Enclosure 9

The 2022 ICRANet Newsletters

ICRANet Newsletter

December 2021 – January 2022

SUMMARY

1. Deep Learning in Searching the Spectroscopic Redshift of Quasars

The new work co-authored by ICRANet scientists is published by MNRAS on January 19, 2022

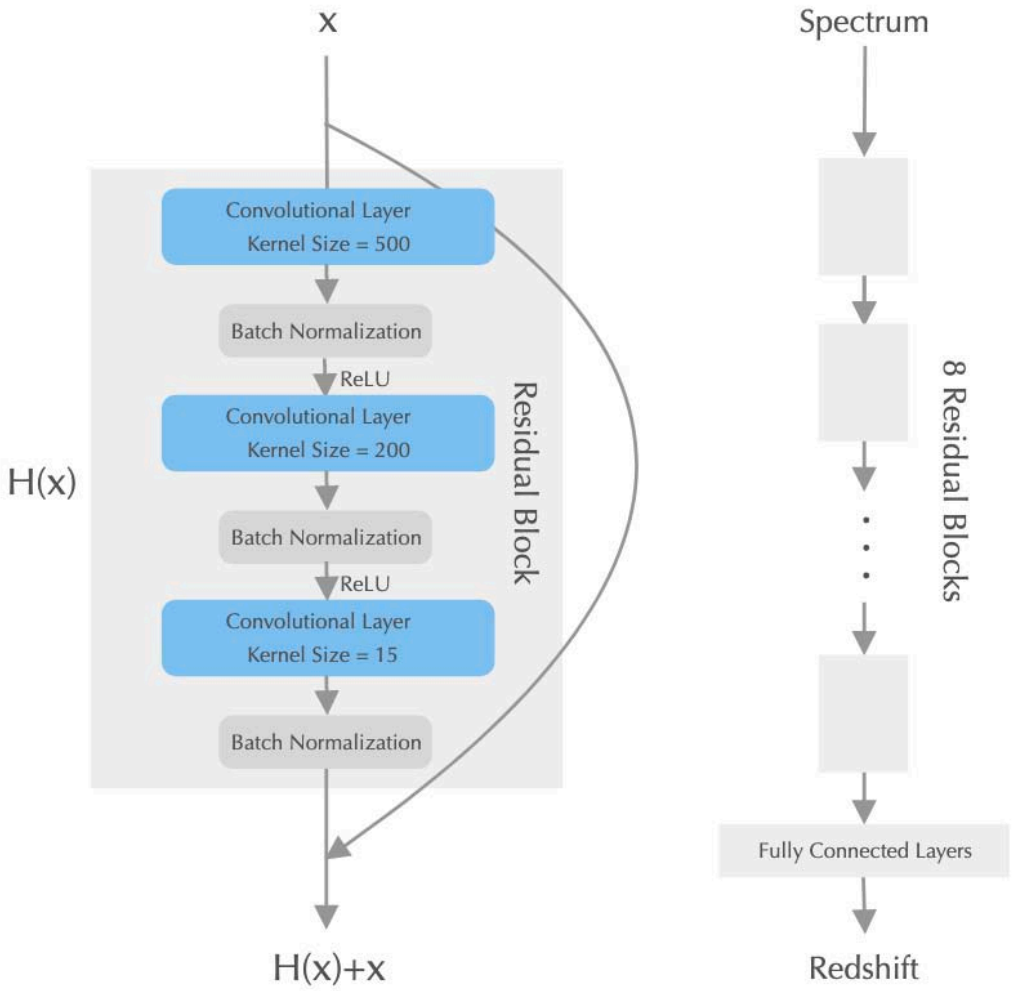


Fig. 1. The chosen architecture of 1-dimensional of FNet to learn higher-order features hidden in the input flux. It slides the flux via convolutional layers of kernel size = 500, 200 and 15, respectively to search for the ``global'' and ``local'' patterns in the flux of quasars. The fully connected layers output the redshift. Left: The structure of a residual block, the input x goes through two convolutional layers as H(x) then add itself as H(x)+x, batch normalization is applied after each convolutional layer, and the activation function ReLU acts on the first batch normalization layer. Right: The entire structure: The flux goes through 24 residual blocks, the first 21 blocks have channel size 32, followed by three blocks of channel size 64, 32 and 16 respectively. The output of blocks then is flattened and passes three fully convolutional layers and eventually outputs the redshift. The rectified linear unit (ReLU) is applied after each fully connected layer.

Quasi-stellar radio sources (Quasars) are high-luminosity active galactic nuclei (AGN). There is a broad consensus that quasars are powered by a gaseous accretion disk around a supermassive black hole (SMBH) of ~10^6 - 10^9 solar mass. Because of their high luminosity, quasars have been observed up to redshifts z~8 when the universe formed its first structures, i.e., in the reionization epoch. It makes quasars a powerful tool to study the cosmic history and structure formation in the early universe and, specifically, probe the physics governing the SMBHs and their surrounding accretion disk, as the rapid growth of SMBHs occurs at redshifts z = 5-10. Regarding their existence in a wide range of redshifts, quasars, as the cosmology's standard candle, can also be utilized to put more constraints on the cosmological parameters.

On the one hand, the massive volume of data of astrophysical surveys makes the procedure for visual inspection of each spectrum to classify and determine the redshift highly time-consuming. For example, the Sloan Digital Sky Survey IV (SDSS-IV) quasar catalog from Data Release 16 (DR16) of the extended Baryon Oscillation Spectroscopic Survey (eBOSS), includes a “superset” of objects labelled as quasars containing 1440615 spectra.

On the other hand, the adapted automatic methods, that operate based on comparing each spectrum with a dataset of spectra, usually perform worse than visual inspection methods in classification tasks. Thus, implementing automated strategies with human–expert precision is of great importance.

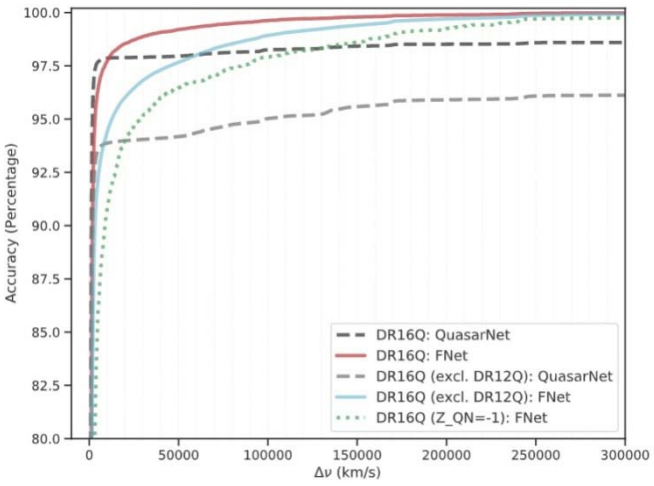


Fig. 2. The accuracy of prediction vs. Δv. The red solid line and black dashed line represent the accuracy of the FNet and QuasarNE, respectively, for DR16Q sample. The blue solid line and grey dashed line represent the accuracy of the FNet and QuasarNET, respectively, for DR16Q sample when DR12Q is excluded. The green dashed lines shows the accuracy of FNet for 5,190 visually inspected sources in DR16Q when QuasarNET fails to estimate.

Over the last few years, machine learning (ML) and deep learning (DL) algorithms have become increasingly popular in astronomy and astrophysics. They are using various recognition patterns and are able to identify the spectral features of astrophysical objects such as emission/absorption lines, spectral breaks, and flux correlations, and perform the classification and redshift determination as accurate as the visual inspection.

With the goal to estimate the redshift of quasars in Sloan Digital Sky Survey IV (SDSS-IV) catalog from DR16 quasar-only (DR16Q) of eBOSS on a broad range of signal-to-noise ratios, the group of researchers which includes ICRANet scientists has developed a new tool, the FNet. FNet is a 1–dimensional convolutional neural network (CNN) with a residual neural network (ResNet) structure. This network has 24 convolutional layers and the ResNet structure with different kernel sizes of 500, 200, and 15, which makes it to discover the “ local ” and “ global ” patterns, as well as correlations of fluxes in a different wavelength, in the whole sample of spectra by a self-learning procedure; see Fig. 1. It reaches the accuracy of 97.0 % for the velocity difference for redshift, $|\Delta v| < 6000$ km/s and 98.0% for $|\Delta v| < 12000$ km/s. Here $\Delta v = c\,(Z - Z\_VI)/(1+ZVI)$ is the velocity difference from redshift, c is the speed of light, Z_VI is the redshift from the visually inspected quasar sample, and Z is the predicted redshift.

While QuasarNET, which is a standard CNN adopted in the SDSS routine and is constructed by 4 convolutional layers (no ResNet structure), with kernel sizes of 10, to measure the redshift via identifying seven emission lines (local patterns), fails in estimating redshift of ~ 1.3% of visually inspected quasars in DR16Q catalog, and it gives 97.8% for $|\Delta v| < 6000$ km/s and 97.9 % for $|\Delta v| < 12000$ km/s; see Fig 2. FNet is applicable for a wider range of SDSS spectra, especially for those missing the clear emission lines, which is necessary for other standard methods to work. These properties of FNet, together with the fast predictive power of machine learning, allow it to be a more accurate alternative for the pipeline redshift estimator and can make it practical in the upcoming catalogs to reduce the number of spectra to inspect visually.

The paper by F. Rastegar Nia, M. T. Mirtorabi, R. Moradi, A. Vafaei. Sadr, Y. Wang «Deep learning in searching the spectroscopic redshift of quasars» is published in Monthly Notices of the Royal Astronomical Society on 19 January 2022.

Link: https://doi.org/10.1093/mnras/stac076

2. LeCosPA 4th International Symposium, online, November 29 – December 3, 2021

The *"LeCosPA 4th International Symposium, Unity of Physics – From Plasma Wakefields to Black Holes"* has been held at the National Taiwan University (Taiwan) and online from November 29 to December 3, 2021. During the meeting, a lot of interesting topics have been discussed, ranging from Extreme Light, High Field Science, and Plasma Wakefields to Early and Late Universe, Particle Astrophysics, Black Holes, Gravitational Waves and Testing of Modified Gravity, Information Loss Paradox and Analog Black Holes.

On December 2, 2021 Prof. Ruffini, Director of ICRANet, presented a lecture titled *"What is the role of the rotational energy extraction from Black Holes"*, here is the abstract:

We have demonstrated that the inner engine of GRBs and AGN produces high-energy emission by synchrotron radiation of electrons/protons that are accelerated in the rotating BH vicinity. The angular momentum of the Kerr BH and the surrounding magnetic field determine the energetics and characteristic radiation frequency, and their relative direction determines whether the motion of the electrons around the magnetic field lines follows a right-handed or a left-handed helix, and likewise the angular momentum inherited by the radiation.

Link to Prof. Ruffini presentation on YouTube: https://www.youtube.com/watch?v=NaUJ7NqW3LQ

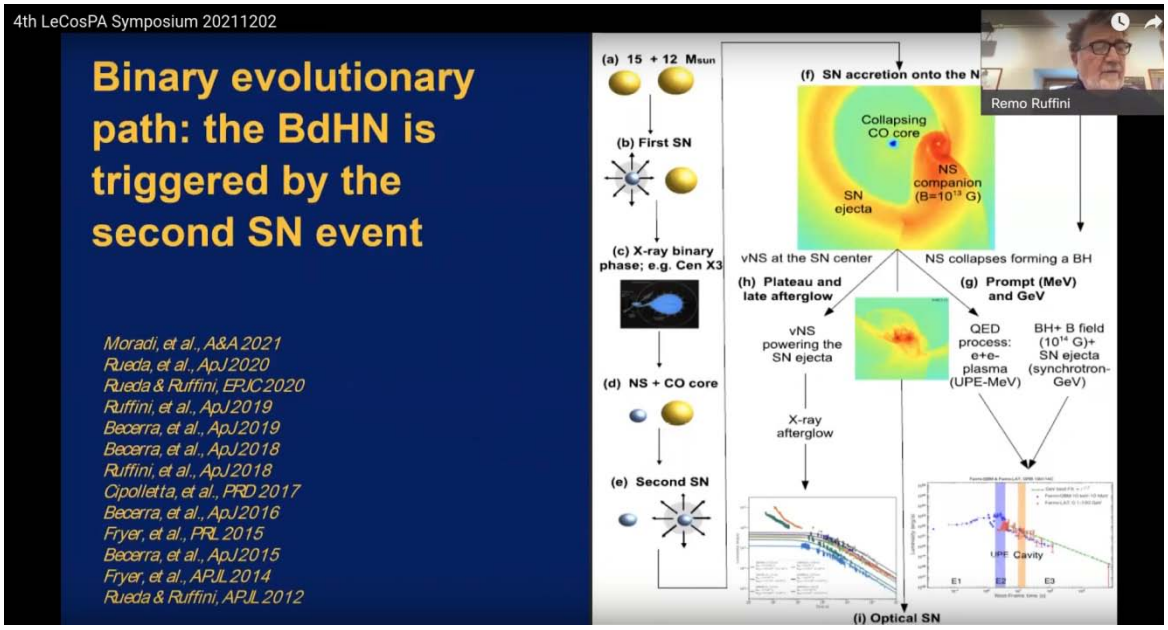


Fig. 3: Prof. Ruffini delivering his lecture on the occasion of the LeCosPA 4th International Symposium, Unity of Physics, on December 2, 2021.

3. Antarctic eclipse and meridian transits, online meeting, December 4, 2021

The meeting "Antarctic eclipse and meridian transits. Experiments of Celestial mechanics and Astrophysics" has been held virtually on December 4, 2021. Prof. Costantino Sigismondi, ICRANet collaborator and chair of the event, thanks also to the support of ICRANet and many other scientists from all over the world, organized this virtual meeting as well as a podcast meeting in order to create a nice occasion for discussion among students and researchers.

The total eclipse of the Sun gave the occasion to reconsider the solar diameter as well as its measures by comparison with the ephemerides with a standard diameter. The virtual meeting started at 10 AM on Saturday December 4, with the opening remarks made by Prof. Sigismondi and went on with some important contributions by other relevant scientists on the field on "*The consultation of ephemerides", "Eclipse and timing: the measurement uncertainty and its role for the eclipse", "Meridian transits and timing", "The first results from the obelisk – meridian of Saint Peter on the transit and the solar diameter", "The entry of the Sun in Scorpio and in Sagittarius 2021 at Saint Peter, with the Sun and the stars (preliminary results and calibration of the instrument)*" as well on "*The eclipse in Antarctica and the double eclipse of the year 810 in the letter by Dungal to Charlemagne*".

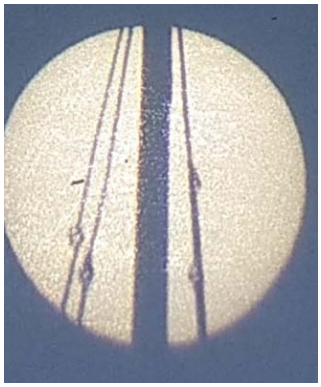


Fig. 4: The Sun projected to the meridian of Saint Peter on November 24, 2021.

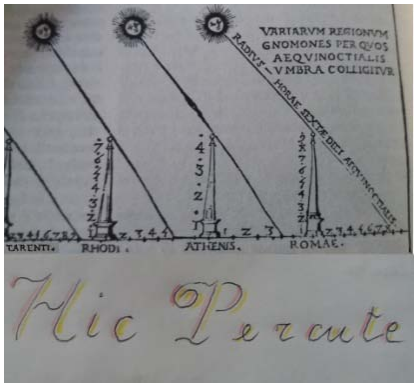


Fig. 5: Engraving of the Cesarean (1521) of Vitruvius, De Architectura, Book IX - chapter VII, with the sentence on the legend of Gerbertus and the reassure of Augustus

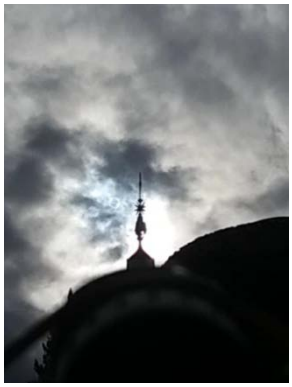


Fig. 6: the Sun at the meridian of Saint Peter, just before the meridian eclipse on November 26, 2021.

This theoretical section was also integrated with the podcast materials prepared by Prof. Sigismondi. The program of the event and all the relevant podcast materials, can be found at the following link: http://www.icranet.org/index.php?option=com_content&task=view&id=1399

A recording of the meeting can also be found on ICRANet YouTube channel: https://www.youtube.com/watch?v=fLfBehXC-H4&t=696s

4. Amati Fest meeting, December 6-7, 2021

On the occasion of the celebration of the 50th anniversary of *"Introducing the Black Hole"* by Prof. Remo Ruffini and Prof. John A. Wheeler, ICRANet organized an online meeting, in order to better discuss about the most recent results on the understanding of Gamma-Ray Bursts (GRBs) and their "inner-engines". In this framework, a particular attention has been given to the understanding of the Amati relation.

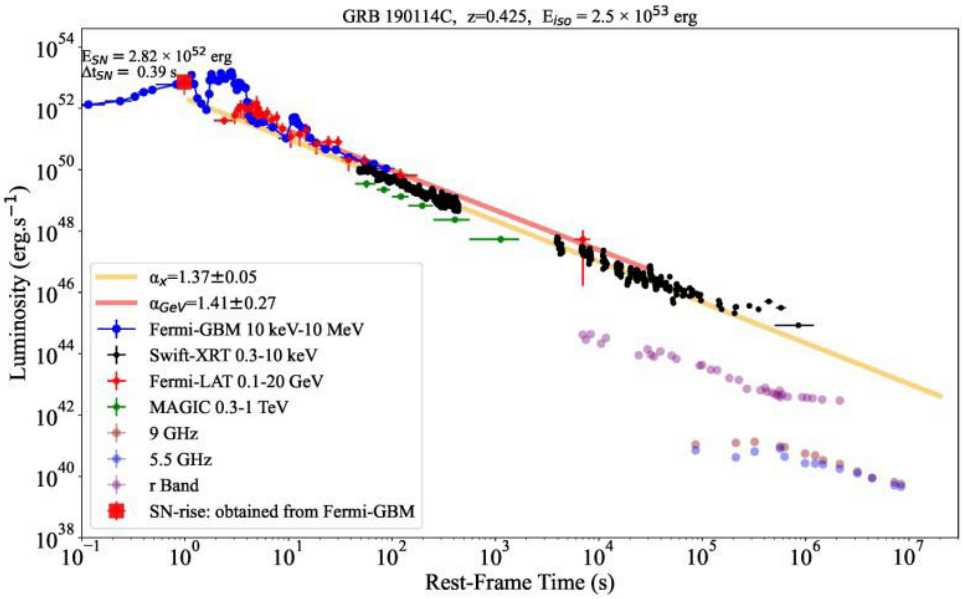


Fig. 7: The afterglow of GRB 140114C as observed from Radio to VHE bands.

This meeting took place at ICRANet Hq in Pescara (Italy) and online from December 6 to 7, 2021 and it has also been broadcasted worldwide on ICRANet YouTube channel. The meeting started with the opening remarks made by Prof. Remo Ruffini, Director of ICRANet, and by Prof. Lorenzo Amati. During the event, several invited speaker took the floor in order to present their recent results, namely Prof. Marco Tavani (President of INAF), Prof. Narek Sahakyan (Director of ICRANet Seat in Armenia), Prof. Michael Kramer (Director - Max-Planck-Institut für Radioastronomie), Prof. Jorge Armando Rueda Hernandez (ICRANet, University of Ferrara), Prof. Carlo Luciano Bianco (ICRA, ICRANet), Prof. Gregory Vereshchagin (ICRANet), Prof. She Sheng Xue (ICRANet), Prof. Carlos Raul Arguelles (ICRANet, CONICET, Universidad Nacional de La Plata), Prof. Soroush Shakeri (ICRANet, Isfahan University of Technology), Prof. Piero Rosati (University of Ferrara), Prof. Razmik Mirzoyan (Max-Planck-Institute for Physics), Prof. Cristiano Guidorzi (University of Ferrara), Prof. Massimo Della Valle (ICRANet, INAF Osservatorio astronomico di Capodimonte), Dr Luca Izzo (Osservatorio astronomico di Capodimonte), Prof. Yifu Cai (University of Sciences and Technology of China), Prof. Yefei Yuan (University of Sciences and Technology of China), Prof. Mimoza Hafizi (University of Tirana), Prof. Claus Lämmerzahl (ZARM University of Bremen), Prof. Stefano Scopel (CQUeST, Sogang University), Prof. Simonetta Filippi (ICRA, University Campus Bio-medico of Rome), Prof. Christian Cherubini (ICRA, University Campus Bio-medico of Rome), Prof. Stefano Ansoldi (University of Udine), Prof. Aldo Treves (University of Insubria), Prof. Francesco Haardt (University of Insubria), Dr Ana Penacchioni (CONICET, Universidad Nacional de La Plata), Dr Laura Marcela Becerra Bayona (ICRANet, Universidad Católica de Chile), Prof. Wang Yu (ICRANet), Prof. Liang Li (ICRANet), Prof. Rahim Moradi (ICRANet), Dr Yerlan Aimuratov (ICRANet, Fesenkov Astrophysical Institute), Dr Yunlong Zheng (ICRANet, University of Sciences and Technology of China), Eduar Antonio Becerra Vergara (ICRANet), Dr Fatemeh Rastegar Nia (ICRANet, Alzahra University) and Dr Sareh Eslamzadeh Askestani (University of Mazandaran).

After those intervention, there has been a long discussion on the data and results presented among all the scientists, who had the opportunity to have fruitful exchanges on these important topics. The meeting ended on Tuesday, December 7 with the concluding remarks made by prof. Remo Ruffini and Prof. Lorenzo Amati.

Fig. 8: Prof. Lorenzo Amati and Prof. Remo Ruffini during the Amati Fest meeting.

Fig. 9: From the left to the right: Prof. Luca Izzo, Prof. Jorge Rueda, Prof. Lorenzo Amati, Prof. Remo Ruffini, Prof. Rahim Moradi, Prof. Liang Lia and Prof Wang Yu, discussing at ICRANet Hq on the occasion of the Amati Fest meeting.

5. Scientific visits to ICRANet

- Prof. Lorenzo Amati

INAF - Osservatorio di Astrofisica e Scienza dello Spazio
December 6-7, 2021

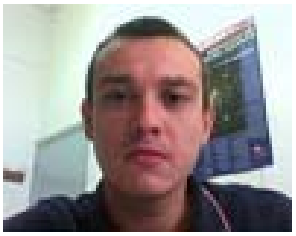
- Prof. Jorge Armando Rueda Hernandez

ICRA, ICRANet and University of Ferrara
December 6-7, 2021

- Prof. Luca Izzo

Observatory of Capodimonte – Italy
December 6-7, 2021

Prof. Lorenzo Amati



Prof. Jorge Armando Rueda Hernandez

Prof. Luca izzo

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. They also took part in the Amati fest meeting, which was held at ICRANet Hq in Pescara (Italy) and online from December 6 to 7, 2021.

6. Recent publications

J. A. Rueda and R. Ruffini, *The quantum emission of an alive black hole*, published in International Journal of Modern Physics D VOL. 30, NO. 14.

A long march of 50 years of successive theoretical progress and new physics discovered using observations of gamma-ray bursts has finally led to the formulation of an efficient mechanism able to extract the rotational energy of a Kerr black hole to power these most energetic astrophysical sources and active galactic nuclei. We here present the salient features of this long-sought mechanism, based on gravito-electrodynamics, and which represents an authentic shift of paradigm of black holes as forever "*alive*" astrophysical objects.

This essay is awarded third prize in the 2021 Essay Competition of the Gravity Research Foundation.

DOI: https://doi.org/10.1142/S0218271821410030

F. Rastegar Nia, M. T. Mirtorabi, R. Moradi, A. Vafaei Sadr, Y. Wang, *Deep learning in searching the spectroscopic redshift of quasars*, published in Monthly Notices of the Royal Astronomical Society on January 19, 2022 .

Studying the cosmological sources at their cosmological rest-frames is crucial to track the cosmic history and properties of compact objects. In view of the increasing data volume of existing and upcoming telescopes/detectors, we here construct a 1–dimensional convolutional neural network (CNN) with a residual neural network (ResNet) structure to estimate the redshift of quasars in Sloan Digital Sky Survey IV (SDSS-IV) catalog from DR16 quasar-only (DR16Q) of eBOSS on a broad range of signal-to-noise ratios, named FNet. Owing to its 24 convolutional layers and the ResNet structure with different kernel sizes of 500, 200 and 15, FNet is able to discover the 'local' and 'global' patterns in the whole sample of spectra by a self-learning procedure. It reaches the accuracy of 97.0 per cent for the velocity difference for redshift, $|\Delta v|<6000$ km s^{-1} and 98.0 per cent for $|\Delta v|<12000$ km s^{-1}. While QuasarNET, which is a standard CNN adopted in the SDSS routine and is constructed by 4 convolutional layers (no ResNet structure), with kernel sizes of 10, to measure the redshift via identifying seven emission lines (local patterns), fails in estimating redshift of ∼1.3 per cent of visually inspected quasars in DR16Q catalog, and it gives 97.8 per cent for $|\Delta v|<6000$ km s^{-1} and 97.9 per cent for $|\Delta v|<12000$ km s^{-1}. Hence, FNet provides similar accuracy to QuasarNET, but it is applicable for a wider range of SDSS spectra, especially for those missing the clear emission lines exploited by QuasarNET. These properties of FNet, together with the fast predictive power of machine learning, allow FNet to be a more accurate alternative for the pipeline redshift estimator and can make it practical in the upcoming catalogs to reduce the number of spectra to visually inspect.

DOI: https://doi.org/10.1093/mnras/stac076

Davood Rafiei Karkevandi, Soroush Shakeri, Violetta Sagun, and Oleksii Ivanytskyi, *Bosonic dark matter in neutron stars and its effect on gravitational wave signal*, published in Phys. Rev. D 105, 023001 on January 3, 2022.

We study an impact of self-interacting bosonic dark matter (DM) on various observable properties of neutron stars (NSs). The analysis is performed for asymmetric DM with masses from few MeV to GeV, the self-coupling constant of order $\mathcal{O}(1)$ and various DM fractions. Allowing a mixture between DM and baryonic matter, the formation of a dense DM core or an extended dark halo has

been explored. We find that both distribution regimes crucially depend on the mass and fraction of DM for sub-GeV boson masses in the strong coupling regime. From the combined analysis of the mass-radius relation and the tidal deformability of compact stars including bosonic DM, we set a stringent constraint on DM fraction. We conclude that observations of $2\ M_{\odot}$ NSs together with $\Lambda_{1.4} \leq 580$ constraint, set by LIGO/Virgo Collaboration, favor sub-GeV DM particles with low fractions below ∼5%.

DOI: https://doi.org/10.1103/PhysRevD.105.023001

Sareh Eslamzadeh, Javad T. Firouzjaee, Kourosh Nozari, *Radiation from Einstein-Gauss-Bonnet de Sitter black hole via tunneling process*, accepted for publication on EPJC on January 4, 2022.

In this paper, we probe in novel 4D Einstein-Gauss-Bonnet (EGB) black hole and its thermodynamics. We illustrate the three asymptotically 4D EGB spacetime as an asymptotically flat, de Sitter, and Anti-de Sitter. Also, we apply the tunneling of the massless particles from the event horizon of 4D EGB gravity and we investigate the correlation between the emission modes and temperature of the event horizon. In asymptotically flat spacetime, the existence of the coupling constant alone constructs the regular spacetime, the radiation deviates from the pure thermal, and the temperature of the black hole horizon would be finite in the final stage of the black hole evaporation. If we consider the 4D ds-EGB structure, then we will have three horizons in the specific mass range of the black hole. By carefully examining the temperature of the black hole and cosmological horizons with the tunneling of the massless particles from these horizons. As a result, the evolution of these temperatures is in direction of the remaining rest mass with the probably same temperature for black hole and cosmological horizon. In addition, the exciting result is that temperature behaviors exactly match with the temperature behaviors of a regular black hole in Lovelock gravity in a higher dimension. This confirms the bypassing of EGB in four dimensions of spacetime from the Lovelock gravity in higher dimensions.

