator, at international level. This year, it has been organized as a series of 4 online lessons, held respectively on April 20, on May 4, on May 11 and on May 17, 2023; this is why it has been renamed *"Gerbertian days"*.

Fig. 7: Busto-Mira of Angelo Secchi on the Pincio; solar eclipse on April 20, 2023 in Com (Timor Leste, courtesy of InstitutTeknologi Sumatra; sunspot at the flap AR 3262, photo of April 23, 2023 refractor 80 mm f/7.5 in Rome @540±10 nm. Pope Silvester II (Turin, Lit. Giordana, GranDidier and Salussolia, 1854).

The Moon and the Sun: one has a diameter of 1 million and a half km, the other one of 3480 km, one is at 150 millions of km far from the Earth, the other one at 384.000 km far. On Thursday, April 20 at 3 AM in Timor Est, in the South Indian Ocean as well as at the North West of Australia, there has been a rare solar and hybrid eclipse, namely annular towards the extremes and total in the middle of the range. We use the Moon, which never changed its diameter since when is has solidified, in order to measure the Sun, well knowing the distances between us, the Moon and the Sun as well as the profile of the Moon with accuracy.

In order to obtain data, this time Prof. Sigismondi proposed, instead of the telescopes, the mobile phone in Telegramma of the astronomers to all the international scientific committee. ATel #15991: https://www.astronomerstelegram.org/?read=15991. In this ATel, Prof. Sigismondi summarized the many lessons held together with the students in order to discover the ghost image of the Sun.

Already in 2012, we had in ICRANet Pescara the international congress in honor of the 400 years from the Clavio's death. On April 20, 2023 the meeting has been devoted to the eclipse with an

online event in the footsteps of Cristoforo Clavio, which observed and described it first, in Rome in 1567. On May 4, 2023 the meeting has been devoted to the preparation of the Moon eclipse of penumbra observation of May 5, twinned with the solar one of April 20,. On May 11, the meeting has been devoted to the inauguration of Volume 20 of Gerbertus with "The Sun" of Angelo Secchi (Italian edition of 1884, now digitalized) as well as with a biography of GerbertusD'Aurillac – Pope Sylvester II, in the 1020th anniversary of his death.

Video of the total annular solar eclipse from West Australia: https://www.youtube.com/watch?t=8455&v=ifILl7GeZpE&feature=youtu.be

The Archimedes experiment to measure the Sun diameter

In Syracuse, Archimedes thought to observe the rise and the set on the sea, putting a cylinders on a ruler. From one side of the ruler he put the eye, and he put the cylinders at the distance he wanted to measure, in order to darken a bit the sun. Prof. Sigismondirepente the experiment with the view camera in the laboratory, in view of the annular eclipse of April 20, in order to better feel the spirit of these event as well as of the science.

The name of Archimedes's text is Arenario and it's one of the firsts classical texts to study the solar diameter.

For all the videos concerning the experiment: https://www.youtube.com/playlist?list=PLJaer2KV4929jBTdkwxA1P6rGOYfgpues

For the original text of Archimedes: http://www.icranet.org/scuola_lavoro/2023-2024/20042023/Archimede_Libro_Alfa_Diametro_del_Sole.pdf

Inauguration of Gerbertus 20

This journal, devoted to the history and the didactic of science, has reached volume 20 (see it from 2010 on www.icra.it/gerbertus). All the subjects covered until now are available here: https://ui.adsabs.harvard.edu/search/p_=0&q=bibstem%3AGerb&sort=date%20desc%2C%20bibcode%20desc

For the 1020thGerbertian anniversary on May 12, 2023 (he died on May 12, 1003), Prof. Sigismondi prepared the monographic n° 20, digital edition of The Sun of Angelo Secchi. It is not so know has the same edition in French, published in 1877.

The Sun was published in 1884 posthumous, in Italian, and is still now a valid text to understand what can be sees observing the Sun with an instruments such the Merz telescope of 25 cm diameter and 2.5 meters of focal length. This telescope burnt in July 1958 when it was on the central dome of Monte Mario.

Questo telescopio bruciò nel luglio del 1958 quando si trovava nella cupola centrale di Monte Mario. Giuseppe Armellini, che era il direttore, morì di crepacuore qualche giorno dopo...

The special guests of these Gerbertian days have been Prof. Remo Ruffini, Director of ICRANet, Prof. Paolo Ochner, Astrophysical Observatory of Asiago and University of Padua, Prof. VirginioOldani, SAS –Astronomical Station of Sozzago and Prof. Francesco Berrilli, University of Rome Tor VergataandAccademiadei Lincei.

Fig. 8: Archimedes, hybrid eclipse of 1996, J.A. Eddy and Clavio: characters of the history of astronomy linked to this type of eclipse for the study of the solar diameter.

For the website of the meeting: http://www.icranet.org/index.php?option=com_content&task=view&id=1491

For the video of the lesson on April 20, 2023:https://www.youtube.com/watch?v=A1iuNAjO4GA

For the video of the lesson on May 4, 2023: https://www.youtube.com/watch?v=R6I2TCdVjW4

For the video of the lesson on May 11, 2023:https://www.youtube.com/watch?v=8AHFy8rc27s

For the video of the lesson on May 17, 2023:https://www.youtube.com/watch?v=17-PYE3KVw0

7. Scientific visits to ICRANet

- Prof. Sergio Torres (Centro Internacional de Fisica, Bogotà, Colombia), April 3-28, 2023
- Prof. Narek Sahakyan (Director of ICRANet Armenia), May 11-17, 2023
- Prof. ArbanUka (Epoka University, Albania), May 11-14, 2023
- Prof. Mohamed Gadri (University of Tripoli, Libya), May 11-16, 2023
- Prof. Massimo Della Valle (Osservatorio di Capodimonte - Italy), May 24-25, 2023

Prof. Sergio Torres

Prof. Narek Sahakyan

Prof. ArbanUka

Prof. Mohamed Gadri

Prof. Massimo Della Valle

During their visit, those scientists had an opportunity to discuss their scientific research and to have fruitful exchange of ideas with other researchers from ICRANet and from different parts of the world.

8. Recent publications

S. O. Komarov, A. K. Gorbatsievich, A. S. Garkun, and G. V. Vereshchagin, *Electromagnetic Radiation and Electromagnetic Self-Force of a Point Charge in the Vicinity of the Schwarzschild Black Hole*, accepted for publication in Nonlinear Phenomena in Complex Systems, vol. 26, no. 1 (2023), pp. 77 – 82.

A point charge, radially moving in the vicinity of a black hole is considered. Electromagnetic field in a wave zone and in the small neighborhood of the charge is calculated. Numerical results of the calculation of the spectrum of electromagnetic radiation of the point charge are presented. Covariant approach for the calculation of the electromagnetic self-force is used for the case of the slowly moving charge. Numerical results for the self-force in the case of the slow motion of a particle are obtained and compared to the results in literature.

DOI: https://doi.org/10.33581/1561-4085-2023-26-1-77-82

Argüelles, C. R.; Becerra-Vergara, E. A.; Rueda, J. A.; Ruffini, R., *Fermionic Dark Matter: Physics, Astrophysics, and Cosmology*, published in Universe, vol. 9, issue 4 on April 20, 2023.

The nature of dark matter (DM) is one of the most relevant questions in modern astrophysics. We present a brief overview of recent results that inquire into the possible fermionic quantum nature of the DM particles, focusing mainly on the interconnection between the microphysics of the neutral fermions and the macrophysical structure of galactic halos, including their formation both in the linear and non-linear cosmological regimes. We discuss the general relativistic Ruffini–Argüelles–Rueda (RAR) model of fermionic DM in galaxies, its applications to the Milky Way, the possibility that the Galactic center harbors a DM core instead of a supermassive black hole (SMBH), the S-cluster stellar orbits with an in-depth analysis of the S2's orbit including precession, the application of the RAR model to other galaxy types (dwarf, elliptic, big elliptic, and galaxy clusters), and universal galaxy relations. All the above focus on the model parameters' constraints most relevant to the fermion mass. We also connect the RAR model fermions with particle physics DM candidates, self-interactions, and galactic observable constraints. The formation and stability of core–halo galactic structures predicted by the RAR model and their relations to warm DM cosmologies are also addressed. Finally, we provide a brief discussion of how gravitational lensing, dynamical friction, and the formation of SMBHs can also probe the DM's nature.

DOI: https://doi.org/10.3390/universe9040197

Argüelles, C. R.; Boshkayev, K.; Krut, A.; Nurbakhyt, G.; Rueda, J. A.; Ruffini, R.; Uribe-Suárez, J. D.; Yunis, R., *On the growth of supermassive black holes formed from the gravitational collapse of fermionic dark matter cores*, accepted for publication in MNRAS on May 2023.

Observations support the idea that supermassive black holes (SMBHs) power the emission at the center of active galaxies. However, contrary to stellar-mass BHs, there is a poor understanding of their origin and physical formation channel. In this article, we propose a new process of SMBH formation in the early Universe that is not associated with baryonic matter (massive stars) or primordial cosmology. In this novel approach, SMBH seeds originate from the gravitational collapse of fermionic dense dark matter (DM) cores that arise at the center of DM halos as they form. We show that such a DM formation channel can occur before star formation, leading to heavier BH seeds than standard baryonic channels. The SMBH seeds subsequently grow by accretion. We compute the evolution of the mass and angular momentum of the BH using a geodesic general relativistic disk accretion model. We show that these SMBH seeds grow to $\sim 10^9$ - $10^{10} M_\odot$ in the first Gyr of the lifetime of the Universe without invoking unrealistic (or fine-tuned) accretion rates.

DOI: https://doi.org/10.48550/arXiv.2305.02430

Helena X. Ren, Matteo Cerruti, Narek Sahakyan, *Quasi-periodic oscillations in the γ-ray light curves of bright active galactic nuclei*, published in Astronomy & Astrophysics, Volume 672 in April 2023.

Context. The detection of quasi-periodic oscillations (QPOs) in the light curves of active galactic nuclei (AGNs) can provide insights into the physics of the super-massive black holes (SMBHs) powering these systems and could represent a signature of the existence of SMBH binaries, setting fundamental constraints on SMBH evolution in the Universe.

Aims. The identification of long-term QPOs, characterized by periods on the order of several months to years, is particularly challenging and can only be achieved via all-sky monitoring instruments that provide unbiased, continuous light curves of astrophysical objects. The *Fermi*-LAT satellite, thanks to its monitoring observing strategy, is an ideal instrument for such a goal. Here, we aim to identify QPOs in the γ-ray light curves of the brightest AGNs within the *Fermi*-LAT catalog.

Methods. We analyzed the light curves of the 35 brightest *Fermi*-LAT AGNs, including data from the beginning of the *Fermi* mission (August 2008) to April 2021, with energies from 100 MeV to 300 GeV. Two time binnings were investigated: 7 and 30 days. The search for quasi-periodic features was then performed using the continuous wavelet transform. The significance of the result was tested via Monte Carlo simulations of artificial light curves with the same power spectral density and probability distribution function as the original light curves. The significances were then corrected for the look-elsewhere effect and provided as post-trials.

Results. We identified 24 quasars with candidate QPOs. Several of our candidates coincide with previous claims in the literature, namely: PKS 0537−441, S5 0716+714, Mrk 421, B2 1520+31, and PKS 2247−131. All our candidates are transient. The most significant multi-year QPO, with a period of about 1100 days, was observed in the quasar S5 1044+71. It is reported here for the first time.

DOI: https://doi.org/10.1051/0004-6361/202244754

Sahakyan, N.; Harutyunyan, G. ; Israyelyan, D., *Origin of multiwavelength emission from flaring high redshift blazar PKS 0537-286*, published in Monthly Notices of the Royal Astronomical Society, Volume 521, Issue 1 on May 2023.

The high redshift blazars powered by supermassive black holes with masses exceeding 10^9 $M_\odot$ have the highest jet power and luminosity and are important probes to test the physics of relativistic jets at the early epochs of the Universe. We present a multifrequency spectral and temporal study of high redshift blazar PKS 0537-286 by analysing data from Fermi-LAT, NuSTAR Swift XRT, and UVOT. Although the time averaged γ-ray spectrum of the source is relatively soft (indicating the high-energy emission peak is below the GeV range), several prominent flares were observed when the spectrum hardened and the luminosity increased above 10^{49} erg s^{-1}. The X-ray emission of the source varies in different observations and is characterized by a hard spectrum $\Gamma \leq 1.38$ with a luminosity of $>10^{47}$ erg s^{-1}. The broad-band spectral energy distribution in the quiescent and flaring periods was modelled within a one-zone leptonic scenario assuming different locations of the emission region and considering both internal (synchrotron radiation) and external (from the disc, broad-line region, and dusty torus) photon fields for the inverse Compton scattering. The modelling shows that the most optimistic scenario, from the energy requirement point of view, is when the jet energy dissipation occurs within the broad-line region. The comparison of the model parameters obtained for the quiescent and flaring periods suggests that the flaring activities are most likely

caused by the hardening of the emitting electron spectral index and shifting of the cut-off energy to higher values.

DOI: https://doi.org/10.1093/mnras/stad517

B. EslamPanah, *Charged Accelerating BTZ Black Holes*, accepted for publication in Fortschritte der Physik (Progress of Physics).

In this paper, we first extract general uncharged accelerating BTZ black hole solutions and study some of their properties. Our analysis shows that spacetime's asymptotical behavior depends on four parameters: the cosmological constant, mass, acceleration, and topological constant. Then, we study the temperature of these black holes and find that the temperature is always positive for AdSspacetime. Next, we extend our study for extracting charged accelerating BTZ black hole solutions in the presence of a nonlinear electrodynamics field known as conformally invariant Maxwell. Our findings indicate a coupling between the electrical charge and other quantities of the accelerating BTZ black holes. The asymptotical behavior of charged accelerating BTZ black holes depends on five parameters: the cosmological constant, the electrical charge, mass, the acceleration parameter, and the topological constant. Then, we studied the effects of charge, acceleration parameters, and the topological constant on the root of these black holes. Finally, we investigate the temperature of these black holes in AdSspacetime. For these black holes, the temperature depends on the electrical charge, accelerating parameter, and cosmological constant. Our analysis indicates that the temperature of charged accelerating BTZ AdS black holes is always positive.

ArXiv: https://arxiv.org/abs/2203.12619

Antonio Enea Romano, MairiSakellariadou, *The mirage of luminal modified gravitational-wave propagation*, accepted for publication in Physical Review Letter.

Using conformal invariance of gravitational waves, we show that for a luminal modified gravity theory, the gravitational-wave propagation and luminosity distance are the same as in general relativity. The relation between the gravitational-wave and electromagnetic-wave luminosity distance gets however modified for electromagnetism minimally coupled to the Jordan frame metric. Using effective field theory we show that the modified relation obtained for luminal theories is also valid for non-luminal theories with Jordan frame matter-gravity coupling. We generalise our analysis to a time-dependent speed of gravitational waves with matter minimally coupled to either the Jordan or Einstein frame metrics.

ArXiv: https://arxiv.org/abs/2302.05413

Shakeri, Soroush; Hajkarim, Fazlollah, *Probing axions via light circular polarization and event horizon telescope*, published in Journal of Cosmology and Astroparticle Physics, Volume 2023, Issue 04 on April 11, 2023.

