ICRANet Executive Summary

Historical premises on relativistic astrophysics

In 1967, there was a proficuous interaction between Edoardo Amaldi and Remo Ruffini, following the path of Enrico Fermi to promote a new era of the study of Einstein's Theory, directing their attention to the newly born Relativistic Astrophysics. It follows an intense interaction between Ruffini and Pasqual Jordan in Hamburg and John Archibald Wheeler, Charlie Misner, and P.A.M. Dirac in Paris at the Institute "Henri-Poincaré". The above activity led Ruffini to a two-year postdoctoral position at Princeton with the help of Pierre Auger, Director General of the European Space Research Organization (ESRO). The interaction with J.A. Wheeler and S. Chandrasekhar led to classical works and Ruffini's promotion, in sequence, to Instructor, Assistant Professor, Member of the Institute for Advanced Studies, Alfred P. Sloan Fellow. Three key results followed: the introduction of the Black Hole with J.A. Wheeler, the mass-energy formula of the Black Hole with D. Christodoulou and Stephen Hawking, using the exact solution by Roy P. Kerr of the Einstein Equations for a rotating mass (see Fig. 1), and finally the discovery of the first Black Hole, Cygnus X-1, made possible by daily interactions with Riccardo Giacconi who had launched the first X-ray satellite (Uhuru) from the San Marco platform of Luigi Broglio. Ruffini returned to Italy on Edoardo Amaldi's suggestion to drive relativistic astrophysics in Italy. Just before his return in 1977, Ruffini visited Korea, Japan, Australia, and China as the first Western astrophysicist to visit Maoist China. A fifty-year collaboration followed, with books in Chinese and English, mentorship of students and outstanding collaborators from the University of Science and Technology (USTC), and even bringing Amaldi to China to meet a Chinese Science founder, Yang Gi Chi and

Figure 1. Remo Ruffini and Roy P. Kerr visit Stephen Hawking's in 2018. The photo depicts the dinner at Stephen Hawking's home. From Left to Right: Remo Ruffini, Roy P. Kerr, Stephen Hawking, and Margaret Kerr (Roy P. Kerr's wife).

Figure 2. Founders of ICRA. Above: George Coyne and Remo Ruffini with His Holiness John Paul II; Francis Everitt; Fang Li-Zhi. Middle: Riccardo Giacconi receiving his Nobel prize in 2002; Riccardo Giacconi (right), with Hagen Kleinert (middle) and Remo Ruffini (left), in the ICRANet Headquarters in Pescara during his 6 years (2006-2012) mandate as ICRANet Scientific Committee President; Abdus Salam. Below: Antonio Ruberti and Remo Ruffini in Sapienza University in the ICRA celebration of the 1986 Halley Comet's passage, in the presence of the President of the Republic of Italy.

his best student, Fang Li Zhi. Ruffini assumed the Theoretical Physics chair at Sapienza University of Rome in 1978, previously held by Enrico Fermi. Among the first steps was securing the US collaboration, founding ICRA in 1985 in cooperation with George Coyne of the Specola Vaticana, Francis Everitt of Stanford University, Riccardo Giacconi, Fang Li-Zhi of USTC, Abdus Salam of ICTP, Antonio Ruberti of the Sapienza University of Rome (Fig. 2).