DOI: 10.1140/epjc/s10052-022-09992-6

Yunis, Rafael; Argüelles, Carlos R.; Scóccola, Claudia G.; López Nacir, Diana; Giordano, Gastón, *Self-Interacting Dark Matter in Cosmology: accurate numerical implementation and observational constraints*, accepted for publication on JCAP (24 January 2022).

This paper presents a systematic and accurate treatment of the evolution of cosmological perturbations in self-interacting dark matter models, for particles which decoupled from the primordial plasma while relativistic. We provide a numerical implementation of the Boltzmann hierarchies developed in a previous paper [JCAP, 09 (2020) 041] in a publicly available Boltzmann code and show how it can be applied to realistic DM candidates such as sterile neutrinos either under resonant or non-resonant production mechanisms, and for different field mediators. At difference with traditional fluid approximations - also known as a c_eff⊢ c_vis parametrizations - our approach follows the evolution of phase-space perturbations under elastic DM interactions for a wide range of interaction models, including the effects of late kinetic decoupling. Finally, we analyze the imprints left by different self interacting models on linear structure formation, which can be constrained using Lyman-α forest and satellite counts. We find new lower bounds on the particle mass that are less restrictive than previous constraints.

ArXiv: https://arxiv.org/abs/2108.02657

MAGIC collaboration, *Search for Very High-energy Emission from the Millisecond Pulsar PSR J0218+4232*, published in ApJ, Volume 922, Number 2 on December 3, 2021.

PSR J0218+4232 is one of the most energetic millisecond pulsars known and has long been considered as one of the best candidates for very high-energy (VHE; >100 GeV) γ-ray emission. Using 11.5 yr of Fermi Large Area Telescope (LAT) data between 100 MeV and 870 GeV, and ~90 hr of Major Atmospheric Gamma Imaging Cherenkov (MAGIC) observations in the 20 GeV to 20 TeV range, we searched for the highest energy γ-ray emission from PSR J0218+4232. Based on the analysis of the LAT data, we find evidence for pulsed emission above 25 GeV, but see no evidence for emission above 100 GeV (VHE) with MAGIC. We present the results of searches for γ-ray emission, along with theoretical modeling, to interpret the lack of VHE emission. We conclude that, based on the experimental observations and theoretical modeling, it will remain extremely challenging to detect VHE emission from PSR J0218+4232 with the current generation of Imaging Atmospheric Cherenkov Telescopes, and maybe even with future ones, such as the Cherenkov Telescope Array.

DOI: https://doi.org/10.3847/1538-4357/ac20d7

MAGIC collaboration, *Observation of the Gamma-Ray Binary HESS J0632+057 with the H.E.S.S., MAGIC, and VERITAS Telescopes*, published in ApJ, Volume 923, Number 2 on December 24, 2021.

The results of gamma-ray observations of the binary system HESS J0632 + 057 collected during 450 hr over 15 yr, between 2004 and 2019, are presented. Data taken with the atmospheric Cherenkov telescopes H.E.S.S., MAGIC, and VERITAS at energies above 350 GeV were used together with observations at X-ray energies obtained with Swift-XRT, Chandra, XMM-Newton, NuSTAR, and Suzaku. Some of these observations were accompanied by measurements of the Hα emission line. A significant detection of the modulation of the very high-energy gamma-ray fluxes with a period of 316.7 ± 4.4 days is reported, consistent with the period of 317.3 ± 0.7 days obtained with a refined analysis of X-ray data. The analysis of data from four orbital cycles with dense observational coverage reveals short-timescale variability, with flux-decay timescales of less than 20 days at very high energies. Flux variations observed over a timescale of several years indicate orbit-to-orbit variability. The analysis confirms the previously reported correlation of X-ray and gamma-ray emission from the system at very high significance, but cannot find any correlation of optical Hα parameters with fluxes at X-ray or gamma-ray energies in simultaneous observations. The key finding is that the emission of HESS J0632 + 057 in the X-ray and gamma-ray energy bands is highly variable on different timescales. The ratio of gamma-ray to X-ray flux shows the equality or even dominance of the gamma-ray energy range. This wealth of new data is interpreted taking into account the insufficient knowledge of the ephemeris of the system, and discussed in the context of results reported on other gamma-ray binary systems.

DOI: https://doi.org/10.3847/1538-4357/ac29b7

ICRANet Newsletter

February - March 2022

SUMMARY

1. ICRA - ICRANet - CONICET – UNLP press release *"One star could finally reveal the nature of what does lie at the Milky Way center"*

A new study deepens on the nature of the compact object sitting at our Galaxy center, SgrA*, by analyzing the astrometric data of one of the closest and long-studied stars that orbit around it. The international team of researchers from ICRA-ICRANet and CONICET-UNLP has found that besides the traditional black hole (BH) hypothesis, a dense concentration of dark matter (DM) made of fermions (called darkinos) can explain the detailed data (positions and velocities) of the star S2. The work provides a way to distinguish observationally between these two scenarios using the precession of the S2 orbit, very much in the same way that the theory of general relativity was proven using the precession of Mercury's orbit around the Sun. This new article, published in the Monthly Notices of the Royal Astronomical Society Letters[1], holds relevant implications about the nature and mass of the dark matter particles.

For about three decades, two independent observational campaigns have monitored a cluster of young and bright stars orbiting the central parsec of our Galaxy to constrain the mass and nature of the massive object harbored at the center. These precise and accurate measurements have been possible thanks to the most powerful telescopes on earth. This achievement led to the Nobel Prize in Physics in 2020 awarded to Reinhard Genzel and Andrea Ghez: for the discovery of a supermassive compact object at the center of our galaxy.

Traditionally, a classical BH has been the most accepted hypothesis for the nature of SgrA*. The reason for this is that the orbits of the few detected S-stars are nearly perfect ellipses, implying the existence of a very compact object placed at its focus. Einstein's theory of general relativity predicts that the orbits cannot be Keplerian because there is a precession of the periapsis. The new work demonstrates that this effect is also present in the case of the DM core model and that its entity agrees with all publicly available data that shows the existence of this relativistic pattern in the S2 orbit. The article predicts that the two scenarios on the nature of SgrA* could be discriminated by measuring the precession of S2 around the next apocenter passage that will occur in 2026. The reason behind this difference is that while the BH predicts a unique prograde precession, in the DM scenario, it can be either retrograde or prograde, depending on the amount of DM filling the orbit, which depends on the mass of the darkinos.

A remarkable aspect of this novel DM interpretation of SgrA* is that the DM distribution is not constrained to the core of the Galaxy. The DM configuration extends to the outskirts of the Galaxy, forming a dilute halo that explains the circular velocity of far away objects as welll!. This result, together with a related study (see https://twitter.com/RAS_Journals/status/1489539729037008899?ref_src=twsrc%5Etfw) obtained by some of the research team, hints towards a paradigm shift in the field of DM halos and supermassive BH formation. It suggests that non-active galaxies as our own host dense DM concentrations at their centers, while more massive and active-galaxies, host supermassive BHs that has been formed from the gravitational collapse of these DM cores.

[1] C. R. Arg¨uelles, M. F. Mestre, E. A. Becerra-Vergara, V. Crespi, A. Krut, J. A. Rueda, and R. Ruffini, Monthly Notices of the Royal Astronomical Society: Letters 511, L35 (2021), arXiv:2109.10729, URL https://doi.org/10.1093/mnrasl/slab126.

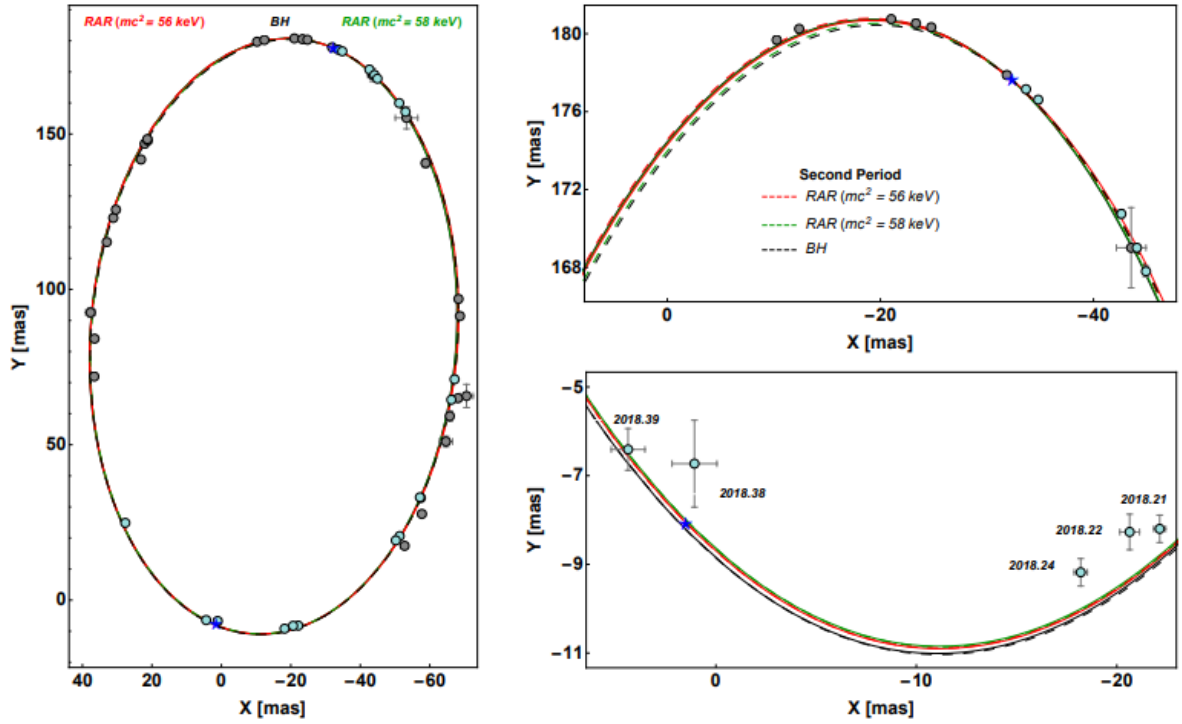


FIG. 1. Figure taken from [1] with the kind permission of the authors. Relativistic precession of S2 in the projected orbit on the plane of the sky as predicted in the BH and RAR DM models. While it is prograde for the BH and RAR (m = 58 keV/c^2) (in dashed black and green respectively), it is retrograde for the RAR DM model (m = 56 keV/c^2) (in dashed red). The solid (theoretical) curves and gray (data) points correspond to the first period (≈ 1994 –2010) while the dashed (theoretical) curves and cyan (data) points to the second period (≈ 2010 –2026). Right panels: zoom of the region around apocentre (*top panel*) and pericentre (*bottom panel*). The astrometric measurements are taken from Do et al.[2].

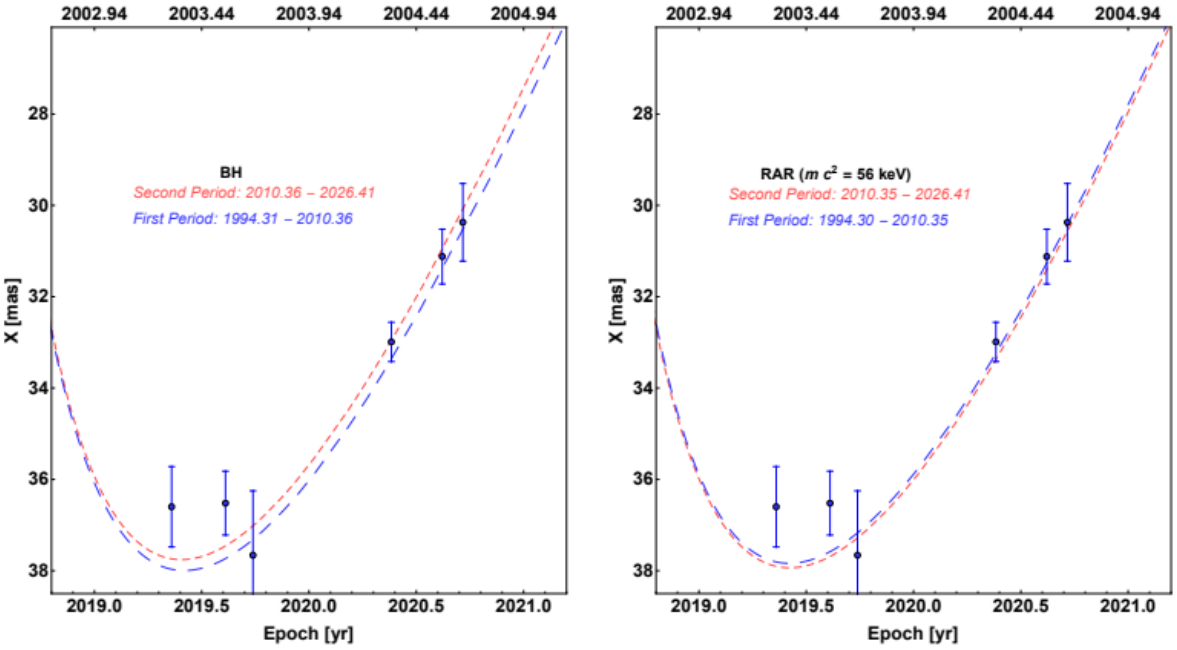


FIG. 2. Relativistic precession of S2 as manifested in the right ascension as a function of time after last pericentre passage, where effects are more prominent. BH model (*Left panel*) and RAR model for m = 56 keV/c^2 (*Right panel*).

[2] T. Do, A. Hees, A. Ghez, G. D. Martinez, D. S. Chu, S. Jia, S. Sakai, J. R. Lu, A. K. Gautam, K. K. O'Neil, et al., Science 365, 664 (2019), 1907.10731.

Press release on ICRANet website: http://www.icranet.org/communication/

Press release on Oxford University press: https://oxfordjournals.altmetric.com/details/113891044

Press release on Conicet-Argentina: https://laplata.conicet.gov.ar/un-nuevo-paso-para-desentranar-que-hay-en-el-centro-de-la-via-lactea/

Upcoming S2-star astrometry could potentially establish if SgrA* is governed by a classical BH or by a quantum DM system: read more in a paper just published in MNRAS (Argüelles et al) at https://t.co/Wbx3kSMokD . #SagittariusA* #darkmatter #darkinos #fermions #blackholes pic.twitter.com/lWMz7d5l8D

— RAS Journals (@RAS_Journals) February 4, 2022

2. GCN published by ICRANet, February 25, 2022

TITLE: GCN CIRCULAR
NUMBER: 31648
SUBJECT: GRB 220101A: The first example of a Petanova
DATE: 22/02/25 11:38:50 GMT
FROM: Remo Ruffini at ICRA <ruffini@icra.it>

R. Ruffini, Y. Aimuratov, L. Becerra, C.L. Bianco, Y-C. Chen, C. Cherubini, Y.F. Cai, S. Eslamzadeh, S. Filippi, M. Karlica, Liang Li, G.J. Mathews, R. Moradi, M. Muccino, G.B, Pisani, F. Rastegar Nia, J.A. Rueda, N. Sahakyan, Y. Wang, S.S. Xue, Y.F. Yuan, Y.L. Zheng, on behalf of ICRA, ICRANet and USTC team, report:

We confirm the results of our previous GCN (Ruffini et al. 2022, GCN 31465). Following the release of the X-ray afterglow (Tohuvavohu et al. 2022, GCN 31347) and the GeV data (Arimoto et al. 2022, GCN 31350) of this source, we can estimate the total (keV+MeV+GeV) isotropic energy (see e.g. Ruffini et al. 2021, MNRAS 504, 5301) to be ~6E54 erg, making this GRB the most powerful GRB in 26 years (a "Petanova"). The period of the new neutron star (see e.g. Ruffini et al. 2021, MNRAS 504, 5301) generating the X-ray afterglow is ~1 ms, the initial mass of the BH (see e.g. Ruffini et al. 2019 ApJ 886, 82) is 6.15 solar mass, the spin parameter is 0.95, and the irreducible mass is 4.98 solar masses (see Fig. 1). The peak of the bolometric flux of supernova is of the order of 1E-17 erg/s/cm^2 and will appear in 73+/-15 days after the GRB trigger, with emissions lasting ~ one month peaking in different infrared bands. The observational follow up of this source is encouraged.

Fig. 1: http://www.icranet.org/docs/GRB220101A.pdf

3. Important Announcements: 80° anniversary of Prof. Remo Ruffini (Nice, May 16 -18, 2022) and 6° Bego Rencontre Summer School (Nice, July 4 - 14, 2022)

The 80th anniversary of Prof. Remo Ruffini

We are happy to invite you to participate to the celebrations of the 80th anniversary of Prof. Remo Ruffini, occurring on May 17, 2022, which will be held from May 16 to 18 at ICRANet Seat Villa Ratti in Nice (France). An hybrid event, both face-to-face and online, will be adopted.

Congratulations, greetings and scientific presentations will be welcomed.

The link to the Indico platform will be announced soon on ICRANet website (http://www.icranet.org/).

The 6th Bego Rencontre Summer School

We are happy to inform you that from July 4 to 14, 2022 ICRANet is organizing the *"6th Bego Rencontre"* at ICRANet Seat Villa Ratti in Nice.

Topics of this summer school will cover the distribution of dark matter in the Universe, the physics of our galactic center, the extraction of rotational energy from Kerr black holes in Gamma-Ray Bursts (GRBs) and Active Galactic Nuclei (AGNs), the associated fields of quantum and classical electrodynamics, neutron stars, white dwarfs, precision measurements of General Relativity and gravitational waves.

Your contributions in these topics are welcomed. The list of lecturers as well as more details on the electronic link to the Indico platform will be announced soon on ICRANet website (http://www.icranet.org/).

4. Visit of H.E. Tsovinar Hambardzumyan, Ambassador of Armenia in Italy, to the ICRANet center in Pescara, March 16, 2022

On March 16, 2022, the Ambassador Extraordinary and Plenipotentiary of the Republic of Armenia to Italy, H.E. Tsovinar Hambardzumyan and her assistant, Dr Naira Ghazaryan, 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. 3, 4 and 5: Prof. Ruffini, Director of ICRANet, presenting the ICRANet center to H.E. Tsovinar Hambardzumyan, Ambassador of the Republic of Armenia to Italy, March 16, 2022.

Prof. Narek Sahakyan, Director of the ICRANet Seat in Armenia joined the visit by GoToMeeting connection and stressed once again the importance of the ICRANet Armenia center to expand the activities of ICRANet in the regional countries. Both parties strongly highlighted the importance of the Armenian-Italian scientific cooperation in the field of astrophysics and discussed the possibilities of further develop and expand the Armenian-Italian scientific cooperation.

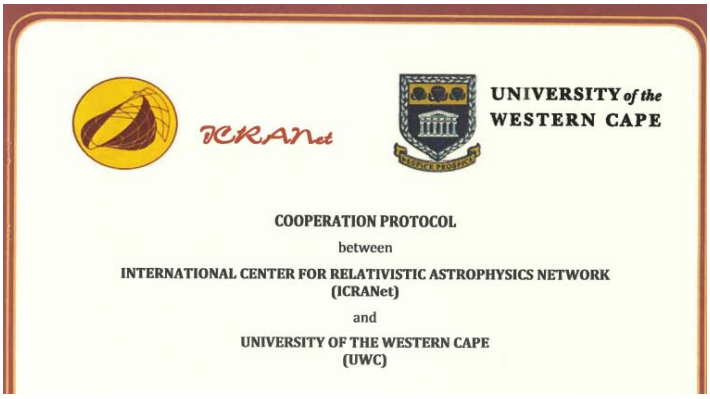
Fig. 6: Prof. Ruffini during his bilateral meeting with H.E. Tsovinar Hambardzumyan, Ambassador of the Republic of Armenia to Italy, March 16, 2022.

Fig. 7: Prof. Narek Sahakyan, Director of the ICRANet Seat in Armenia, joining the meeting with Ambassador Hambardzumyan via GoToMeeting, March 16, 2022.

The news has been also published on the official Facebook webpage of the Armenian Embassy in Italy, available at the following link: https://www.facebook.com/HayastaniDespanutyun/

5. New cooperation protocol between ICRANet and the University of Western Cape (UWC), March 1, 2022

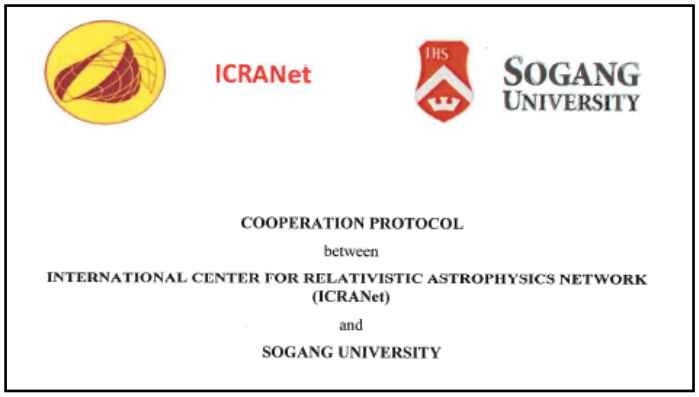
On March 1, 2022 ICRANet has signed a new Cooperation protocol with the University of Western Cape (UWC) in South Africa. The Cooperation Protocol has been signed by Prof. Tyrone Brian Pretorius (Rector of UWC), by Prof. Roy Marteens (Prof. in Astronomy & Astrohysics at UWC), by Prof. Remo Ruffini (Director of ICRANet) and by Prof. Narek Sahakyan (Director of ICRANet Seat in Armenia).



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=1411

6. New cooperation protocol between ICRANet and Sogang University, March 28, 2022

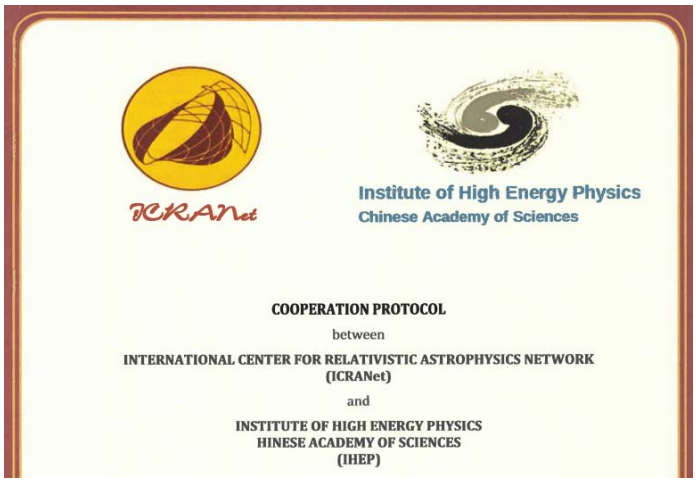


On March 28, 2022 ICRANet has signed a new Cooperation protocol with the Sogang University in South Korea. The Cooperation Protocol has been signed by Prof. Luke Sim Jong-Hyeok SJ (President of Sogang University), by Prof. Stefano Scopel (Director of CQUeST, Sogang University), by Prof. Remo Ruffini (Director of ICRANet) and by Prof. Carlo Luciano Bianco (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=1414

7. Renewal of the cooperation protocol between ICRANet and the Institute of High Energy Physics within the Chinese Academy of Sciences (IHEP CAS), March 7, 2022



On March 7, 2022, the Cooperation Protocol between ICRANet and the Institute of High Energy Physics within the Chinese Academy of Sciences (IHEP CAS) has been renewed. The renewal was signed by Prof. Shuang-Nan Zhang (Director of the Key Laboratory of Particle Astrophysics at IHEP CAS) 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/ihep

8. Podcast of Prof. Remo Ruffini "*March 20, 1916: Einstein publishes the General Theory of Relativity*", Radio Storia La Repubblica, March 20, 2022

On March 20, 2022 the web channel Radio Storia of La Repubblica, one of the most important daily newspaper in Italy, released a podcast registered by Prof. Remo Ruffini, Director of ICRANet.

The podcast, titled *"March 20, 1916: Einstein publish the General Theory of Relativity"* has been directed by the italian journalist Francesco De Leo and addressed important historical events, as if they are just happened. This podcast has been realized as if we were living on March 20, 1916, when Einstein just published his General Theory of Relativity in the Annals of Physics n° 7. In this article, Einstein illustrated the equation which indicates the gravitational force as the space-time curvature and this represented one of the most impressive combinations of philosophy, physical intuition and mathematical skill.

Prof. Ruffini has been invited to comment this article, in order to better understand its importance and influence on general relativity with Einstein theory of gravitation. Prof. Ruffini pointed out that this was a very important text, since in his work, Einstein resumes and generalize the theory of relativity and he starts to define it as special theory of relativity. He recalls us that one of the most important contribution in this field has been the work of Hermann Minkowski, who recognized the formal equivalence between the spatial and temporal co-ordinates and make them usable for the building of this theory. Einstein explained the mathematical formalism of Tullio Levi Civita and Matteo Ricci and finally obtained the equation of the field and of General Relativity. He showed that, if a ray of light passes close to the Sun, there could be the deflection of the ray of light due to the gravitational field of the Sun and this happen also for a signal of light passing close to a planet.

This vision totally changes the traditional Newtonian physics, which claimed that a ray of light propagates itself in a straight line. Einstein also expected that the light originated from a star should change the frequency of its motion in departing from the star, indicating the shift towards longer wavelengths: this is also another concept totally different from the one envisaged by Newton. Moreover, at the times of Newton and Kepler, the classical astronomy conceived the motion as a motion in ellipse; Einstein in 1916 affirmed that there was a small quantity which modified this motion and predicted a motion "a rosetta" of 43 seconds of arc per century: this is a small quantity, but it's conceptually revolutionary.

In commenting the article of Einstein, Prof. Ruffini went on explaining that, as affirmed also by Einstein, it does not exist "the time" but there are 3 spatial components and 1 temporal one which work together, as also expressed by Minkowski. Therefore, since then, Physics has been no more intended as a theory with 1 or 3 components, but as a theory made up by the interaction of 4 dimensions. Einstein said that there is not "the time" but it exists the space – time, described by the metrics introduced by Tullio Levi Civita and Matteo Ricci: all the above represented a big conceptual revolution and gave origin to a new physics, new observations and new knowledge.

To hear the podcast (in Italian): https://www.repubblica.it/podcast/storie/radio-storia/stagione1/

9. Recent publications

Rueda, J. A.; Ruffini, R.; Kerr, R. P., *Gravitomagnetic interaction of a Kerr black hole with a magnetic field as the source of the jetted GeV radiation of gamma-ray bursts*, The Astrophysical Journal; in press.

We show that the gravitomagnetic interaction of a Kerr black hole (BH) with a surrounding magnetic field induces an electric field that accelerates charged particles to ultra-relativistic energies in the vicinity of the BH. Along the BH rotation axis, these electrons/protons can reach energies of even thousands of PeV, so stellar-mass BHs in long gamma-ray bursts (GRBs) and supermassive BHs in active galactic nuclei (AGN) can contribute to the ultrahigh-energy cosmic rays (UHECRs) thorough this mechanism. At off-axis latitudes, the particles accelerate to energies of hundreds of GeV and emit synchrotron radiation at GeV energies. This process occurs within 60° around the BH rotation axis, and due to the equatorial-symmetry, it forms a double-cone emission. We outline the theoretical framework describing these acceleration and radiation processes, how they extract the rotational energy of the Kerr BH and the consequences for the astrophysics of GRBs.

Link preprint: https://arxiv.org/abs/2203.03471

C. R. Argüelles, E. A. Becerra-Vergara, A. Krut, R. Yunis, J. A. Rueda and R. Ruffini, *Reshaping our understanding on structure formation with the quantum nature of the dark matter*, published on International Journal of Modern Physics D Vol. 31, No. 02, 2230002 (2022).