The impact of axion-like particles on the light polarization around the horizon of supermassive black hole (SMBH) is discussed in the light of the latest polarization measurement of the Event Horizon Telescope (EHT). We investigate different sources of the polarization due to axion interaction with photons and the magnetic field of SMBH. These can modify the linear and circular polarization parameters of the emitted light. We have shown that a significant circular polarization can be produced via the photon scattering from the background magnetic field with axions as off-shell particles. This can further constrain the parameter space of ultralight axion-like particles and their couplings with photons. The future precise measurements of circular polarization can probe the features of ultralight axions in the near vicinity of SMBH.

DOI: 10.1088/1475-7516/2023/04/017

ICRANet Newsletter

June – July– August 2023

SUMMARY

1. ICRA-ICRANET press release *"GRB-SN Association within the Binary-Driven Hypernova Model"*

Long gamma-ray bursts (GRBs), in a few seconds, release luminosities (in gamma-rays) comparable to the luminosity of all stars in the observable Universe, which makes them detectable to the dawn of galaxy and stellar formation. One of the most striking observational properties of some of these sources is that they are accompanied by a supernova (SN) of type Ic, traditionally called GRB SN association or connection. The GRB-SN association, probably the most constraining property of GRB theoretical models, is the subject of a new article by an ICRA-ICRANet collaboration, accepted for publication in The Astrophysical Journal [ApJ, 955 (2023) 93]: https://doi.org/10.3847/1538-4357/ace721

SNe Ic are considered part of the so-called core-collapse SNe, thought to occur in the gravitational collapse of the iron core of an evolved star, forming a neutron star (NS). The outer layers are expelled because the energy released from the core collapse exceeds their binding energy. On the other hand, long GRBs are mostly thought to be related to events forming stellar-mass black holes (BHs). Therefore, it appears difficult to render the two above theories compatible to produce a GRB-SN by a single object. The new research deepens into this matter, highlighting observational and theoretical facts revealing the possible role of binaries in these sources. Indeed, it lists some facts that conspicuously evidence that most (if not all) GRB-SN should occur in binaries:

1. GRB-SN are related to massive star explosions; most massive stars belong to binaries. Therefore, most (if not all) GRB-SN progenitors are binary systems.
2. GRBs are associated with SNe Ic, which lack hydrogen (H) and helium (He), and most SN Ic models use the interaction with a binary companion to remove the H and He layers.
3. Stellar evolution predicts the direct formation of a BH only from zero-age main-sequence (ZAMS) stars above $25M_{\odot}$ and without a SN, while observed pre-SN stars are lighter than $18M_{\odot}$.

The article analyzes the SN emission in the optical wavelengths of 24 GRB-SN associations. The SN optical emission is thought to be powered by the decay of nickel into cobalt in the ejected material. The peak luminosity and time of occurrence of the SN are shown to be similar among the sources, spanning less than an order of magnitude difference. In contrast, the emission of the associated GRB spans nearly seven orders of magnitude! One should add this result to the above list: it does not seem simple for a single object to explain a cataclysmic event with these two simultaneous properties.

From the modeling viewpoint, the publication focuses on the binary-driven hypernova (BdHN) scenario. In the BdHN model, the GRB-SN event occurs in binary composed of a carbon-oxygen (CO) star and an NS companion. The core of the CO star collapses, generating a newborn NS and the supernova. The supernova triggers the GRB-observed episodes whose physical processes are scrutinized. The CO-NS fates explain the diversity of GRBs: BdHNe I are the most extreme with energies 10^{52}–10^{54} erg. Their orbital periods are about 5–10 minutes. In these sources, the material ejected in the SN is easily accreted by the NS companion, so it reaches the point of gravitational collapse, forming a rotating BH. In BdHNe II, the orbital period is 20–40 minutes and emit energies 10^{52}–10^{54} erg. The accretion is lower, so the NS remains stable. BdHN III have an orbital period of hours, and the accretion is negligible. They explain GRBs with energies lower than 10^{50} erg.

The new article features the BdHN frontier multimessenger physics and astrophysics: emission of neutrinos, gravitational waves, and electromagnetic radiation from the radio to the X-rays, to the gamma-rays, to the GeV, to the TeV, to ultra-high-energy cosmic rays (UHECRs). These occur in seven episodes, identified via time-resolved analysis of observational data, probing new physical ultrarelativistic regimes previously unknown in our galaxy. Attention is given to the first episode, the early SN explosion originating from the $10M_{\odot}$ CO core collapse (SN-rise), and to the second episode, the accretion of the SN ejecta on the νNS (νNS-rise). The BH formation occurs by accretion of the SN ejecta on the companion NS, rather than the direct massive star collapse, and originates the associated

MeV and GeV emission. The energetics are determined by the rotational energy extraction from a Kerr BH originating overcritical electromagnetic fields leading to an ultra-relativistic expanding e^+e^- plasma that loads baryons from the ambient and manifests when it reaches transparency in the third episode, the UPE (ultrarelativistic prompt emission).

The corresponding process in the under critical regimes occurring in a test electromagnetic field aligned with the BH rotation axis leads to the GeV emission, the fourth episode. The fifth Episode addressed the νNS emission with associated synchrotron emission in the X-rays, optical, and radio bands, followed by the sixth and seventh episodes given the Gamma-ray and X-ray flares. The optical radioactive decay of the SN ashes finally follows these seven episodes. Specific examples are given by the SPH simulations performed in collaboration with Los Alamos National Laboratory (see Fig. 1). The energetics of selected BdHNe types and the peak luminosity and time of the 24 SNe are compared and contrasted (see Fig. 2). The cases of two BdHNe I are analyzed in detail (GRB 180720B and GRB 190114C, see Fig. 3). For BdHNe II, the paper describes GRB190829A, and for BdHNe III, GRB171205A.

The unveiled details of the GRB episodes auspices a new era: to use the strongest high-energy sources on planet Earth, such as the European Hard X-ray Free Electron Laser (XFEL) operated by DESY at Hamburg and, for the TeV radiation, the *accelerators* of the European Organization for Nuclear Research (CERN) in Geneva, in order to perform the *diagnosis* of GRB physics.

Reference article:
"GRB-SN Association within the Binary-Driven Hypernova Model"; Aimuratov, Y.; Becerra, L. M.; Bianco, C. L.; Cherubini, C.; Della Valle, M.; Filippi, S.; Li, Liang; Moradi, R.; Rastegarnia, F.; Rueda, J. A.; Ruffini, R.; Sahakyan, N.; Wang, Y.; Zhang, S. R.; ApJ, 955 (2023) 93; DOI: https://doi.org/10.3847/1538-4357/ace721

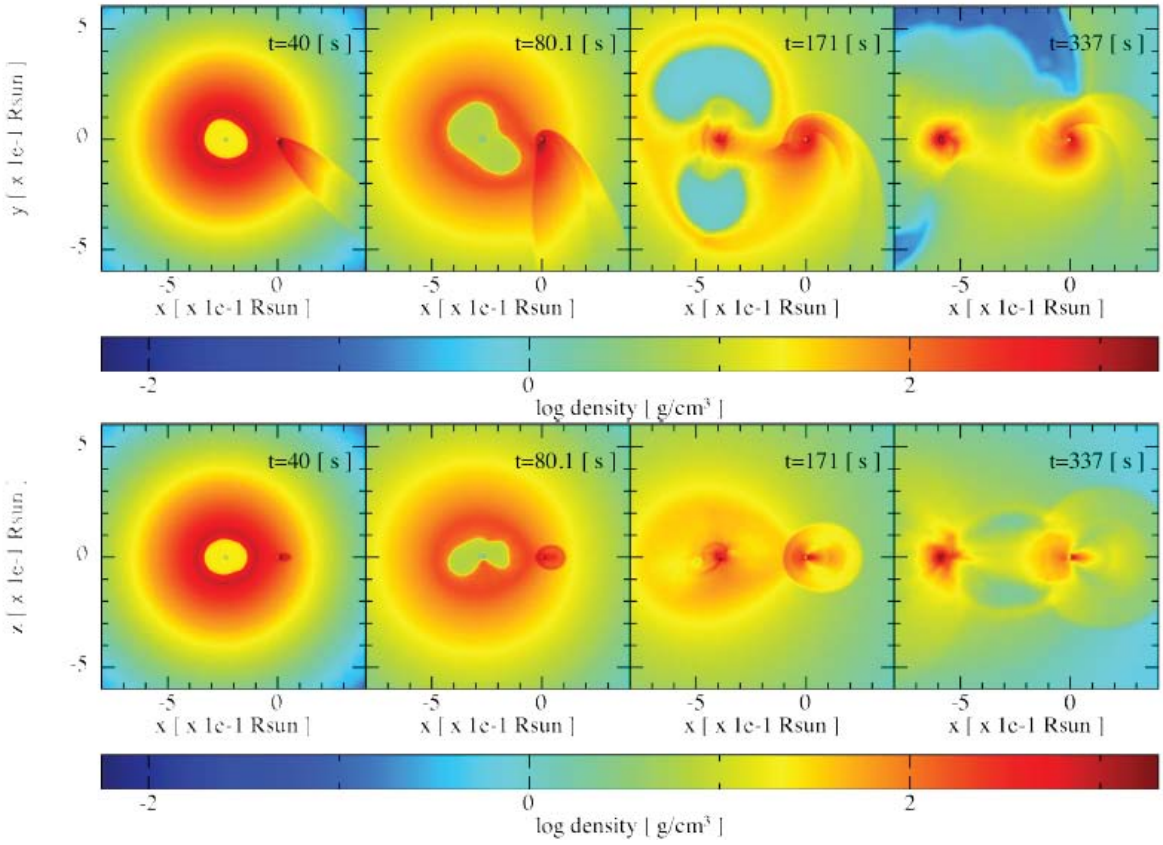


Fig. 1. SPH simulation of a BdHN I

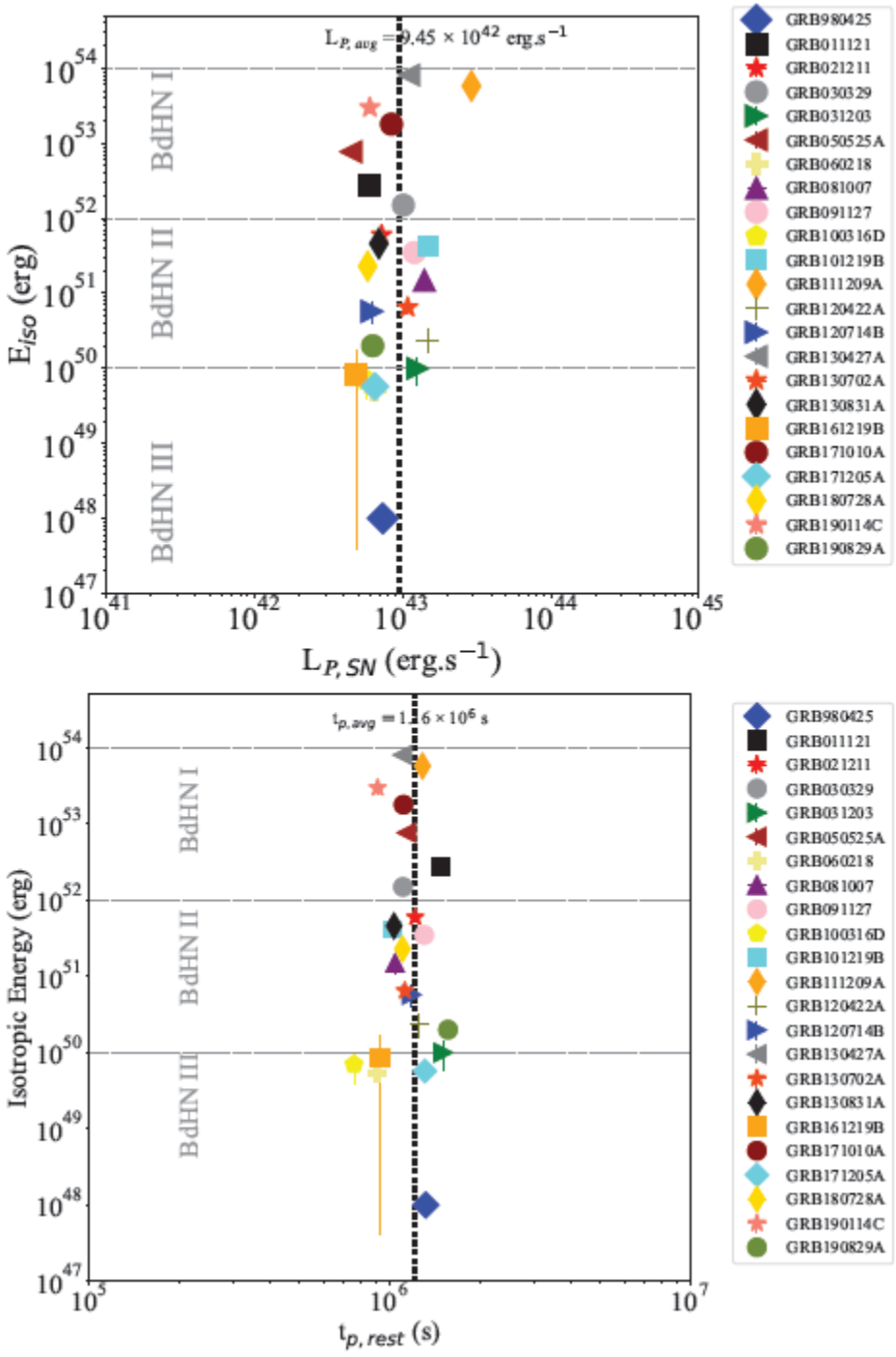


Fig. 2: Isotropic-equivalent energy of GRB versus the peak luminosity and time of the bolometric light curve of the associated SN.