At the time, Ruffini was president of the Italian Space Agency (ASI) Scientific Committee. A dramatic moment arose when the new proposal for Space Science had a risk of being canceled because of gross mismanagement. It had been the fulgid idea of Giuseppe Occhialini, teacher of Riccardo Giacconi, to unify in a satellite the X-ray detectors, developed by Riccardo Giacconi, and the gamma-ray detectors developed by Goddard Space Center and military research in USA for the Vela satellites that had discovered the Gamma-Ray Bursts (GRBs). The lack of funds had caused the risk that the X-ray detectors, developed by the Netherlands, could not be assembled into the satellite. It was a matter of less than a million dollars. With Amaldi, they had agreed to ask the Italian Government to insert 10% of ASI's budget for fundamental research. They never had assurance, but boldly, the scientific urgency also expressed by Cesare Perola led Ruffini to request ASI to use that amount of money to pay for the "wide-field X-ray camera". The BeppoSAX satellite flew onboard Atlas-Centaur from Cape Canaveral, possibly one of the greatest successes of Astrophysics. A new era in astronomy was born. Soon, the wide field X-ray camera located GRBs with great accuracy. Caltech large optical telescopes on Mauna Kea in Hawaii discovered the cosmological redshift of GRBs and their enormous energy, a yet unimagined amount predicted in the theoretical work by Ruffini and collaborators: **10^{54} erg** (Fig. 3). That number proved the correctness of our theoretical approach, Ruffini said to one close collaborator: "We are right. That amount corresponds to the energy emitted by all our galaxy stars multiplied by 10^9, which is the total number of galaxies in our Universe! We are right!"

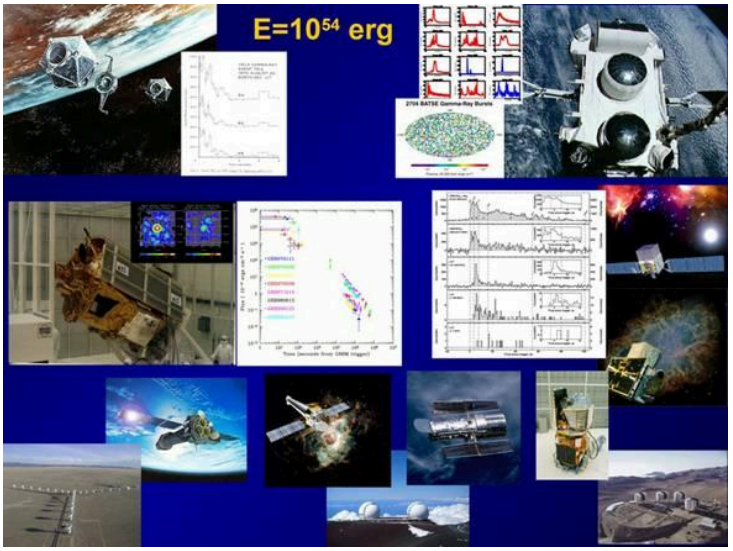

Figure 3: Ground- and space-based facilities observing Gamma-Ray Bursts, confirming their extragalactic origin and enormous energy that equals, for a few seconds, that of all visible stars in the Universe!

With much more energy, a path involving young scientists and professors started. A new structure to expand scientific cooperation worldwide was needed. The Italian, Armenian, and Vatican State governments, the University of Stanford, and the University of Tucson were ready for founding ICRANet, which occurred on February 10th, 2005. ICRANet was established following the government and university proposal, and it now counts on beautiful structures in Pescara (Italy), Nice (France), and Yerevan (Armenia). After signing **86** collaboration agreements worldwide and opening new seats, ICRANet is looking further.

Foundation, Members, and Structure

The International Center for Relativistic Astrophysics Network (ICRANet—www.icranet.org) was created in 2005 by a law of the Italian Government, unanimously ratified by the Italian Parliament and signed by the then President of the Italian Republic, Carlo Azeglio Ciampi, on February 10, 2005, published in the Gazzetta Ufficiale n° 53 of March 5, 2005.

The institutions and State Members of ICRANet are the Republic of Armenia, Italy, the Vatican State, the International Center for Relativistic Astrophysics (ICRA), the University of Arizona, and Stanford University.

- Seat Agreement in Italy: Law of May 13, 2010, published in Gazzetta Ufficiale n° 151 of June 10, 2010.

- Seat Agreement in Armenia: It was signed with the former Armenian Ambassador in Rome, H. E. Sargis Ghazaryan, unanimously ratified by the Armenian Parliament in its plenary session on November 13, 2015, and made fully operative in December 2015 by its official registration at the Ministry of Foreign Affairs.