We study the nonlinear structure formation in cosmology accounting for the quantum nature of the dark matter (DM) particles in the initial conditions at decoupling, as well as in the relaxation and stability of the DM halos. Different from cosmological N-body simulations, we use a thermodynamic approach for collisionless systems of self-gravitating fermions in general relativity, in which the halos reach the steady state by maximizing a coarse-grained entropy. We show the

ability of this approach to provide answers to crucial open problems in cosmology, among others: the mass and nature of the DM particle, the formation and nature of supermassive black holes in the early Universe, the nature of the intermediate mass black holes in small halos, and the core-cusp problem.

DOI: https://doi.org/10.1142/S0218271822300026

Gregory Vereshchagin, Liang Li, Damien Bégué, *Is magnetically dominated outflow required to explain GRBs?*, published on Monthly Notices of the Royal Astronomical Society, stac757, on March 22, 2022.

The composition of relativistic outflows producing gamma-ray bursts is a long standing open question. One of the main arguments in favour of magnetically dominated outflows is the absence of photospheric component in their broadband time resolved spectra, with such notable example as GRB 080916C. Here, we perform a time-resolved analysis of this burst and confirm the previous detection of an additional spectral component. We show that this subdominant component is consistent with the photosphere of ultrarelativistic baryonic outflow, deep in the coasting regime. We argue that, contrary to previous statements, the magnetic dominance of the outflow is not required for the interpretation of this GRB. Moreover, simultaneous detection of high energy emission in its prompt phase requires departure from a one-zone emission model.

DOI: https://doi.org/10.1093/mnras/stac757

MAGIC collaboration, *Combined searches for dark matter in dwarf spheroidal galaxies observed with the MAGIC telescopes, including new data from Coma Berenices and Draco*, published in Physics of the Dark Universe, Volume 35, March 2022, 100912.

Milky Way dwarf spheroidal galaxies (dSphs) are among the best candidates to search for signals of dark matter annihilation with Imaging Atmospheric Cherenkov Telescopes, given their high mass-to-light ratios and the fact that they are free of astrophysical gamma-ray emitting sources. Since 2011, MAGIC has performed a multi-year observation program in search for Weakly Interacting Massive Particles (WIMPs) in dSphs. Results on the observations of Segue 1 and Ursa Major II dSphs have already been published and include some of the most stringent upper limits (ULs) on the velocity-averaged cross-section $\sigma_{ann}\, v$ of WIMP annihilation from observations of dSphs. In this work, we report on the analyses of 52.1 h of data of Draco dSph and 49.5 h of Coma Berenices dSph observed with the MAGIC telescopes in 2018 and in 2019 respectively. No hint of a signal has been detected from either of these targets and new constraints on the $\sigma_{ann}\, v$ of WIMP candidates have been derived. In order to improve the sensitivity of the search and reduce the effect of the systematic uncertainties due to the -factor estimates, we have combined the data of all dSphs observed with the MAGIC telescopes. Using 354.3 h of dSphs good quality data, 95% CL ULs on $\sigma_{ann}\, v$ have been obtained for 9 annihilation channels. For most of the channels, these results reach values of the order of 10^{-24} cm^3/s at $\sim$ 1 TeV and are the most stringent limits obtained with the MAGIC telescopes so far.

DOI: https://doi.org/10.1016/j.dark.2021.100912

MAGIC collaboration, *Investigating the Blazar TXS 0506+056 through Sharp Multiwavelength Eyes During 2017-2019*, published on The Astrophysical Journal, Volume 927, Issue 2, id.197.

The blazar TXS 0506+056 got into the spotlight of the astrophysical community in 2017 September, when a high-energy neutrino detected by IceCube (IceCube-170922A) was associated at the 3σ level with a γ-ray flare from this source. This multi-messenger photon-neutrino association remains, as per today, the most significant association ever observed. TXS 0506+056 was a poorly studied object before the IceCube-170922A event. To better characterize its broadband emission, we organized a multiwavelength campaign lasting 16 months (2017 November to 2019 February), covering the radio band (Metsähovi, OVRO), the optical/UV (ASAS-SN, KVA, REM, Swift/UVOT), the X-rays (Swift/XRT, NuSTAR), the high-energy γ rays (Fermi/LAT), and the very high-energy (VHE) γ rays (MAGIC). In γ rays, the behavior of the source was significantly different from the behavior in 2017: MAGIC observations show the presence of flaring activity during 2018 December, while the source only shows an excess at the 4σ level during the rest of the campaign (74 hr of accumulated exposure); Fermi/LAT observations show several short (on a timescale of days to a week) flares, different from the long-term brightening of 2017. No significant flares are detected at lower energies. The radio light curve shows an increasing flux trend that is not seen in other wavelengths. We model the multiwavelength spectral energy distributions in a lepto-hadronic scenario, in which the hadronic emission emerges as Bethe-Heitler and pion-decay cascade in the X-rays and VHE γ rays. According to the model presented here, the 2018 December γ-ray flare was connected to a neutrino emission that was too brief and not bright enough to be detected by current neutrino instruments.

DOI: https://doi.org/10.3847/1538-4357/ac531d

MAGIC collaboration, *Multiwavelength study of the gravitationally lensed blazar QSO B0218+357 between 2016 and 2020*, published on Monthly Notices of the Royal Astronomical Society, Volume 510, Issue 2.

We report multiwavelength observations of the gravitationally lensed blazar QSO B0218+357 in 2016-2020. Optical, X-ray, and GeV flares were detected. The contemporaneous MAGIC observations do not show significant very high energy (VHE; $\gtrsim$100 GeV) gamma-ray emission. The lack of enhancement in radio emission measured by The Owens Valley Radio Observatory indicates the multizone nature of the emission from this object. We constrain the VHE duty cycle of the source to be <16 2014-like flares per year (95 per cent confidence). For the first time for this source, a broad-band low-state spectral energy distribution is constructed with a deep exposure up to the VHE range. A flux upper limit on the low-state VHE gamma-ray emission of an order of magnitude below that of the 2014 flare is determined. The X-ray data are used to fit the column density of $(8.10 \pm 0.93_{\mathrm{stat}}) \times 10^{21}$ cm^{-2} of the dust in the lensing galaxy. VLBI observations show a clear radio core and jet components in both lensed images, yet no significant movement of the components is seen. The radio measurements are used to model the source-lens-observer geometry and determine the magnifications and time delays for both components. The quiescent emission is modelled with the high-energy bump explained as a combination of synchrotron-self-Compton and external Compton emission from a region located outside of the broad-line region. The bulk of the low-energy emission is explained as originating from a tens-of-parsecs scale jet.

DOI: https://doi.org/10.1093/mnras/stab3454

Behzad Eslam Panah, and Khadijie Jafarzade, *Thermal stability, P-V criticality and heat engine of charged rotating accelerating black holes,* General Relativity and Gravitation. 54 (2022) 19

In this paper, we study thermodynamic features of the charged rotating accelerating black holes in anti-de Sitter spacetime. First, we consider these black holes as the thermodynamic systems and analyze thermal stability/instability through the use of heat capacity in the canonical ensemble. We also investigate the effects of angular momentum, electric charge and string tension on the thermodynamic quantities and stability of the system. Considering the known relation between pressure and the cosmological constant, we extract the critical quantities and discuss how the mentioned parameters affect them. Then, we construct a heat engine by taking into account this black hole as the working substance, and obtain the heat engine efficiency by considering a rectangle heat cycle in the P–V plane. We examine the effects of black hole parameters on the efficiency and analyze their effective roles. Finally, by comparing the engine efficiency with Carnot efficiency, we investigate conditions in order to have a consistent thermodynamic second law.

DOI: https://doi.org/10.1007/s10714-022-02904-9

Tayyebeh Yazdizadeh, Gholam Hossein Bordbar, and Behzad Eslam Panah, *The structure of hybrid neutron star in Einstein-Λ gravity*, Physics of the Dark Universe 35 (2022) 100982.

In this paper, we investigate the structure of neutron stars by considering both the effects of the cosmological constant and the existence of quark matter for neutron stars in Einstein's gravity. For this purpose, we use a suitable equation of state (EoS) which includes a layer of hadronic matter, a mixed phase of quarks and hadrons, and a quark matter in the core. To investigate the effect of the cosmological constant on the structure of hybrid neutron stars, we utilize the modified TOV equation in Einstein -Λ gravity. Then we derive the mass–radius relation for different values of the cosmological constant. Our results show that for small values of the cosmological constant (Λ), especially for the cosmological constant from the cosmological perspective ($\Lambda=10^{-52}m^{-2}$),Λ has no significant effect on the structure of hybrid neutron stars. But for higher values, for example, by considering $\Lambda>10^{-14}$ m^{-2}, this quantity affects the maximum mass and radius of these stars. We find an upper limit for the cosmological constant as $\Lambda<9\times10^{-13}m^{-2}$, based on the fact that the gravitational redshift cannot be more than 1 for stars. The maximum mass and radius of these stars decrease by increasing the cosmological constant Λ. Also, by determining and analyzing radius, the compactness, Kretschmann scalar, and gravitational red shift of the hybrid neutron stars with $M=1.4M_{\odot}$ in the presence of the cosmological constant, we find that by increasing Λ, they are contracted. Also, our results for dynamical stability show that these stars satisfy this condition.

DOI: https://doi.org/10.1016/j.dark.2022.100982

ICRANet Newsletter

April - May – June 2022

SUMMARY

1. ICRA – ICRANet press release *"Gravitomagnetic interaction of a Kerr black hole with a magnetic field as the source of the jetted GeV radiation of gamma-ray bursts"*

The new article coauthored by Rueda, J. A., Ruffini R., and Kerr P. R., Gravitomagnetic Interaction of a Kerr Black Hole with a Magnetic Field as the Source of the Jetted GeV Radiation of Gamma-Ray Bursts, has been published in the Astrophysical Journal, Volume 929, Number 1 on April 12, 2022. On that occasion, ICRA and ICRANet released a press release titled *"Gravitomagnetic interaction of a Kerr black hole with a magnetic field as the source of the jetted GeV radiation of gamma-ray bursts"*.

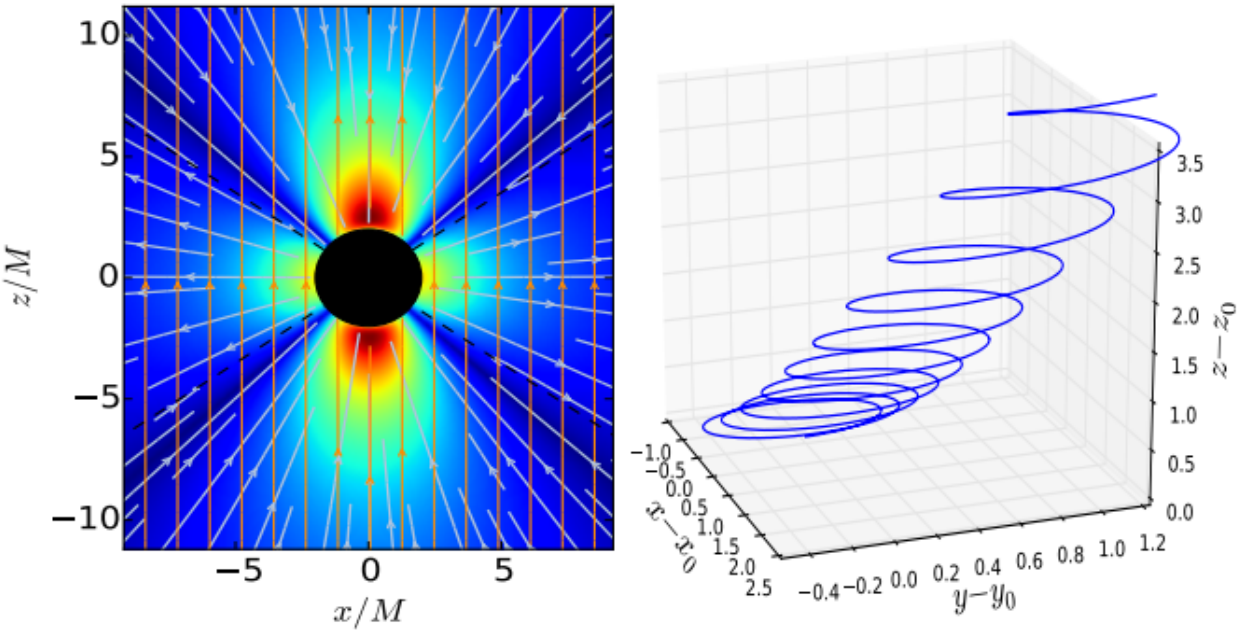


FIG. 1. Figures taken from [1] with the kind permission of the authors. Left panel: electric (light blue) and magnetic (orange) field lines surrounding the rotating black hole. Electrons located in these northern and southern hemisphere cones of semi aperture angle of nearly 60 are outwardly accelerated leading to GeV photons. Right panel: helical motio n of an electron around the magnetic field lines in the vicinity of the black hole leading to synchrotron radiation.

A new theory explains the high-energy (photon energies of gigaelectronvolts — GeV) observed in the energetic long-duration gamma-ray bursts (GRBs) as originated in the vicinity of the black hole horizon. The theory, published today in The Astrophysical Journal [1] (https://iopscience.iop.org/article/10.3847/1538-4357/ac5b6e), led by an ICRA-ICRANet research team (some INAF associates), is based on the *"inner engine"* previously introduced by the team [2, 3]. The theory, which is also shown to work in active galactic nuclei (AGNs), proofs that the rotational energy of a black hole can indeed be extracted from the horizon of the black hole, and efficiently used to power the most energetic and powerful objects in the Universe.

GRBs and binary-driven hypernovae. GRBs are one of the most complex astrophysical systems observed from ground and space in a wide window of the electromagnetic spectrum, including radio, optical, X-rays, gamma-rays in the megaelectronvolt (MeV) and the gigaelectronvolt (GeV) regimes, and ultrahigh-energy cosmic rays (UHECRs). GRBs are the most powerful transient sources of energies in the sky, releasing up to a few 10^{54} erg in just a few seconds. Therefore, the luminosity of a GRB is comparable to the sum of the luminosities of all the stars in the Universe!. The emission of an energetic GRB is characterized by seven Episodes produced by specific physical processes with widely different characteristic evolution timescales ranging from 10^{-14} s to 10^{7} s or longer [4]. Although researchers soon identified that black holes must fuel GRBs, it is hard to think

that a single object can explain all the above complexity. Another crucial piece of information is that one of such Episodes is an associated supernova explosion. How can a single astrophysical object lead to a supernova explosion, a black hole, and all the observed emissions at the different wavelengths? An answer to this question arises from the binary-driven hypernova (BdHN) model (see, e.g., [4], and references therein). In the BdHN scenario, the GRB originates in a binary system composed of a carbon-oxygen (CO) star and a neutron star (NS) companion. The CO star undergoes a core-collapse supernova, forming at its center a newborn neutron star, while the ejected material causes a massive accretion process onto the neutron star companion. The entity of the accretion process depends mostly on the orbital period, and only in tight binaries with orbital periods as short as a few minutes the accretion onto the neutron star companion induces its gravitational collapse, forming a newborn black hole. Three-dimensional numerical simulations of the above process in a BdHN were presented in [5]. The different fates of the binary explains the variety of GRBs, while the different physical components of the binary powered the different emission Episodes. The binaries in which the black hole is formed are called BdHN of type I. In a BdHN I, the rotational energy of the fast rotating, newborn neutron star and its interaction with the ejected material in the supernova powers the synchrotron radiation that explains the radio, optical, and X-rays emissions (see, e.g., [6]). Only the observed GeV emission [3, 7] is associated with the black hole and the process of energy extraction that is the topic of the new publication.

Black holes are storehouses of energy. Black holes were initially conceptualized either as *"dead"* objects or as sinks of energy. Subsequently, it was realized that much as the thermodynamical systems, black holes may interact with their surroundings exchanging energy [8, 9]. This result led to one of the most important concepts in black hole physics and astrophysics: the Christodoulou-Ruffini-Hawking black hole mass-energy formula [8–10]. In its most general form, for a rotating charged black hole, it relates the black hole mass-energy to three independent pieces: its "*irreducible mass*, its charge, and its angular momentum. It led to a corollary of paramount importance in astrophysics: up to 50% of the mass-energy of a charged black hole, and up to 29% of the one of a rotating black hole, could be in principle extracted!. This extraordinary result led to the alternative view of black holes as storehouses of energy which nature could potentially use, and since then this concept has permeated for fifty years as of this writing, relativistic astrophysics both theoretically and experimentally.

How much energy do we need to extract from black holes?. As we have mentioned above, researchers think that stellar-mass (i.e., of a few solar masses) black holes are involved in the emission of GRBs while, AGNs, releasing 10^{46} erg s^{-1} for billion years, must be powered by supermassive black holes of up to a few billion solar masses. However, the specific physical mechanism leading to the emission is up-to-now unknown, and theoretical efforts to find how to extract the black-hole energy have evanesced by the implausibility of their realization in nature (see, e.g. [11]). The existing models of AGN explain the observed jetted emission with massive jets powered by accretion disks around black holes, and GRBs models have inherited the same idea. These models have avoided, in practice, solving the problem of energy extraction from a black hole. Therefore, finding an astrophysically viable process that extracts the energy from a black hole has remained elusive. Because the efficiency of accretion power is low and, as such, very costly for nature, there was a need for new physics!.

From charge to effective charge. A much more efficient mechanism for the acceleration of particles should use electromagnetic fields instead of pure gravity. In particular, electric fields can be great accelerators of charged particles. One could think of allowing the black hole to have stably some net charge that produces a stable electric field. This has been a most debated topic in astrophysics because, in principle, a charged black hole could be rapidly neutralized by absorbing an electric charge of the opposite sign to its charge. In 1973, Ruffini and Treves calculated the ground state configuration of a conducting rotating sphere endowed with charge and magnetic field [12]. In classical electromagnetism, Faraday induction implies that a rotating conductor in an external magnetic field generates an electric field. Accounting for this effect, they obtained the

electromagnetic field structure of the configuration and showed that in its ground state, the electric charge of the object is not a free parameter: it has a precise value that depends on the mass and size of the object, the angular momentum, and the magnetic field strength. In 1974, R. Wald studied a similar question by analyzing a rotating black hole in an external magnetic field [13]. In this case, Einstein's theory of general relativity predicts a unique effect based on the concept of *gravitomagnetism*: the interaction of the gravitational field of the rotating black hole with the magnetic field induces an electric field. This is somehow analogous to the Faraday induction, but here there is no charge generating that electric field! If we think of this electric field as produced by some charge, an effective charge, then the value of such an effective charge turns out to be determined, again, only by the black-hole angular momentum and the magnetic field strength. The existence of electric fields without electric charge has led to the possibility of astrophysical black holes being efficient particle accelerators without being electrically charged objects!

The new physical mechanism. The engine presented in the new publication uses the above purely general relativistic effect of *gravitomagnetism* by considering a rotating black hole in an external magnetic field that induces the an electric field (see Figure 1). The theory exploits this induced electric field to accelerate charged particles (e.g. electrons/protons) in the vicinity of the black hole. Along the black hole rotation axis, the electrons are accelerated to energies of even thousands of PeV, so stellar-mass black holes in GRBs and supermassive black holes in AGNs can contribute to the observed flux of UHECRs using this mechanism. At off-axis latitudes, electrons accelerate to energies of hundreds of GeV and emit synchrotron radiation at GeV energies. This process occurs within 60° around the black hole rotation axis, and due to the equatorial -symmetry, it forms a double-cone of outgoing radiation. The black hole energy extraction. The energy carried out by this electromagnetic radiation is paid by the black hole which, in turn, loses its mass and angular momentum with time. This proves that we can efficiently extract energy from a rotating black hole to power the high-energy jetted emissions of GRBs and AGNs. The jetted emission does not originate from an ultra-relativistic acceleration of matter in bulk (e.g., massive jets powered by accretion disks), but from very special energy-saving general relativistic and electrodynamical process. A long march of successive theoretical progress and new physics discovered using GRBs has brought to this long-awaited result for about fifty years of relativistic astrophysics. We refer the interested reader to [1] for further details. As pointed out by the Referee: *this paper pursues a very important problem in astrophysics, the generation of GRBs ... the problem of ultra-high energy radiation production using clean general relativistic approach.*

[1] J. A. Rueda, R. Ruffini, and R. P. Kerr, Astroph. J. 929, 56 (2022), arXiv: 2203.03471.
[2] J. A. Rueda and R. Ruffini, European Physical Journal C 80, 300 (2020), 1907.08066.
[3] R. Ruffini, R. Moradi, J. A. Rueda, L. Becerra, C. L. Bianco, C. Cherubini, S. Filippi, Y. C. Chen, M. Karlica, N. Sahakyan, et al., Astroph. J. 886, 82 (2019), 1812.00354.
[4] R. Ruffini, R. Moradi, J. A. Rueda, L. Li, N. Sahakyan, Y. C. Chen, Y. Wang, Y. Aimuratov, L. Becerra, C. L. Bianco, et al., MNRAS (2021), 2103.09142.
[5] L. Becerra, C. L. Ellinger, C. L. Fryer, J. A. Rueda, and R. Ruffini, Astroph. J. 871, 14 (2019), 1803.04356.
[6] J. A. Rueda, R. Ruffini, M. Karlica, R. Moradi, and Y. Wang, Astroph. J. 893, 148 (2020), 1905.11339.
[7] R. Moradi, J. A. Rueda, R. Ruffini, and Y. Wang, Astron. Astroph. 649, A75 (2021), 1911.07552.
[8] D. Christodoulou, Phys. Rev. Lett. 25, 1596 (1970).
[9] D. Christodoulou and R. Ruffini, Phys. Rev. D 4, 3552 (1971).
[10] S. W. Hawking, Physical Review Letters 26, 1344 (1971).
[11] R. Penrose and R. M. Floyd, Nature Physical Science 229, 177 (1971).
[12] R. Ruffini and A. Treves, Astroph. Lett. 13, 109 (1973).
[13] R. M. Wald, Phys. Rev. D 10, 1680 (1974).

Press release on ICRANet website: http://www.icranet.org/communication/

2. ICRANet GCN 32169, June 26, 2022

TITLE: GCN CIRCULAR
NUMBER: 32169
SUBJECT: GRB 220527A: A BdHN I with a clear UPE phase
DATE: 22/06/06 15:33:00 GMT
FROM: Remo Rufinni at ICRA ruffini@icra.it

R. Ruffini, Y. Aimuratov, L. Becerra, C.L. Bianco, Y.-C. Chen, C. Cherubini, S. Eslamzadeh, S. Filippi, M. Karlica, L. Li, G.J. Mathews, R. Moradi, M. Muccino, G.B. Pisani, F. Rastegarnia, J.A. Rueda, N. Sahakyan, Y. Wang, S.-S. Xue, on behalf of the ICRA, ICRANet-INAF team, report:

GRB 220527A is observed by AGILE (Ursi et al. 2022, GCN 32129), Fermi (GCN 32130, Bissaldi et al. 2022, GCN 32131, Mangan et al. 2022, GCN 32133), Swift (B. Sbarufatti et al. 2022 GCN 32135, A. Tohuvavohu. 2022, GCN 32136), CALET (Yamaoka et al. 2022, GCN 32139), AstroSat (Gopalakrishnan et al. 2022, GCN 32140), and Konus-Wind (Lysenko et al. 2022, GCN 32152).

With the redshift z = 0.857 of GRB 220527A (D. Xu et al. 2022, GCN 32141), the isotropic energy of this GRB in 10 keV - 10 MeV, and 20 keV - 16 MeV ranges are E_iso=(2.60 +\- 0.14)x10^{53} erg, and E_iso=1.22(-0.06,+0.07)x10^{53} erg, respectively (A. Lysenko et al. 2022, GCN 32152). The ultra-relativistic prompt emission phase of this GRB, originating from the over-criticl electric field around the black hole (Moradi et al 2021, Phys. Rev. D 104, 063043) extends from rest-frame time of 3.7s to 5.4s. The UPE phase is best fitted by a cutoff power-law plus blackbody spectrum (CPL+BB) with best fit parameters of: alpha = -0.57, Ep = 109.5 keV, beta = -2.36, kT = 47.8 keV.

In addition to the above observations, the following observation of the GeV emission (E. Bissaldi et al. 2022, GCN 32131), originated from the newborn black hole (R. Ruffini et al. 2019 ApJ 886 82) and the afterglow emission (B. Sbarufatti et al. 2022 GCN 32135, A. Tohuvavohu. 2022, GCN 32136) originated from the newborn neutron star (J.A. Rueda et al. 2020 ApJ 893 148), confirm this GRB is a BDHN I.

Following Ruffini et al. 2021 (MNRAS, 504, 5301,doi:10.1093/mnras/stab724), we predict the emergence of an optical supernova peak to be detected at (25.1+/-3.5) days after the trigger (June 21th 2022, uncertainty from June 18th 2022 to June 24th 2022), with the bolometric optical luminosity of L_SN,b=(9.0+/-2.7)x10^{42} erg/s.

Follow-up optical observations for the SN peak are encouraged.

3. *Prof. Remo Ruffini Festschrift. A conference in celebration of Prof. Remo Ruffini 80th birthday*, May 16-18, 2022, Nice and online

Prof. Remo Ruffini Festschrift, a conference in celebration of Prof. Ruffini's 80th birthday, has been held from May 16 to 18, 2022 at ICRANet Seat Villa Ratti in Nice (France). An hybrid event, both face-to-face and online, was adopted.

More than 90 speakers from 26 different countries joined the conference, delivering scientific presentations, remembering the important role played by Prof. Ruffini in the field of Relativistic Astrophysics, or just sharing with the audience some good memories with Prof. Ruffini and their warmest greetings. Among them: Yerlan Aimuratov (ICRANet, Fesenkov Astrophysical Institute), Lorenzo Amati (INAF OAS), Stefano Ansoldi (University of Udine), Carlos Arguelles (UNLP, CONICET), Xinhe Bao (President of USTC), Laura Becerra (Pontificia Universidad Católica de Chile), Donato Bini (CNR), Yifu Cai (USTC), Pascal Chardonnet (attaché for scientific cooperation at the French Embassy in Algeria), Pisin Chen (LeCoSpa), Christian Cherubini (University Campus Bio-medico of Rome), Demetrios Christodoulou (ETH Zurich), Zigao Dai (USTC, Nanjing University), Thibault Damour (IHES), Massimo Della Valle (INAF), Nathalie Deruelle (IHES), Hansjoerg Dittus (ZARM, University of Bremen), Simonetta Filippi (University Campus Bio-medico of Rome), Christopher Fryer (Los Alamos National Laboratory), Jiangong Gao, Daniele Gregoris (Jiangsu University of Science and Technology), Mimoza Hafizi (University of Tirana), Wenbiao Han (SHAO), Luca Izzo (University of Copenhagen), Robert Jantzen (Villanova University), Vladimir Karas (Czech Academy of Sciences), Roy Kerr (University of Canterbury, New Zeland), Claus Laemmerzahl (ZARM, University of Bremen), Giovanni Lamanna (LAPP), Liang Li (ICRANet), Manuel Malheiro (Istituto Tecnologico de Aereonautica –ITA), Grant Mathews (University of Notre Dame), Felix Mirabel (IAFE Argentina, CEA Saclay), Rahim Moradi (ICRANet), Ehud Nakar (Tel Aviv University), Tsvi Piran (Hebrew University of Jerusalem), Peter Predehl (MPE), Brian Punsly (ICRANet), Sang Pyo Kim (Gunsan National University), Hernando Quevedo (UNAM), Johann Rafelski (University of Arizona), José Rodriguez (UIS, ICRANet), Jorge Rueda (ICRANet Ferrara), Sara Saghafi (University of Mazandaran), Narek Sahakyan (Director ICRANet Seat in Armenia), Stefano Scopel (Sogang University, CQeST), Soroush Shakeri (Isfahan University of Technology), Zhiqiang Shen (Director General SHAO), Costantino Sigismondi (ICRANet), Yousef Sobouti (IASBS), Rashid Sunyaev (IKI, Russian Academy of Sciences), Marco Tavani (INAF), Saken Toktarbay (Al-Farabi Kazakh University), Aldo Treves (University of Insubria), Gregory Vereshchagin (ICRANet), Yu Wang (ICRANet), Hyung Won Lee (Inje University), Shesheng Xue (ICRANet), Yefei Yuan (USTC), Alexander Zakharov (ITEP), Cesar Zen Vasconcellos (UFRGS), Bing Zhang (University of Nevada) and Yunlong Zheng (USTC)

Some of these speakers, participated in person and went to Villa Ratti in Nice to join Prof. Ruffini. Also Dr Agnès Rampal, assistant of the Mayor of Nice and Dr Xavier Latour, Vice-president of the Métropole Nice Côte d'Azur joined the meeting in person on May 17, the day of Prof. Ruffini's birthday, in order to express him their sincere greetings, also on behalf of the Mayor of Nice, H.E. Christian Estrosi.