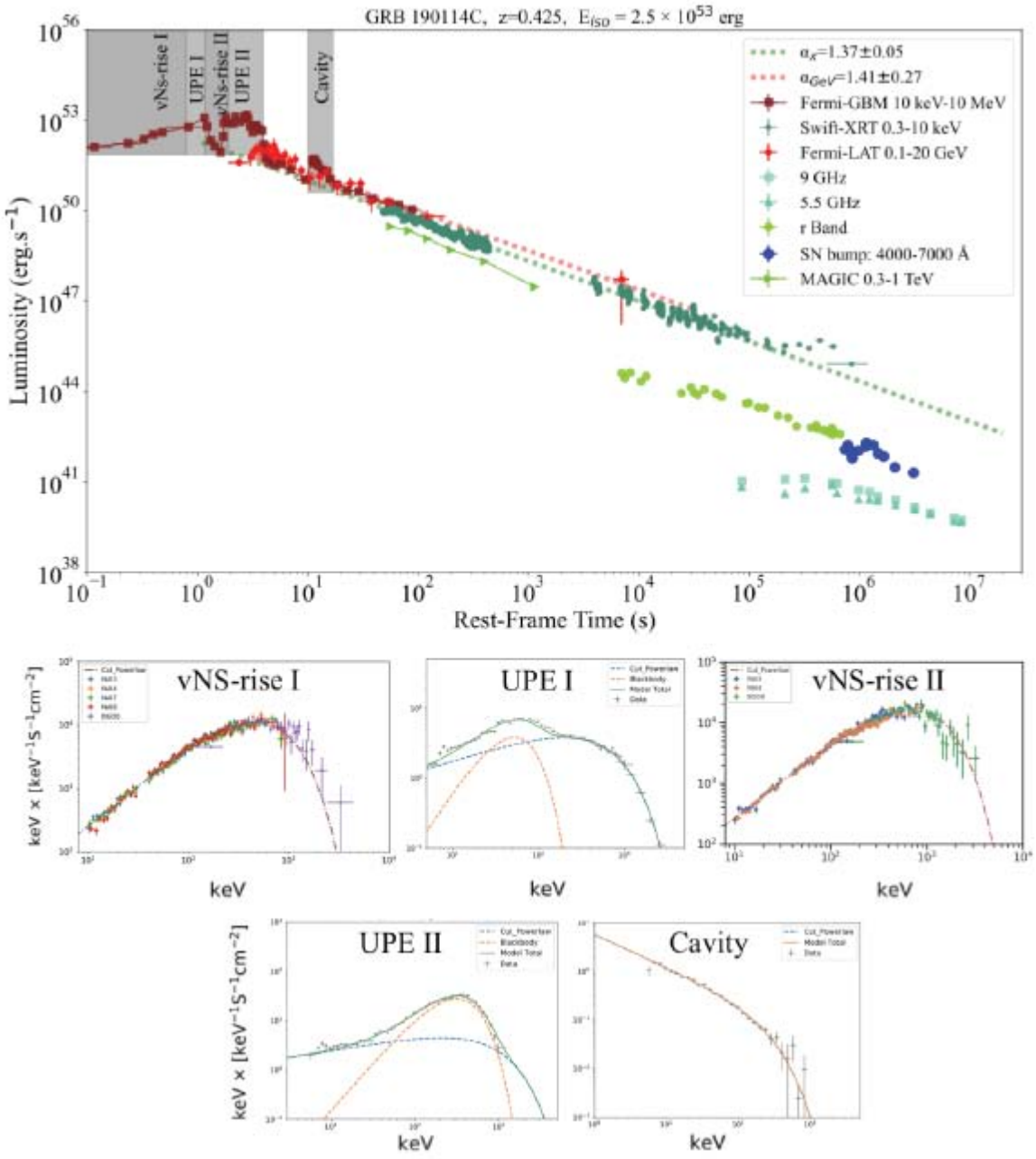


Fig. 3: The case of GRB 190114C.

2. The 5th Zeldovich meeting, June 12-16, 2023, Yerevan (Armenia)

The Fifth Zeldovich meeting, organized by ICRANet, is an international conference in honor of Ya. B. Zeldovich, which has been held in Ani Plaza Hotel in Yerevan (Armenia) from June 12 to 16, 2023. This event has also commemorated the 80th anniversary of the National Academy of Sciences of the Republic of Armenia, whose members gave equally fundamental contributions to the field of Relativistic Astrophysics.

Fig. 2: the 5th Zeldovich meeting audience in presence.

Fig. 3: Photo collage of the 5th Zeldovich meeting speakers.

The meeting started on Monday morning, June 12 with the opening remarks by Prof. Remo Ruffini (Director of ICRANet), Prof. Narek Sahakyan (Director of ICRANet Armenia) and H.E. Hakob Arshakyan, Vice President of the Armenian National Assembly, at the presence of eminent authorities, such as H. E. Vahe Gevorgyan, Deputy Minister of Foreign affairs of Armenia, H. E. Ashot Saghyan, President of the Armenian National academy of Sciences, H.E. Avet Poghosyan, Deputy Minister of High-Tech Industry of Armenia, H.E. Alfonso Di Riso, Ambassador of Italy in Armenia, as well as Ms. Nilakshi Saha Sinha, Ambassador of India in Armenia.

H.E Arshakyan underlined how Armenia is historically rich in scientific achievements and discoveries, especially in the fields of astrophysics, mathematics and physics. He also emphasized the strong participation of Armenian scientific institutions in similar programs and the leading role played by the Armenian National Academy of Sciences in the field. Deputy Minister Vahe Gevorgyan highlighted the role of ICRANet as an important platform for international cooperation and noted how the organization of this prestigious international conference is an important step for the development of the field of astrophysics not only in Armenia, but also in all participating countries.

Fig. 4, 5, 6 and 7: Prof. Remo Ruffini, Director of ICRANet (top left), Prof. Narek Sahakyan, Director of ICRANet Armenia (top right), H.E. HakobArshakyan, Vice President of the Armenian National Assembly (bottom left) and H. E. Vahe Gevorgyan, Deputy Minister of Foreign affairs of Armenia (bottom right), during the opening ceremony of the 5thZeldovich meeting in Yerevan on June 12, 2023.

Fig. 8: Prof. Remo Ruffini presenting to Prof. Marat Glifanov the MG16 Marcel Grossmann Award on behalf of the Russian Academy of Sciences Institute of Space Research.

Fig. 9: Prof. Remo Ruffini greeting H.E. Vahagn Khachaturyan, President of the Republic of Armenia, on the occasion of their meeting on June 14, 2023.

During the opening ceremony, the Russian scientist Marat Glifanov accepted the MG16 Marcel Grossmann Award on behalf of the Institute of Space Research (IKI) of the Russian Academy of Sciences. The award was presented by ICRANet Director Remo Ruffini for the Spektr-RG/eROSITA satellite.

More than 100 participants from 17 different countries joined the conference and presented, in total, 75 talks on the most relevant recent results on multimessanger astrophysics, early universe, large scale structure, cosmic microwave background, neutron stars, black holes, gamma-ray bursts, supernovae, hypernovae, gravitational waves and quantum and gravity. New results on the leading space projects from space based and ground based astrophysical observatories were also reported, such as: the James Webb Space Telescope JWST (USA), presented by Prof. Massimo Stiavelli and Prof. Garth Illingworth; the radio telescope FAST (China), the X-ray observatory Insight-HXMT (China) as well as the high energy particle observatory LHAASO (China), presented for the first time by Prof. Zha Min, Prof. Li Di and Prof. Shuang-Nan Zhang; the Cherenkov telescopes MAGIC (Germany), the gamma-ray telescope DAMPE (China and Italy), the X-ray polarimeter IXPE (USA and Italy), the X-ray observatory Spektr-RG (Russia and Germany, presented by Prof. Rashid Sunyaev and Prof. Marat Gilfanov of the Russian Academy of Sciences), the network of robotic telescopes MASTER (Russia), the neutrino

observatories ICECube (Antarctica) and the Baikal-GVD (Russia) as well as planned missions eXTP (enhanced X-ray Timing and Polarimetry mission) and German-Brazilian-Italian ground-based gamma-ray telescope SWGO.

On the occasion of the conference, the President of the Republic of Armenia H.E. Vahagn Khachaturyan received on Wednesday, June 14 a delegation of participants and organizers of the 5thZeldovich meeting. This delegation was composed ofProf. Remo Ruffini, Prof. Narek Sahakyan, Academician Ashot Saghyan (President of the NAS RA), Prof. Shuang-Nan Zhang (Center for Particle Astrophysics, Institute of High Energy Physics, CAS), Prof. Di Li (National Astronomical Observatories, Chinese Academy of Sciences), Prof. Tsvi Piran (the Hebrew University of Jerusalem), Prof. Paolo Soffitta (INAF IAPS) and Prof. Alexei Starobinsky (Landau Institute for Theoretical Physics RAS). President Khachaturyan highly valued the organization of such events and expressed his willingness to support programs and initiatives in the field of science to the best of his ability, stressing the importance of ICRANet activities in Armenia. Prof. Ruffini welcomed cooperation with Armenia and noted that there is an intention to implement new programs with the countries of Central Asia via Armenia. All the interlocutors discussed possibilities of the implementation of joint programs and further deepening of cooperation with the world's leading centers, organizations, and universities, such as ICRANet.

Fig. 10: H.E. Vahagn Khachaturyan, President of the Republic of Armenia, meeting the 5thZeldovich meeting delegation, together with representatives from the italian Embassy in Yerevan on June 14, 2023.

Fig. 11: Group photo of the 5thZeldovich meeting delegation with the President of Armenia. From the left to the right: Prof. Alexei Starobinsky, Prof. Narek Sahakyan, Prof. Shuang-Nan Zhang, Prof. Remo Ruffini, H.E. Vahagn Khachaturyan, Prof. Di Li, Prof. Tsvi Piran, Prof. Paolo Soffitta, Prof. Vahram Dumanyan (Adviser to the President Khachaturyan) and Academician Ashot Saghyan.

All the abstracts submitted for the conference have been collected in the book of abstracts, available on the conference website at the following link: https://indico.icranet.org/event/6/book-of-abstracts.pdf

The concluding remarks, summarizing the new and important scientific results presented along the meeting, have been made by Prof. Remo Ruffini as well as by Prof. Narek Sahakyan.

The proceedings of the 5thZeldovich meeting will be published in the refereed journal Astronomy Reports, the leading Russian journal on Astronomy and Astrophysics with high impact factor (for the website of the journal: https://www.springer.com/journal/11444). The editors will be Prof. Remo Ruffini, Prof. Narek Sahakyan and Prof. Gregory Vereshchagin.

This meeting was the fifth international conference dedicated to Ya. B. Zeldovich. The previous meetings were held from April 23 to 27, 2018 in Minsk, from April 20 to 23, 2009 in Minsk (jointly organized by ICRANet and the Belarusian State University BSU, celebrating also the 2009 Year of Astronomy), from March 11 to 14, 2014 (celebrating 100thanniversary of Ya. B. Zeldovich) and from September 7 to 11, 2020 online.

The recordings of all the sessions are available on ICRANet YouTube channel at the following link:https://www.youtube.com/watch?v=cQuXRbnJ6o4&list=PLr5RLbSWSonvawHlYpDVmRJIUoPHtopw7

For the website of the meeting and the speakers' presentations:http://www.icranet.org/zeldovich5

For the press release on the website of the National Assembly of the Republic of Armenia: http://www.parliament.am/news.php?cat_id=2&NewsID=18950&year=2023&month=06&day=12&lang=arm&enc=utf8

For the press release on the website of the Public Radio of Armenia: https://en.armradio.am/2023/06/12/eminent-astronomers-and-astrophysicists-in-yerevan-for-5th-international-zeldovich-conference/

For the press release on the website Armen Press: https://armenpress.am/eng/news/1113073/

For the press release on the NAS RA website:https://www.sci.am/m/newsview.php?id=706&arch=&langid=2

For the press release on the website of the President of the Republic of Armenia: https://www.president.am/en/press-release/item/2023/06/14/President-Vahagn-Khachaturyan/

For the video on the YouTube channel of the Armenian Parliament: https://www.youtube.com/watch?v=foQYriAY0Ck&t=107s

3. The 18th Italian- Korean Symposium (IK18), June 19 – 23, 2023, Pescara (Italy)

The 18th Italian-Korean Symposium on Relativistic Astrophysics has been held from June 19 to 23, 2023 at ICRANet center in Pescara and online.The meeting has been co organized by Kunsan National University, CQUeST and Sogang University (on the Korean side) and, on the italian side, by ICRANet. The Italian-Korean Symposia on Relativistic Astrophysics is a series of biannual meetings, alternatively organized in Italy and in Korea since 1987. The main purpose of this symposium is to accelerate the exchange between scientists of Italy and Korea, especially young researchers.

Members of the IK18 Italian Committee are Remo Ruffini (Director of ICRANet, ICRA), Carlo Luciano Bianco (ICRA, ICRANet), Massimo Della Valle (Capodimonte Astronomical Observatory, INAF, ICRANet), Luca Izzo (Capodimonte Astronomical Observatory, INAF), Paolo Giommi (ASI), Roy Patrick Kerr (ICRANet), Liang Li (ICRANet), Rahim Moradi (ICRANet), Jorge A. Rueda H. (ICRANet, University of Ferrara), Narek Sahakyan (Director of ICRANet center in Armenia), Gregory Vereshchagin (ICRANet), Yu Wang (ICRANet) and Shesheng Xue (ICRANet). Members of IK18 Korean Committee are Stefano Scopel (CQUeST, Sogang University), Bum-Hoon Lee (CQUeST, Sogang University), Sang Pyo Kim (Kunsan National University), Sung-WonKin (Ehwa University), Wonwoo Lee (CQUeST, Sogang University), Hyeong Chan Kim (AIP) and Lee Heongwon.

The topics addressed during the IK symposia have been, traditionally, astrophysics and cosmology, gamma-ray bursts, compact starts high energy cosmic rays, dark energy and dark matter, general relativity, black holes and new physic related to cosmology. This year, the focus has been on the irriducible mass, the gravitational wave emission from GRBs as well as the ellipsoidal configurations of equilibrium in General Relativity. The most recent scientific developments were presented by eminent Professors and researchers.

The opening remarks have been presented by Prof. Remo Ruffini and Prof. Stefano Scopel. The speakers were Prof. Dong-Hoon Kim, Prof. Wonwoo Lee, Prof. Sang Pyo Kim, Prof. Stefano Scopel, Prof. Dong-hun Lee, Prof. Chanyong Park, Prof. Chan Park, Prof. Bum-Hoon Lee, Prof. Sung-Won Kim, Prof. Remo Ruffini, Prof. Carlo Luciano Bianco, Prof. Gregory Vereshchagin, Prof. Massimo Della Valle, Prof. Lorenzo Amati, Prof. JorgeRueda, Prof. Rahim Moradi, Prof. Yu Wang, Prof. Antonio Enea Romano, Shurui Zhang, Dr Josè Fernando Rodriguez Ruiz, Prof. Shesheng Xue, Prof. Muhammad Sharif and Abdel Nasser Tawfik.

For more information about the meeting, please see:https://indico.icranet.org/event/7/

4. ICRANet participation at the *"XV International Conference on Gravitation, Astrophysics and Cosmology (ICGAC15)"*, July 3-7, 2023, APCTP, Gyeongju (South Korea)

On July 7, 2023, Prof. Ruffini (Director of ICRANet) has been invited to present a plenary lecture on the occasion of the 2023 edition of the International Conference on Gravitation, Astrophysics and Cosmology (ICGAC15), held in Gyeongju (South Korea) and online from July 3 to 7, 2023.

On Friday July 7, Prof. Ruffini presented his plenary lecture titled *"GRB 220101A: the most powerful GRB with seven BdHN Episodes observed"*.

Prof. Ruffini was also a member of ICGAC15 International Standing Committee, International Advisory Committee and Scientific Committee.