- Vatican: Letter received on July 17, 2003, by the Secretary of State, Card. Angelo Sodano, stating the ratification on the part of the Holy See of the Agreement on the Establishment of ICRANet, signed on March 19, 2003, by father George V. Coyne, S.J., Director of the Vatican Observatory, on behalf of the Holy See.

- Seat Agreement with the Municipality of Nice: October 23, 2006.

ICRANet is an international organization that promotes research activities in relativistic astrophysics and related areas. The organizational structure comprises the Director, the Steering Committee, and the scientific committee. The committees' members are representatives of countries and member institutions. ICRANet has permanent Faculty positions supported by administrative staff and secretariat personnel. According to the statute, ICRANet is financed by government funds, voluntary contributions, and donations.

Principles

Three founding scientific principles of ICRANet are inspired by Galileo Galilei, Enrico Fermi, and the idealistic Niels Bohr's thoughts:

1. "Suppose we discuss a point of law or the humanities in which neither true nor false exists. In that case, one might trust in the subtlety of mind and readiness of tongue and the greater experience of the writers and expect those who excelled in those things to make the reasoning most plausible, and one might judge it to be the best. But in the natural sciences, whose conclusions are true and necessary and have nothing to do with human will, one must take care not to place oneself in defense of error, for here a thousand Demostheneses and a thousand Aristotle would be left in the lurch by every mediocre wit who happened to hit upon the truth for himself." (Galileo Galilei, Sidereus Nuncius).

2. Humanity has given significant attention to the work of Enrico Fermi, and ICRANet has been following his work with great attention and inspiring its research activity. Many books have been written on Fermi's works and movies describing the magic moments in Via Panisperna. ICRANet has been publishing three books on less-known Fermi activities, which could be recognized as the most important in the long term. The first covers Fermi's work while in Pisa, which left the first inception of the physical content in the mathematics of general relativity. A second book is dedicated to the relevance of Fermi statistics in astrophysics, solving a multiyear dispute on the final evolution of stars. The third is about Fermi's last works, which maximizes his knowledge of fundamental interactions, explaining cosmological nucleosynthesis, a novel approach to magnetic galactic structures and the nature of cosmic rays, on which we return to the physics of gamma-ray bursts.

3. "Above everything else, the goal must be an open world in which each nation can assert itself solely by the extent to which it can contribute to the common culture and help others with experience and resources." (Niels Bohr)

Three events motivating the birth of ICRANet

- **1968-1975**: The inception of the new conceptual process of relativistic astrophysics (Princeton University, USA).
- **1985**: The ICRA foundation in Sapienza (Europe).
- **1997**: The first look at the Cosmos with the BeppoSAX satellite, Keck Observatory, and the Very Large Telescope (Global: Europe, Asia, and the Americas).

ICRANet was founded in **2005**, harvesting new physical laws of the extreme Universe, with global activities in Europe, Asia, and the Americas, and born under the following premises:

- Research in relativistic astrophysics is essential for understanding the life and evolution of stars, the structure of our universe, and the fundamental laws of nature.
- Research in this area is a global endeavor, necessitating international cooperation.
- Observations and studies of celestial and astrophysical objects have deep roots in most cultures.
- Discoveries of astrophysical sources like pulsars, supernovae, quasars, and black holes have a broad popular appeal in all countries.
- Human civilization has advanced, and the relevance of using technologies and techniques developed in and associated with relativistic astrophysics, such as optical, radio, space, and telecommunication technologies, has been seen.

ICRANet research lines are pivotal for understanding the evolution of stars, galaxies, and our Universe through fundamental natural laws. They have a global impact in advancing scientific knowledge and promoting international cooperation, diplomacy, and the strategic interests of the funding countries. The above premises have driven ICRANet and impacted its sphere of influence across different sectors.

Importance and Global Impact of ICRANet

ICRANet is a vital hub for international collaboration in astrophysics, with far-reaching implications extending beyond scientific research. Furthermore, advancements in relativistic

astrophysics at ICRANet are strategic for technological innovation, while the institute's global outreach underscores its commitment to bridging science and community. Below are key aspects highlighting ICRANet's multifaceted impact:

1. Diplomatic and Cultural Exchange: ICRANet is a platform for international collaboration, fostering diplomatic ties and cultural exchange among participating nations and academic institutions. The institute promotes scientific cooperation, building bridges between countries and enhancing mutual understanding.