The rich program of the meeting was articulated in 4 main sessions, in order to accommodate all the different time zones and to facilitate the participation of many speakers from all over the world. The one organized every day in the early morning was mainly devoted to the connections with China, Korea and Iran. This was followed by a morning session, a lunch break one (which both saw the participation of many scientists from Europe) as well as by an afternoon one, mainly attended by scientist from North and South America.

The meeting webpage is available at the following link: https://indico.icranet.org/event/3/.

The recordings of the different sessions are now available on the ICRANet YouTube channel, at the following link: https://www.youtube.com/playlist?list=PLr5RLbSWSonvwinAmihhTf675um9A_GqZ

4. MG16 Awards ceremony, May 17, 2022 (Nice, France) and June 1, 2022 (Moscow, Russia)

On the occasion of the conference in celebration of Prof. Ruffini's 80th birthday, the official ceremony to deliver the MG16 Awards' statues in person to the Awardees has been also organized. The MG16 meeting took place from July 5 to 10, 2021 only online, in observance of the Covid-19 safety regulations which then imposed strict restrictions to travels and meetings' organization. The MG16 Awards have been therefore presented at ICRANet Seat in Villa Ratti in Nice on May 18, 2022 by Prof. Nathalie Deruelle, Prof. Jorge Rueda and Prof. Narek Sahakyan to Prof. Tsvi Piran (Hebrew University of Jerusalem), Prof. Peter Predehl (on behalf of Max Planck Institute for Extraterrestrial Physics - MPE) and Prof. Rashid Sunyaev (on behalf of Space Research Institute IKI of the Russian Academy of Sciences).

Fig. 3: Prof. Tsvi Piran receiving his MG16 Award at ICRANet Seat in Villa Ratti (Nice) on May 17, 2022, by Prof. Nathalie Deruele (IHES).

Fig. 4: Prof. Peter Predehl receiving his MG16 Award at ICRANet Seat in Villa Ratti (Nice) on May 17, 2022, by Prof. Jorge Rueda (ICRANet).

At the end of the MG16 Awards ceremony, Prof. Piran and Prof. Sunyaev left their signatures on the wall of Villa Ratti, next to those of other eminent personalities (scientists, politicians, artists, ...) who visited the center.

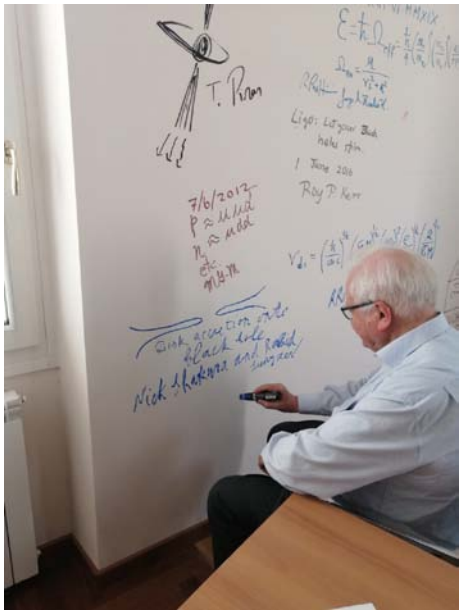


Fig. 5: Prof. Rashid Sunyaev, Russian Academy of Sciences, signing the wall of ICRANet Seat at Villa Ratti (Nice) on May 17, 2022.

Fig. 6: Prof. Tsvi Piran, Hebrew University of Jerusalem, signing the wall of ICRANet Seat at Villa Ratti (Nice) on May 17, 2022.

On June 1, 2022 the MG16 Award has been delivered in person to Prof. Alexander Shirshakov (on behalf of S.A. Lavochkin Association, part of Roskosmos), who received this award back in 2021. The solemn ceremony was organized in the museum of the enterprise in Moscow (Russia).
This award has been attributed for *"the unique achievements in the study of Black Holes, in particular for the very precise X-ray map of the sky"*.
"Spektr-RG is a great project. This is really so. So much has been done. I wish to add that this project allowed to grow the whole new generation of engineers, developers and manufacturers. I sincerely believe that this award is not the last one." - said the first deputy Director, Aleksandr Shirshakov during the delivery of the award.
"The award is cast is silver and represents the projection of particle orbits around the rapidly rotating Black Holes" - said the PI of the Spektr-RG project, the head of the division of high energy astrophysics in the Institute for Space Research (IKI) of the Russian Academy of Sciences, Rashid Sunyaev. *"This is almost the limiting rotation of the black hole, and here is a number of particle trajectories represented"* - he said, giving the award to the first deputy Director of the Lavochkin association.

Fig. 7: from the left to the right: Prof. Alexander Shirshakov (Deputy Director S.A. Lavochkin Association) and Prof. Rashid Sunyaev with the MG16 Award sculpture, June 1, 2022.

Some press relases on that event (in Russian) are available at the following links:

– https://360tv.ru/news/mosobl/npo-imeni-lavochkina-v-himkah-poluchil-mezhdunarodnuju-premiju/?utm_source=yxnews&utm_medium=desktop

– https://www.laspace.ru/press/news/events/010620222/

– https://tass.ru/kosmos/14791015?utm_source=google.com&utm_medium=organic&utm_campaign=google.com&utm_referrer=google.com

– https://novosti-kosmonavtiki.ru/news/83790/

– https://www.interfax.ru/russia/844440

5. *"Lunar eclipse and Mersenne Prize ceremony"*, a parallel meeting to Prof. Remo Ruffini Festschrift, May 16 – 18, 2022, Pescara and online

On the occasion of the 80th birthday of Prof. Remo Ruffini, Director of ICRANet and President of ICRA, as well as on the occasion of the total eclipse of the Moon in 2022, Prof. Costantino Sigismondi, ICRANet collaborator, organized and chaired a parallel meeting at the ICRANet center in Pescara from May 16 to 18, 2022.

The meeting was attended by the students from 2 classes of Galileo Galilei High School in Pescara, under the supervision of their tutor, Prof. Tiziana Pompa.

It started on Monday, May 16 from 4 to 6 AM in Lanciano (Abruzzo, Italy) with the online lunar eclipse observations and the sunrise at 256 m above the sea level, horizon's depression and refraction. The meeting went on from 3 to 4 PM at the ICRANet center in Pescara, starting with a visit of the center by the students. Then, Prof. Sigismondi presented a talk on the differential measures of ΔUT1 at the meridian line of Santa Maria degli Angeli in Rome and Prof. J.M. Pasachoff (by remote connection), presented a talk titled *"preliminary analysis on the Lunar Total Eclipse of May 16,2022: is there still science with eclipses?"*. From 8 to 10 PM, Prof. Sigismondi organized an observation of the sunset behind the hills and of the moonrise from the canal harbor of Pescara, still in opposition to the Sun, as well as an observation of the transit of the international space station and of its instant immersion in the shadow of the Earth (as has been for the eclipse of Moon) at h 21:01:24.

Fig. 8: Pescara - May 17, h 5:52 AM.

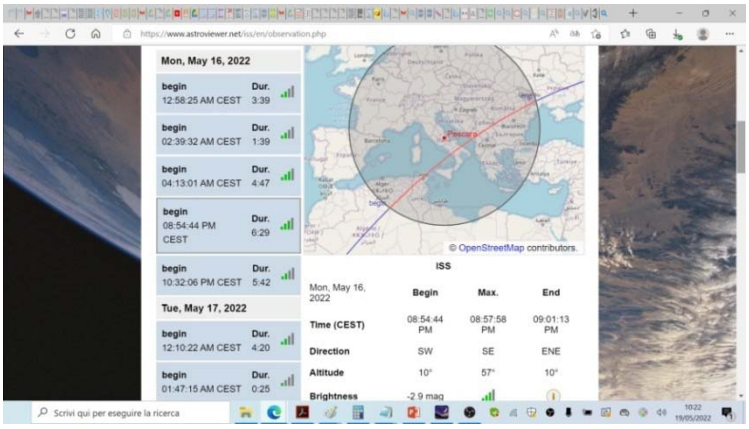


Fig. 9: Ephemerides calculated for Pescara, May 16, slightly in advance to the observed data. In fact, the orbital elements of the ISS are manually changed with periodical lighting of rockets, in order to avoid that it falls in the atmosphere for the even minimum friction which experiments at 400 km of height.

On Tuesday May 17, Prof. Sigismondi organized in Pescara. from 5 to 6 AM, the observation of Venus, Jupiter, Mars and Saturn and Sunrise at the sea level. These observation have been followed in the afternoon by a presentation on the solar forcing to climate change.

Immediately after, there was an official ceremony for the attribution of the Mersenne Prizes 2022 by Dr Carlo Masci, Mayor of Pescara, in honor of Prof. Remo Ruffini's 80th birthday. This event was in fact broadcasted and inserted in the program of Prof. Ruffini Festschrift, which was ongoing. Inspired by the figure of Marino Mersenne (1588-1648), than European referent for all the scientists, ICRANet promoted and established this prize in 2019, with the sponsorship of the IAU Commission on History of Astronomy (Commission C3) and ideally continues his work in the field of Relativistic Astrophysics, representing a strong network of scientists from all over the world.

Several eminent students have been awarded by the Mayor of Pescara, namely Daniele Spalletti (Galileo Ferraris Technical Institute- Rome), Gabriele Orsini (Galileo Ferraris Technical Institute- Rome) and Giulia Andreasi Bassi (Galileo Ferraris Technical Institute- Rome) for the 2022 edition of the Mersenne Prize; Aurora Delli Rocioli (Galileo Galilei High School- Pescara) and Diego Guglielmi (Galileo Ferraris Technical Institute- Rome) for the 2021 edition; and Christian Genghini (IIS Federico Caffè- Rome), Francesco Di Iacovo (IIS Federico Caffè- Rome), Gabriele Becagli (IIS Federico Caffè- Rome) and Roberta Chaicchiaretta (Galileo Galilei High School- Pescara) for the 2020 edition.

Fig. 10: H.E. Carlo Masci, Mayor of Pescara, together with prof. Costantino Sigismondi, during the official ceremony for the attribution of the Mersenne Prizes 2022 at the ICRANet center in Pescara on May 17, 2022.

Fig. 11: H.E. Carlo Masci, Mayor of Pescara, together with some students awarded by the Mersenne Prize at the ICRANet center in Pescara on May 17, 2022.

For the press release on that event: http://www.icranet.org/communication/16052022/ita.pdf

For the article appeared on the local newspaper "Il Centro": https://www.ilcentro.it/pescara/studenti-scienziati-i-premiati-1.2876541

This theoretical section was also integrated with the podcast materials prepared by Prof. Sigismondi. The program of the event and all the relevant podcast materials, can be found at the following link: http://www.icranet.org/index.php?option=com_content&task=view&id=1444

6. *"Gerbertus' Meeting in tour"*, Rome, May 12, 2022

The annual congress in honor of Gerbert of Aurillac, scientist, scholastic astronomer and Pope, took place on May 12, 202 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 "meeting in tour" in 3 main places, symbolic for Gerbertus.

Fig. 12: Sun and Moon in the apse mosaic of St. Maria Maggiore in Rome, made by Jacopo Torriti (XIII century).

The meeting started at 11 AM on Thursday May 12, 2022 from the papal Basilica of Santa Maria Maggiore in Rome. The Sun and the Moon in the apse of this Basilica have been made by Jacopo Torriti in the 13th century. The Latin inscription below Jesus and Mary says *"Maria Virgo Assumpta Est ad Aethereum Thalamum in quo Rex Regum Stellato Sedet Solio"*. The Virgin Mary has been assumpted at the heavenly thalamus, where the King of kings sits on the starry throne where Gerbert-Sylvester II guided a famous procession in the night of August 15, 1000 to the Lateran.

After this visit, the meeting moved to the Basilica of Santa Croce in Gerusalemme, where Gerbert celebrated mass on May 3, 1003 and started to be ill. A legend appeared in 1080 AD (William of Malmesbury) attributed to Gerbert the invention of an *automat*. It predicted that Gerbert will not die if not going to Jerusalem, and the mass in Santa Croce *"in Jerusalem"* represented the violation to the *"immortality condition"* obtained by the magic automat.

The meeting moved then to the Basilica of San Giovanni in Laterano, where the epitaph of Gerbertus' tomb is still there, included by Francesco Borromini in the renovation of the Basilica in 1648, upon the will of Pope Benedict XIV (founder of the Pontifical Academy of Sciences). Beyond the legend of his tomb, which would emit humidity for the death of a Pope or a Cardinal, and beyond another one about his body cut in pieces (false, upon verification in 1648), Gerbert of Aurillac (ca 938-12 May 1003) was renowned as the greatest scholar of his time. Bishop of Reims, Ravenna and Rome he *"jumped from R to R in R"* in his three archbishoprics, in a period of time characterized by the rule that a Bishop could not change site.

Gerbert of Aurillac introduced in Europe the Astrolabe and the Abacus from the Arabs, even inventing new algorithms for speeding their calculations. He was also a music theorist and organ builder, as well as a philosopher who anticipated Scholastic school. His epistolary is the vaster of his time, showing a fine politician, geographer, scientist, teacher and pastor.

A special guest of this event was Prof. Luca Montecchio (UniEcampus), historian and author of *"Gerberto d'Aurillac. Silvestro II"* with graphe.it (2011).

Fig. 13: The tomb of Gerbert visited on May 12, 2022: the cockade placed by the Hungarian Government, each year, is a symbol for remembering the role of Pope Sylvester II in creating that country, by the consecration in 1000 AD of the crown to its King St. Steven.

For the website of the meeting: http://www.icra.it/gerbertus/gerb-tour2022.htm

For the history of the previous meetings since 2003: http://www.icra.it/gerbertus

7. Prof. Ruffini at the presentation of the book *"Somnium. Urla dall'Universo"* by Ambassador Bruno Scapini, May 27, 2022, Rome

On May 27, 2022, Prof. Ruffini has been invited to intervene on the occasion of the presentation of the book *"Somnium. Urla dall'Universo"* by Ambassador Bruno Scapini, former Ambassador of Italy in the Republic of Armenia.

The book, edited by Calibano, has been presented in the conference room of Hotel Donna Laura Palace in Rome (Italy). Ambassador Scapini claims that geopolitics is now moving also to the space and that its militarization could be the risk that humanity could face in the future. In this work, Scapini reports the story of Timothy Sanders, young astrophysicist and aspirant astronaut of NASA, who detects from the Observatory of Mount Palomar, the approaching of a mysterious object not identified. This discovery involves him in a tricky espionage affair between USA and Russia, as well as in a dangerous love story. Anyway, Sanders will discover the creator of this nefarious militarization project only after a series of adventures in which he will also risk his life.

The event has been moderated by Dr Maria Grazia De Angelis, President of the italian association for the study of the work for the organizational development and saw the participation of the literary critic, Prof. Marina Pratici, and of Prof. Remo Ruffini, Director of ICRANet. During his intervention, Prof. Ruffini thanked Ambassador Scapini for his kind invitation and illustrated his recent research and results achieved also thanks to the constant collaboration with his research group as well as with scientists from all over the world. Every day, every minute and every second, thanks to the observations and to the data analysis, they are making new discoveries which contribute to understand always more the structure of our Universe.

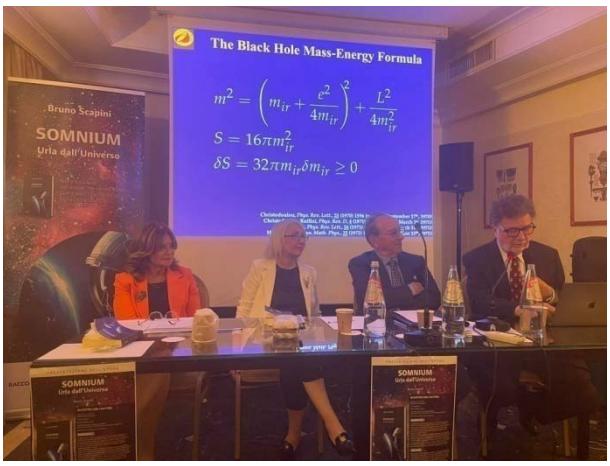


Fig. 14: Prof. Ruffini on the occasion of the presentation of the book *"Somnium. Urla dall'Universo"* by Ambassador Bruno Scapini on May 27, 2022 in Rome, together with Dr Maria Grazia De Angelis and Prof. Marina Pratici.

For more information about that event (in Italian):
http://www.ln-international.net/home/news/10597/bruno-scapini--presenta-a-roma-il-suo-ultimo-romanzo--somnium-urla-dall-universo
https://kmetro0.it/2022/05/29/somnium-urla-dalluniverso-fantapolitica-o-realta/

8. Dr Eduar Becerra, ICRANet PhD student and UIS, won the 2022 ICTP-SAIFR Prize in Classical Gravity and Applications, June 2022

It is our pleasure to announce that Dr Eduar Becerra (ICRANet PhD student and Universidad Industrial de Santander-Bucaramanga, Colombia) obtained an honorable mention for the 2022 ICTP-SAIFR Prize in Classical Gravity and Applications for *"Geodesics in space-time of self-gravitating dark matter and its application to stellardynamics around the Galactic center"*.

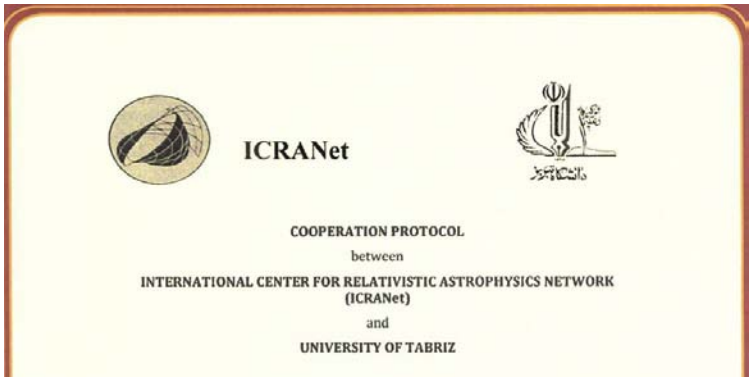
The annual competition for the 2022 ICTP-SAIFR Prize in Classical Gravity and Applications has been created to stimulate the growth of a Latin-American community in the rapidly evolving research areas related to gravitational wave observations. This prize recognizes doctoral thesis research of outstanding quality and achievement in the area of classical gravity and its applications in gravitational wave physics, astrophysics and cosmology. The annual award consists of $1000 Brazilian reais, a certificate, and travel and local expenses to present an invited talk at the annual ICTP-SAIFR Workshop on Classical Gravity and Applications.

For the webpage of the Prize: https://www.ictp-saifr.org/gravityprize/

9. New collaboration agreement between ICRANet and the University of Tabriz (Iran), April 26, 2022

On April 26, 2022 ICRANet has signed a new Cooperation protocol with the University of Tabriz in Iran. The Cooperation Protocol has been signed by Dr Safar Nasrollahzadeh (Chancellor of the

University of Tabriz), by Prof. Amin Rezaei Akbarieh (Faculty of Physics at University of Tabriz), by Prof. Remo Ruffini (Director of ICRANet) and by Prof. Narek Sahakyan (Director of ICRANet Seat in Armenia).


ICRANet

COOPERATION PROTOCOL
between
INTERNATIONAL CENTER FOR RELATIVISTIC ASTROPHYSICS NETWORK (ICRANet)
and
UNIVERSITY OF TABRIZ

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=1445

10. Renewal of 3 ICRANet cooperation agreements with Istituto Nazionale di Astrofisica (INAF), University of Novi Sad (Serbia) and the University of Belgrade (Serbia)

Renewal of the cooperation agreement between ICRANet and Istituto Nazionale di Astrofisica (INAF), March 25, 2022


INAF
ISTITUTO NAZIONALE
DI ASTROFISICA

CONVENZIONE QUADRO
TRA
L'ISTITUTO NAZIONALE DI ASTROFISICA
E
L'INTERNATIONAL CENTER FOR RELATIVISTIC ASTROPHYSICS
NETWORK

On April 7, 2022, ICRANet has received the official confirmation that the agreement between ICRANet and Istituto Nazionale di Astrofisica (INAF) has been renewed. The renewal was signed on March 25, 2022 by Prof. Marco Tavani (President of INAF) and by Prof. Remo Ruffini (Director of ICRANet). This agreement will be valid for further 3 years and the main joint activities to be developed under its framework include: the promotion of theoretical and observational activities within the field of Relativistic Astrophysics; the 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.

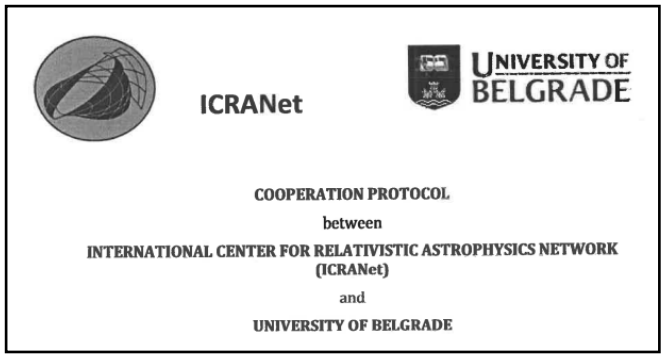
For the text of the agreement: http://www.icranet.org/inaf

Renewal of the cooperation agreement between ICRANet and the University of Novi Sad (Serbia), May 27, 2022

On May 27, 2022, the cooperation protocol between ICRANet and the University of Novi Sad (UNS) has been renewed. The renewal was signed by Prof. Dejan Madić (Rector of UNS), by Prof. Milica Pavkov-Hrvojević (Dean Faculty of Sciences UNS), by Prof. Remo Ruffini (Director of ICRANet) and by Prof. Jorge Rueda (ICRANet Faculty Professor). 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/novi-sad

Renewal of the cooperation agreement between ICRANet and the University of Belgrade (Serbia), June 21, 2022



On June 21, 2022, the cooperation protocol between ICRANet and the University of Belgrade sad has been renewed. The renewal was signed by Prof. Vladan Đokić (Rector of the University of Belgrade) 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/belgrade

11. Seminar by Dr Stanislav Komarov at ICRANet center, May 27, 2027

On Friday, May 27, 2022, Dr Stanislav Komarov (Belarusian State University and ICRANet center in Minsk) presented a seminar titled *"Spectrum of electromagnetic radiation of a particle, falling into Schwarzschild black hole"* with the following abstract:

The purpose of the work is determination of electromagnetic field of a test charge moving in the vicinity of a black hole, as well as determination of the spectrum of its electromagnetic radiation. We use multiple expansion of electromagnetic potential to find solution of the problem.

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

12.Scientific visits to ICRANet

- Prof. Massimo Della Valle

Osservatorio di Capodimonte - Italy
April 11 – 12, 2022

- Dr Stanislav Komarov

Belarusian State University, ICRANet center in Minsk (Belarus)
May 9 – 30, 2022

- Prof. Yerlan Aimuratov

Fesenkov Astrophysical Institute and al-Farabi Kazakh National University
June 11 – July 31, 2022

- Tursynbek Yernazarov

Al-Farabi Kazakh National University
June 23 – September 10, 2022

- Mohamed Gadri

University of Tripoli
June 28 – July 2, 2022

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.

13.Recent publications

J. A. Rueda, R. Ruffini, R. P. Kerr, *Gravitomagnetic Interaction of a Kerr Black Hole with a Magnetic Field as the Source of the Jetted GeV Radiation of Gamma-Ray Bursts*, published on Aprile 12, 2022 on ApJ, Volume 929, Number 1.

We show that the gravitomagnetic interaction of a Kerr black hole (BH) with a surrounding magnetic field induces an electric field that accelerates charged particles to ultra-relativistic energies in the vicinity of the BH. Along the BH rotation axis, these electrons/protons can reach energies of even thousands of petaelectronvolts, so stellar-mass BHs in long gamma-ray bursts (GRBs) and supermassive BHs in active galactic nuclei can contribute to the ultrahigh-energy cosmic rays thorough this mechanism. At off-axis latitudes, the particles accelerate to energies of hundreds of gigaelectronvolts and emit synchrotron radiation at gigaelectronvolt energies. This process occurs within 60° around the BH rotation axis, and due to the equatorial symmetry, it forms a double-cone emission. We outline the theoretical framework describing these acceleration and radiation processes, how they extract the rotational energy of the Kerr BH and the consequences for the astrophysics of GRBs.

DOI: https://doi.org/10.3847/1538-4357/ac5b6e

J. Sedaghata, S.M. Zebarjadab, G.H. Bordbarac, B. Eslam Panah, *Structure of Magnetized Strange Quark Star in Perturbative QCD*, published in Physics Letters B 829 (2022), 137032.

We have performed the leading order perturbative calculation to obtain the equation of state (EoS) of the strange quark matter (SQM) at zero temperature under the magnetic field $B= 10^{18}$ G . The SQM comprises two massless quark flavors (up and down) and one massive quark flavor (strange). Consequently, we have used the obtained EoS to calculate the maximum gravitational mass and the corresponding radius of the magnetized strange quark star (SQS). We have employed two approaches, including the regular perturbation theory (RPT) and the background perturbation theory (BPT). In RPT the infrared (IR) freezing effect of the coupling constant has not been accounted for, while this effect has been included in BPT. We have obtained the value of the maximum gravitational mass to be more than three times the solar mass. The validity of isotropic structure calculations for SQS has also been investigated. Our results show that the threshold magnetic field from which an anisotropic approach begins to be significant lies in the interval 2×10^{18} G < B < 3×10^{18} G . Furthermore, we have computed the redshift, compactness and Buchdahl-Bondi bound of the SQS to show that this compact object cannot be a black hole.

DOI: https://doi.org/10.1016/j.physletb.2022.137032

Hajar Noshad, Seyed Hossein Hendi and Behzad Eslam Panah, *Neutron Stars in Mimetic Gravity*, published on May 3, 2022 in European Physical Journal C 82 (2022) 394.

In this paper, a modified version of the hydrostatic equilibrium equation based on the mimetic gravity in the presence of perfect fluid is revisited. By using the different known equation of states, the structural properties of neutron stars are investigated in general relativity and mimetic gravity. Comparing the obtained results, we show that, unlike general relativity, we can find the appropriate equation of states that support observational data in the context of mimetic gravity. We also find that the results of relativistic mean-field-based models of the equation of states are in better agreement with observational data than non-relativistic models.

DOI: https://doi.org/10.1140/epjc/s10052-022-10358-1

Sahakyan, N.; Giommi, P., *A thirteen-year-long broadband view of BL Lac*, accepted for publication in MNRAS on April 12, 2022.

We present the results of an extensive analysis of the optical, ultraviolet, X-ray and γ-ray data collected from the observations of the BL Lac objects prototype BL Lacertae carried out over a period of nearly 13 years, between August 2008 and March 2021. The source is characterized by strongly variable emission at all frequencies, often accompanied by spectral changes. In the γ-ray band several prominent flares have been detected, the largest one reaching the flux of $F_\gamma(> 196.7$ MeV) = $(4.39 \pm 1.01) \times 10^{-6}$ photon cm^{-2} s^{-1}. The X-ray spectral variability of the source during the brightest flare on MJD 59128.18 (06 October 2020) was characterized by a softer-when-brighter trend due to a shift of the synchrotron peak to ~10^{16} Hz, well into the HBL domain. The widely changing multiwavelength emission of BL Lacertae was systematically investigated by fitting leptonic models that include synchrotron self-Compton and external Compton components to 511 high-quality and quasi-simultaneous broad-band spectral energy distributions (SEDs). The majority of selected SEDs can be adequately fitted within a one-zone model with reasonable parameters. Only 46 SEDs with soft and bright X-ray spectra and when the source was observed in very high energy γ-ray bands can be explained in a two-zone leptonic scenario. The HBL behaviour observed during the brightest X-ray flare is interpreted as due to the emergence of synchrotron emission from freshly accelerated particles in a second emission zone located beyond the broad line region.