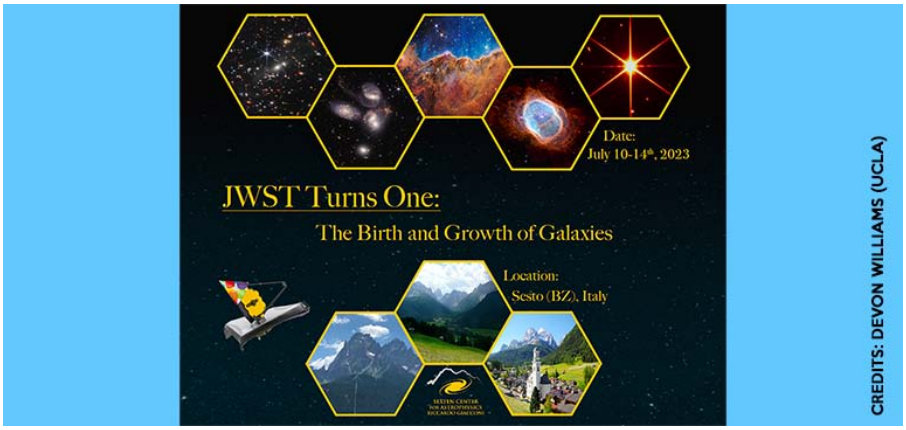
ICGAC is the series of triennial conferences on Gravitation, Astrophysics and Cosmology which take place in the Asia-Pacific region, with the goals to promote cooperation among the member countries and within an international context, high level studies on hot topics and to encourage young physicists on these fields. This conference has been one of the key programs sponsored by APCTP over the past twenty years and has been hosted by AP regions: Seoul, Korea (1993); Hsinchu, Taiwan (1995); Tokyo, Japan (1997); Beijing, China (1999); Moscow, Russia (2001); Seoul, Korea (2003); Jhongli, Taiwan (2005); Nara, Japan (2007); Wuhan, China (2009); Qui-Nhon, Vietnam (2011); Almaty, Kazakhstan (2013); Moscow, Russia (2015), Seoul, Korea (2017) and Taiwan (2020).

The main topics covered during the ICGAC15 meeting included classical Gravity and GR Extensions, Classical and Quantum Cosmology, Dark Matter and Dark Energy, Black Holes, Wormholes, Strings, Branes, Higher Spin Fields and Quantum Gravity, extra Dimensions and Variation of Constants, Experimental Studies of Gravity and Fundamental Physics Space Projects, Gravitational Waves, Multi

Messenger Astronomy, Numerical Relativity, Relativistic Astrophysics, White Dwarfs, Neutron Stars and Gamma Ray Bursts, Alternative Theory and Education.

For the website of the meeting: https://www.apctp.org/theme/d/html/activities/activities01_read-pop.php?id=1801&m_id=212

5. ICRANet participation at the meeting *"The James Webb Space Telescope turns one: the birth and growth of galaxies"*, July 10-14, 2023, Sesto (Italy)



On July 10, 2023, Prof. Remo Ruffini (Director of ICRANet) took part in opening day of the meeting *"The James Webb Space Telescope turns one: the birth and growth of galaxies"*, which has been held from July 10 to 14 in the Sexten Center for Astrophysics Riccardo Giacconi (Italy)

One year after the release of the first data of the James Webb Space Telescope, the meeting aimed to gather relevant scientist, researchers and students to discuss the transformative science enabled by Webb's observations in the field of galaxy formation and evolution, from its earliest stages to more mature phases in cosmic history. The main topics covered during the meeting were the process from the first stars to the current star formation, the dust and circum-galactic medium in distant galaxies, the reionization history, the galaxy mass growth and early morphological evolution, as well as the AGN activity at high redshift.

After the opening ceremony, the first day of the meeting was mainly devoted to a presentation on the status and the overview of results of the JWST, as well as on the first results on Early galaxy formation and evolution from the JWST surveys.

For the website of the meeting: https://www.sexten-cfa.eu/event/jwebb23/

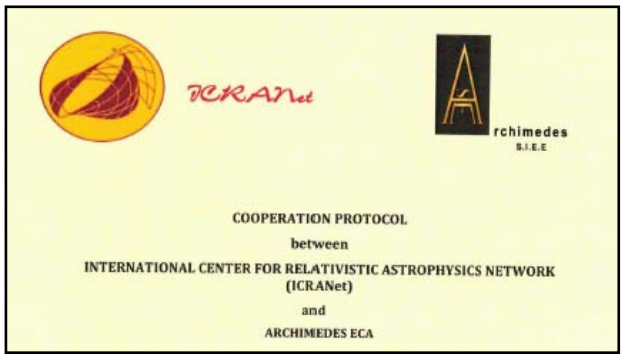
6. New cooperation protocol between ICRANet and Epoka University, June 9, 2023

On June 9, 2023ICRANet has signed a new Cooperation protocol with the Epoka University in Albania. The Cooperation Protocol has been signed by Prof. Ahmet Öztaş (Rector of Epoka University), by Prof. Arban Uka (Epoka University), by Prof. Remo Ruffini (Director of ICRANet) and by Prof. Jorge A. Rueda (ICRANet Faculty Professor).

The agreement will be valid for 5 years and the main joint activities to be developed under their framework 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, the development of inter-institutional research areas associated to local graduate programs and joint publications.

For the text of the agreement:http://www.icranet.org/index.php?option=com_content&task=view&id=1493

7. New cooperation protocol between ICRANet and Archimedes ECA, July 31, 2023



On July 31, 2023 ICRANet has signed a new Cooperation protocol with the association Archimedes ECA in France. The Cooperation Protocol has been signed by Prof. Joseph Kouneiher (President of Archimedes ECA) and by Prof. Remo Ruffini (Director of ICRANet).

The agreement will be valid for 5 years and the main joint activities to be developed under their framework 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, the development of inter-institutional research areas associated to local graduate programs and joint publications.

For the text of the agreement: http://www.icranet.org/index.php?option=com_content&task=view&id=1499

8. Renewal of the cooperation protocol between ICRANet and the Universidade Federal da Paraíba (UFPB), June 7, 2023

On June 7, 2023, the Cooperation Protocol between ICRANet and the Universidade Federal da Paraíba (UFPB) has been renewed. The renewal was signed by Prof. Valdiney Neloso Gouveia (Rector of UFPB) and by Prof. Remo Ruffini (Director of ICRANet). This agreement will be valid for further 5 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 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, the development of inter-institutional research areas associated to local graduate programs and joint publications.

For the text of the agreement:http://www.icranet.org/index.php?option=com_content&task=view&id=1019

9. Seminar of Prof. Felix Mirabel at ICRANet center in Pescara, July 27, 2023

On Thursday, July 27, 2023, Prof. Felix Mirabel (IAFE-University of Buenos Aires and CEA-Saclay) presented a seminar titled *"Did Black hole-jets enhancedthe formation of Pop-III stars at cosmic dawn?"* with the following abstract:

The existence of supermassive black holes (SMBHs) of 10^9 solar masses in quasars at cosmic ages of less than 700 Myr is an intriguing puzzle. How the seeds of these SMBHs have formed and grown so fast to become so large? Models of the compact seeds of the SMBHs observed at redshifts z > 6 propose in the context of dark matter cosmologies those seeds are formed by direct collapse in dark matter haloes. I will show that recent high-z ALMA and JWST observations are consistent with the astrophysical hypotheses in those models. Finally, integrating those recent theoretical and observational contexts, with past extensive studies of the environments of BH-jets in the local and distant universe, I will conclude that the relativistic jets and associated massive outflows from rapidly growing BHs at cosmic dawn must have enhanced the formation of Pop-III massive stars.

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

For the video of the seminar:https://www.youtube.com/watch?v=H9_cGdVT35A

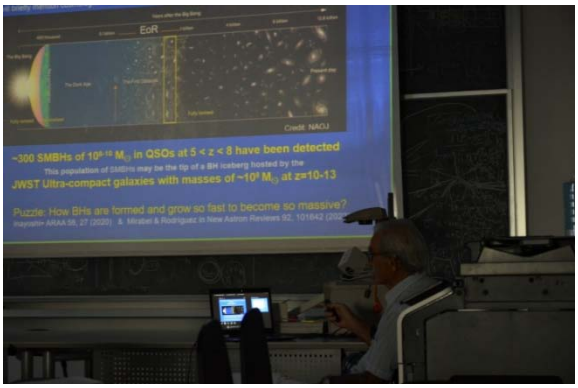


Fig. 12 and 13:Prof.Felix Mirabel giving his seminar at ICRANet center in Pescara, July 27, 2023.

10.Scientific visits to ICRANet

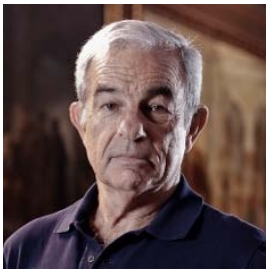
- Prof. Mohamed Gadri (University of Tripoli, Libya), June 6-11, 2023
- Prof. Stefano Scopel (Sogang University, South Korea), June 7-25, 2023
- Prof. Antonio Enea Romano (Universidad de Antioquia UDEA, Colombia), June 20 – July 5, 2023
- Dr Mikalai Prakapenia (ICRANet-Minsk and Belarusian State University), July 17-29, 2023

- Prof. Felix Mirabel (IAFE-University of Buenos Aires & CEA-Saclay, France), July 26 – August 8, 2023


Prof. Mohamed Gadri


Prof. Stefano Scopel


Dr Mikalai Prakapenia


Prof. Felix Mirabel

During their visit, those scientists had an opportunity to discuss their scientific research and to have fruitful exchange of ideas with other researchers from ICRANet and from different parts of the world.

11. Recent publications

Y. Aimuratov, L. M. Becerra, C.L. Bianco, C. Cherubini, M. Della Valle, S. Filippi, Liang Li, R. Moradi, F. Rastegarnia, J. A. Rueda, R. Ruffini, N. Sahakyan, Y. Wang, S. R. Zhang, *GRB-SN Association within the Binary-Driven Hypernova Model*, accepted for publication in The Astrophysical Journal.

The observations of supernovae (SNe) Ic occurring after the prompt emission of long gamma-ray bursts (GRBs) are addressed within the binary-driven hypernova (BdHN) model where GRBs originate from a binary composed of a $\sim 10 M_{\odot}$ carbon-oxygen (CO) star and a neutron star (NS). The CO core collapse gives the trigger, leading to a hypernova with a fast-spinning newborn NS (νNS) at its center. The evolution depends strongly on the binary period, P_{bin}. For P_{bin}∼5min, BdHNe I occur with energies 10^{52}-10^{54}erg. The accretion of SN ejecta onto the NS leads to its collapse, forming a black hole (BH) originating the MeV/GeV radiation. For P_{bin}∼10min, BdHNe II occur with energies 10^{50}-10^{52}erg and for P_{bin}∼hours, BdHN III occurs with energies below 10^{50}erg. {In BdHNe II and III,} no BH is formed. The 1-1000ms *ν*NS originates, in all BdHNe, the X-ray-optical-radio afterglows by synchrotron emission. The hypernova follows an independent evolution, becoming an SN Ic, powered by nickel decay, observable after the GRB prompt emission. We report 24 SNeIc associated with BdHNe. Their optical peak luminosity and time of occurrence are similar and independent of the associated GRBs. {From previously identified 380 BdHN I comprising redshifts up to z=8.2, we analyze} four examples with their associated hypernovae. By multiwavelength extragalactic observations, we identify seven new Episodes, theoretically explained, fortunately not yet detected in galactic sources, opening new research areas. Refinement of population synthesis simulations is needed to map the progenitors of such short-lived binary systems inside our galaxy.

ArXiv: https://doi.org/10.3847/1538-4357/ace721

Antonio Enea Romano, Mairi Sakellariadou, *Mirage of Luminal Modified Gravitational-Wave Propagation*, publish in Phys. Rev. Lett. 130, 231401 on June 8, 2023.

Using conformal invariance of gravitational waves, we show that for a luminal modified gravity theory, the gravitational-wave propagation and luminosity distance are the same as in general relativity. The relation between the gravitational-wave and electromagnetic-wave luminosity distance gets modified, however, for electromagnetism minimally coupled to the Jordan frame metric. Using effective field

theory we show that the modified relation obtained for luminal theories is also valid for nonluminal theories with Jordan frame matter-gravity coupling. We generalize our analysis to a time-dependent speed of gravitational waves with matter minimally coupled to either the Jordan or Einstein frame metrics.

DOI: https://doi.org/10.1103/PhysRevLett.130.231401

Laura M. Becerra, Chris Fryer, Jose F. Rodriguez, Jorge A. Rueda and Remo Ruffini, *Neutron Star Binaries Produced by Binary-Driven Hypernovae, Their Mergers, and the Link between Long and Short GRBs*, published in Universe 2023, 9(7), 332 on July 12, 2023.

The binary-driven hypernova (BdHN) model explains long gamma-ray bursts (GRBs) associated with supernovae (SNe) Ic through physical episodes that occur in a binary composed of a carbon-oxygen (CO) star and a neutron star (NS) companion in close orbit. The CO core collapse triggers the cataclysmic event, originating the SN and a newborn NS (hereafter νNS) at its center. The νNS and the NS accrete SN matter. BdHNe are classified based on the NS companion fate and the GRB energetics, mainly determined by the orbital period. In BdHNe I, the orbital period is of a few minutes, so the accretion causes the NS to collapse into a Kerr black hole (BH), explaining GRBs of energies $>10^{52}$ erg. BdHN II, with longer periods of tens of minutes, yields a more massive but stable NS, accounting for GRBs of 10^{50}–10^{52} erg. BdHNe III have still longer orbital periods (e.g., hours), so the NS companion has a negligible role, which explains GRBs with a lower energy release of $<10^{50}$ erg. BdHN I and II might remain bound after the SN, so they could form NS-BH and binary NS (BNS), respectively. In BdHN III, the SN likely disrupts the system. We perform numerical simulations of BdHN II to compute the characteristic parameters of the BNS left by them, their mergers, and the associated short GRBs. We obtain the mass of the central remnant, whether it is likely to be a massive NS or a BH, the conditions for disk formation and its mass, and the event's energy release. The role of the NS nuclear equation of state is outlined.

DOI: https://doi.org/10.3390/universe9070332

Jonas P. Pereira and Jorge A. Rueda, *Matching Slowly Rotating Spacetimes Split by Dynamic Thin Shells*, published in Universe 2023, 9(7), 305 onJune 24, 2023.

We investigated within the Darmois–Israel thin-shell formalism the match of neutral and asymptotically flat, slowly rotating spacetimes (up to second order in the rotation parameter) when their boundaries are dynamic. It has several important applications in general relativistic systems, such as black holes and neutron stars, which we exemplify. We mostly focused on the stability aspects of slowly rotating thin shells in equilibrium and the surface degrees of freedom on the hypersurfaces splitting the matched slowly rotating spacetimes, e.g., surface energy density and surface tension. We show that the stability upon perturbations in the spherically symmetric case automatically implies stability in the slow rotation case. In addition, we show that, when matching slowly rotating Kerr spacetimes through thin shells in equilibrium, the surface degrees of freedom can decrease compared to their Schwarzschild counterparts, meaning that the energy conditions could be weakened. The frame-dragging aspects of the match of slowly rotating spacetimes are also briefly discussed.

DOI: https://doi.org/10.3390/universe9070305

Vitaliy Kim, Adel Umirbayeva and YerlanAimuratov, *Estimates of the Surface Magnetic Field Strength of Radio Pulsars*, published in Universe 2023, 9(7), 334 on July 14, 2023.