2. Astrophysics as a Gateway to STEM Education: Beyond its intrinsic scientific interest, astrophysics is a gateway to engaging young generations in the STEM (Science, Technology, Engineering, and Mathematics) fields, particularly astrophysics. By supporting institutions like ICRANet, nations commit to fostering scientific literacy among youth. This investment ignites interest in cosmos knowledge and lays the groundwork for practical applications in various STEM-related disciplines. The study of astrophysics involves cutting-edge technologies and methodologies, providing hands-on learning experiences that cultivate skills transferable to fields with broader societal and economic implications to tackle the challenges of tomorrow.

3. Science Diplomacy: Relativistic astrophysics transcends geopolitical boundaries, making it an ideal vehicle for science diplomacy. By supporting ICRANet, the Ministries of Foreign Affairs can leverage scientific collaboration for diplomacy, facilitating dialogue and cooperation with countries worldwide.

4. Strategic Importance: Advancements in relativistic astrophysics have significant strategic implications, particularly in technology development. Given the intersection of this field with areas such as optical, radio, space, and telecommunication technologies, funding from the Ministry of Foreign Affairs underscores the strategic importance of investing in cutting-edge research and its applications. Thus, ICRANet's contribution is not just to science but also a strategic investment in the future of technology and innovation.

5. Global Relevance and Outreach: The discoveries and breakthroughs from research conducted at ICRANet resonate globally, capturing people's interest from diverse cultural backgrounds. This initiative manifests ICRANet's commitment to building bridges between science and the community and strengthening international ties through education and scientific collaboration. By being a part of ICRANet's journey, each contributes to a global scientific community united in the pursuit of knowledge and understanding.

Mission and Vision

To promote and coordinate research, academic activities, and international scientific cooperation in relativistic astrophysics and related areas within theoretical, experimental, and observational research using underground, ground, and space facilities.
ICRANet is dedicated to advancing the field of physics and astrophysics, with a particular focus on relativistic astrophysics, through cutting-edge research, comprehensive training programs, and wide-reaching dissemination of scientific knowledge. ICRANet collaborates with leading international institutions worldwide working in relativistic astrophysics, driving the forefront of research under the flag of scientific excellence and fostering an ever-larger

global community to unveil and comprehend the fundamental law of physics, enjoy their beauty and understand the unique role of humanity in the Universe.

Strategic Objectives

1. Research Excellence: Conduct and support groundbreaking research in relativistic astrophysics, including (but not limited to) general relativity theory, cosmology, high-energy astrophysics, astroparticle physics, relativistic astrophysics plasmas, theoretical physics, and mathematical physics with astrophysics and cosmology applications.

2. Educational Programs and Formation of Future Leaders: Promote, design, develop, and deliver advanced training programs at doctoral and post-doctoral levels for the next generation of astrophysicists, providing opportunities for students, postdoctoral researchers, and professionals to enhance their skills and knowledge and become the next generation of scientists and leaders in relativistic astrophysics.

3. Public Engagement: Promote public understanding and appreciation of advances and astrophysics discoveries through various outreach initiatives, including public conferences, lectures, workshops, publications, and multimedia content.

4. International Scientific Cooperation: Coordinate research and academic activities with Universities and Research Centers in different geographical areas. Each Center will share its facilities with all other members of the Network. Such facilities are often of significant economic and scientific value and essential in research projects. It promotes affiliation with international scientific organizations.

Core Activities

1. Research Initiatives

- Collaborate with leading universities, research institutions, and space agencies globally to conduct high-impact research in astrophysics.
- Encourage and secure funding and resources to support long-term projects.
- Develop and use new electronic communication standards among Research Centers.
- Establish integrated data for all astrophysical sources in all possible observable wave bands and multimessenger astrophysics data, including developing novel science data centers that implement cutting-edge artificial intelligence methods.
- Encourage the mobility of scientists and students among research centers.
- Publish in prestigious scientific journals and present at international conferences.