DOI: https://doi.org/10.1093/mnras/stac1011

Middei, Riccardo; Giommi, Paolo; Perri, Matteo; Turriziani, Sara; Sahakyan, Narek; Chang, Y. L.; Leto, C.; Verrecchia, F., *The first hard X-ray spectral catalogue of Blazars observed by NuSTAR*, accepted for publication in MNRAS on May 2022.

Blazars are a peculiar class of active galactic nuclei (AGNs) that enlighten the sky at all wavelengths. The electromagnetic emission of these sources is jet-dominated resulting in a spectral energy distribution (SED) that has a typical double-humped shape. X-ray photons provide a wealth of information on the physics of each source as in the X-ray band we can observe the tail of SED first peak, the rise of the second one or the transition between the two. NuSTAR, thanks to its capability of focusing X-rays up to 79 keV provides broadband data particularly suitable to compute SEDs in a still poorly explored part of the spectrum. In the context of the Open Universe initiative we developed a dedicated pipeline, NuSTAR_Spectra, a shell-script that automatically downloads data from the archive, generates scientific products and carries out a complete spectral analysis. The script homogeneously extracts high level scientific products for both NuSTAR's telescopes and the spectral characterisation is performed testing two phenomenological models. The corresponding X-ray properties are derived from the data best-fit and the SEDs are also computed. The systematic processing of all blazar observations of the NuSTAR public archive allowed us to release the first hard X-ray spectroscopic catalogue of blazars (NuBlazar). The catalogue, updated to September 30th, 2021, includes 253 observations of 126 distinct blazars, 30 of which have been multiply observed.

ArXiv: https://arxiv.org/abs/2205.05089

MAGIC collaboration, *Proton acceleration in thermonuclear nova explosions revealed by gamma rays*, published on April 14, 2022 in Nature Astronomy.

Classical novae are cataclysmic binary star systems in which the matter of a companion star is accreted on a white dwarf[1,2]. Accumulation of hydrogen in a layer eventually causes a thermonuclear explosion on the surface of the white dwarf[3], brightening the white dwarf to ~10^5 solar luminosities and triggering ejection of the accumulated matter. Novae provide the extreme conditions required to accelerate particles, electrons or protons, to high energies. Here we present the detection of gamma rays by the MAGIC telescopes from the 2021 outburst of RS Ophiuchi, a recurrent nova with a red giant companion, which allowed us to accurately characterize the emission from a nova in the 60 GeV to 250 GeV energy range. The theoretical interpretation of the combined Fermi LAT and MAGIC data suggests that protons are accelerated to hundreds of gigaelectronvolts in the nova shock. Such protons should create bubbles of enhanced cosmic ray density, of the order of 10 pc, from the recurrent novae.

DOI: https://doi.org/10.1038/s41550-022-01640-z

Shesheng Xue, *Spontaneous Peccei-Quinn symmetry breaking renders sterile neutrino, axion and χboson to be candidates for dark matter particles,* accepted for publication in Nuclear Physics B.

We study the Peccei-Quinn (PQ) symmetry of the sterile right-handed neutrino sector and the gauge symmetries of the Standard Model. Due to four-fermion interactions, spontaneous breaking of these symmetries at the electroweak scale generates top-quark Dirac mass and sterile-neutrino Majorana mass. The top quark channel yields massive Higgs, $W^{\pm}$ and Z^0 bosons. The sterile neutrino channel yields the heaviest sterile neutrino Majorana mass, sterile Nambu-Goldstone axion (or majoron) and massive scalar χboson. Four-fermion operators effectively induce their tiny couplings to SM particles. We show that a sterile QCD axion is the PQ solution to the strong CP problem. The lightest and heaviest sterile neutrinos ($m^e_N \sim 10^2$ keV and $m^t_N \sim 10^2$ GeV), a sterile QCD axion ($m_a < 10^{-8}$ eV, $g_{a\gamma} < 10^{-13}\text{GeV}^{-1}$) and a Higgs-like χboson ($m_\chi \sim 10^2$ GeV) can be dark matter particle candidates, for the constraints of their tiny couplings and long lifetimes inferred from the W-boson decay width, Xenon1T and precision fine-structure-constant experiments. The axion and χboson couplings to SM particles are below the values reached by current laboratory experiments and astrophysical observations for directly or indirectly detecting dark matter particles.

ArXiv: https://arxiv.org/abs/2012.04648

ICRANet Newsletter

July – August – September 2022

SUMMARY

1. ICRA – ICRANet press release *"GRB 190829A - A Showcase of Binary Late Evolution"*

GRB 190829A is the fourth closest gamma-ray burst (GRB) to date (z = 0.0785). Owing to its wide range of radio, optical, X-ray, and especially the very-high-energy (VHE) observations by H.E.S.S., it has become an essential new source examined by various models with complementary approaches.

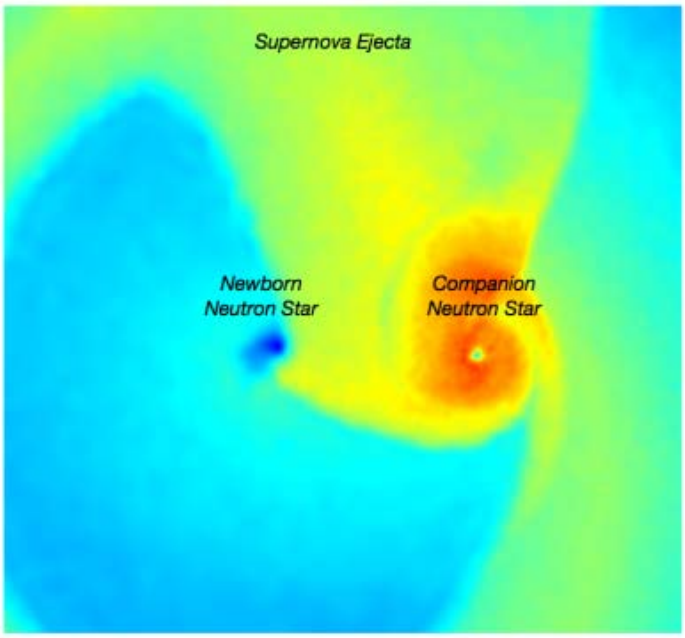


Fig 1. Ongoing accretion process onto the νNS and the NS companion simulated in Becerra et al. (2019). The νNS is located at the center of the dark blue spot, and is accreting the surrounding material. The SN ejecta are also being accreted by the NS companion, which is located at the center of the green spot. We also notice that the expansion of SN ejecta is distorted by the companion NS and a part of the SN ejecta is flowing back to the νNS. This process creates a unique feature of BdHNe: the fallback accretion onto the νNS is enhanced creating a second peak of accretion at about an orbital-period time after the SN explosion (see, e.g., Becerra et al. 2019, for more details).

The traditional fireball model of GRBs is based on a single system, at times indicated as a "collapsar", possibly a Black Hole (BH), giving origin to an ultra-relativistic jetted emission. The slowing down of such a jet in the interstellar medium has been assumed to explain the main properties of the GRBs in all wavelengths. These results have been expressed, prior to 2002, in many reviews, see e.g. Shemi and Piran 1990, Fishman and Meegan 1995, Piran 2000, Van Paradijs et al 2000, Meszaros 2002. The review of Meszaros traces back the historical developments of GRB theories at a time the observations were the domain of gamma-ray astronomy observed by the BATSE instrument in the 20 to 600 KeV and the EGRET instrument in the 20 MeV to 30 GeV both on board the Compton CGRO satellite.

Our model based on a binary system was proposed in 2012 (Rueda & Ruffini 2012) and has been in development for one decade. Our approach was motivated by an alternative set of data following the launching of the Beppo-SAX satellite with on board the Wide Field X-rays camera which promoted a direct collaboration between the gamma-ray community and the much larger X-ray community. In the meantime, indeed following the UHURU satellite, a large number of X-ray missions including the Einstein telescope, the Chandra telescope, and the XMM were developed leasing to the discovery of the first black hole in our galaxy , Cygnus X1, the binary X-ray sources, and the structure galactic halos. The extragalactic origin of the GRBs, made possible by the discovery of the X-ray afterglow, did open an additional collaboration with the new class of large optical telescopes including Keck and the VLT. A new era linking GRBs to supernovae started. New space missions followed by the AGILE telescope in the GeV range, the Neil Gehrels Swift

Observatory and the Fermi telescope in the MeV, GeV and TeV, recently involving also the MAGIC telescopes. A detailed high-quality data from the new observations made clear the new complexity of the GRB structure, composed of selected independent episodes each one characterized by a specific spectral feature observed in their rest frame. We advanced in 2012 a basic change of paradigm based on binary systems: the Binary driven Hypernovae (BdHN). The physical picture evolved gradually including the needed physics that allowed to study of a wide range of binary parameters including the explosion energy, the mass, the binary separation, the density profile, the equations of state and et al., as well as the statistical analysis of different GRB components (Ruffini et al. 1999, 2000, 2010, 2015; Wang et al. 2015; Ruffini et al. 2018a,b; Wang et al. 2018; Ruffini et al. 2018c; Wang et al. 2019b; Ruffini et al. 2019; Rueda et al. 2020; Rueda & Ruffini 2020; Moradi et al. 2021b; Ruffini et al. 2021). The numerical simulations of the occurring physical processes have been upgraded from one dimension (Fryer et al. 2014) to two-dimensions (Becerra et al. 2015), to three-dimensions (Becerra et al. 2016, 2019). The latest simulations (Becerra et al. 2019) implemented a smoothed particle-hydrodynamics (SPH) method, and examined a large selection of initial conditions and the outcomes of the binary system after the SN explosion, see Fig 2, Rueda et al. (2019) and Rueda et al. (2021) have reviewed the entire development process. The case of GRB 190829A is indeed the first detailed verification of the validity of a BDHN model in view of the exceptionality of the available data.

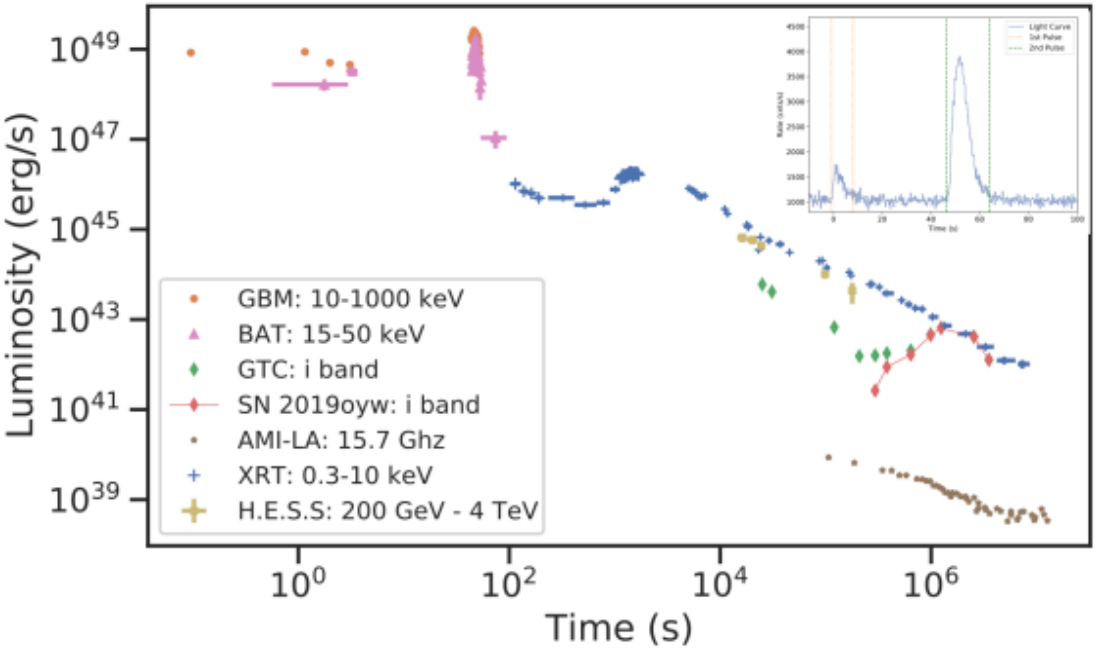


Fig. 2: Luminosity of GRB 190829A including the data from H.E.S.S (yellow) for TeV, Fermi-GBM (orange dots), Swift-BAT (purple triangles) for the prompt emission of hard X-ray and gamma-ray, Swift-XRT (blue crosses) for the soft X-ray (absorbed), GTC (green diamonds) for the optical i band, from which the SN 2019yw is extracted (red diamonds), the optical signal of SN over-shots the optical emission from the synchrotron, and AMI-LA (brown stars) for the radio observation. Top right corner: The count rate of GRB 190829A prompt emission from the raw data of Fermi-GBM: The first pulse is from −0.75 s to 8.05 s, indicated by the orange dotted line, and the second pulse is from 46.50 s to 64.00 s, indicated by the green dashed line.

Unlike the traditional fireball model, the BdHN model considers a central engine that arises in the final evolutionary stage of the CO core in the presence of a binary NS companion. An SN explosion occurs, it triggers the GRB emission and generates a νNS. Therefore, in addition to the physical processes of single-star collapse models, we need to consider not only the binary interactions but also the appearance of the νNS, see Fig 2. The most influential interactions are the accretion of SN ejecta onto the NS companion and the fallback accretion onto the νNS spins it up. The afterglow is produced by the mildly relativistic expanding SN ejecta which contains a large number of electrons accelerated by the kinetic energy of the SN and the energy injection from the rapidly spinning νNS and its subsequently spin-down. Unlike the BdHN I, which were by the hypercritical accretion of

the SN ejecta into the NS companion form a BH, here we describe GRB 190829A by a BdHN II where no BH is formed but a more massive NS.

The low redshift characteristic of GRB 190829A makes it possible to have detailed temporal observations of various bands, hence GRB 190829A becomes the first GRB to fully exhibit the final evolution of this special class of binary systems. Our BdHN II model has been successfully applied on this burst, explaining its prompt emission composed of two pulses, its radio, optical and X-ray afterglow, as well as the emergence of the SN signal, as follows:

As the COcore gravitationally collapses, an SN explosion occurs and a newborn NS (νNS) originates at its center. Most of the SN energy (~ 10^{53} erg) is deposited in the neutrino, about a few percent of energy goes to the kinetic energy of SN ejecta (~10^{51}–10^{52} erg), which expands outward at velocities of around 0.1 c. The low-density outermost layer has the highest speed while the denser regions expand with slower velocities. After a few minutes, the SN ejecta reaches the companion NS, and the hypercritical accretion starts. The accretion rate onto the companion NS rises exponentially and peaks in a few minutes. The numerical simulations show that the entire hypercritical accretion process may last for hundreds of minutes, but the peak accretion rate of more than 10^{-4} $M_\odot$ s^{-1}, supplied by the high density and slow-moving part of the SN ejecta, holds only for tens of seconds to tens of minutes depending on the binary separation, see Fig. 1, The accretion translates into an electromagnetic power of 10^{48}–10^{49} erg s^{-1} assuming a 10% of efficiency in the conversion from gravitational to radiation energy. This procedure of accretion onto the companion NS in a 20-40 minutes orbital period binary system well explains the first prompt pulse of GRB 190829A.

In the meanwhile, some matter falls back leading to an accretion process onto the νNS, see Fig 2. This fallback accretion is significantly amplified by the companion NS which alters the trajectory of a partial SN ejecta that flows back to the νNS. The accretion onto the νNS has two components, the first is the typical fallback matter the same as the case of the SN from a single star, it leads the accretion rate to reach a peak to then decay nearly as a power-law with time. The peak luminosity produced by it is weak < 10^{48} erg s^{-1} and can hardly be seen for cosmological distances. The second is the unique feature of the binary system, the presence of the companion enhances the fallback onto the νNS creating the second peak of accretion, see Fig 1. The second part contributes most to the accreting mass for a duration of about an orbital-period time. The fallback accretion also transfers angular momentum to the νNS, spinning it up to a rotation period of a few milliseconds. So the peak luminosity from the fallback accretion is in the order of 10^{48}–10^{49} erg s^{-1}. The fallback accretion onto the νNS explains the second prompt pulse of GRB 190829A.

The fallback accretion continues as a source injecting energy into the mildly relativistic expanding SN ejecta, as well as the spin-down energy from the νNS. The synchrotron emission from the SN ejecta leads to the afterglow. We adopt the associated synchrotron emission for explaining the radio, optical and X-ray afterglow emissions. Contrary to the traditional model which assumes the origin of synchrotron emission from an ultra-relativistic jet, we here assume that the ejecta expands at a constant velocity at a wide angle. Second, our magnetic field is from the νNS, we assume that at large distances from the νNS, beyond its light cylinder, the magnetic field decreases linearly with distance. This implies that the magnetic field strength felt by the expanding ejecta evolves with time. Third, the energy injection in the synchrotron originates from the fallback accretion and the spin-down of νNS. Our numerical computation shows that a νNS spinning at an 8 ms period with a dipole field of 5×10^{12} Gauss and quadruple field of about $1x10^{14}$ Gauss, and an SN ejecta moving at 10^9 cm s^{-1} generates the observed radio, optical and X-ray afterglows.

We do not explain the origin of VHE emission observed in the 0.2–4 TeV energy band of H.E.S.S. neither by the above synchrotron model, nor the synchrotron self-Compton process: the synchrotron self-Compton emission peaks at a few hundreds of MeV, cutoffs at < 10 GeV, and has a lower luminosity to the observed in the H.E.S.S. energy bandwidth. However, the similar power-law behavior of the VHE and the X-ray light curves observed as well in GRB 190114C and GRB

180720B see e.g. Acciari et al., 2019 and Abdalla et al., 2019 allow us to advance the hypothesis the VHE can be related to some transient activity possibly related to a new physics originating in the νNS.

The BdHN model naturally contains an SN, which produces ~0.4$M_{\odot}$ nickel whose radioactive decay energy is emitted mainly at optical wavelengths with a corresponding flux that peaks around ~13 days in the source rest-frame, common to all other GRBs (Aimuratov et al 2022, in preparation), and indeed it was observed by GTC.

Having succeeded in this special case of BdHN II GRB 190829A we are now progressing in the explanation of the BdHN I GRB 910114C and in the case of BdHN III GRB 170215A.

References:

Abdalla, H., Adam, R., Aharonian, F., et al. 2019, Nature, 575, 464, doi: 10.1038/s41586-019-1743-9
Becerra, L., Bianco, C. L., Fryer, C. L., Rueda, J. A., & Ruffini, R. 2016, ApJ, 833, 107, doi: 10.3847/1538-4357/833/1/107
Becerra, L., Cipolletta, F., Fryer, C. L., Rueda, J. A., & Ruffini, R. 2015, ApJ, 812, 100, doi: 10.1088/0004-637X/812/2/100
Becerra, L., Ellinger, C. L., Fryer, C. L., Rueda, J. A., & Ruffini, R. 2019, ApJ, 871, 14, doi: 10.3847/1538-4357/aaf6b3
Fishman, G. J., & Meegan, C. A. 1995, ARA&A, 33, 415, doi: 10.1146/annurev.aa.33.090195.002215
Fryer, C. L., Rueda, J. A., & Ruffini, R. 2014, ApJL, 793, L36, doi: 10.1088/2041-8205/793/2/L36
MAGIC Collaboration, Acciari, V. A., Ansoldi, S., et al. 2019, Nature, 575, 455, doi: 10.1038/s41586-019-1750-x
Meszaros, P. 2002, ARA&A, 40, 137, doi: 10.1146/annurev.astro.40.060401.093821
Moradi, R., Rueda, J. A., Ruffini, R., & Wang, Y. 2021, A&A, 649, A75, doi: 10.1051/0004-6361/201937135
Piran, T. 2000, PhR, 333, 529, doi: 10.1016/S0370-1573(00)00036-3
Rueda, J. A., & Ruffini, R. 2012, ApJL, 758, L7, doi: 10.1088/2041-8205/758/1/L7
—. 2020, European Physical Journal C, 80, 300, doi: 10.1140/epjc/s10052-020-7868-z
Rueda, J. A., Ruffini, R., Karlica, M., Moradi, R., & Wang, Y. 2020, ApJ, 893, 148, doi: 10.3847/1538-4357/ab80b9
Rueda, J. A., Ruffini, R., Moradi, R., & Wang, Y. 2021, International Journal of Modern Physics D, 30, 2130007, doi: 10.1142/S021827182130007X
Rueda, J. A., Ruffini, R., & Wang, Y. 2019, Universe, 5, 110, doi: 10.3390/universe5050110
Ruffini, R., Karlica, M., Sahakyan, N., et al. 2018a, ApJ, 869, 101, doi: 10.3847/1538-4357/aaeac8
Ruffini, R., Salmonson, J. D., Wilson, J. R., & Xue, S. S. 1999, A&A, 350, 334.
Ruffini, R., Salmonson, J. D., Wilson, J. R., & Xue, S.-S. 2000, A&A, 359, 855
Ruffini, R., Vereshchagin, G., & Xue, S. 2010, PhR, 487, 1, doi: 10.1016/j.physrep.2009.10.004
Ruffini, R., Wang, Y., Enderli, M., et al. 2015, ApJ, 798, 10, doi: 10.1088/0004-637X/798/1/10
Ruffini, R., Wang, Y., Aimuratov, Y., et al. 2018b, ApJ, 852, 53, doi: 10.3847/1538-4357/aa9e8b
Ruffini, R., Becerra, L., Bianco, C. L., et al. 2018c, ApJ, 869, 151, doi: 10.3847/1538-4357/aaee68
Ruffini, R., Moradi, R., Rueda, J. A., et al. 2019, ApJ, 886, 82, doi: 10.3847/1538-4357/ab4ce6
—. 2021, MNRAS, 504, 5301, doi: 10.1093/mnras/stab724
Shemi, A., & Piran, T. 1990, ApJL, 365, L55, doi: 10.1086/185887
van Paradijs, J., Kouveliotou, C., & Wijers, R. A. M. J. 2000, ARA&A, 38, 379, doi: 10.1146/annurev.astro.38.1.379
Wang, Y., Rueda, J. A., Ruffini, R., et al. 2019, ApJ, 874, 39, doi: 10.3847/1538-4357/ab04f8
Wang, Y., Ruffini, R., Kovacevic, M., et al. 2015, Astronomy Reports, 59, 667, doi: 10.1134/S1063772915070148

2. The 6th Bego Rencontre Summer School, July 4 – 14, 2022, Nice and online

The 6th Bego Rencontre Summer School has been held from July 4 to 14, 2022 as an hybrid event, both in person at the ICRANet Seat Villa Ratti in Nice (France) and online.

The School aimed to discuss recent developments in the theory and observations of gamma-ray bursts (GRBs), active galactic nuclei (AGNs), and dark matter (DM). Some relevant topics discussed about GRBs and AGNs have been:

- the energy extraction process from rotating black holes (BHs) in the inner engine of the high-energy (e.g. GeV) emission of long GRBs and AGNs. Special attention is given to inner

engines comprising a Kerr BH immersed in a magnetic field and ionized plasma. Recent developments on the topic, especially the problem of field screening, electric discharge, radiation properties, black hole physics, magneto hydrodynamics, and the maximum electric charge allowed in the inner engines;

- the recent progress in GRB theory, for instance in the binary-driven hypernova (BdHN) model. This includes the physical explanation of the ultra relativistic prompt emission (UPE) phase in the MeV regime, the afterglow emission in the X-rays, optical, and radio wavelengths, and the GeV emission;
- the Supernova associated with GRBs and the role of the supernova explosion in the entire emission of a long GRB;
- GRBs at high-redshift and GRB-cosmology
- the emission of GRB cocoons (observations);
- the emission of M87* (theory and observations).

Some relevant topics discussed about dark matter have been:

- Fermionic and bosonic dark matter: microphysics;
- Fermionic and bosonic dark matter: macrophysics;
- Recent developments in the description of the Galactic center (Sgr A*) as a core of dark matter;
- Latest astrometric observations of stars orbiting Sgr A* and observational constraints on the nature of Sgr A*;
- Latest news on the baryonic content in galaxies;
- Strong gravitational lensing;
- Dark matter in early cosmology, cosmological simulations and dark matter halo formation.

More than 90 participants from 19 different countries joined the conference, and several lecture have been presented by Profs. Yerlan Aimuratov, Lorenzo Amati, Carlos Raul Arguelles, Davide Astesiano, Laura Becerra, Carlo Luciano Bianco, Stefano Bondani, Kunatay Boshkayev, Valentina Crespi, Mariateresa Crosta, Maria Giovanna Dainotti, Massimo Della Valle, Christopher Fryer Daniele Gregoris, Luca Izzo, Petr Kotlarik, Liang Li, Francesco Longo, Wentao Luo, Nick Mavromatos, Massimo Meneghetti, Martin Mestre, Felix Mirabel, Rahim Moradi, Ehud Nakar, Florian Peissker, Vahe Petrosian, Tsvi Piran, Federico Re, Paola Re Fiorentin, José Rodriguez, Piero Rosati, Jorge Rueda, Narek Sahakyan, Costantino Sigismondi, Alessandro Spagna, Eleonora Troja, Gregory Vereshchagin, Matteo Viel, Yu Wang, Eli Waxman, Shesheng Xue, Rafael Yunis and Bing Zhang.

The meeting webpage is available at the following link: https://indico.icranet.org/event/4/

The recordings of the different sessions are now available on the ICRANet YouTube channel, at the following link: https://www.youtube.com/channel/UCU19scWRGvlIiKBcN1QXCRQ

3. Announcement of the 5th Zeldovich meeting, June 12 – 17, 2023, Yerevan (Armenia)

We are happy to inform you that ICRANet is organizing the 5th Zeldovich meeting, an international conference in honor of Ya. B. Zeldovich, which will be held in Yerevan (Armenia) on June 12-17, 2023. This conference will follow a series of very successful international conferences in honor of Ya. B. Zeldovich, respectively held in Minsk in 2009, 2014, 2018 and online in 2020.

Exceptionally wide research interests of Ya. B. Zeldovich, ranging from chemical physics, elementary particle and nuclear physics to astrophysics and cosmology, provide the topics to be covered during the conference:

- multimessanger astrophysics;
- early universe, large scale structure, cosmic microwave background;
- neutron stars, black holes, gamma-ray bursts, supernovae, hypernovae;
- gravitational waves;
- quantum and gravity.

Traditionally, among the invited speakers, there will be members of the world-famous scientific school in astrophysics and cosmology, founded by Ya. B. Zeldovich.

The registration to this meeting has just started.

All the information on this event are posted on its official website:
http://www.icranet.org/zeldovich5

4. The European Researchers' Night, September 30, 2022, online event

On the occasion of the European Researchers' Night 2022, ICRANet, in collaboration with Prof. Costantino Sigismondi (ICRANet collaborator), organized an online event, in order to create a nice occasion for discussion among researchers and students. This event attracted a lot of people, as every year, and offered to the participants a unique opportunity to take part in science activities aiming to showcase both the fascination of research as a career and its significant societal impact.

The online meeting was held on Friday September 30, 2044, starting from 4:30 PM. After the opening remarks, Prof. Remo Ruffini, Director of ICRANet, presented a talk on the Supernovae and the recent development in the field of Relativistic astrophysics. After him, Prof. Liang Li and Prof. Wang Yu, both ICRANet Faculty Professors, presented 2 lectures respectively on the Supernovae's progenitors and the numerical models. Then Prof. Costantino Sigismondi spoke about Antares and the stellar variability, about the measurement of the Earth radius, as well as about ICRANet and high school. He also discussed with participants about the present and future perspectives of science and about Supernovae and binary Stars.