We investigate the geometry of the magnetic field of rotation-powered pulsars. A new method for calculating an angle (β) between the spin and magnetic dipole axes of a neutron star (NS) in the ejector stage is considered within the frame of the magnetic dipole energy loss mechanism. We estimate the surface magnetic field strength (Bns) for a population of known neutron stars in the radio pulsar (ejector) stage. The evaluated $B_{ns}(\beta)$ may differ by an order of magnitude from the values without considering the angle β. It is shown that $B_{ns}(\beta)$ lies in the range 10^8–10^{14}G for a known population of short and middle periodic radio pulsars.

DOI: https://doi.org/10.3390/universe9070334

Mikalai Prakapenia, Gregory Vereshchagin, *Pauli blocking effects on pair creation in strong electric field*, published in Phys. Rev. D 108, 013002 on July12, 2023.

The process of electron-positron pair creation and oscillation in a uniform electric field is studied, taking into account the Pauli exclusion principle. Generally, we find that pair creation is suppressed; hence, coherent oscillations occur on longer timescales. Considering pair creation in already existing electron-positron plasma, we find that the dynamics depends on pair distribution function. We considered Fermi-Dirac distribution of pairs and found that for small temperatures pair creation is suppressed, while for small chemical potentials it increases: heating leads to enhancement of pair creation.

DOI: https://journals.aps.org/prd/abstract/10.1103/PhysRevD.108.013002

Roohollah Mohammadi, Jafar Khodagholizadeh, Mahdi Sadegh, Ali Vahedi, She-sheng Xue, *Cross-correlation Power Spectra and Cosmic Birefringence of the CMB via Photon-neutrino Interaction*, published in JCAP 06 (2023) 044 onJune 20, 2023.

In the context of the standard model of particles, the weak interaction of cosmic microwave background (CMB) and cosmic neutrino background (CνB), can generate non-vanishing TB and EB power spectra in the order of one loop forward scattering, in the presence of scalar perturbation, which is in contrast with the standard scenario cosmology. Comparing our results with the current experimental data may provide, significant information about the nature of CνB, including CMB-CνB forward scattering for TB, TE, and EB power spectra. To this end, different cases were studied, including Majorana CνB and Dirac CνB. On the other hand, it was shown that the mean opacity due to cosmic neutrino background could behave as an anisotropic birefringent medium and change the linear polarization rotation angle. Considering the contributions from neutrino and anti-neutrino forward scattering with CMB photons (in the case of Dirac neutrino), we introduce relative neutrino and anti-neutrino density asymmetry ($\delta\nu = \Delta n_\nu/n_\nu = n_\nu\text{-}n_{\bar{\nu}}/n_\nu$). Then, using the cosmic birefringence angle reported by the Planck data release $\beta = 0.30° \pm 0.11°$ (68%*C.L.*), some constraints can be put on $\delta\nu$. Also, the value of cosmic birefringence due to Majorana CνB medium is estimated at about $\beta|_\nu \simeq 0.2$ rad. In this respect, since Majorana neutrino and anti-neutrino are exactly the same, both CB contributions will be added together. However, this value is at least two orders larger than the cosmic birefringence angle reported by the Planck data release, $\beta = 0.30° \pm 0.11°$ (68%*C.L.*). Finally, we shortly discussed this big inconsistency. It is noteworthy that to calculate the contribution of photon-neutrino forward scattering for cosmic birefringence, we just consider the standard model of particles and the standard scenario of cosmology.

DOI: https://doi.org/10.1088/1475-7516/2023/06/044

She-Sheng Xue, *Massive particle pair production and oscillation in Friedman Universe: reheating energy and entropy, and cold dark matter*, published in Eur. Phys. J. C (2023) 83: 355.

Suppose that the early Universe starts with a cosmological Λ-term originating from quantum spacetime at the Planck scale. Dark energy drives inflation and reheating by reducing its value for massive

particle-antiparticle pairs production and oscillation, resulting in a holographic and massive pair plasma state. The back-and-forth reaction of dark energy and massive pairs slows inflation to its end and starts reheating by rapidly producing stable and unstable pairs. We introduce the Boltzmann-type rate equation describing the back-and-forth reaction. It forms a close set with Friedman equations and reheating equations for unstable pairs decay to relativistic particles. The numerical solutions show preheating, massive pairs dominated and genuine reheating episodes. We obtain the reheating temperature and entropy in terms of the tensor-to-scalar ratio $0<r<0.047$ consistently with observations. Stable massive pairs represent cold dark matter particles and weakly interact with dark energy. The resultant cold dark matter abundance $\Omega_c \sim 10^{-1}$ is about a constant in time.

ArXiv: https://arxiv.org/abs/2006.15622

Argüelles, C. R.; Boshkayev, K.; Krut, A.; Nurbakhyt, G.; Rueda, J. A.; Ruffini, R.; Uribe-Suárez, J. D.; Yunis, R., *On the growth of supermassive black holes formed from the gravitational collapse of fermionic dark matter cores,* published in Monthly Notices of the Royal Astronomical Society, Volume 523, Issue 2 on August 2023.

Observations support the idea that supermassive black holes (SMBHs) power the emission at the centre of active galaxies. However, contrary to stellar-mass BHs, there is a poor understanding of their origin and physical formation channel. In this article, we propose a new process of SMBH formation in the early Universe that is not associated with baryonic matter (massive stars) or primordial cosmology. In this novel approach, SMBH seeds originate from the gravitational collapse of fermionic dense dark matter (DM) cores that arise at the centre of DM haloes as they form. We show that such a DM formation channel can occur before star formation, leading to heavier BH seeds than standard baryonic channels. The SMBH seeds subsequently grow by accretion. We compute the evolution of the mass and angular momentum of the BH using a geodesic general relativistic disc accretion model. We show that these SMBH seeds grow to $\sim 10^{9}$–$10^{10} M_{\odot}$ in the first Gyr of the lifetime of the Universe without invoking unrealistic (or fine-tuned) accretion rates.

DOI: https://doi.org/10.1093/mnras/stad1380

B. Eslam Panah, *Three-dimensional energy-dependent C-metric: black hole solutions,* published in Physics Letters Bon August 19, 2023.

Considering a three-dimensional *C*-metric and adding energy-dependent to this spacetime, we first create a three-dimensional energy-dependent *C*-metric. Then, we extract accelerating BTZ black hole solutions in gravity's rainbow. Besides, we show that (A)dS black holes cover by an event horizon that depends on all the parameters of this theory. Using the definition of Hawking temperature, we obtain the temperature of these black holes and study the effects of various parameters on this quantity. We find a critical radius in which the temperature is always positive (negative) before (after) it. Then, we obtain the entropy of such black holes. Our analysis indicates that there is the same behavior for entropy, similar to the temperature. Indeed, before (after) the critical radius, the entropy is positive (negative). In order to study the local stability of such black holes, we calculate the heat capacity. We find two different behaviors for the heat capacity, which depend on the cosmological energy-dependent constant. As a final result, accelerating AdS BTZ black holes can satisfy the physical condition and local stability at the same time.

DOI: https://doi.org/10.1140/epjp/s13360-023-04339-w

Li Liang, *Revisiting the Spectral Energy Correlations of GRBs with Fermi Data. I. Model-wise Properties,* published in The Astrophysical Journal Supplement Series, Volume 266, Number 2 on June 5, 2023.

Gamma-ray bursts (GRBs) exhibit a diversity of spectra. Several spectral models (e.g., Band, cutoff power law (CPL), and blackbody) and their hybrid versions (e.g., Band+blackbody) have been widely used to fit the observed GRB spectra. Here, we attempt to collect all the bursts detected by Fermi/GBM with known redshifts from 2008 July to 2022 May, having been motivated to (i) provide a parameter catalog independent of the official Fermi/GBM team and (ii) achieve a "clean" model-based GRB spectral energy correlation analysis. A nearly complete GRB sample is created, containing 153 such bursts (136 long GRBs and 17 short GRBs). Using the sample and by performing detailed spectral analysis and model comparisons, we investigate two GRB spectral energy correlations: the correlation of the cosmological rest-frame peak energy ($E_{p,z}$) of the νF_ν prompt emission spectrum with (i) the isotropic-bolometric-equivalent emission energy $E_{\gamma,iso}$ (the Amati relation) and (ii) the isotropic-bolometric-equivalent peak luminosity $L_{p,iso}$ (the Yonetoku relation). From a linear regression analysis, a tight correlation between $E_{p,z}$ and $E_{\gamma,iso}$ (and $L_{\gamma,iso}$) is found for both Band-like and CPL-like bursts (except for CPL-like long burst $E_{p,z}$–$E_{\gamma,iso}$ correlation). More interestingly, CPL-like bursts do not fall on the Band-like burst Amati and Yonetoku correlations, suggesting distinct radiation processes, and pointing to the fact that these spectral energy correlations are tightly reliant on the model-wise properties.

DOI: https://doi.org/10.3847/1538-4365/acc867

Gómez, Gabriel; Rodríguez, José F., ***New non-Abelian Reissner-Nordström black hole solutions in the generalized SU(2) Proca theory and some astrophysical implications,*** **published in Phys. Rev. D 108, 024069 on July 31, 2023.**

The generalized SU(2) Proca theory is a vector-tensor theory of gravity whose action is invariant under global transformations of the SU(2) group and includes second-order derivative self-interactions of the vector field beyond the massive Yang-Mills theory. We find, in particular, that the presence of two Lagrangian pieces consisting of four gauge fields minimally coupled to gravity gives rise to an exact Reissner-Nordström black hole solution endowed with two different non-Abelian effective charges that depend on the specific combination $\chi=2\chi 1+\chi 2$ of the respective coupling constants. After studying the spacetime structure of the black hole, which allows us to characterize the parameter space that preserves the weak cosmic censorship conjecture, some astrophysical implications of the black hole solutions are investigated. First, joint analysis of observations of the Event Horizon Telescope's first images of Sagittarius A$\star$ of our Galaxy and the Keck telescope set the first serious constraint on the free parameters of the theory beyond the theoretical bounds found. Second, we investigate the accretion properties of spherical steady flows around this class of non-Abelian Reissner-Nordström black hole. Specifically, we examine the general conditions under which transonic flow is allowed. An analytical solution for critical accretion is found in terms of the coupling constant. In addition, we explore the effect of changing χ on the radial velocity and mass density numerically and show how the extremal Reissner-Nordström and the standard Schwarzschild solutions as limit cases are achieved. Finally, working in the fully relativistic regime, an analytical expression for the critical mass accretion rate of a polytropic fluid onto a black hole is derived. As a main result, we find that the critical accretion rate efficiency can be noticeably improved compared to the Schwarzschild case for a specific region of the parameter space where the non-Abelian charge becomes imaginary.

DOI: https://doi.org/10.1103/PhysRevD.108.024069

ICRANet Newsletter

September– October2023

SUMMARY

- *The paper "GRB-SN Association within the Binary-Driven Hypernova Model" by Aimuratov at al., published in ApJ, 955 (2023) 93 on October 1, 2023*
- *ICRA-ICRANet press release "A New Predicted Class of Astrophysical Sources: White Dwarf Binary Mergers Poised for Discovery at The Vera Rubin Observatory", November 2, 2023*
- *ICRANet GCN 34779, September 28, 2023*
- *Visit of H.E. Giancarlo Di Vincenzo, Prefect of Pescara, to the ICRANet center in Pescara, October 12, 2023*
- *The European Researchers' Night, September 29, 2023*
- *Prof. Ruffini European XFEL Science Seminar, XFEL Hamburg (Germany), September 12, 2023*
- *ICRANet participation at the VIII Leopoldo Garcia-Colin Mexican Meeting on Mathematical and Experimental Physics, October 23-27, 2023, Mexico City (Mexico)*
- *Dedication of the ICRANet Hq building to Carlo Pace, Pescara (Italy), October 28, 2023*
- *New cooperation protocol between ICRANet and University of South China, September 28, 2023*
- *Renewal of 5 ICRANet cooperation agreements with National Academy of Sciences of Belarus (NASB), University of Tirana, Universidade Federal Fluminense (UFF), Universidade Federal de Itajubà (UNIFEI) and Instituto Tecnológico de Aeronáutica (ITA)*
- *Scientific visits to ICRANet*
- *Recent publications*

1. The paper "GRB-SN Association within the Binary-Driven Hypernova Model" by Aimuratov at al., published in ApJ, 955 (2023) 93 on October 1, 2023

The Astrophysical Journal, 955:93 (29pp), 2023 October 1 https://doi.org/10.3847/1538-4357/ace721

GRB-SN Association within the Binary-driven Hypernova Model

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Abstract

Observations of supernovae (SNe) Ic occurring after the prompt emission of long gamma-ray bursts (GRBs) are addressed within the binary-driven hypernova (BdHN) model where GRBs originate from a binary composed of a $\sim 10 M_{\odot}$ carbon–oxygen (CO) star and a neutron star (NS). The CO core collapse gives the trigger, leading to a hypernova with a fast-spinning newborn NS (νNS) at its center. The evolution depends strongly on the binary period, $P_{\rm bin}$. For $P_{\rm bin} \sim 5$ min, BdHNe I occur with energies 10^{52}–10^{54} erg. The accretion of SN ejecta onto the NS leads to its collapse, forming a black hole (BH) originating the MeV/GeV radiation. For $P_{\rm bin} \sim 10$ min, BdHNe II occur with energies 10^{50}–10^{52} erg and for $P_{\rm bin} \sim$ hours, BdHNe III occur with energies below 10^{50} erg. In BdHNe II and III, no BH is formed. The 1–1000 ms νNS originates, in all BdHNe, the X-ray-optical-radio afterglows by synchrotron emission. The hypernova follows an independent evolution, becoming an SN Ic, powered by nickel decay, observable after the GRB prompt emission. We report 24 SNe Ic associated with BdHNe. Their optical peak luminosity and time of occurrence are similar and independent of the associated GRBs. From previously identified 380 BdHN I comprising redshifts up to $z = 8.2$, we analyze four examples with their associated hypernovae. By multiwavelength extragalactic observations, we identify seven new episodes, theoretically explained, fortunately not yet detected in Galactic sources, opening new research areas. Refinement of population synthesis simulations is needed to map the progenitors of such short-lived binary systems inside our galaxy.

Unified Astronomy Thesaurus concepts: Gamma-ray bursts (629)

Reference article:

Y. Aimuratov, L. M. Becerra, C.L. Bianco, C. Cherubini, M. Della Valle, S. Filippi, Liang Li, R. Moradi, F. Rastegarnia, J. A. Rueda, R. Ruffini, N. Sahakyan, Y. Wang, S. R. Zhang, GRB-SN Association within the Binary-Driven Hypernova Model, ApJ, 955 (2023) 93; DOI: https://doi.org/10.3847/1538-4357/ace721

For more details, please see the previous issue of ICRANet newsletter.

2. ICRA-ICRANet press release *"A New Predicted Class of Astrophysical Sources: White Dwarf Binary Mergers Poised for Discovery at The Vera Rubin Observatory"*, November 2, 2023

Astrophysicists are about to take an important step forward: recent research that will be published in The Astrophysical Journal anticipates that the Vera Rubin Observatory (VRO), scheduled to release the first

public datain 2025, will be able to observe a new type of astrophysical source: the merger of binary systems of white dwarfs. The research was conducted by an Italian team from the International Center for Relativistic Astrophysics Network(ICRANet) and the University of Ferrara, associates of the National Institute of Astrophysics (INAF), together withBrazilian colleagues from the Instituto Nacional de Pesquisas Espaciais (INPE), the Universidade Federal do Espìrito Santo (UFES), and the Universidade Tecnologica Federal do Paranà (UTFPR).