2. Training and Education

- Depending upon available funds, ICRANet offers full or partial fellowships and programs for students and researchers at doctoral and post-doctoral levels.
- Promote and participate in doctoral and exchange programs through lectures, mentorship, and research supervision.

- Organize international summer schools, workshops, and seminars featuring renowned astrophysicists.
- Develop courses and educational materials that are accessible to a global audience.

3. Dissemination and Outreach

- Produce and distribute educational resources to engage the public, including articles, books, videos, and interactive tools; see, e.g., ICRANet YouTube Channel at www.youtube.com/@icranet5462.
- Partner with schools, museums, and similar institutions to promote scientific culture.
- Host public lectures and events featuring prominent scientists to inspire and inform the community. For details, see www.icranet.org/PublicEvents.
- Publish and distribute the *ICRANet Newsletter every two months to* the global community. It informs the latest activities, research developments, and upcoming ICRANet events. The Newsletter is published in Armenian, Chinese, English, Italian, Portuguese, and Russian. For details, see www.icranet.org/Newsletter.

4. International Meetings and Conferences

- Organize and host prestigious international conferences and symposiums, such as the Marcel Grossmann Meetings, which bring together leading experts in astrophysics to discuss the latest research and developments.
- Facilitate workshops and focused meetings like the Galileo-Xu Guangqi Meetings, The Italian-Korean Symposium on Relativistic Astrophysics, and the Zeldovich Meetings, promoting international collaboration on relativistic astrophysics.

4. ICRANet Adjunct Faculty

In addition to the permanent Faculty, ICRANet promotes an Adjunct Faculty composed of leading experts in their field, many of whom have received prestigious awards. These extensive connections result from decades of accumulated scientific collaboration and the influence of its founders, international conferences and awards, and the students it has trained who have become leaders in their fields. As a result of these connections, despite being a relatively small research institute, ICRANet influences some aspects comparable to that of a large institution. For instance, ICRANet can direct dialogue with high-level government officials from various countries. With the help of these connections, ICRANet can undertake the different activities listed in this report with very limited funding. Additional funding can significantly aid ICRANet in amplifying its effectiveness through its well-connected network. For details, see www.icranet.org/adjunct.

Productivity and Impact

Scientific Publications

Since 2005, ICRANet researchers authored about **1000** publications, **80%** of them in refereed high-impact journals such as *Science, Nature*, *The Astrophysical Journal (also Letters)*, *Astronomy and Astrophysics (also Letters)*, *Monthly Notices of the Royal Astronomical Society (also Letters), Physical Review (C, D, Letters), and The European*

Physical Journal C. From **2006 to 2023**, ICRANet published **1017** articles (**831** peer-reviewed in high-impact factor journals), cited **18538 times** excluding self-citations (data up to 20 February 2024 from NASA/ADS). The number of ICRANet articles' citations is increasing exponentially, with an e-folding time of about six years (Fig. 4). It shows a significantly growing impact of ICRANet's research in the scientific community. For the publication list, consult www.icranet.org/Publications.
These publications have significantly contributed to advances in the physics of black holes, supernovae, gamma-ray bursts, neutron stars, high-energy and astroparticle physics, dark matter, and cosmology. Press releases highlighting ICRANet research show the impact of ICRANet science. For details, see www.icranet.org/PressReleases.