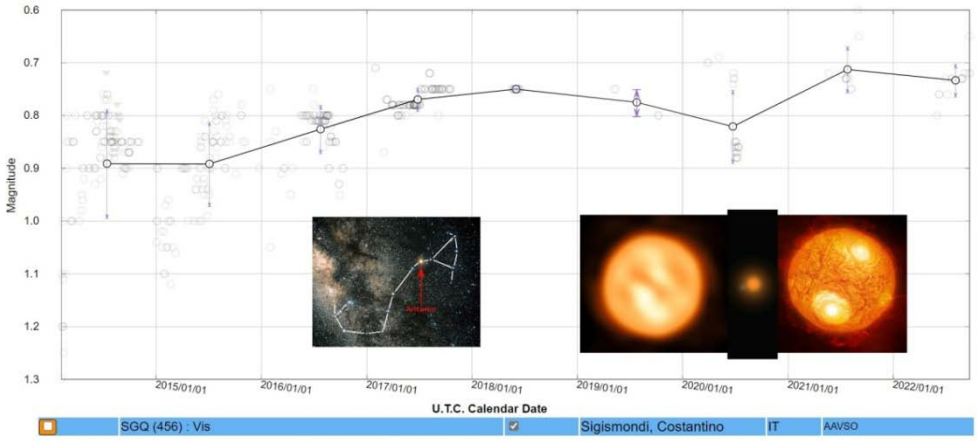


Fig. 3: 456 observations of Antares in 2014.

He explained that the majority of the stars are in multiple systems and the interactions among their components can determine the trigger for the explosion of a Supernova, the most luminous phenomenon in the Universe. The binary Stars' systems and the Supernovae's progenitors are 2 topics which attracted theoretical studies for a long time. Sophisticated numerical models, based on the General Relativity equations, necessary when the mass and the dimension of the stellar object lead the material to overcome the density of the atomic nucleus, allow to represent today the observational data with high accuracy. At the same time, the observational data are enhanced by multi-spectral information received by a constantly increasing number of instruments, devoted to the detection of the sky in its different wavelengths, both from Earth and from Space: this is what Prof. Li and Wang presented.

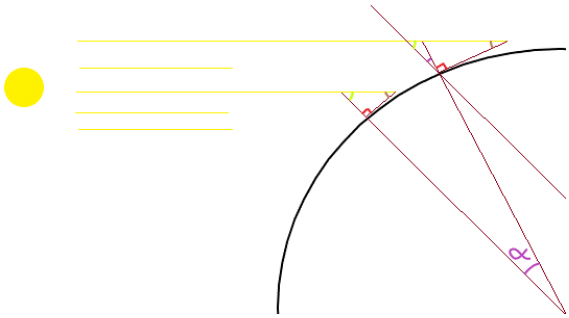
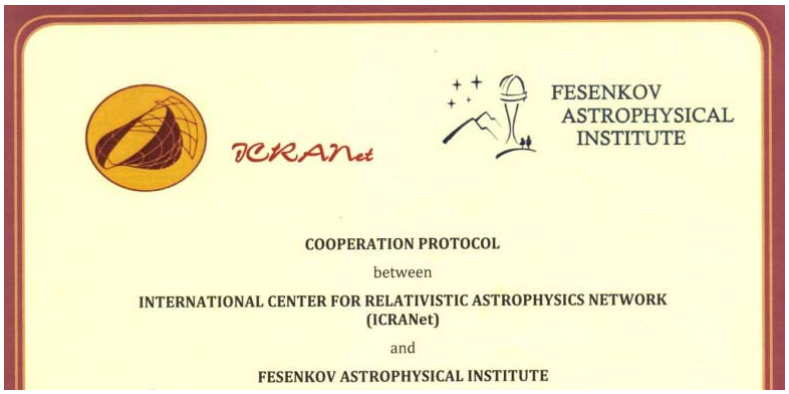


Fig. 4: Geometrical schema of the method of Eratostene for the measurement of the Earth radius (Federico Battistol, Liceo Scarpa di Motta di Livenza (TV)

The observation of the stellar variability of the red and binary supergiant Antares, registered in the last 8 years, has been the main topics presented and commented by Prof. Sigismondi: ranges of few hundredth of magnitude are visible at naked eye, provided that it should be corrected, for the atmospheric extinction, the comparison with stars similarly bright, which are distant from Antares several tens of grades. The observations made by the satellite SOHO complete the framework. The concept of magnitude and the logarithmic scale of luminosities, at the base of a correct interpretation of the astrophysical phenomena, have been also presented to the students.

5. New collaboration agreements signed by ICRANet

New collaboration agreement between ICRANet and the Fesenkov Astrophysical Institute (Kazakhstan), August 5, 2022

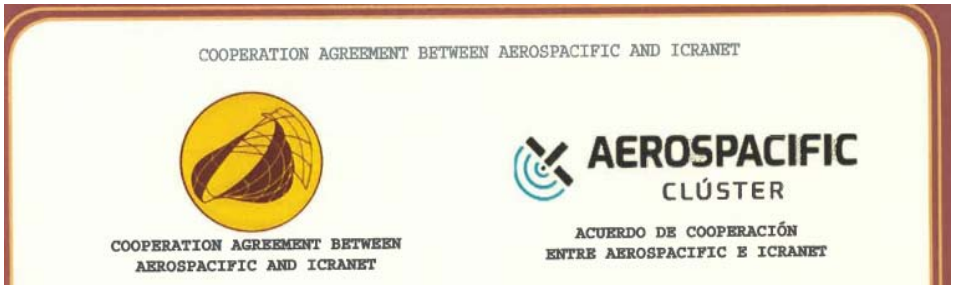


On August 5, 2022 ICRANet has signed a new Cooperation protocol with the Fesenkov Astrophysical Institute in Kazakhstan. The Cooperation Protocol has been signed by Prof. Chingis Omarov (Director of the Fesenkov Astrophysical Institute), by Prof. Yerlan Aimuratov (Fesenkov Astrophysical Institute), by Prof. Remo Ruffini (Director of ICRANet) and by Prof. Jorge 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=1451

New collaboration agreement between ICRANet and AEROSPACIFIC (Colombia), September 1, 2022

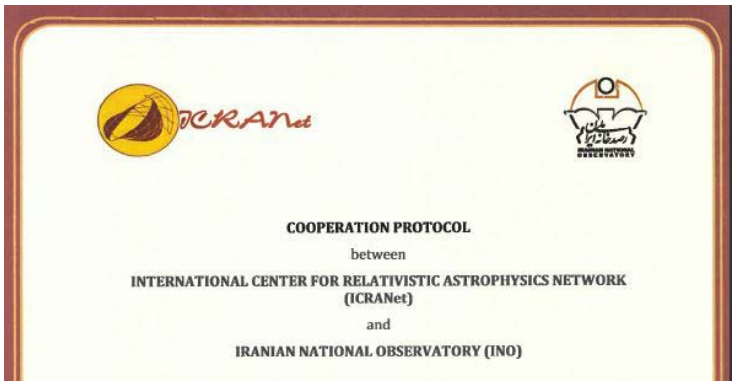


On September 1, 2022 ICRANet has signed a new Cooperation protocol with the AEROSPACIFIC cluster in Colombia. The Cooperation Protocol has been signed by Dr Cesar Augusto Rodriguez Adaim (President of AEROSPACIFIC) and by Prof. Remo Ruffini (Director of ICRANet).

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=1452

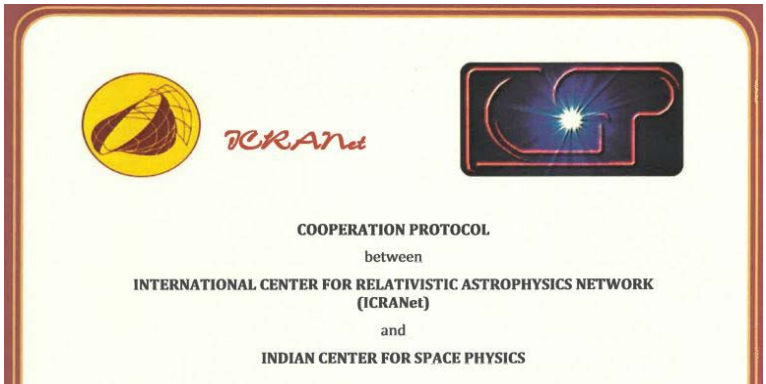
New collaboration agreement between ICRANet and the Iranian National Observatory (INO), September 8, 2022



On September 8, 2022 ICRANet has signed a new Cooperation protocol with the Iranian National Observatory (INO) in Iran. The Cooperation Protocol has been signed by Prof. Habib Khosroshahi (Director of INO) 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/documents/agreementICRANet-INO.pdf



New collaboration agreement between ICRANet and the Indian Center for Space Physics, September 21, 2022

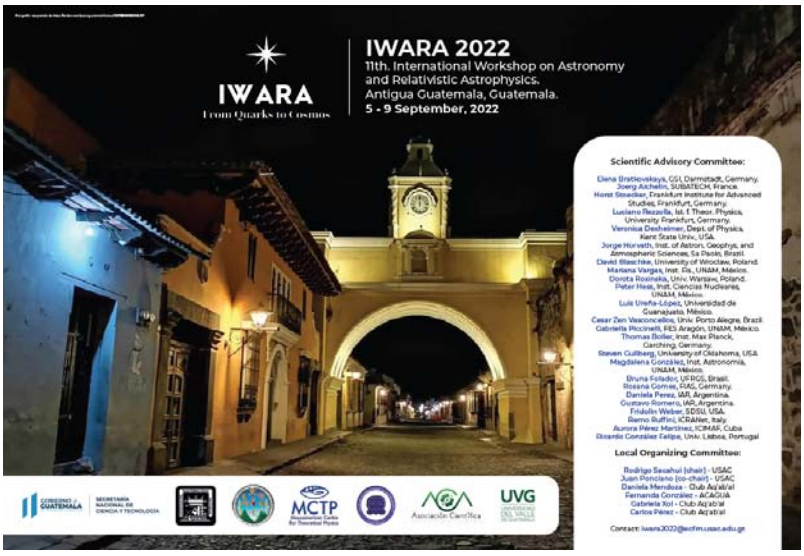
On September 21, 2022 ICRANet has signed a new Cooperation protocol with the Indian Center for Space Physics in India. The Cooperation Protocol has been signed by Prof. Sandip Chakrabarti (Director of the Indian Center for Space Physics) and by Prof. Remo Ruffini (Director of ICRANet).

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=1453

6. ICRANet participation at the *IWARA 2022. The 10th international workshop on Astronomy and Relativistic Astrophysics*, September 5-9, 2022, Guatemala and online

From September 5 to 9, 2022 Professor Remo Ruffini, Director of ICRANet has been invited to deliver a plenary lecture on the occasion of the meeting "IWARA 2022. The 10th international workshop on Astronomy and Relativistic Astrophysics". This meeting was the tenth in a series of meetings, gathering scientists working on astroparticle physics, cosmology, gravitation, nuclear physics, and related fields. The event has been held in an hybrid format, both in person in Guatemala and online.



On Monday, September 5, Prof. Ruffini presented online a lecture titled *"The role of a standard family of Ic Supernovae in BdHN I, BDHN II and BDHN III GRBs"*, here below the abstract:

A profound difference has occurred in the analysis of GRBs initially analyzed in the domain of Gamma-ray astronomy with the Compton Gamma Ray Observatory and the BATSE Detector with the extension to X-Ray Astronomy and optical astronomy introduced by Beppo SAX and the KEK and VLT optical observatory, followed by the AGILE, Fermi mission, Niels Gehrels SWIFT mission as well as HEHSS and MAGIC observations.

An authentic "Copernican revolution" has occurred in the transition from the traditional model of GRBs originating in a single star progenitor (collapsar) to GRBs with a binary progenitor composed of a CO core and a companion NS.
We evidence from 24 SN observations related to GRBs that all of them, once analyzed with the general relativistic corrections can be identified with I Bc Sn with a common value of the Luminosity and common time of occurrence of the peak of the optical emission .this can be understood in term of a precursor composed of a CO core and a binary NS companion. By contrast, the GRBs differ profoundly in their energetic which can be expressed in terms of 3 different classes of BDHNe: BDHNI, BDHNII, BDHN III, also originating from Precursors composed of a CO core and a Binary companion.
It is pointed out how the analysis of these systems has profoundly modified the concept of the BH and the associated fundamental physics necessary for their description since the "introducing of the Black Hole " by Ruffini and Wheeler in 1971. At first, it is illustrated how the most radical change has occurred in the introduction of the effective BH charge, with an electric field only function of the BH dimensionless spin and a background magnetic field Bo. This definitely indicates the abandon of the Kerr-Newmann solution in favor of the Kerr metric, for energy extraction processes in BH physics . We then enter in the detailed description of the "seven Seals" , the seven Episodes characterizing GRB 190114c and the associated SN 1998 bW.

The proceedings of the meeting will be published by the Astronomische Nachrichten.

For the website of the meeting: https://indico.cern.ch/event/921532/

7. ICRANet participation at the *Bad Honnef Physics School*, September 5-9, 2022, Bad Honnef (Germany)

From September 5 to 9, 2022 Professor Remo Ruffini, Director of ICRANet has been invited to present a lecture on the occasion of the Bad Honnef Physics School in Bad Honnef (Germany), together with Prof. Liang Li and Prof. Rahim Moradi (both ICRANet Faculty Professors).

This School was dedicated to the observational, theoretical and also epistemological aspects of Black Hole physics and covered the following topics: tentative definition of a Black Hole, observational evidence and possible alternative explanations for Black Holes, formation of Black Holes, global structure and causality of Black Hole space times, rigorous definition of a Black Hole, singularity theorems, uniqueness of Black Hole solutions (no-hair theorems), stability properties, Black Holes in generalized theories of gravity, modeling Black Holes in analog-gravity models, quantum fields in Black Hole-space times, Black Holes in quantum gravity proper, epistemological and philosophical aspects of Black Holes. The meeting has been co-organized by Prof. Dr. Domenico Giulini (ITP, University of Hannover & ZARM, University of Bremen), Dr. Eva Hackmann (ZARM, University of Bremen) and Prof. Dr. Claus Lämmerzahl (ZARM, University of Bremen).

On Thursday, September 8, Prof. Ruffini, followed by Prof. Li and Prof. Moradi, presented a lecture titled *"The role of a standard family of Ic Supernovae in BdHN I, BDHN II and BDHN III GRBs"*. Here below the abstract:

A profound difference has occurred in the analysis of GRBs initially analyzed in the domain of Gamma-ray astronomy with the Compton Gamma Ray Observatory and the BATSE Detector with the extension to X-Ray Astronomy and optical astronomy introduced by Beppo SAX and the KEK and VLT optical observatory, followed by the AGILE, Fermi mission, Niels Gehrels SWIFT mission as well as HEHSS and MAGIC observations.

An authentic "Copernican revolution" has occurred in the transition from the traditional model of GRBs originating in a single star progenitor (collapsar) to GRBs with a binary progenitor composed of a CO core and a companion NS.
We evidence from 24 SN observations related to GRBs that all of them, once analyzed with the general relativistic corrections can be identified with I Bc Sn with a common value of the Luminosity and common time of occurrence of the peak of the optical emission .this can be understood in term of a precursor composed of a CO core and a binary NS companion. By contrast, the GRBs differ profoundly in their energetic which can be expressed in terms of 3 different classes of BDHNe: BDHNI, BDHNII, BDHN III, also originating from Precursors composed of a CO core and a Binary companion.
It is pointed out how the analysis of these systems has profoundly modified the concept of the BH and the associated fundamental physics necessary for their description since the "Introducing of the Black Hole" by Ruffini and Wheeler in 1971. At first, it is illustrated how the most radical change has occurred in the introduction of the effective BH charge, with an electric field only function of the BH dimensionless spin and a background magnetic field Bo. This definitely indicates the abandonment of the Kerr-Newmann solution in favor of the Kerr metric, for energy extraction processes in BH physics. After we enter in the detailed description of the "seven Seals", the seven Episodes characterizing GRB 190114c and the associated SN 1998 bW . We finally enter into the quantum and classic electro dynamical process describing the energy extraction of a BH in the UPE phase of GRBs, in the GeV emission of GRBs , in the emission of synchrotron radiation from spinning NS. turn then to specific examples in GRB 190114c (Moradi and Liang Li)in GRB 171205 A and GRB 190829A (Wang Yu). Possible presence of Jorge if compatible with Space-time situation.

For the website of the School: https://www.dpg-physik.de/veranstaltungen/2022/black-holes

8. ICRANet participation at the *31st Texas Symposium on Relativistic Astrophysics*, September 12-16, 2022, Prague (Czech Republic)

From September 12 to 16, 2022 Professor Remo Ruffini, Director of ICRANet has been invited to present a lecture on the occasion of 31st Texas Symposium on Relativistic Astrophysics, held in Prague (Czech Republic). Together with him, also Prof. Rahim Moradi and Prof. Yu Wang (both ICRANet Faculty Professors) have been invited to present a lecture on that occasion.

Fig. 5: group photo of all the participants to the 31st Texas Symposium on Relativistic Astrophysics in Prague.

Since 1963, the Texas Symposium has been one of the major meetings on Relativistic Astrophysics. Traditionally, it moves around the globe and takes place in different cities every 2 years. The main topics addressed during the conference have been Gravity (Classical, Numerical, Quantum, Modified, Tests), Relativity (Black Holes, Neutron Stars, Accretion, Jets), Multimessanger (Cosmic Rays, Neutrinos, Gamma Rays, X Rays, Gravitational Waves), Cosmology (Cosmic Microwave Background, Reionization, Early Universe, Large Scale Structure, Dark Matter), as well as special sessions on the Event Horizon Telescope, GRAVITY, X-ray Polarimetry and the James Webb Space Telescope.

On Wednesday, September 14, Prof. Ruffini presented a lecture titled *"The role of a standard family of Ic Supernovae in BdHN I, BDHN II and BDHN III GRBs"*. Here below the abstract:

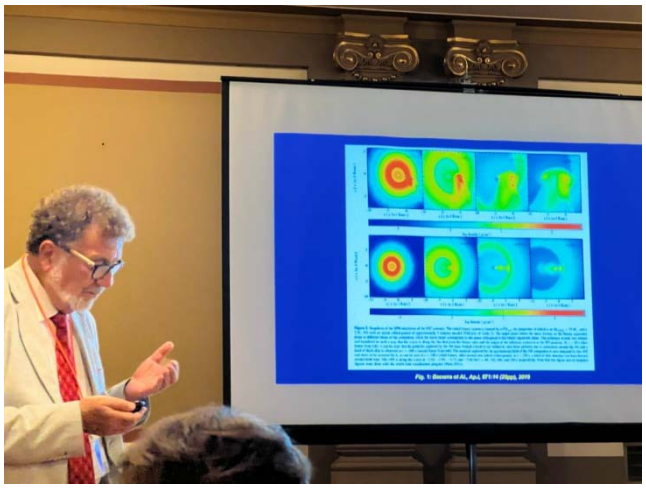


Fig. 6: Prof. Remo Ruffini presenting his lecture at the 31st Texas Symposium on Relativistic Astrophysics in Prague, September 14, 2022.

Following the Beppo SAX mission, the exponential growth of observatories in all wavelengths ranging from radio optical, all the way to X-ray, Mev, Gev, Tev radiation prolific of an exponential growth of data which have been following in the recent 25 years. For this, the BDHN model was started by the concept of induced gravitational collapse (Rueda Ruffini 1972), evolved collaboration with Los Alamos National Lab and Chris Freyer. The binary model assumes as a progenitor a binary system composed of a Co Core and a binary NS companion see FiG. Three different BDHN types exist mainly as a function of their binary period. The collapse of the Co Core leads to the SN explosion with the creation of a V NS (pulsar) which originates the X-ray afterglow. Starting from these results we can as well pose new problems to be addressed: 1) the possible nature of SN 1054 as a GRB; 2) The universality of the X-ray afterglow in all long GRBs originating from the pulsar; 3) the understanding of the Supernova explosion, including the formation of the new neutron star (pulsar).

On the same day, Prof. Yu Wang (ICRANet Faculty Professor) presented a lecture titled *"GRB 190829A - A Showcase of Binary Late Evolution"*. Here below the abstract:

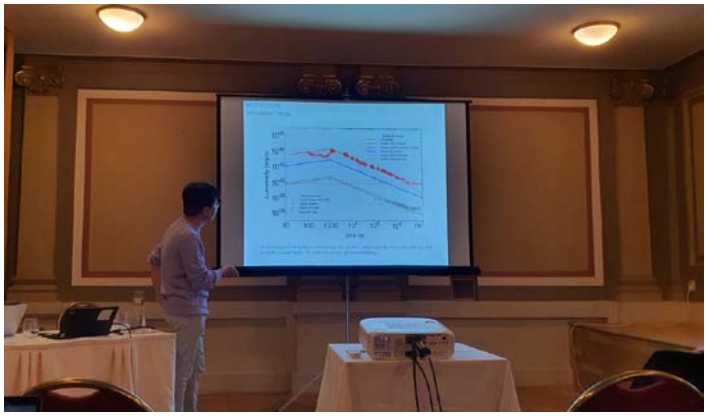


Fig. 7: Prof. Yu Wang presenting his lecture at the 31st Texas Symposium on Relativistic Astrophysics in Prague, September 14, 2022.

GRB 190829A is the fourth closest gamma-ray burst (GRB) to date (z=0.0785). We show in GRB 190829A, that the double-prompt pulses and the multiwavelength afterglows are consistent with the type II binary-driven hypernova (BdHN II) model. The progenitor is a binary composed of a carbon-oxygen (CO) star and a neutron star (NS) companion. The gravitational collapse of the iron core of the CO star produces a supernova (SN) explosion and leaves behind a new neutron star (vNS) at its center. The accretion of the SN ejecta onto the NS companion and onto the vNS via matter fallback spins up the NSs and produces the double-peak prompt emission. The synchrotron emission from the expanding SN ejecta with the energy injection from the rapidly spinning vNS and its subsequent spin-down leads to the afterglow in the radio, optical, and X-ray. We model the sequence of physical and related radiation processes in BdHNe and focus on individuating the binary properties that play the relevant roles.

On Thursday, September 15, 2022, Prof. Rahim Moradi presented a lecture titled *"Nature of the ultra-relativistic prompt emission (UPE) phase in GRB 180720B and GRB 190114C"*. Here below the abstract:

Fig. 8: Prof. Rahim Moradi presenting his lecture at the 31st Texas Symposium on Relativistic Astrophysics in Prague, September 15, 2022.

We investigate the ultra relativistic prompt emission (UPE) of GRB 180720B and GRB 190114C, observed by Fermi-GBM. The time-resolved spectral analysis performed in time sub-intervals reveals the UPE hierarchical structure: the spectrum in each shorter time interval is always fitted by a composite blackbody plus cutoff power-law model. This structure is explained using the inner engine of a binary-driven hypernova (BdHN) model operating in the quantum electrodynamics (QED) regime. The electric field induced by the gravitomagnetic interaction of the newborn Kerr BH with the surrounding magnetic field is overcritical in this regime. The overcritical field polarizes the vacuum, resulting in an electron-positron pair plasma that loads baryons from its surroundings during its expansion. The dynamics of the self-acceleration of pair-electromagnetic-baryon (PEMB) pulses to their point of transparency are calculated. The radiation timescale, Lorentz factors, and transparency radius of the PEMB pulses are determined to characterize the quantum vacuum polarization process in the sequences of decreasing time bins of the UPE. We also estimate the strength of the surrounding magnetic field and derive a lower limit to the BH mass, and a corresponding upper limit to the spin parameter, under the assumption that the UPE is powered by Kerr BH extractable energy and its mass is bound from below by the NS critical mass.

For the website of the meeting: https://texas2021.org/

9. Prof. Ruffini participation at the event "*The cultural diplomacy between Italy and America*", July 7, 2022, Italian Senate in Rome (Italy)

On July 7, 2022 Prof. Ruffini has been invited to participate to the event "The cultural diplomacy between Italy and America", held in the sala Capitolare of the Italian Senate in Rome (Italy).

The conference has been organized by the Italian Senator Pier Ferdinando Casini, in collaboration with the American think tank Renaissance Evolution, aiming at the promotion of culture as the engine for dialogue, harmony and wealth among people and countries. Several eminent personalities joined the conference and took the floor, such as the Italian Ministry of Culture Dario Franceschini, the Archbishop Vincenzo Paglia, the Italian Ambassador in Santo Domingo Stefano Queirolos Palmas, the Secretary general of the International Organization Italian- Latin- American Antonella Cavallari, as well as the expert in geopolitics Michele Pavan and the political analyst Tim Phillips.
For the video of the event: https://www.youtube.com/watch?v=xTDPZFOTuHI

10. Prof. Massimo Della Valle, President of the ICRANet Scientific Committee, appointed correspondent member of the Academy of Lincei

It is our pleasure to announce that Prof. Massimo Della Valle, Director of the Capodimonte Astronomical Observatory and President of the ICRANet Scientific Committee, has been appointed correspondent partner of the Academy of Lincei on July 28, 2022, for the division of Physical Sciences.

For the news on the Academy of Lincei website: https://www.lincei.it/it/news/nuovi-soci-2022

11. Royal Society Publishing special issue of Philosophical Transactions A "*The future of mathematical cosmology (part 1)*", compiled and edited by Prof. Spiros Cotsakis and Prof. Alexander Yefremov

Royal Society Publishing has recently published a special issue of Philosophical Transactions A entitled The future of mathematical cosmology (part 1), compiled and edited by Spiros Cotsakis and Alexander P. Yefremov. Here below the abstract:

What are the main achievements in theoretical cosmology in the past 100 years? What is its present status and future prospects? What do we know about the big bang, dark energy, the future of the universe, the shape of spacetime, the multiverse, and the quantum nature of the cosmos? Mathematical cosmology was born in 1917 when Albert Einstein showed us how to build entire universes consistent with the laws of physics. Since then, it has developed into a fascinating field providing explanations for the new data and observations. This theme issue is the first devoted solely to the intricate nature of the universe, and provides a clear outline for future developments in this fundamental area of modern science.

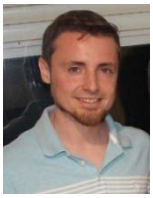
The articles can be accessed directly at the following link: www.bit.ly/TransA-2222

12.Scientific visits to ICRANet

- Prof. Soroush Shakeri (Isfahan University of Technology, Iran), July 2 – August 17, 2022
- Prof. Massimo Della Valle (Osservatorio di Capodimonte – Italy), July 6 – 9, 2022
- Prof. Carlos Raul Arguelles (UNLP Argentina), July 6 – 20, 2022
- Prof. Yerlan Aimuratov (Fesenkov Astrophysical Institute and Al-Farabi Kazakh National University), June 11 – July 31, 2022
- Tursynbek Yernazarov (Al-Farabi Kazakh National University), June 23 – September 9, 2022
- Prof. Behzad Eslam Panah (University of Mazandaran, Iran), September 1 – 25, 2022
- Prof. Sergio Torres (Centro Internacional de Fisica, Bogotà, Colombia), September 13 – 16, 2022


Prof. Soroush Shakeri


Prof. Massimo Della Valle


Prof. Carlos Arguelles


Prof. Yerlan Aimuratov


Tursynbek Yernazarov


Prof. Behzad Eslam Panah


Prof. Sergio Torres

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.

13.Recent publications

F. Rastegarnia, R. Moradi, J. A. Rueda, R. Ruffini, Liang Li, S. Eslamzadeh, Y. Wang & S. S. Xue, *The structure of the ultrarelativistic prompt emission phase and the properties of the black hole in GRB 180720B*, published on September 2, 2022 in the European Physical Journal C, volume 82, article number 778.