In some cases, it is believed that mergers of binary white dwarfs occur in a completely destructive way, producing a supernova explosion called Ia. These supernovae are regularly observed from distant galaxies. However, many of these mergers can follow a different fate: they form a massive white dwarf with an associated transient source less luminous than a supernova and with a more rapid evolution. Although they are estimated to be very abundant, these less catastrophic mergers have escaped any observation by current telescopes, as they are not sufficiently sensitive. The research predicts that the emission produced by mergers of binary systems of white dwarfs, in wavelengths from infrared to ultraviolet, will be observed by VRO with an astonishing frequency, up to a thousand per year!

The light source emitted by the material expelled at high speed (about 1000 km/s) with temperatures of 100thousand degrees for a few hours, is 10 to 100 million times brighter than the Sun. However, the rapid expansion causes the material to cool quickly, making their identification elusive. The most exciting result of the research is that, by putting together the expected population of these mergers and their emission characteristics, the researchers estimated that VRO, equipped with cutting-edge instrumentation and a wide field of view, is ready to discover these mergers in great abundance. Observing these stellar mergers will allow unprecedented insights into their birth and evolution if the predictions are confirmed. The authors say such observations will profoundly impact our knowledge of astrophysical phenomena linking massive white dwarfs to the formation of neutron stars. They will also provide crucial information on the possible generation of Type Ia supernovae from binary white dwarf mergers.

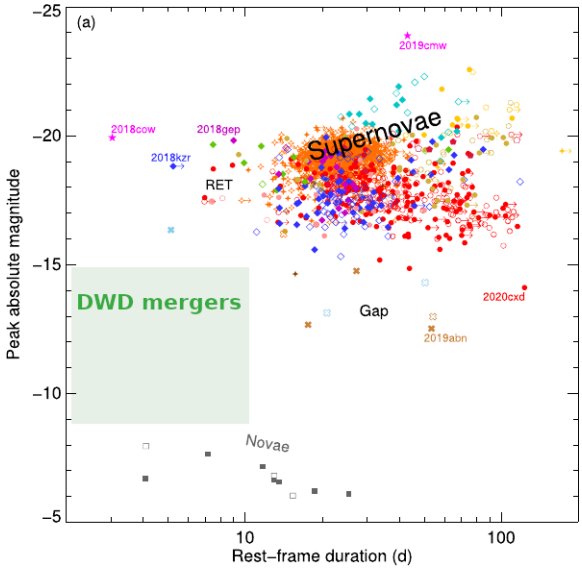


Fig. 1. Different populations of fast optical transients observed by the Zwicky Transient Facility Bright Transient Survey (Perley et al. 2020). The shaded box highlights where most DWD mergers might be detected, according to the paper results.

To the various types of transient sources that VRO is preparing to discover in abundance, we add the merger of binary systems of white dwarfs, whose observations will offer a revolutionary contribution to the knowledge of the life and evolution of these types of stars, including the genesis of ultraintense magnetic fields.

Contact:
Prof. Jorge A. Rueda

ICRANet Faculty
E-mail: jorge.rueda@icra.it

Reference article: *On the optical transients from double white-dwarf mergers*
Authors: M.F. Sousa, J.G. Coelho, J.C.N. de Araujo, C. Guidorzi, J.A. Rueda
To be published in The Astrophysical Journal
Preprint: https://arxiv.org/abs/2310.06655

For the press release on ICRANet website: http://www.icranet.org/index.php?option=com_content&task=view&id=1032&Itemid=920

In Italy:
- For the press release on the University of Ferrara website: https://www.unife.it/it/notizie/2023/scienza-cultura-e-ricerca/origine-stelle-nane-bianche-vera-rubin
- For the press release on Ansa.it website: https://www.ansa.it/emiliaromagna/notizie/2023/11/02/unife-in-team-per-scoprire-origine-delle-stelle-nane-bianche_75f3c2be-3992-4df0-80a8-49db4a4d8fcd.html
- For the press release on Ferraratoday.it website: https://www.ferraratoday.it/cronaca/astrofisica-unife-icranet-brasile-scoperta-origine-stelle-nane-bianche.html
- For the press release on Ultimometro.it website: https://www.ultimometro.it/uncategorized/unife-in-team-per-scoprire-origine-delle-stelle-nane-bianche-notizie/235580/
- For the press release on 30scienze.com website: https://30science.com/2023/11/news/unife-icranet-e-brasile-insieme-per-scoprire-lorigine-delle-stelle-nane-bianche/
- For the press release on Estense.com website: https://www.estense.com/2023/1047157/astrofisica-unife-icranet-e-brasile-insieme-per-scoprire-le-stelle-nane-bianche/

In Brasile:
- For the press release on the Universidade Tecnológica Federal do Paraná website: https://portal.utfpr.edu.br/noticias/geral/divulgacao-cientifica/fusoes-estelares-podem-explicar-a-descoberta-de-nova-fonte-astrofisica
- For the press release on the Universidade Federal do Espírito Santo website: https://www.ufes.br/conteudo/estudo-conduzido-por-pesquisador-da-ufes-preve-observacao-de-nova-fonte-astrofisica

3. ICRANet GCN 34779, September 28, 2023

Subject: transient AT2023sva: A Binary Driven Hypernova with a possible associated supernova
Date: 2023-09-28T16:05:44Z
From: Remo Ruffini at ICRA <ruffini@icra.it>
Via: Web form

R. Ruffini, Y. Aimuratov, L. Becerra, C.L. Bianco, C. Cherubini, S. Filippi, Liang Li, R. Moradi, F. Rastegar Nia, J.A. Rueda, N. Sahakyan, Y. Wang, S.S. Xue, S.R. Zhang, on behalf of the ICRANet team, report:

Following the BdHN classification [Aimuratov, et al., ApJ 955 (2023) 93] and the determination of the redshift z=2.2 of transientAT2023sva(de Ugarte Postigo, et al., GCN34740), from the energetics evaluated by Liang Li (2023) from Fermi GBM data in (2.15+/-0.13)x10^{52} erg (see attached figure), we conclude that the source is a BdHN II (GRB230916A).

We Propose to look with the James Webb Space Telescope the appearance of the associated supernova (SN) on October 31 (+/-1 day), in order to extend the GRB-SN connection in the range 1<z<3 and verify the standard candle nature of SNe Ib/c.

Figure: http://www.icranet.org/documents/GRB230916A.pdf

4. Visit of H.E. Giancarlo Di Vincenzo, Prefect of Pescara, to the ICRANet center in Pescara, October 12, 2023

On October 12, 2023, the Prefect of Pescara, H.E. Giancarlo Di Vincenzo, visited the ICRANet center in Pescara. Prof. Remo Ruffini, Director of ICRANet, showed and presented to her the center as well as its library and the precious books, pictures and documents collected there. Prof. Ruffini illustrated as well ICRANet current activities, the main research topics and the obtained results. Also, the current projects implemented with the ICRANet center in Pescara have been presented and discussed. The important role by ICRANet in daily fostering scientific exchanges worldwide and establishing agreements with the major Universities and research Institutes worldwide was also highlighted and discussed.

Fig. 1 and 2: Prof. Ruffini showing the ICRANet center to H.E. Giancarlo Di Vincenzo, Prefect of Pescara, on the occasion of his visit on October 12, 2023.

Dr Di Vincenzo also met ICRANet staff, Faculty and scientists, who told him about their important work and experience here in Pescara.

Fig. 3: Dr Di Vincenzo meeting ICRANet Faculty and scientists during his visit on October 12, 2023.

Fig.4: from the left to the right: Prof. Wang Yu (ICRANet Faculty Professor and President of ICRA), Prof. Hernando Quevedo (ICRANet adjunct Professor, UNAM Mexico), Dr Giancarlo Di Vincenzo (Prefect of Pescara), Prof. Remo Ruffini (Director of ICRANet), Prof. Liang Li (ICRANet Faculty Professor), Prof. Gregory Vereshchagin _(ICRANet Faculty Professor), Shurui Zhang (USTC China) and Prof. Shesheng Xue (ICRANet Faculty Professor).

5. The European Researchers' Night, September 29, 2023

As every year, ICRANet organized an event on the occasion of the European Researchers' Night, in order to create a nice occasion for discussion among citizens and researchers. This event attracted a lot of people, as every year, and offered visitors 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 event was held at ICRANet center in Pescara, in Nice and online, on Friday September 29, 2023, from 4 PM to 10 PM.

After the welcoming addresses by Prof. Ruffini, Director of ICRANet, the meeting started in the ICRANet Seat at Villa Ratti in Nice (France) - and broadcasted worldwide, where Prof. Ruffini presented his talk *"Black Holes in the Universe"*, followed by the one by Prof. Joseph Kouneiher (President of Projet Archimedes E.C.A.) titled *"Les Rencontres de Villa Ratti"*.

Soon after, the meeting was held in ICRANet center in Pescara (and broadcasted worldwide) and has been attended by the students from 2 classes of Galileo Galilei High School in Pescara, under the supervision of their tutor, Prof. Tiziana Pompa.Prof. Costantino Sigismondi (ICRANet collaborator and ITIS Galileo Ferraris, Rome) presented a talk titled *"Super-Moon, equinoctial tides and rogue waves"*, followed by Dr Liang Li (ICRANet Faculty) presenting his talk *"The energy source of GRB 230916"* and by Prof. Gregory Vereshchagin (ICRANet Faculty) presenting his talk *"Electron-positron creation and Pauli blocking"*.

Fig. 5: students from Galileo Galilei High School attending the European Researchers' Night event at ICRANet center in Pescara, September 29, 2023.

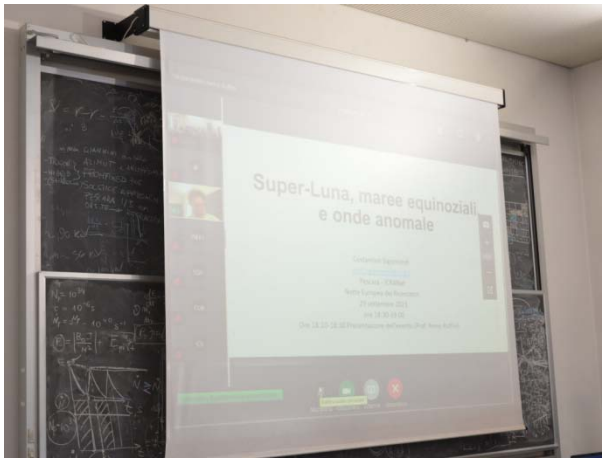


Fig. 6: Prof. Costantino Sigismondi presenting his online talk on the occasion of the European Researchers' Night event at ICRANet center in Pescara, September 29, 2023.

Fig. 7: Dr Liang Li presenting his talk on the occasion of the European Researchers' Night event at ICRANet center in Pescara, September 29, 2023.

Fig. 8: Prof. Gregory Vereshchagin presenting his talk on the occasion of the European Researchers' Night event at ICRANet center in Pescara, September 29, 2023.

Moreover, from 6 PM to 9 PM, ICRANet Hq center in Pescara was opened to the citizens for guided visits, where ICRANet Faculty members replied to visitors' questions.

At 9 PM, the meeting went on with the broadcast of the conference by Prof. Jorge A. Rueda Hernandez (ICRANet Faculty and University of Ferrara) titled *"Invisible Universe"* in the framework of the project *"Universo a km0"*. This conference was held in Marano di Valpolicella (Italy) and has been followed by the observation of Saturn with the telescopes.

The concluding remarks have been presented by Prof. Ruffini, who thanked all the participants for joining this event.

The program of this event can be found here: http://www.icranet.org/documents/program_ruropean_researchers_night_2023.pdf

6. Prof. Ruffini European XFEL Science Seminar, XFEL Hamburg (Germany), September 12, 2023

On September 12, 2023, Prof. Ruffini, Director of ICRANet, accompanied by Prof. Arban Uka (Epoka University – Albania), has been invited to give a seminar at the XFEL center in Hamburg (Germany). This seminar has been inserted in the series of the *"European XFEL Science Seminars"*, regularly held in Hamburg. Prof. Ruffini presented a talk titled*"GRB220101A the most powerful GRB with seven BdHN Episodes observed"*; here below the abstract:

A long GRB that occurred at 2022-01-01 05:11:13 (UT), was triggered by multiple satellites, including Swift (Tohuvavohu et al. 2022), Fermi (Arimoto et al. 2022), AGILE (Ursi et al. 2022), and Konus-Wind (Tsvetkova et al. 2022). The optical observation by Xinglong -2.16 m telescope (Fu et al. 2022) revealed a broad absorption feature in the spectrum indicating the presence of Lyman alpha absorption, as well as from the absorption lines, the redshift was determined to be z= 4.61, which was confirmed by the Liverpool telescope (Perley 2022) and NOT (Fynbo et al. 2022). The burst exhibited a bright , complex multi-peaked time profile within the first ~ 150 s. An estimated isotropic equivalent energy is of E_{iso}~$4x10^{54}$ erg, and a peak luminosity is of

Fig. 9: Prof. Ruffini presenting his seminar at the XFEL center in Hamburg, September 12, 2023.

L_p~ 9 x 10^{53} erg s^{-1}, making GRB 220101 A as one of the most luminous GRB ever observed. The fact that it occurs at z=4.6 gives a great opportunity to exploit new perspectives of observations as presented in Bianco et al. 2023. The discovery of a radio source with a mean frequency of 6.0 GHz was reported in Laskar (2022a). This finding aligns with the X-ray position noted in Osborne et al. (2022), as well as the optical positions reported by Tohuvavohu et al. 2022 and Hentunen et al. (2022), along with the mm-band position mentioned in Laskar (2022b). All seven episodes characterizing a BdHN I, as predicted in Ruffini et al. (2022 a,b), have been identified, details are presented in Ruffini et al., (submitted). our attention in this article is to identify the earliest XRT observations made possible by the use of the cosmological redshift of z=4.61 and to obtain an unprecedented accurate description of the rising part and the power-law decay part of the x-ray emission evidencing the transition from a Jacobi ellipsoid into a Mac Laurin spheroid in the description of a new NS originating the afterglow.

On that occasion, he visited XFEL and DESY centers and laboratories, and also had the possibility to meet Prof. Sakura Pascarelli (scientific Director at XFEL) and Prof. Beate Heinemann (Director in charge of Particle Physics at DESY).

For the announcement of the seminar on EuXFEL website: https://indico.desy.de/event/39848/

7. ICRANet participation at the VIII Leopoldo Garcia-Colin Mexican Meeting on Mathematical and Experimental Physics, October 23-27, 2023, Mexico City (Mexico)

On October 23, 2023, Prof. Ruffini, Director of ICRANet, has been invited to present a plenary lecture on the occasion of the VIII Leopoldo Garcia-Colin Mexican Meeting on Mathematical and Experimental Physics, held in Mexico City (Mexico) from October 23 to 27, 2023.