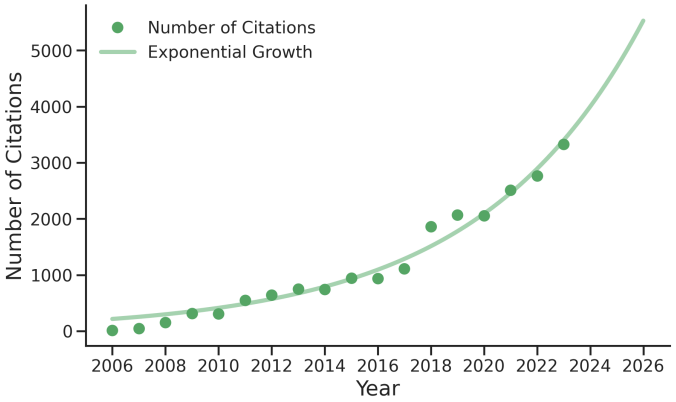

Figure 4: Citation number from 2006 to 2023 of refereed ICRANet articles. Data from the NASA Astrophysics Data System (https://adsabs.harvard.edu/). The number of citations is growing exponentially.

Educational Impact

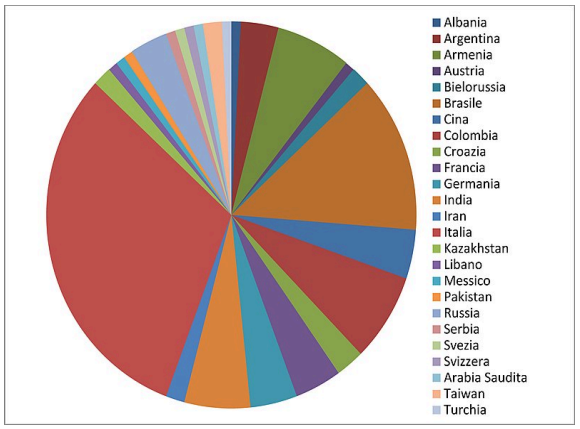

Figure 5: Native country of the IRAP PhD students, which ICRANet founded in 2005 and promoted since.

Since 2005, the International Relativistic Astrophysics (IRAP) PhD Program, founded and promoted by ICRANet, has allowed **120 students** to pursue a PhD in astrophysics. About **60%** of students are from non-European countries, including underdeveloped and emerging countries. The IRAP-PhD was awarded the Erasmus Mundus label (Erasmus Mundus Joint Doctorate - EMJD) and was funded by the European Commission from 2010 to 2017. From 2005 to 2019, it awarded more than **120** PhD degrees to students from **25** countries (see Fig. 5). For more details, visit the website: www.icranet.org/irap-phd.

Thanks to the ICRANet Permanent and Adjunct Faculty, the EMJD program brought together top professors worldwide, lecturing students on their pioneering works, which have been included in textbooks. It required students to study at the host university and engage in mobility at other universities. This approach broadens students' horizons and helps them build their professional connections. The goal was to train students who are academically excellent and capable of fostering international cooperation. Indeed, many of them have returned to their countries upon completing their PhD, becoming leaders in astrophysics, and becoming promoters and coordinators of ICRANet bilateral cooperation programs. Thus, besides scientific leadership, our PhD graduates become ambassadors of international cooperation, facilitating knowledge exchange with their nations.

In April 2021, the USTC and the University of Ferrara (UNIFE), with the collaboration of

ICRA and ICRANet signed a cooperation agreement to establish the Joint International Relativistic Astrophysics (JIRA) PhD Programme. After the challenging times of the COVID-19 pandemic, in December 2022, the first Chinese student of the JIRA PhD program arrived in Italy. The student completed the first year of PhD at ICRANet-Pescara and currently follows the program at ICRANet-Ferrara at UNIFE. The JIRA PhD expects a new wave of students with the 2024-2025 call, which has also seen the collaboration and support of two PhD fellowships from the University "G. d'Annunzio" Chieti-Pescara, whose integration into the JIRA PhD Program is currently in progress.

Since 2022, ICRANet-Ferrara has participated in the International PhD Program in Astrophysics, Cosmology, and Gravitation (PPGCosmo) through the mentorship of PhD students. PPGCosmo is a joint PhD program of **16** institutions in **9** countries. Currently, **3** PhD students with PPGCosmo fellowships perform their research under the supervision of Prof. Rueda from ICRANet-Ferrara. The students perform **6-month** academic visits to ICRANet-Ferrara as part of their research activities.