In analogy with GRB 190114C, we here analyze the ultrarelativistic prompt emission (UPE) of GRB 180720B observed in the rest-frame time interval t_{rf} = 4.84–10.89 s by Fermi-GBM. We reveal the UPE hierarchical structure from the time-resolved spectral analysis performed in time sub-intervals: the spectrum in each shorter time interval is always fitted by a composite blackbody plus cutoff power-law model. We explain this structure with the *inner engine* of binary-driven hypernova (BdHN) model operating in a quantum electrodynamics (QED) regime. In this regime, the electric field induced by the gravitomagnetic interaction of the newborn Kerr BH with the surrounding magnetic field is overcritical, i.e., $E \geq E_c$, where $E_c=m^2e^3/(e\hbar)$. The overcritical field polarizes the vacuum leading to an $e^+ e^-$ pair plasma that loads baryons from the surroundings during its expansion. We calculate the dynamics of the self-acceleration of the pair-electromagnetic-baryon (PEMB) pulses to their point of transparency. We characterize the quantum vacuum polarization process in the sequences of decreasing time bins of the UPE by determining the radiation timescale, Lorentz factors, and transparency radius of the PEMB pulses. We also

estimate the strength of the surrounding magnetic field $\sim 10^{14}$ G, and obtain a lower limit to the BH mass, M=2.4 $M_{\odot}$, and correspondingly an upper limit to the spin, α=0.6, from the conditions that the UPE is powered by the Kerr BH extractable energy and its mass is bound from below by the NS critical mass.

DOI: https://doi.org/10.1140/epjc/s10052-022-10750-x

Wang, Yu; Rueda, J. A.; Ruffini, R.; Moradi, R.; Li, Liang; Aimuratov, Y.; Rastegarnia, F.; Eslamzadeh, S.; Sahakyan, N.; Zheng, Yunlong, *GRB 190829A-A Showcase of Binary Late Evolution*, published on September 14, 2022 in The Astrophysical Journal, Volume 936, Issue 2, id.190.

GRB 190829A is the fourth-closest gamma-ray burst to date (z = 0.0785). Owing to its wide range of radio, optical, X-ray, and very-high-energy observations by HESS, it has become an essential new source that has been examined by various models with complementary approaches. Here, we show in GRB 190829A that the double prompt pulses and the three multiwavelength afterglows are consistent with the type II binary-driven hypernova model. The progenitor is a binary composed of a carbon–oxygen (CO) star and a neutron star (NS) companion. The gravitational collapse of the iron core of the CO star produces a supernova (SN) explosion and leaves behind a new NS (νNS) at its center. The accretion of the SN ejecta onto the NS companion and onto the νNS via matter fallback spins up the NSs and produces the double-peak prompt emission. The synchrotron emission from the expanding SN ejecta, with energy injection from the rapidly spinning νNS and its subsequent spindown, leads to the afterglow in the radio, optical, and X-ray bands. We model the sequence of physical and related radiation processes in BdHNe, and focus on individuating the binary properties that play the relevant roles.

DOI: https://doi.org/10.3847/1538-4357/ac7da3

Becerra, L. M.; Moradi, R.; Rueda, J. A.; Ruffini, R.; Wang, Y, *The first minutes of a binary-driven hypernova*, accepted for publication on September 21, 2022 in Physical Review D.

We simulate the first minutes of the evolution of a binary-driven hypernova (BdHN) event, with a special focus on the associated accretion processes of supernova (SN) ejecta onto the newborn neutron star (νNS) and the NS companion. We calculate the rotational evolution of the νNS and the NS under the torques exerted by the accreted matter and the magnetic field. We take into account general relativistic effects and use realistic hypercritical accretion rates obtained from three-dimensional smoothed-particle-hydrodynamics (SPH) numerical simulations of the BdHN for a variety of orbital periods. We show that the rotation power of the νNS has a unique double-peak structure while that of the NS has a single peak. These peaks are of comparable intensity and can occur very close in time or even simultaneously depending on the orbital period and the initial angular momentum of the stars. We outline the consequences of the above features in the early emission and their consequent observation in long gamma-ray bursts (GRBs).

ArXiv: https://arxiv.org/abs/2208.03069

Rueda, J. A.; Ruffini, R.; Li, L.; Moradi, R.; Rodriguez, J. F.; Wang, Y., *Evidence for the transition of a Jacobi ellipsoid into a Maclaurin spheroid in gamma-ray bursts*, accepted for publication on September 21, 2022 in Physical Review D.

In the binary-driven hypernova (BdHN) scenario, long gamma-ray bursts (GRBs) originate in a cataclysmic event that occurs in a binary system composed of a carbon-oxygen (CO) star and a neutron star (NS) companion in close orbit. The collapse of the CO star generates at its center a newborn NS (νNS), and a supernova (SN) explosion. Matter from the ejecta is accreted both onto the νNS because of fallback and onto the NS companion, leading to the collapse of the latter into a black hole (BH). Each of the ingredients of the above system leads to observable emission episodes in a GRB. In particular, the νNS is expected to show up (hereafter νNS-rise) in the early GRB emission, nearly contemporary or superimposed to the ultrarelativistic prompt emission (UPE) phase, but with a different spectral signature. Following the νNS-rise, the νNS powers the afterglow emission by injecting energy into the expanding ejecta leading to synchrotron radiation. We here show that the νNS-rise and the subsequent afterglow emission in both systems, GRB 180720B and GRB 190114C, are powered by the release of rotational energy of a Maclaurin spheroid, starting from the bifurcation point to the Jacobi ellipsoid sequence. This implies that the νNS evolves from a triaxial Jacobi configuration, prior to the νNS-rise, into the axially symmetric Maclaurin configuration observed in the GRB. The triaxial νNS configuration is short-lived (less than a second) due to a copious emission of gravitational waves, before the GRB emission, and it could be in principle detected for sources located at distances closer than 100 Mpc. This appears to be the sole process of emission of gravitational waves in long GRBs.

ArXiv: https://arxiv.org/abs/2203.16876

G. Vereshchagin, M. Prakapenia, *Kinetics of Degenerate Electron–Positron Plasmas*, published on September 9, 2022 in Universe.

Relativistic plasma can be formed in strong electromagnetic or gravitational fields. Such conditions exist in compact astrophysical objects, such as white dwarfs and neutron stars, as well as in accretion discs around neutron stars and black holes. Relativistic plasma may also be produced in the laboratory during interactions of ultra-intense lasers with solid targets or laser beams between themselves. The process of thermalization in relativistic plasma can be affected by quantum degeneracy, as reaction rates are either suppressed by Pauli blocking or intensified by Bose enhancement. In addition, specific quantum phenomena, such as Bose–Einstein condensation, may occur in such a plasma. In this review, the process of plasma thermalization is discussed and illustrated with several examples. The conditions for quantum condensation of photons are formulated. Similarly, the conditions for thermalization delay due to the quantum degeneracy of fermions are analyzed. Finally, the process of formation of such relativistic plasma originating from an overcritical electric field is discussed. All these results are relevant for relativistic astrophysics as well as for laboratory experiments with ultra-intense lasers.

DOI: https://www.mdpi.com/2218-1997/8/9/473

J. Sedaghat, S.M. Zebarjad, G.H.Bordbar, B. Eslam Panah, R. Moradi, *Is the remnant of GW190425 a strange quark star?*, published on August 18, 2022 in Physics Letters B, Volume 833, 10 October 2022, 137388.

This study investigates the effects of different QCD models on the structure of strange quark stars (SQS). In these models, the running coupling constant has a finite value in the infrared region of energy. By imposing some constraints on the strange quark matter (SQM) and exploiting the analytic and background perturbation theories, the equations of states for the SQM are obtained. Then, the properties of SQSs in general relativity are evaluated. By using component masses of GW190425 [1] as well as some conversion relations between the baryonic mass and the

gravitational mass, the remnant mass of GW190425 is obtained. Our results for the maximum gravitational mass of SQS are then compared with the remnant mass of GW190425. The results indicate that the obtained maximum gravitational masses are comparable to the remnant mass of GW190425. Therefore, it is proposed that the remnant mass of GW190425 might be a SQS.

DOI: https://doi.org/10.1016/j.physletb.2022.137388

ICRANet Newsletter

October - November 2022

SUMMARY

1. ICRANet 4 GCN

TITLE: GCN CIRCULAR

NUMBER: 32780

SUBJECT: GRB 221009A: A type I BdHN of exceptional energetics

DATE: 22/10/17 11:16:22 GMT

FROM: Remo Rufinni at ICRA ruffini@icra.it

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

GRB221009A detected by Swift (Kennea et al. 2022 GCN32635), Fermi-GBM (Veres et al. 2022, GCN32636, Lesage et al. 2022, GCN32642), Fermi-LAT(Bissaldi et al. 2022, GCN32637), with redshift of z=0.151 and an isotropic equivalent energy of $E_{iso}=2x10^{54}$ erg (de Ugarte Postigo et al. 2022, GCN32648 and GCN32642) is a typical Binary driven Hypernova of type I (BdHNI), originating from the collapse of a carbon-oxygen core (CO-core) in presence of a companion neutron star (NS) with common feature with three BdHN I: GRB130427A with "pile up" in the prompt phase (Ruffini et al. 2013, GCN14526); GRB190114C (Ruffini et al. 2019, GCN23715); and GRB180720B (Ruffini et al. 2018, GCN23019). As the above three sources, GRB221009 Apresents: 1) the optical (Lipunov et al. 2022, GCN32634 and GCN32639; Perley. 2022 GCN32638; Broens. 2022, GCN32640; Hu et al. 2022, GCN32644; Mondy: Belkin et al. 2022, GCN32645; de Wet et al.2022, GCN32646; Xu et al.2022 GCN32647; Odeh 2022, GCN32649; Brivio et al. 2022, GCN32652; Izzo et al. 2022, GCN32765), radio (Bright et al. 2022, GCN32653 and Farah et al. 2022, GCN32655) and X-ray (Kennea et al, 2022, GCN32635, and GCN32651) synchrotron afterglow emissions as well as the TeV emission (Yong Huang et al. 2022, GCN32677), which in BdHN I originate from accreting millisecond spinning newborn NS (Rueda et al. 2022, e-Print: 2204.00579 [astro-ph.HE]); 2) the ultra-relativistic prompt emission (UPE) phase (Moradi et al. 2021, PRD 104, 063043 and Rastegarnia et al. 2022, EPJC 82, 778) and GeV emission (Rueda et al 2022 ApJ 929 56) originated from the black hole formed by hypercritical accretion of the supernova ejecta on the NS companion; and 3) the optical emission of the nickel decay of the supernova (SN), created by the collapse of the CO-core. The first evidence of the supernova rise is reported by S. Belkin et al. 2022 (GCN32769). In this GRB the bolometric optical peak of SN is expected to be observed at 15.57+/-2.0 days after the Fermi-GBM trigger (October 24^{th} 2022, uncertainty from October 22^{nd} 2022 to October 26^{th} 2022, with the bolometric optical luminosity of $L=(9.45+/-2.8)\ x10^{42}$ erg/s; Aimuratov et al. in preparation).

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TITLE: GCN CIRCULAR

NUMBER: 32802

SUBJECT: GRB 221009A X-ray light-curve and the indication of TeV light-curve

DATE: 22/10/19 15:28:45 GMT

FROM: Remo Rufinni at ICRA <ruffini@icra.it>

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

LHAASO observed more than 5000 very high energy (VHE) photons in GRB 221009A, with the highest energy reaching 18 TeV (GCN 32677). Previously, high energy TeV emissions were also observed in GRB 180720B (Abdalla et al. 2019), 190114C (MAGIC Collaboration 2019), 190829A (H.E.S.S. Collaboration 2021) and 201216C (Blanch et al. GCN 29075). A common feature of

these bursts is that the TeV light-curve follows a power-law decay with a similar index as the X-ray light-curve, and the TeV luminosity is tens of percent of the X-ray luminosity (see attached figure 1 and the references of Abdalla et al. 2019, MAGIC Collaboration 2019 and H.E.S.S. Collaboration 2021, Ruffini et al. 2021, Rueda et al. 2022, Rastegarnia et al. 2022, Wang et al. 2022). Here we present the X-ray light-curve of GRB 221009A observed by Swift-XRT (GCN 32651), and the t0 is taken from the Fermi-GBM trigger time (GCN 32636), see attached figure 2, a power-law of index -1.58 is fitted. The shadow region shows 20%-60% of the X-ray luminosity, which is expected to be the 0.3-1 TeV luminosity (17% less luminous for 0.5-18 TeV assuming a power-law spectrum of photon index -2) of this new burst if it shares the same behavior as the previous ones. We encourage further observations, especially the VHE observations, because this burst probably is more luminous than the previous ones, and it will be precious to have a late time (after days) VHE luminosity which was never achieved before, as well as the optical observations for the supernova appearance (GCN 32670, GCN 32780).

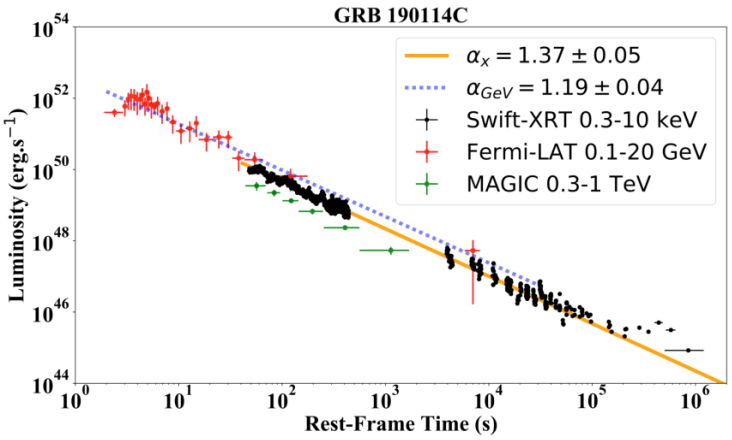

Figure 1: http://www.icranet.org/docs/fig1.png

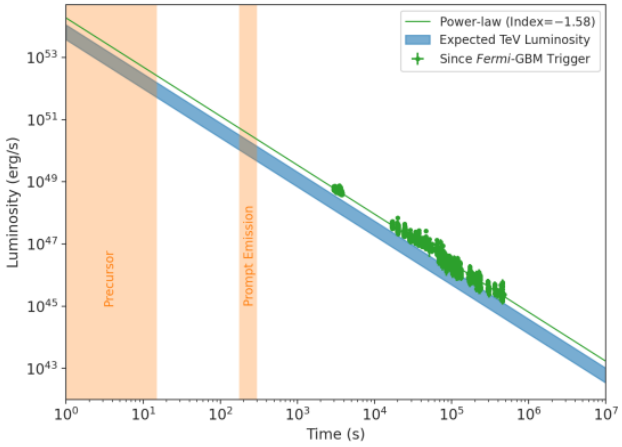

Figure 2: http://www.icranet.org/docs/fig2.png

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TITLE: GCN CIRCULAR
NUMBER: 32808
SUBJECT: GRB 221009A: Peak luminosity of the supernova vs. synchrotron afterglow
DATE: 22/10/20 14:57:47 GMT
FROM: Remo Ruffini at ICRA <ruffini@icra.it>

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

GRB 221009A appears to be a rare example (Jean-Luc Atteia et al. 2022, GCN 32793) of a particularly energetic and close GRB (de Ugarte Postigo et al. 2022, GCN 32648 and Lesage et al. 2022, GCN 32642 and N.P.M. Kuin et al. 2022, GCN 32656). Within the BdHN model, we have followed the X-ray, optical, and radio afterglows originating from synchrotron emission powered by fast spinning newborn neutron stars (vNS) with initial periods of fraction of a millisecond, accreting the supernova ejecta, created by the collapse of a carbon-oxygen core (Rueda et al. 2022, arXiv:2204.00579). Figures 1, 2 and 3 show the afterglows of three type I BdHNe, namely GRB 180720B (Ruffini et al. 2018, GCN 23019), GRB 190114C (Ruffini et al. 2019, GCN 23715), and GRB 211023A (Aimuratov et al. 2021, GCN 31056), and the prediction of their associated

supernova. We have indicated the expected time of the occurrence of the supernova in GRB 221009A (Aimuratov et al. 2022, GCN 32780). The ongoing observations in optical, radio, and X-ray bands are strongly recommended for allowing the determination of the spin and magnetic field of the vNS. This will probe as well if the optical synchrotron emission, at ~ 106 s from the Fermi-GBM trigger, impedes the observations of the optical emission of the supernova originating from nickel decay (Aimuratov et al. in preparation, see also data from Ilfan Bikmaev et al. 2022, GCN 32752, and Jia. Ren et al. 2022, arXiv:2210.10673, reproduced in Fig. 4).

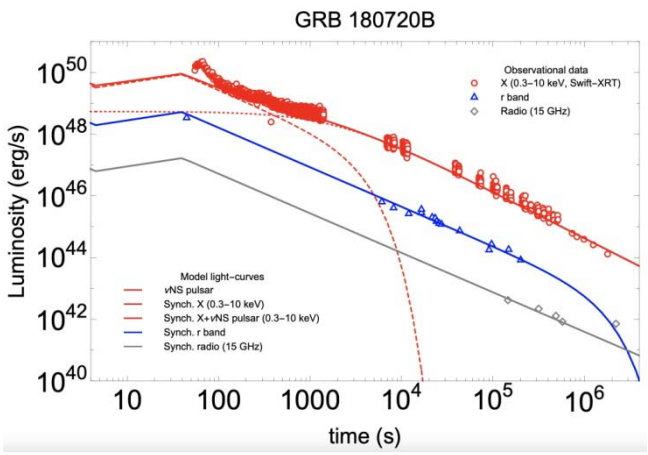

Fig1: http://www.icranet.org/docs/Fig1.pdf

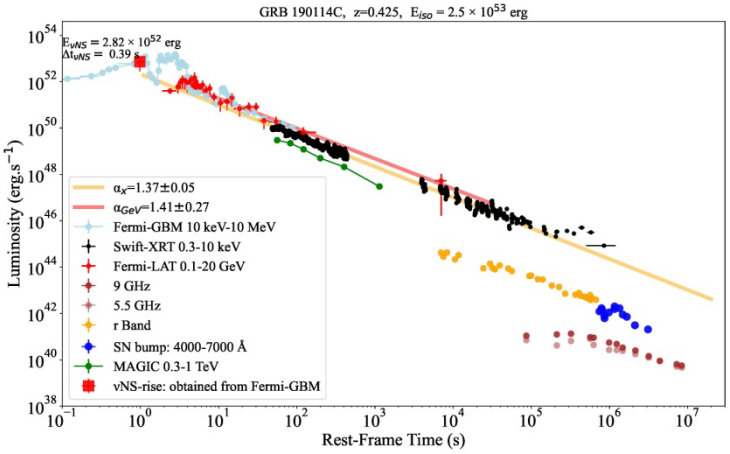

Fig2: http://www.icranet.org/docs/Fig2.pdf

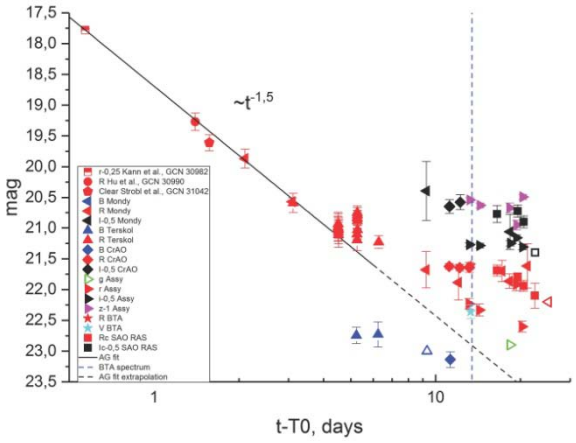

Fig3: http://www.icranet.org/docs/Fig3.pdf

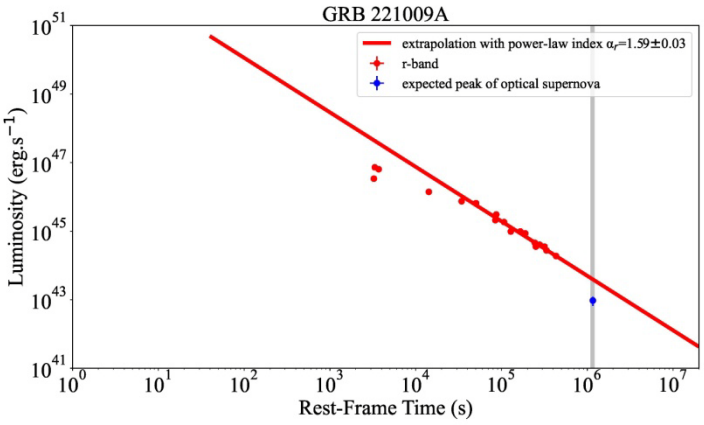

Fig4: http://www.icranet.org/docs/Fig4.pdf

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TITLE: GCN CIRCULAR
NUMBER: 32828
SUBJECT: GRB 221009A: Determination of the black holes mass and spin
DATE: 22/10/24 15:43:08 GMT
FROM: Remo Ruffini at ICRA <ruffini@icra.it>

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

In GRB 221009A, as in GRB 130427A (Ackermann et al. 2014, Science, 343, 42; and Ruffini et al. 2019, ApJ, 886, 82), the Fermi-GBM data in the prompt phase are piled up (Lesage et al. 2022, GCN 32642). In both cases there are missing the ultra-relativistic prompt emission (UPE) phases originating from quantum electro dynamical process around a Kerr BH (Ruffini et al. 2019, ApJ, 886, 82; and Rueda et al. 2022, ApJ, 929, 56), which were well observed in GRB 190114C (Moradi et al. 2021, Phys Rev D 104, 063043) and GRB 180720B (Rastegarnia et al. 2022, EPJC 82, 77). Under these conditions, for GRB 130427A the 0.1-100 GeV data of Fermi-LAT had allowed to determine only the lower limit on the BH mass, $M>2.31$ solar masses, and the upper limit of its spin parameter, $\alpha<0.4$ (Ruffini et al. 2019, ApJ, 886, 82). For the BDHNI GRB 190114C (Ruffini et al. 2019, GCN 23715), the values of the BH mass and spin had been determined by taking into account the UPE contribution: $M=4.53$ solar masses, $\alpha=0.54$ (Moradi et al. 2021, Phys Rev D 104, 063043). The analysis of GRB 130427A applied to GRB 221009A gives for the BH mass and spin parameters: $M>2.36$ solar masses and $\alpha<0.5$. We identify the spike at 500s as the X-ray flare (see e.g. Ruffini et al. 2021 MNRAS 504, 5301-5326 for similar GRBs). We also identify the trigger in the 10 keV-10 MeV data of Fermi-GBM as the dawn of the supernova (SN-rise), associated with the gravitational collapse of the progenitor CO-core. The SN ejecta, accreting on the binary NS companion, give origin to the BH (BH rise, Rueda & Ruffini 2012, ApJ L, 758, L7) and accreting on the vNS they originate the afterglow (vNS rise, Ruffini et al. 2018, ApJ, 869.101; Becerra, et al. 2022, Phys Rev D 106, 083002). Additional data analysis from AGILE (GCN 32650), Fermi (GCN 32636, 32637, 32642, 32819), Swift (GCN 32635), LHAASO (GCN 32677), HXMT (Atel 15660) are needed to relate the SN-rise to the first appearance of the vNS (the vNS-rise) by the TeV radiation (GCN 32780, 32820, 32808), and also to relate the appearance of the BH (BH-rise) to the identification of the first GeV emission.

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

We are happy to inform you that the abstract submission for the 5th Zeldovich meeting is now open.

The list of invited speakers includes:

- Gennady Bisnovatyi-Kogan, Space Research Institute (IKI), Russia
- Massimo Della Valle, Capodimonte Astronomical Observatory and INAF, Italy (TBC)
- Marat Gilfanov, Max-Planck Institute for Astrophysics, Germany and IKI, Russia (TBC)
- Paolo Giommi, Italian Space Agency (ASI), Italy
- Luca Izzo, Niels Bohr Institute, Denmark (TBC)
- Michael Kramer, Max-Planck-Institut fuer Radioastronomie, Germany (TBC)
- Jutta Kunz, University of Oldenburg, Germany (TBC)
- Klaus Laemmerzahl, University Bremen, Germany
- Di Li, National Astronomical Observatories of China, China
- Ruoyu Liu, Nanjing University, China
- Andrea Merloni, Max Planck Institute for extraterrestrial Physics, Germany (TBC)
- Razmik Mirzoyan, Max-Planck-Institute for Physics, Germany
- Tsvi Piran, The Hebrew University, Israel
- Konstantin Postnov, Sternberg Astronomical Institute, Moscow State University, Russia
- Rashid Sunyaev, Max-Planck Institute for Astrophysics, Germany and IKI, Russia (TBC)

- Alexei Starobinsky, Landau Institute for Theoretical Physics, Russia
- Lev Titarchuk, University di Ferrara, Italy and Astro Space Center, Lebedev Physical Institute, Russia
- Nan Zhang, Institute of High Energy Physics, China

At this 5th Zeldovich meeting, the new discoveries from the leading scientific missions in Relativistic Astrophysics will be reported:

- Russian-German Spektr-RG telescope (SRG)
- USA-European-Canadian James Webb Space Telescope (JWST)
- USA-Italian Imaging X-ray Polarimetry Explorer (IXPE)
- Chinese-European enhanced X-ray Timing and Polarimetry mission (eXTP)
- Chinese Large High Altitude Air Shower Observatory (LHAASO)
- Chinese Five-hundred-meter Aperture Spherical Telescope (FAST)
- European Major Atmospheric Gamma Imaging Cherenkov Telescope (MAGIC)

The early bird registration fee is 300 euro (100 euro for students). The late registration fee will be 400 euro (150 euro for students). It will cover conference kit, coffee breaks and publication of the conference papers.

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

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

3. Mission of Prof. Ruffini to the USA, November 6-11, 2022: lectures at the Cosmos Club, at the Institute for Advanced Studies (IAS) and at Princeton University

From November 6 to 11, 2022, Prof. Remo Ruffini, Director of ICRANet, visited the USA. During that visit, he has been invited to deliver a seminar at the prestigious Cosmos Club in Washington DC on Monday, November 7, 11:30 AM EST, titled *"The Role of Supernovae in Triggering the Formation of a Black Hole in Gamma Ray Bursts"*. Here below the abstract:

Supernovae of constant luminosities, with a tight neutron star companion, trigger complex systems leading to the formation of fast rotating Kerr Black Holes. Their rotational energy feeds gamma ray bursts which are extremely luminous. This presentation identifies extensions of known physical laws, inquiring on the unique role of these cosmic events. We follow their implications for the life evolution of our universe.

We also present recent understanding on the largest ever GRB221009A exploded on last October 19 and followed by the largest number of Observatories in all wavelengths from the ground and from space, from radio all the way to MeV , GeV and TeV radiation and UHCR.

Fig. 1: announcement of the seminar of Prof. Remo Ruffini at Cosmos Club, Washington DC, on November 7, 2022.

Fig. 2: Prof. Remo Ruffini in front of the wall members awarded Nobel Prizes at the Cosmos Club in Washington.

On the following day, November 8, Prof. Ruffini moved to Princeton, since he was invited to take part to the traditional Bahcall lunch at the Institute for Advanced Studies (IAS) a special joint lunch for both astrophysics and physics, members and faculty in Dilworth Room, Simons Hall.

Following the lunch, Prof. Ruffini moved to Princeton University, where he was invited to present his seminar titled *"The Role of Supernovae in Triggering the Formation of a Black Hole in Gamma Ray Bursts"* at Jadwin Hall, in the new Gravity Initiative section.

While at Princeton University, Prof. Ruffini also met, among others, Prof. Neta Bahcall, Prof. Lyman Page and Prof. Bruce Partridge and took this occasion to have fruitful scientific discussions with them.

On the following days, Prof. Ruffini met Dr David Nirenberg, Director of IAS, in order to discuss with him about relevant scientific issues as well as about the recent scientific results obtained by ICRANet group. He also visited Princeton University Library and met Dr Abigail Johnson, from Princeton University Press, with whom he discussed about relevant editorial matters.