On Monday, October 23, Prof. Ruffini presented a talk titled "*A new look at Cygnus X-1 following the comprehension of GRBs-2"*; here below the abstract:

The understanding of Gamma-Ray Bursts (GRBs) has used, as successful models, progenitors binary systems of massive stars of mass up to 18 solar masses. Such progenitors evolve themselves in a supernova (SN) event: the most massive of the binary undergoes an SN, forming a neutron star (NS), which remains bound to the companion less massive binary star companion. The NS induces a co-rotation on the CO core of the companion star, which undergoes a gravitational collapse, leading to an SN creating a new NS (vNS). The SN ejecta accreting onto the companion NS binary leads to the forming of a Black Hole (BH). The newly formed BH and the vNS are the basic components of the most powerful GRBs: 10 examples of CO-core collapse triggering the GRB process will be presented. The BH originates by electrodynamics process to the observed GeV emission, while the fat spinning vNS leads to the observed X-ray, optical, and radio emission of the GRB afterglow. Some preliminary results for the evolution of binary systems composed of masses higher than 18 solar masses connected to Cygnus X-1, here revisited 50 years after I identified it as a BH for the first time at the Sixth Texas Symposium on Relativistic Astrophysics in New York on December 18-22, 1972.

For the recording of Prof. Ruffini plenary lecture on ICRANet YouTube channel: https://www.youtube.com/watch?v=b00i6iKr5WM

8. Dedication of the ICRANet Hq building to Carlo Pace, Pescara (Italy), October 28, 2023

The ICRANet Hq building, located in Piazza della Repubblica 10 in Pescara (Italy), has been dedicated to Dr Carlo Pace, former Mayor of Pescara from 1994 to 2003, accidentally dead in 2017. In order to celebrate this event, an official ceremony has been organized by the Municipality of Pescara on Saturday October 28, 2023.

Fig. 10 and 11: dedication of the ICRANet Hq building to Carlo Pace, Pescara (Italy), October 28, 2023. Photo credit to the Municipality of Pescara.

Eminent local and national authorities took part in this ceremony, namely the Mayor of Pescara Carlo Masci, the President of the Regional Council Lorenzo Sospiri, the President of the Municipal Council Marcello Antonelli, the italian deputy Nazario Pagano, many Councilors and City Councilmen and the Vice Rector of the *University of Chieti-Pescara Gabriele D'Annunzio* Tonio Di Battista. The ceremony was attended also by the family of Carlo Pace, by civil and military authorities, by academic and cultural representatives as well as by a delegation of students from the Technical Institute *Tito Acerbo* of Pescara.

In the first years of 2000, Carlo Pace had the idea to transform the former train station of Pescara in a brilliant research center, that is ICRANet, since he wanted to project Pescara, the city he loved, into the knowledge of the word and of the stars, which looks at the future. As well expressed by the Mayor Masci, Carlo Pace had a great vision, great competencies and honesty. The dedication of the building to him has been strongly supported by the Municipality of Pescara, in order to commemorate a leading personality of the city administrative life, who carried out his work with self-sacrifice, carrying out brilliant cultural and human work and becoming an irreplaceable point of reference for administrators.

Prof. Ruffini, Director of ICRANet, drew hopes that local institutions and the University would stand by ICRANet, in the name of Carlo Pace who believed so much in this reality. He hoped that these spaces will increasingly become places of science and research for a growing number of PhD students, as those educated by ICRANet.

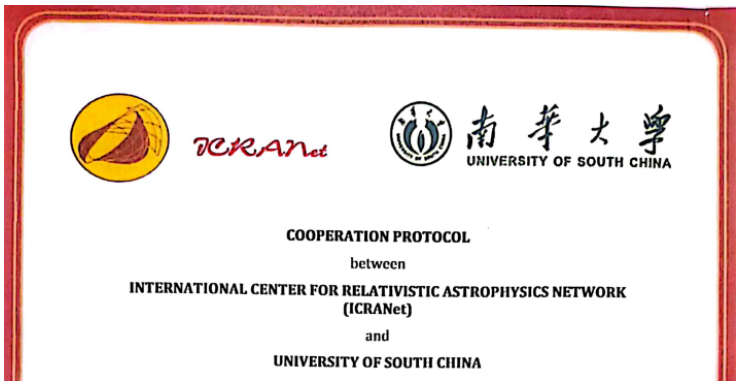
For the press releases (in Italian):

- Municipality of Pescara: https://www.comune.pescara.it/node/8897
- Il Centro: https://www.ilcentro.it/pescara/omaggio-all-ex-sindaco-pace-sede-icranet-intitolata-a-lui-1.3210457
- Rete 8: https://www.rete8.it/cronaca/pescara/pescara-licranet-intitolato-a-carlo-pace/
- Il Pescara: https://www.ilpescara.it/politica/carlo-pace-icranet-piazza-repubblica.html
- Abruzzo news 24: https://www.abruzzonews24.com/pescara-da-questa-mattina-ledificio-che-ospita-la-sede-dellicranet-porta-il-nome-del-compianto-sindaco-carlo-pace/
- La città news: https://lacittanews.it/pescara-licranet-intitolato-a-carlo-pace/

For the video (in Italian):

- Rete 8: https://www.youtube.com/watch?v=m0tHk8KTCEU&t=1s
- Tv Sei: https://www.youtube.com/watch?v=8Vj4RvxpwQU

9. New cooperation protocol between ICRANet and University of South China, September 28, 2023



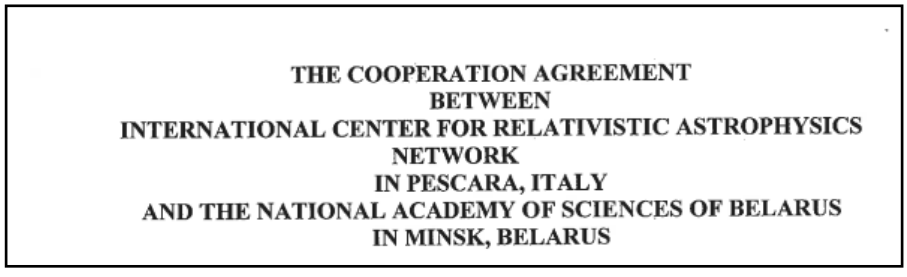
On September 9, 2023 ICRANet has signed a new Cooperation protocol with the University of South China (USC) in China. The Cooperation Protocol has been signed by Prof. Dr. Zhang Zhuohua (President of USC), Prof. Dr. Wenbin Lin (Dean School of mathematics and physics USC), Prof. Remo Ruffini (Director of ICRANet) and Prof. Shesheng Xue (ICRANet Faculty Professor).

The agreement will be valid for 5 years and the main joint activities to be developed under their framework include: the institutional exchange of graduate, post-graduate students, researchers and faculty members, the development of teaching and/or research activities related to the areas of expertise and interest of both the organizations, the organization of symposia, seminars, conferences and short courses, the promotion and support of technical-scientific and cultural events and activities open to the public; the development of opportunities to form university teachers and researchers, the organization of training and recycling courses and activities as well as the developing of inter-institutional research areas associated to local graduate programs; the promotion of joint publications; the implementation of socially oriented activities through the academic extension; the exchange of information concerning teaching and research activities in both institutions as well as the applications to the international grant programs to promote joint research projects or implement mobility exchange programs.

For the text of the agreement:http://www.icranet.org/index.php?option=com_content&task=view&id=1500

10. Renewal of 5 ICRANet cooperation agreements with National Academy of Sciences of Belarus (NASB), University of Tirana, Universidade Federal Fluminense (UFF), Universidade Federal de Itajubà (UNIFEI) and Instituto Tecnológico de Aeronáutica (ITA)

Renewal of the cooperation agreement between ICRANet and the National Academy of Sciences of Belarus (NASB)

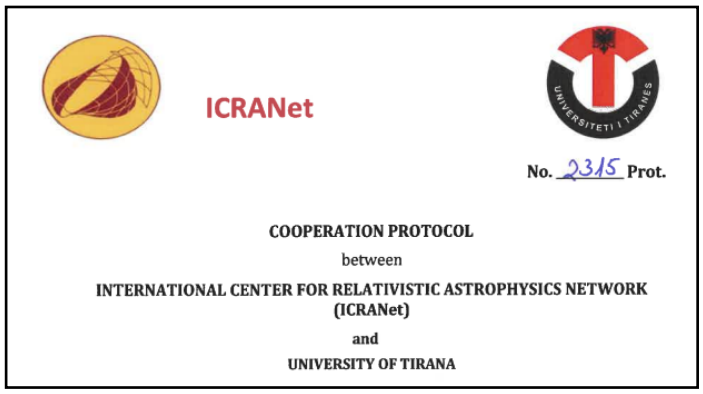

THE COOPERATION AGREEMENT
BETWEEN
INTERNATIONAL CENTER FOR RELATIVISTIC ASTROPHYSICS
NETWORK
IN PESCARA, ITALY
AND THE NATIONAL ACADEMY OF SCIENCES OF BELARUS
IN MINSK, BELARUS

On September 7, 2023, the Cooperation Agreement between ICRANet and the National Academy of Sciences of Belarus (NASB) has been renewed. The renewal was signed by Academician Vladimir G. Gusakov (Chairman of the Presidium of NASB), Prof. Alexander Shumilin (Chairman of the State Committee on Science and Technology of the Republic of Belarus), Prof. Remo Ruffini (Director of ICRANet) and Prof. Gregory Vereshchagin (ICRANet Faculty Professor).This agreement will be valid for additional5 years and the main joint activities to be developed under its framework include: the conduction of joint research on scientific issues of interest to both Parties, the organization of bilateral scientific and scientific-practical events, the

exchange of experience between employees involved in research and teaching, the publication of joint scientific works in international journals as well as the exchange of publications, teaching materials and lecture courses.

For the text of the agreement:http://www.icranet.org/index.php?option=com_content&task=view&id=1050

Renewal of the cooperation protocol between ICRANet and the University of Tirana (Albania)


ICRANet

No. 2315 Prot.

COOPERATION PROTOCOL

between

INTERNATIONAL CENTER FOR RELATIVISTIC ASTROPHYSICS NETWORK (ICRANet)

and

UNIVERSITY OF TIRANA

On September 14, 2023, the Cooperation Protocol between ICRANet and the University of Tirana (Albania) has been renewed. The renewal was signed by Prof. Dr Artan Hoxha (Rector of the University of Tirana), Prof. Mimoza hafizi (University of Tirana), Prof. Remo Ruffini (Director of ICRANet) and Prof. Jorge A. Rueda H. (ICRANet Faculty Professor).This agreement will be valid for additional5 years and the main joint activities to be developed under its framework include: the conduction of joint research on scientific issues of interest to both parties, the organization of bilateral scientific and scientific-practical events, the exchange of experience between employees involved in research and teaching, the publication of joint scientific works in international journals as well as the exchange of publications, teaching materials and lecture courses.

For the text of the agreement:http://www.icranet.org/index.php?option=com_content&task=view&id=1187

Renewal of the academic cooperation agreement between ICRANet and the Universidade Federal Fluminense (UFF)


Universidade Federal Fluminense

ICRANet

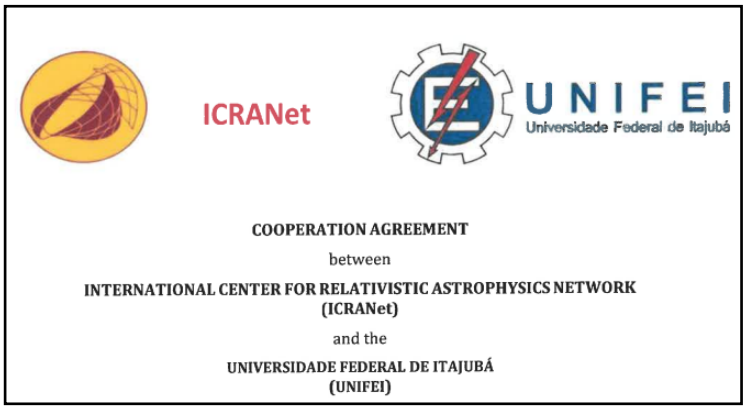
ACORDO DE COOPERAÇÃO ACADÊMICA
ENTRE A
UNIVERSIDADE FEDERAL FLUMINENSE
(Niterói, RJ – Brasil)
E A
REDE INTERNACIONAL DE CENTROS DE ASTROFÍSICA. RELATIVÍSTICA
(Pescara – Italia)

ACCORDO DI COOPERAZIONE
ACCADEMICA TRA
UNIVERSIDADE FEDERAL FLUMINENSE
(Niterói, RJ – Brasile)
E
INTERNATIONAL CENTER FOR RELATIVISTIC ASTROPHYSICS NETWORK
(Pescara – Italia)

On September 20, 2023, the academic cooperation agreement between ICRANet and the Universidade Federal Fluminense – UFF (Brazil) has been renewed. The renewal was signed by Prof. Antonio Claudio Lucas da Nobrega (Rector of UFF) and by Prof. Remo Ruffini (Director of ICRANet).This agreement will be valid for additional5 years and the main joint activities to be developed under its framework include: the conduction of joint research on scientific issues of interest to both parties, the organization of bilateral scientific and scientific-practical events, the exchange of experience between employees involved in research and teaching, the publication of joint scientific works in international journals as well as the exchange of publications, teaching materials and lecture courses.

For the text of the agreement:http://www.icranet.org/index.php?option=com_content&task=view&id=1024

Renewal of the cooperation agreement between ICRANet and the Universidade Federal de Itajubà (UNIFEI)


ICRANet

UNIFEI
Universidade Federal de Itajubá

COOPERATION AGREEMENT
between
INTERNATIONAL CENTER FOR RELATIVISTIC ASTROPHYSICS NETWORK
(ICRANet)
and the
UNIVERSIDADE FEDERAL DE ITAJUBÁ
(UNIFEI)

On October 4, 2023, the cooperation agreement between ICRANet and the Universidade Federal de Itajubà - UNIFEI (Brazil) has been renewed. The renewal was signed by Prof. Dr. Tales Cleber Pimenta (Director International relations office UNIFEI),Prof. Remo Ruffini (Director of ICRANet) and Prof. Jorge A. Rueda H. (ICRANet Faculty Professor).This agreement will be valid for additional 5 years and the main joint activities to be developed under its framework include: the conduction of joint research on scientific issues of interest to both parties, the organization of bilateral scientific and scientific-practical events, the exchange of experience between employees involved in research and teaching, the publication of joint scientific works in international journals as well as the exchange of publications, teaching materials and lecture courses.

For the text of the agreement:http://www.icranet.org/index.php?option=com_content&task=view&id=1021

Renewal of the cooperation agreement between ICRANet and the Instituto Tecnológico de Aeronáutica (ITA)


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:

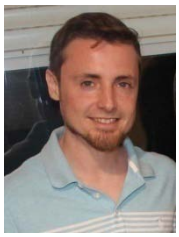
On October 5, 2023 ICRANet has received the official confirmation that the agreement between ICRANet and - ITA (Brazil)was renewed. The renewal was signed by Prof. Dr. Anderson Ribeiro Correia (Rector of ITA) and by Prof. Remo Ruffini (Director of ICRANet). This agreement will be valid for additional 3 years and the main joint activities to be developed under its framework include: the conduction of joint research on scientific issues of interest to both parties, the organization of bilateral scientific and scientific-practical events, the exchange of experience between employees involved in research and teaching, the publication of joint scientific works in international journals as well as the exchange of publications, teaching materials and lecture courses.

For the text of the agreement:http://www.icranet.org/index.php?option=com_content&task=view&id=1014

11.Scientific visits to ICRANet

- Tursynbek Yernazarov (Al-Farabi Kazakh National University), August 28 – September 10, 2023
- Prof. Arban Uka (Epoka University, Albania), September 8 – 10, 2023
- Prof. Carlos Raul Arguelles (Universidad Nacional de La Plata, Argentina), September 8 – 10, 2023
- Prof. Hernando Quevedo (Universidad Nacional Autonoma De Mexico), October 2, 2023 – still ongoing
- Prof. Sergey Bulanov and Gabriele Grittani (ELI-Beamlines, Czech Republic), October 25-28, 2023
- Prof. Costantino Sigismondi (ICRANet adjunct Professor, ITIS Galileo Ferraris Rome), October 30 – still ongoing







Tursynbek Yernazarov | **Prof. Arban Uka** | **Prof. Carlos Raul Arguelles** | **Prof. Hernando Quevedo** | **Prof. Sergey Bulanov** | **Prof. Gabriele Maria Grittani** | **Prof. Costantino Sigismondi**

During their visit, those scientists had an opportunity to discuss their scientific research and to have fruitful exchange of ideas with other researchers from ICRANet and from different parts of the world.

12.Recent publications

Y. Aimuratov, L. M. Becerra, C.L. Bianco, C. Cherubini, M. Della Valle, S. Filippi, Liang Li, R. Moradi, F. Rastegarnia, J. A. Rueda, R. Ruffini, N. Sahakyan, Y. Wang, S. R. Zhang, *GRB-SN Association within the Binary-Driven Hypernova Model*, published in The Astrophysical Journal 955:93 (29pp), on October 1, 2023.

Observations of supernovae (SNe) Ic occurring after the prompt emission of long gamma-ray bursts (GRBs) are addressed within the binary-driven hypernova (BdHN) model where GRBs originate from a binary composed of a $\sim 10 M_{\odot}$ carbon–oxygen (CO) star and a neutron star (NS). The CO core collapse gives the trigger, leading to a hypernova with a fast-spinning newborn NS (νNS) at its center. The evolution depends strongly on the binary period, P_{bin}. For $P_{bin} \sim$ 5 min, BdHNe I occur with energies 10^{52}–10^{54} erg. The accretion of SN ejecta onto the NS leads to its collapse, forming a black hole (BH) originating the MeV/GeV radiation. For $P_{bin} \sim$ 10 min, BdHNe II occur with energies 10^{50}–10^{52} erg and for $P_{bin} \sim$ hours, BdHNe III occur with energies below 10^{50} erg. In BdHNe II and III, no BH is formed. The 1–1000 ms νNS originates, in all BdHNe, the X-ray-optical-radio afterglows by synchrotron emission. The hypernova follows an independent evolution, becoming an SN Ic, powered by nickel decay, observable after the GRB prompt emission. We report 24 SNe Ic associated with BdHNe. Their optical peak luminosity and time of occurrence are similar and independent of the associated GRBs. From previously identified 380 BdHN I comprising redshifts up to z = 8.2, we analyze four examples with their associated hypernovae. By multiwavelength extragalactic observations, we identify seven new episodes, theoretically explained, fortunately not yet detected in Galactic sources, opening new research areas. Refinement of population synthesis simulations is needed to map the progenitors of such short-lived binary systems inside our galaxy.

DOI: https://doi.org/10.3847/1538-4357/ace721

Rodríguez, J. F.; Rueda, J. A.; Ruffini, R.; Zuluaga, J. I.; Blanco-Iglesias, J. M.; Lorén-Aguilar, P., *Chirping compact stars: gravitational radiation and detection degeneracy with binaries*, published in Journal of Cosmology and Astroparticle Physics, Volume 2023, Issue 10, on October 6, 2023.

Compressible, Riemann S-type ellipsoids can emit gravitational waves (GWs) with a chirp-like behavior (hereafter chirping ellipsoids, CELs). We show that the GW frequency-amplitude evolution of CELs (mass $\sim 1\ M_{\odot}$, radius $\sim 10^3$ km, polytropic equation of state with index $n \approx 3$) is indistinguishable from that emitted by double white dwarfs and by extreme mass-ratio inspirals (EMRIs) composed of an intermediate-

mass (e.g. $10^3 M_\odot$) black hole and a planet-like (e.g. $10^{-4} M_\odot$) companion, in the frequency interval within the detector sensitivity band in which the GW emission of these systems is quasi-monochromatic. For reasonable astrophysical assumptions, the local universe density rate of CELs, double white dwarfs, and EMRIs in the mass range here considered are very similar, posing a detection-degeneracy challenge for space-based GW detectors. We outline the astrophysical implications of this CEL-binary detection degeneracy by space-based GW-detection facilities.

DOI: https://doi.org/10.48550/arXiv.1907.10532

Rueda, J. A.; Ruffini, R.,*Extracting the energy and angular momentum of a Kerr black hole*, published on the European Physical Journal C, Volume 83, Issue 10, article id.960 on October 2023.

It has been thought for decades that rotating black holes (BHs) power the energetic gamma-ray bursts (GRBs) and active galactic nuclei (AGNs), but the mechanism that extracts the BH energy has remained elusive. We here show that the solution to this problem arises when the BH is immersed in an external magnetic field and ionized low-density matter. For a magnetic field parallel to the BH spin, the induced electric field accelerates electrons outward and protons inward in a conical region, centered on the BH rotation axis, and of semi-aperture angle $0 \approx 60°$ from the BH rotation axis. For an antiparallel magnetic field, protons and electrons exchange their roles. The particles that are accelerated outward radiate off energy and angular momentum to infinity. The BH powers the process by reducing its energy and angular momentum by capturing polar protons and equatorial electrons with net negative energy and angular momentum. The electric potential allows for negative energy states outside the BH ergosphere, so the latter does not play any role in this electrodynamical BH energy extraction process.

DOI: https://doi.org/10.1140/epjc/s10052-023-12153-y

Sousa, M. F.; Coelho, J. G.; de Araujo, J. C. N.; Guidorzi, C.; Rueda, J. A., *On the optical transients from double white-dwarf mergers*, accepted for publication in The Astrophysical Journal.

Double white-dwarf (DWD) mergers are relevant astrophysical sources expected to produce massive, highly-magnetized WDs, supernovae (SNe) Ia, and neutron stars (NSs). Although they are expected to be numerous sources in the sky, their detection has evaded the most advanced transient surveys. This article characterizes the optical transient expected from DWD mergers in which the central remnant is a stable (sub-Chandrasekhar) WD. We show that the expansion and cooling of the merger's dynamical ejecta lead to an optical emission peaking at 1-10 d post-merger, with luminosities of 10^{40}-10^{41} erg s^{-1}. We present simulations of the light-curves, spectra, and the color evolution of the transient. We show that these properties, together with the estimated rate of mergers, are consistent with the absence of detection, e.g., by The Zwicky Transient Facility (ZTF). More importantly, we show that the Legacy Survey of Space and Time (LSST) of the Vera C. Rubin Observatory will likely detect a few/several hundred per year, opening a new window to the physics of WDs, NSs, and SN Ia.

arXiv: https://arxiv.org/abs/2310.06655

Punsly B., *HST-1 as a window into the energetics of the jet spine of M 87*, published in Astronomy & Astrophysics, Volume 677 on September 2023.

We present a new interpretation of the optical knot, HST-1, in the jet of M 87. High-sensitivity 22 GHz Very Large Array images have located HST-1 to within 6 mas of the jet axis immediately upstream. Based on 1.7 GHz Very Long Baseline Array images of a bright flare in 2005, we see that preponderance of emission in the early stages originates from an elongated region that is tilted 12.5° from the jet axis. The superluminal motion, shape, location, and the large jet-aligned optical/UV polarization suggest an identification with the putative relativistic spine of the jet. As such, energy flux estimates for HST-1, ~870 mas from the nucleus, published in 2006, indicate that the central engine injected, $Q_{spine} \approx 2.5 \times 10^{41}$ ergs

s^{-1}, into the base of the spine about 200 yr earlier. Furthermore, previous studies have revealed a tubular protonic jet on sub-mas scales that envelopes a low luminosity core, presumably the faint spine base. It was estimated that the central engine injected, $Q_{\rm tubular\,jet} \approx 6.1 \times 10^{41}$ ergs s^{-1}, about 1.5 yr earlier. If one component of the jet is inherently more powerful, a firm constraint on total jet power in the recent past would then exist. If the emitted jet is inherently dominated by the spine (tubular jet), then the total bilaterally symmetric jet power emitted from the central engine was $< 4Q_{\rm spine} \approx 1.0 \times 10^{42}$ ergs s^{-1} ($< 4Q_{\rm tubular\,jet} \approx 2.4 \times 10^{42}$ ergs s^{-1}) ~200 (~1.5) yr earlier. Assuming a nearly constant central engine injected jet power for ~200 yr indicates a total jet power of $\lesssim 2 \times 10^{42}$ ergs s^{-1} in epochs of modern observation or $\lesssim$3.5% jet production efficiency for an accretion rate of 0.001 $M_\odot$ yr^{-1}. Seemingly, the focus of Event Horizon Telescope Collaboration (EHTC) numerical models should be biased toward jet powers of $\lesssim 2 \times 10^{42}$ ergs s^{-1}, as opposed to larger estimates from ejections many centuries or millennia earlier.

DOI: https://doi.org/10.1051/0004-6361/202346831

Benaoum, Hachemi B.; Chavanis, Pierre-Henri; Luongo, Orlando; Muccino, Marco; Quevedo, Hernando, *High redshift constraints on extended logotropic models,* published in Astroparticle Physics, Volume 151 on September 2023.

A single logotropic fluid, responsible for the existence of the whole dark sector, is here extensively revised at intermediate redshifts. In particular, by investigating possible generalizations that conceptually overcome previous issues of standard logotropic scenarios, we fix bound over classes of logotropic models that exhibit additional terms in the equation of state. Employing $\sigma_8$measurements combined with low redshift data sets of Supernovae and Hubble observational data, we show the statistical significance of those extensions and their departure from the standard cosmological model. Evidences against generalized versions of logotropic models are, in particular, prompted. Our outcomes definitively show that any departure from the original logotropic model, including the Anton–Schmidt dark energy, are clearly disfavored at the level of perturbations and/or background cosmology. This indicates that, in order to have a logotropic fluid, plausible generalized versions of it would point out to reduce the complexity of the fluid itself, instead of adding extra terms.

DOI: https://doi.org/10.1016/j.astropartphys.2023.102852

Guetta, Dafne; Langella, Aurora; Gagliardini, Silvia; Della Valle, Massimo, *Low- and High-energy Neutrinos from SN 2023ixf in M101,* published in The Astrophysical Journal Letters, 955:L9 (7pp) on September 20, 2023.

Supernova (SN) 2023ixf in M101 is the closest SN explosion observed in the last decade. Therefore, it is a suitable test bed to study the role of jets in powering the SN ejecta. With this aim, we explored the idea that high-energy neutrinos could be produced during the interaction between the jets and the intense radiation field produced in the SN explosion and eventually be observed by the IceCube neutrino telescope. The lack of detection of such neutrinos has significantly constrained both the fraction of stellar collapses that produce jets and/or the theoretical models for neutrino production. Finally, we investigated the possibility of detecting low-energy neutrinos from SN 2023ixf with the Super- and Hyper-Kamiokande experiments, obtaining, in both cases, subthreshold estimates.

DOI: https://doi.org/10.3847/2041-8213/acf573

A. Bagheri Tudeshki, G.H. Bordbar, B. Eslam Panah, *Effect of massive graviton on dark energy star structure,* published in Physics of the Dark Universe, Volume 42, on October 2023.

The presence of massive gravitons in the field of massive gravity is considered an important factor in investigating the structure of compact objects. Hence, we are encouraged to study the dark energy star

structure in the Vegh's massive gravity. We consider that the equation of state governing the inner spacetime of the star is the extended Chaplygin gas, and then using this equation of state, we numerically solve the Tolman-Oppenheimer-Volkoff (TOV) equation in massive gravity. In the following, assuming different values of free parameters defined in massive gravity, we calculate the properties of dark energy stars such as radial pressure, transverse pressure, anisotropy parameter, and other characteristics. Then, after obtaining the maximum mass and its corresponding radius, we compute redshift and compactness. The obtained results show that for this model of dark energy star, the maximum mass and its corresponding radius depend on the massive gravity's free parameters and anisotropy parameter. These results are consistent with the observational data and cover the lower mass gap. We also demonstrate that all energy conditions are satisfied for this model, and in the presence of anisotropy, the dark energy star is potentially unstable.

DOI: https://doi.org/10.1016/j.dark.2023.101354

H. Barzegar, B. Eslam Panah, G. H. Bordbar, and M. Bigdeli, *Structure of 3D gravastars in the context of massive gravity*, published in Phys. Lett. B 847 (2023) 138280.

In this paper, we investigate a new model of dimensional (3D) gravitational vacuum stars (gravastars) with an isotropic matter distribution anti-de Sitter (AdS) spacetime in the context of massive gravity. For this purpose, we explore free singularity models with a specific equation of state. Using Mazur-Mottola's approach, we predict 3D gravastars as alternatives to BTZ black holes in massive gravity. We find analytical solutions to the interior of gravastars free of singularities and event horizons. For a thin shell containing an ultra-relativistic stiff fluid, we discuss length, energy, and entropy. In conclusion, the parameter of massive gravity plays a significant role in predicting the proper length, energy contents and entropy and parameters of gravastars.

DOI: https://doi.org/10.1016/j.physletb.2023.138280

B. Eslam Panah, M. Khorasani, and J. Sedaghat, *Three-dimensional accelerating AdS black holes in F(R) gravity*, published in Eur. Phys. J. Plus 138 (2023) 728.

The presence of massive gravitons in the field of massive gravity is considered an important factor in investigating the structure of compact objects. Hence, we are encouraged to study the dark energy star structure in the Vegh’s massive gravity. We consider that the equation of state governing the inner spacetime of the star is the extended Chaplygin gas, and then using this equation of state, we numerically solve the Tolman–Oppenheimer–Volkoff (TOV) equation in massive gravity. In the following, assuming different values of free parameters defined in massive gravity, we calculate the properties of dark energy stars such as radial pressure, transverse pressure, anisotropy parameter, and other characteristics. Then, after obtaining the maximum mass and its corresponding radius, we compute redshift and compactness. The obtained results show that for this model of dark energy star, the maximum mass and its corresponding radius depend on the massive gravity’s free parameters and anisotropy parameter. These results are consistent with the observational data and cover the lower mass gap. We also demonstrate that all energy conditions are satisfied for this model, and in the presence of anisotropy, the dark energy star is potentially unstable.

DOI: https://doi.org/10.1016/j.dark.2023.101354