Fig. 3: from left to right: Prof. Remo Ruffini, Prof. Neta Bahcall, Prof. Lyman Page and Prof. Bruce Partridge.

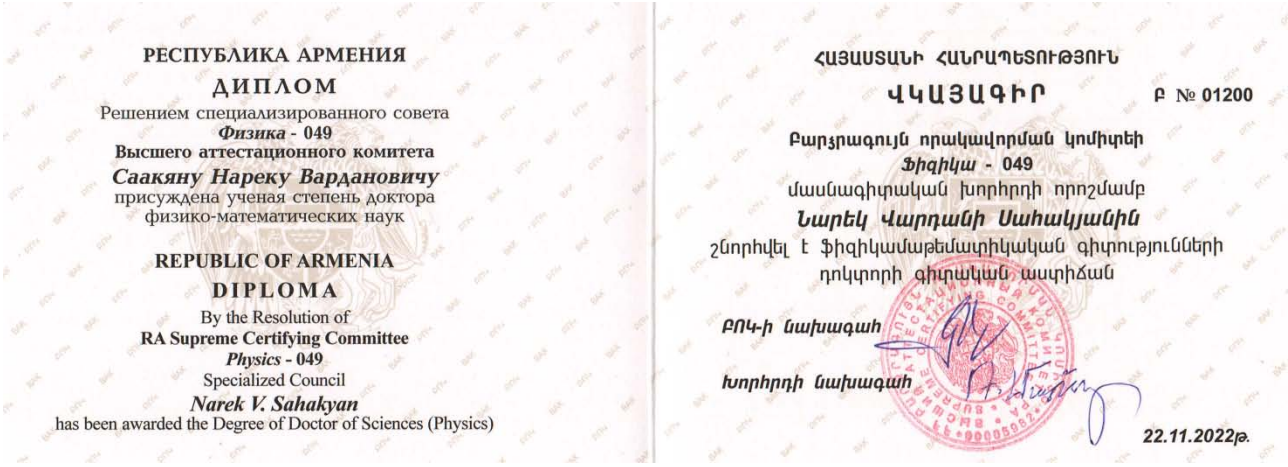
Fig. 4: Prof. Ruffini together with Dr Abigail Johnson (Princeton University Press).

4. Prof. Ruffini among the top 2% of the most cited authors, according to Elsevier

Recent update of the publicly available database of over 100,000 top-scientists listed by Elsevier, show that Prof. Remo Ruffini (Director of ICRANet), Prof. Behzad Eslam Panah (ICRANet-Mazandaran, Iran) and several other ICRANet scientists are in this list.

Elsevier has created this publicly available database of top-cited scientists, which provides standardized information on citations, h-index, co-authorship adjusted hm-index and citations to papers in different authorship positions. Scientists are classified into 22 scientific fields and 174 sub-fields, which are also provided for all scientists with at least 5 papers. Career-long data are updated to the end of 2021 and single recent year data pertain to citations received during 2021. The selection is based on the top 100,000 scientists by c-score (with and without self-citations) or a percentile rank of 2% or above in the sub-field. This version of the list is based on the September 1, 2022 snapshot from Scopus, updated to end of citation year 2021. This work uses Scopus data provided by Elsevier through ICSR Lab (https://www.elsevier.com/icsr/icsrlab) and calculations were performed using all Scopus author profiles as of September 1, 2022.

5. Congratulations to Director of ICRANet-Armenia and ICRANet Faculty Professor Narek Sahakyan, awarded of the Doctor of Sciences (DSc) degree in physics, November 22, 2022



РЕСПУБЛИКА АРМЕНИЯ
ДИПЛОМ
Решением специализированного совета
Физика - 049
Высшего аттестационного комитета
Саакяну Нареку Вардановичу
присуждена ученая степень доктора
физико-математических наук

REPUBLIC OF ARMENIA
DIPLOMA
By the Resolution of
RA Supreme Certifying Committee
Physics - 049
Specialized Council
Narek V. Sahakyan
has been awarded the Degree of Doctor of Sciences (Physics)

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ԲՈԿ-ի նախագահ
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22.11.2022թ.

It is our pleasure to announce that on November 22, 2022, the Director of ICRANet-Armenia Narek Sahakyan has been awarded the Doctor of Sciences (D Sc) degree in physics, as announced by the Higher Attestation Commission (VAK) of Armenia (https://www.bok.am/en/node/14246). His dissertation *"Study of multiwavelength and neutrino emission from blazars"* has been successfully defended on the June 25, 2022.
Professor Sahakyan has so become one of the few young Armenian researchers, awarded of this highest scientific degree in his country under the age of 40.

6. Partial solar eclipse and measurement of the solar diameter (October 25, 2022) and lunar eclipse at the antipodes (November 8, 2022), online and podcast events

Partial solar eclipse and measurement of the solar diameter (October 25, 2022)

On the occasion of the partial solar eclipse of October 25, 2022, Prof. Costantino Sigismondi, ICRANet collaborator, organized an online and podcast event, in a project carried on together with high school students from Pescara, Rome and Motta di Liveza (Italy), on the measurement of the solar diameter.

This study is placed in a project of astrometry structured as follows: *"Eclipses, equinoxes and sunsets: the methods to tame the horses of the Sun"*. The mythological wagon of Febo is channeled through a clear orbit, whose parameters are the object of study of the celestial mechanics. The astronomers after Galileo, with this sentence, alluded to the comprehension of the phenomenon of the atmospheric refraction which was measured exactly with the Sun between 20° and 70° from the Zenith by Giandomenico Cassini in 1655, after being measured by Tycho Brahe in 1572 with the Supernova in Cassiopeia observed by all over Europe.

Prof. Sigismondi illustrated the following observational methods and analysis data with measurements of the position and the diameter of the Sun meridian and over the horizon: elements of astrometry (systems of celestial coordinates, Right Ascension and declination, eclectic longitude and latitude); the seasons form the astronomical point of view (the form of the Earth' orbit: eccentricity and line of the apsides), the form and dimension of Earth from the data on the meridian at Rome S. Maria degli Angeli and dei Martiri in Motta di Livenza, timing of an astronomical

observation using the video synchronized with UTC, timing of an astronomical observation from the webcam and the synchronization with the protocol NTP, the astronomical ephemerides NASA, IMCCE and the program Stellarium, the linear fit on the data from the autumnal equinox in 2022, the quadratic fit on the data from the summer solstice in 2022, the quadratic fit on the data from the partial eclipse of the Sun on October 25, 2022 and the online database of the observations held at the Clementine meridian as well as the worksheet for the reduction of the data.

For the scientific rationale of the event: http://www.icranet.org/index.php?option=com_content&task=view&id=1461

For the videos analyzed during the event:

http://www.icranet.org/index.php?option=com_content&task=view&id=1460#EclissiLuna

For the YouTube playlist on the solar eclipse of October 25, 2022: https://www.youtube.com/playlist?list=PLJaer2KV492_Nu3nCaB3LhVxKXsAHhR7S

The lunar eclipse at the antipodes (November 8, 2022)

Fig. 5: simulation of the Lunar meridian transit on November 7, 2022

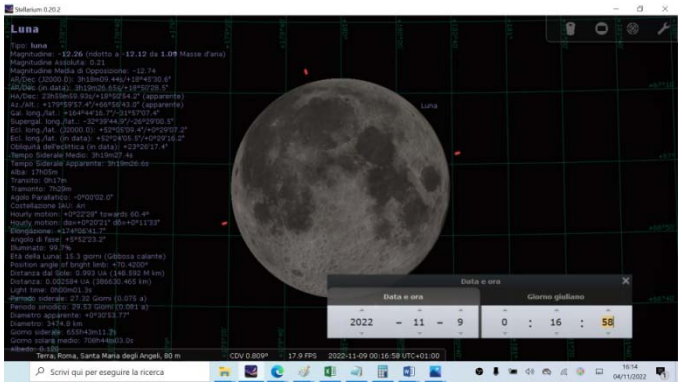


Fig. 6: simulation of the Lunar meridian transit on November 9, 2022

The lunar eclipse at the antipodes has been seen thanks to the calculations (November 8, 2022).

In fact, in every eclipses' season, every 6 *draconitics* months, the eclipses manifests them in pairs, sometimes also in three. All these statistics are legacies of the Celestial mechanics, and Prof. Costantino Sigismondi, ICRANet collaborator, has traced their main steps through 2 events.

The first one has been held on November 5, 2022 at the Basilica of S. Maria degli Angeli (Rome). On the Clementine Line it has been simulated the meridian passages of the Moon of November 7 and 9, 2022 and computed the interpolation on November 8, imposing the condition of alignment among the centers of the Moon, the Earth as well as the Sun. It has been finally discovered that the Moon would be at almost 180° from the Sun on November 8, 2022 at h 12:00.

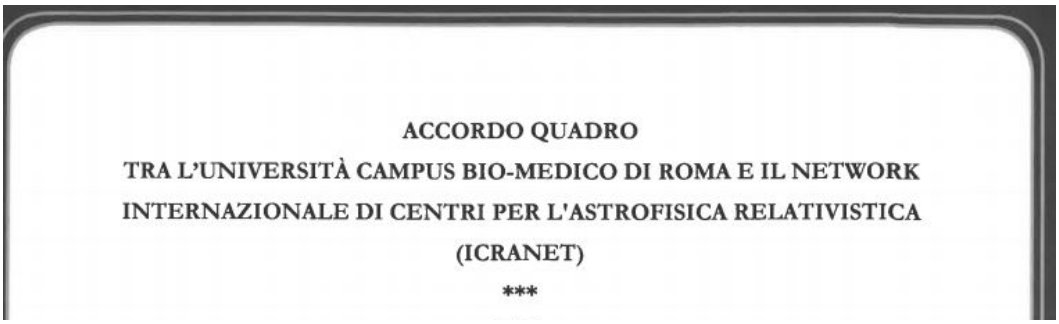
The second one has been held on November 8, through the link to the website Timeanddate, where the images of the eclipse have been transmitted: https://www.timeanddate.com/eclipse/lunar/2022-november-8. Meanwhile, Prof. Sigismondi provided the scientific and historical comment in Italian.

The lunar eclipses have been used to measure the longitude of the observational point, having a meridian. They represent the most accurate method for this purpose until the whole XVIII century. Also Cristoforo Colombo evaluated the longitude of Hispaniola with the lunar eclipse of February 29, 1504. Prof. Sigismondi then illustrated all the lunar eclipses that he had observed from January 9, 1982 in Lanciano, repeated after a cycle of Saros on January 21, 2000, while he was in Padua, as

well as after a cycle of Metone on January 21, 2019 in Pescara and on August 7, 2017 from Snat'Angelo bridge in Rome. The last eclipse he observed has been on May 16, 2022 in Lanciano.

For the website of the meeting, as well as the references on the works concerning the lunar eclipses: http://www.icranet.org/index.php?option=com_content&task=view&id=1460

7. Renewal of the cooperation agreement between ICRANet and the University Campus Bio-Medico of Rome (Italy), October 11, 2024


ACCORDO QUADRO
TRA L'UNIVERSITÀ CAMPUS BIO-MEDICO DI ROMA E IL NETWORK
INTERNAZIONALE DI CENTRI PER L'ASTROFISICA RELATIVISTICA
(ICRANET)
***

On October 11, 2022, the agreement between ICRANet and the Campus Bio-medico University of Rome has been renewed. This agreement will be valid for 2 years and the main joint activities to be developed under its framework include: the promotion of theoretical and observational activities within the field of Relativistic Astrophysics; the joint collaboration of faculty members, researchers, post-doctorate fellows and students; the organization of training and teaching courses, seminars, conferences, workshops or short courses, and the joint work on scientific publications.

For the text of the agreement: http://www.icranet.org/bio-medico

8. Seminars at ICRANet center in Pescara, November 25, 2022

Seminar of Prof. Gennady Bisnovatyi-Kogan

On Friday, November 25, 2022, Prof. Gennady Bisnovatyi-Kogan (Space Research Institute of the Russian Academy of Sciences - SRI RAS) presented a seminar titled *"About the Observational Check of the Mechanism of Gamma Radiation in Soft Gamma Repeaters (SGR)"* with the following abstract:

Soft gamma repeaters (SGR) are identified as single neutron stars (NS) inside the Galaxy, or nearby galaxies, with sporadic transient gamma radiation. A total number of discovered SGR, including relative Anomalous X-ray pulsars (AXP), is a few tens of objects. Many of them show periodic radiation, connected with NS rotation, with periods 2–12 s. The slow rotation is accompanied by small rate of loss of rotational energy, which is considerably smaller than the observed sporadic gamma ray luminosity, and is many orders less than the luminosity during giant bursts, observed in 4 SGR. Therefore the energy source is usually connected with annihilation of a very strong NS magnetic field. Another model is based on the release of nuclear energy stored in the NS non-equilibrium layer. We suggest here an observational test which could distinguish between these two models.

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

For the video of the seminar: https://youtu.be/1lZLqJ_pogk

Fig. 7 and 8: Prof. Gennady Bisnovatyi-Kogan giving his seminar at ICRANet center in Pescara, November 25, 2022.

Seminar of Prof. Marco Merafina

On Friday, November 25, 2022, Prof. Marco Merafina (University of Rome La Sapienza) presented a seminar titled *"Multimass King models with Kroupa mass function"* with the following abstract:

Statistical analysis on Milky Way globular clusters distribution is developed in order to extract the best fit function and carry out the critical value of the onset of gravothermal catastrophe, connected with the maximum of the distribution function. Results show that gravothermal collapse for globular clusters onsets earlier than commonly believed and in accordance with theoretical results obtained by considering the presence of the effective potential which describes the effects of the tidal forces induced by the hosting galaxy. N-body simulations confirm the presence of the effective potential with the predicted form. Theoretical model is generalized to multimass one by using Kroupa mass function. A detailed description of the projected densities at different W0 indicates similar luminosity profiles in complete accordance with observations. We also consider the effects of the mass segregation on the distribution of stars and the consequences on the equipartition process. N-body simulations in connection with mass distribution and segregation as well the computational development applied to multimass model are also shown at the present state of the art.

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

For the video of the seminar: https://youtu.be/gW4yGYbLdNA

Fig. 9 and 10: Prof. Marco Merafina giving his seminar at ICRANet center in Pescara, November 25, 2022.

9. Scientific visits to ICRANet

- Prof. Seyed Mohammad Taghi Mirtorabi (Alzahra University – Iran), October 1 – 18, 2022
- Prof. Massimo Della Valle (Osservatorio di Capodimonte - Italy), October 30 – November 1, 2022
- Prof. Gennady Bisnovatyi-Kogan (Space Research Institute of the Russian Academy of Sciences - SRI RAS), November 25 – 27, 2022
- Prof. Marco Merafina (University of Roma La Sapienza), November 25, 2022

Prof. Seyed Mohammad Taghi Mirtorabi

Prof. Massimo Della Valle

Prof. Gennady Bisnovatyi-Kogan

Prof. Marco Merafina

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.

10.Recent publications

J. A. Rueda, Liang Li, R. Moradi, R. Ruffini, N. Sahakyan, and Y. Wang, *On the X-Ray, Optical, and Radio Afterglows of the BdHN I GRB 180720B Generated by Synchrotron Emission*, published on November 3, 2022 in ApJ, Volume 939, Number 2.

Gamma-ray bursts (GRBs) are systems of unprecedented complexity across all the electromagnetic spectrum, including the radio, optical, X-rays, gamma rays in the MeV and GeV regimes, as well as ultrahigh-energy cosmic rays, each manifested in seven specific physical processes with widely different characteristic evolution timescales ranging from 10^{-14} s to 10^{7} s or longer. We here study the long GRB 180720B originating from a binary system composed of a massive carbon-oxygen

(CO) star of about $10M_{\odot}$ and a companion neutron star (NS). The gravitational collapse of the CO star gives rise to a spinning newborn NS (νNS), with an initial period of $P_0 = 1$ ms that powers the synchrotron radiation in the radio, optical, and X-ray wavelengths. We here investigate solely the GRB 180720B afterglows and present a detailed treatment of its origin based on the synchrotron radiation released by the interaction of the νNS and the SN ejecta. We show that in parallel to the X-ray afterglow, the spinning νNS also powers the optical and radio afterglows and allows to infer the νNS and ejecta parameters that fit the observational data.

DOI: http://dx.doi.org/10.3847/1538-4357/ac94c9

J. A. Rueda, R. Ruffini, L. Li, R. Moradi, J. F. Rodriguez, and Y. Wang, *Evidence for the transition of a Jacobi ellipsoid into a Maclaurin spheroid in gamma-ray bursts*, published on October 7, 2022 in Phys. Rev. D 106, 083004.

In the binary-driven hypernova (BdHN) scenario, long gamma-ray bursts (GRBs) originate in a cataclysmic event that occurs in a binary system composed of a carbon-oxygen (CO) star and a neutron star (NS) companion in close orbit. The collapse of the CO star generates at its center a newborn NS (νNS), and a supernova (SN) explosion. Matter from the ejecta is accreted both onto the νNS because of fallback and onto the NS companion, leading to the collapse of the latter into a black hole (BH). Each of the ingredients of the above system leads to observable emission episodes in a GRB. In particular, the νNS is expected to show up (hereafter νNS-rise) in the early GRB emission, nearly contemporary or superimposed to the ultrarelativistic prompt emission (UPE) phase, but with a different spectral signature. Following the νNS-rise, the νNS powers the afterglow emission by injecting energy into the expanding ejecta leading to synchrotron radiation. We here show that the νNS-rise and the subsequent afterglow emission in both systems, GRB 180720B and GRB 190114C, are powered by the release of rotational energy of a Maclaurin spheroid, starting from the bifurcation point to the Jacobi ellipsoid sequence. This implies that the νNS evolves from a triaxial Jacobi configuration, prior to the νNS-rise, into the axially symmetric Maclaurin configuration observed in the GRB. The triaxial νNS configuration is short-lived (less than a second) due to a copious emission of gravitational waves, before the GRB emission, and it could be in principle detected for sources located at distances closer than 100 Mpc. This appears to be a specific process of emission of gravitational waves in the BdHN I powering long GRBs.

DOI: https://doi.org/10.1103/PhysRevD.106.083004

L. M. Becerra, R. Moradi, J. A. Rueda, R. Ruffini, and Y. Wang, *First minutes of a binary-driven hypernova*, published on October 3, 2022 in Phys. Rev. D 106, 083002.

We simulate the first minutes of the evolution of a binary-driven hypernova event, with a special focus on the associated accretion processes of supernova ejecta onto the newborn neutron star (νNS) and the NS companion. We calculate the rotational evolution of the νNS and the NS under the torques exerted by the accreted matter and the magnetic field. We take into account general relativistic effects through effective models for the NSs binding energy and the specific angular momentum transferred by the accreted matter. We use realistic hypercritical accretion rates obtained from three-dimensional smoothed-particle-hydrodynamics numerical simulations of the binary-driven hypernova event for a variety of orbital periods. We show that the rotation power of the νNS has a unique double-peak structure while that of the NS has a single peak. These peaks are of comparable intensity and can occur very close in time or even simultaneously depending on the orbital period and the initial angular momentum of the stars. We outline the consequences of the above features in the early emission and their consequent observation in long gamma-ray bursts.

DOI: https://doi.org/10.1103/PhysRevD.106.083002

Carvalho, G. A.; Anjos, R. C. dos; Coelho, J. G.; Lobato, R. V.; Malheiro, M.; Marinho, R. M.; Rodriguez, J. F.; Rueda, J. A.; Ruffini, R., *Orbital Decay of Double White Dwarfs: Beyond Gravitational-wave Radiation Effects*, published on November 23, 2022 in ApJ, Vol. 940, n. 1.

The traditional description of the orbital evolution of compact-object binaries, like double white dwarfs (DWDs), assumes that the system is driven only by gravitational-wave (GW) radiation. However, the high magnetic fields with intensities of up to gigagausses measured in WDs alert a potential role of the electromagnetic (EM) emission in the evolution of DWDs. We evaluate the orbital dynamics of DWDs under the effects of GW radiation, tidal synchronization, and EM emission by a unipolar inductor generated by the magnetic primary and the relative motion of the nonmagnetic secondary. We show that the EM emission can affect the orbital dynamics for magnetic fields larger than megagausses. We applied the model to two known DWDs, SDSS J0651+2844 and ZTF J1539+5027, for which the GW radiation alone does not fully account for the measured orbital decay rate. We obtain upper limits to the primary's magnetic field strength, over which the EM emission causes an orbital decay faster than observed. The contribution of tidal locking and the EM emission is comparable, and together they can contribute up to 20% to the measured orbital decay rate. We show that the gravitational waveform for a DWD modeled as purely driven by GWs and including tidal interactions and EM emission can have large relative dephasing detectable in the mHz regime of frequencies relevant for space-based detectors like LISA. Therefore, including physics besides GW radiation in the waveform templates is essential to calibrate the GW detectors using known sources, e.g., ZTF J1539+5027, and to infer binary parameters.

DOI: 10.3847/1538-4357/ac9841

S-S. Xue, *W boson mass tension caused by its right-handed gauge coupling at high energies?*, published on October 16, 2022 in Nuclear Physics B, Volume 985.

The CDF collaboration's recent high-precision measurement of the W mass is in 7.0σ disagreement with the Standard Model expectation. This tension will be relieved if the W boson has a non-trivial right-handed gauge coupling at high energies. At TeV scales, the SM gauge symmetric four-fermion interactions induce a right-handed gauge coupling, and SM fermions compose massive composite particles. We investigate the top-quark mass produced by spontaneous symmetry breaking and compute the W and Z boson propagators and decays. The right-handed coupling corrections to their masses and widths are consistent with experimental measurements. We discuss how SM gauge bosons and composite particles can restore parity-preserving gauge symmetries at TeV scales.

DOI: https://doi.org/10.1016/j.nuclphysb.2022.115992

N. Sahakyan, D. Israyelyan, G. Harutyunyan, S. Gasparyan, V. Vardanyan, M. Khachatryan, *Modelling the time variable spectral energy distribution of the blazar CTA 102 from 2008 to 2022*, published on October 2, 2022 in Monthly Notices of the Royal Astronomical Society.

We present long-term multiwavelength observations of blazar CTA 102 (z = 1.037). Detailed temporal and spectral analyses of γ-ray, X-ray, and UV/optical data observed by Fermi-LAT, Swift XRT, NuSTAR, and Swift-UVOT over a period of 14 yr, between 2008 August and 2022 March, were performed. We found strong variability of source emission in all the considered bands; especially in the γ-ray band it exhibited extreme outbursts when the flux crossed the level of 10^{-5} photon cm^{-2} s^{-1}. Using the Bayesian Blocks algorithm, we split the adaptively binned γ-ray light curve into 347 intervals of quiescent and flaring episodes and for each period built corresponding multiwavelength spectral energy distributions (SEDs), using the available data.

Among the considered SEDs, 117 high-quality (quasi) contemporaneous SEDs, which have sufficient multiwavelength data, were modelled using JETSET framework within a one-zone leptonic synchrotron and inverse-Compton emission scenario assuming the emitting region is within the broad-line region and considering internal and external seed photons for the inverse-Compton up scattering. As a result of modelling, the characteristics of the relativistic electron distribution in the jet as well as jet properties are retrieved and their variation in time is investigated. The applied model can adequately explain the assembled SEDs and the modelling shows that the data in the bright flaring periods can be reproduced for high Doppler boosting and magnetic field. The obtained results are discussed in the context of particle cooling in the emitting region.

DOI: https://doi.org/10.1093/mnras/stac2875

B. Eslam Panah, *Two-dimensional Lifshitz-like AdS black holes in F(R) gravity*, published on November 2 in the Journal of Mathematical Physics 63, 112502 (2022).

Two-dimensional (2D) Lifshitz-like black holes in special F(R) gravity cases are extracted. We indicate an essential singularity at $r = 0$, covered by an event horizon. Then, conserved and thermodynamic quantities, such as temperature, mass, entropy, and the heat capacity of 2D Lifshitz-like black holes in F(R) gravity, are evaluated. Our analysis shows that 2D Lifshitz-like black hole solutions can be physical solutions, provided that the cosmological constant is negative ($\Lambda < 0$). Indeed, there is a phase transition between stable and unstable cases by increasing the radius of AdS black holes. In other words, the 2D Lifshitz-like AdS black holes with large radii are physical and enjoy thermal stability. The obtained 2D Lifshitz-like AdS-black holes in *F(R)* gravity turn into the well-known 2D Schwarzschild AdS-black holes when the Lifshitz-like parameter is zero ($s = 0$). Moreover, correspondence between these black hole solutions and the 2D rotating black hole solutions is found by adjusting the Lifshitz-like parameter.

DOI: https://doi.org/10.1063/5.0104272

A. Bagheri Tudeshki, G. H. Bordbar, and B. Eslam Panah, *Dark Energy Star in Gravity's Rainbow*, published on October 19 in Physics Letters B. 835, 137523 (2022).

The concept of dark energy can be a candidate for preventing the gravitational collapse of compact objects to singularities. According to the usefulness of gravity's rainbow in UV completion of general relativity (by providing a new description of spacetime), it can be an excellent option to study the behavior of compact objects near phase transition regions. In this work, we obtain a modified Tolman-Openheimer-Volkof (TOV) equation for anisotropic dark energy as a fluid by solving the field equations in gravity's rainbow. Next, to compare the results with general relativity, we use a generalized Tolman-Matese-Whitman mass function to determine the physical quantities such as energy density, radial pressure, transverse pressure, gravity profile, and anisotropy factor of the dark energy star. We evaluate the junction condition and investigate the dynamical stability of dark energy star thin shell in gravity's rainbow. We also study the energy conditions for the interior region of this star. We show that the coefficients of gravity's rainbow can significantly affect this non-singular compact object and modify the model near the phase transition region.

DOI: https://doi.org/10.1016/j.physletb.2022.137523

García, Cristhian; Santa, Camilo; Romano, Antonio Enea, *Deep learning reconstruction of the large scale structure of the Universe from luminosity distance*, published on October 19, 2022 in Monthly Notices of the Royal Astronomical Society.

Supernovae Ia (SNe) can provide a unique window on the large-scale structure (LSS) of the Universe at redshifts where few other observations are available, by solving the inversion problem (IP) consisting in reconstructing the LSS from its effects on the observed luminosity distance. So far the IP was solved assuming some restrictions about space–time, such as spherical symmetry for example, while we obtain for the first time solutions of the IP problem for arbitrary space–time geometries using deep learning. The method is based on the use of convolutional neural networks (CNN) trained on simulated data. The training data set is obtained by first generating random density and velocity fields, and then computing their effects on the luminosity distance. The CNN, based on an appropriately modified version of U-Net to account for the tridimensionality of the data, is then trained to reconstruct the density and velocity fields from the luminosity distance. We find that the velocity field inversion is more accurate than the density field, because the effects of the velocity on the luminosity distance only depend on the source velocity, while in the case of the density it is an integrated effect along the line of sight, giving rise to more degeneracy in the solution of the IP. Improved versions of these neural networks, modified to accommodate the non-uniform distribution of the SNe, can be applied to observational data to reconstruct the LSS of the Universe at redshifts at which few other observations are available.

DOI: https://doi.org/10.1093/mnras/stac2916

Cadavid, Alexander Gallego; Romano, Antonio Enea; Liddle, Andrew R., *Reconstructing homospectral inflationary potentials*, published on October 13, 2022 in Phys. Rev. D 106, 083512.

Purely geometrical arguments show that there exist classes of homospectral inflationary cosmologies, i.e., different expansion histories producing the same spectrum of comoving curvature perturbations. We develop a general algorithm to reconstruct the potential of minimally coupled single scalar fields from an arbitrary expansion history. We apply it to homospectral expansion histories to obtain the corresponding potentials, providing numerical and analytical examples. The infinite class of homospectral potentials depends on two free parameters, the initial energy scale and the initial value of the field, showing that, in general, it is impossible to reconstruct a unique potential from the curvature spectrum unless the initial energy scale and the field value are fixed, for instance, through observation of primordial gravitational waves.

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