ICRANet-Armenia receives PhD positions from the government of the Republic of Armenia, allowing students to pursue a PhD in astrophysics at ICRANet. Five **(5)** students have obtained their PhD degrees since 2015, and two **(2)** students are currently in the third and second years of their PhD programs, respectively.

Social Impact

ICRANet's outreach initiatives have brought astronomy education to underserved communities, sparking interest in STEM among young students. Public lectures and media appearances by ICRANet scientists have made complex astrophysical concepts accessible and exciting to a broad general audience.

Lectures, meetings, and conferences organized by ICRANet are transmitted online through the ICRANet YouTube Channel and remain available for consultation anytime. Since its creation in March 2016, ICRANet has uploaded **372** videos to the channel and received **47.120** visualizations. For details, visit www.youtube.com/@icranet5462.

ICRANet participates annually in the "European Research Night" by organizing initiatives for the general public in all its seats, enhancing interaction with the local community. Along the same lines, the ICRANet Seat at Pescara organizes specific programs for local high school students within the "Alternanza Scuola Lavoro" Italian framework. For details, see www.icranet.org/PublicEvents.

ICRANet-Ferrara promotes the monthly outreach activity "*Universo a km 0*", which offers public conferences by distinguished scientists joined with didactic and laboratory experiences. Since it started in September 2023, this activity has brought science to a public of more than **700** people. For details: www.universokm0.com.

International Cooperation Impact

ICRANet has **86** active cooperation agreements with Universities, Research Centers, and National Agencies across all continents and geographic areas. For details, visit www.icranet.org/OfficialDocuments. The agreements allow ICRANet to promote joint international activities worldwide. This initiative is a tangible manifestation of ICRANet's commitment to building bridges and strengthening international ties through education and

scientific collaboration. **Given the current geopolitical situation, and following the request by the Italian government at the ICRANet Steering Committee Meeting on February 17, 2023, ICRANet has frozen the collaboration with the Belarusian government.** Figure 6 shows the world map of ICRANet's international cooperation activities; also, see www.icranet.org/ScientificAgreements.

Figure 6: ICRANet promotes international cooperation activities worldwide, such as professor, researcher, and postdoc exchanges and joint meetings. For an interactive version of this map, with details of each country and related institutions, see www.icranet.org/ScientificAgreements.

ICRANet also participates in international collaborations with leading world-level observational facilities. Since 2017, ICRANet-Armenia has been a member of the MAGIC (Major Atmospheric Gamma Imaging Cherenkov) Telescopes Collaboration with full rights and responsibilities. The MAGIC Collaboration counts about **165** astrophysicists from **24** institutions and consortia from **12** countries. It operates two 17-meter Imaging Atmospheric Cherenkov Telescopes at the Roque de los Muchachos Observatory on La Palma, one of the Canary Islands. The membership of ICRANet-Armenia enables the acquisition and analysis of high and very high-energy gamma-ray data from astrophysical objects such as blazars and GRBs. Each year, PhD students, researchers, and professors from ICRANet-Armenia perform **one-month** visits to the MAGIC telescopes to assist with observations. These visits provide valuable expertise in operating large telescopes.

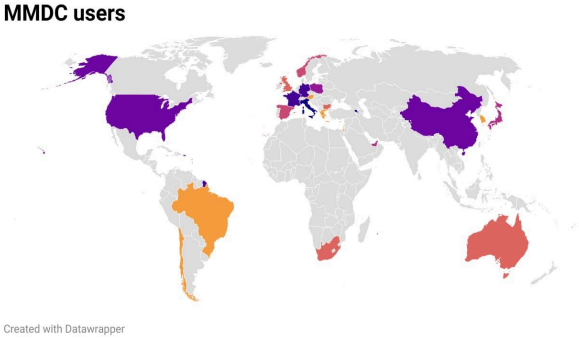

Figure 7: Countries from which users accessed the MMDC from February to May 2024. Courtesy: MMDC.

ICRANet-Armenia has developed the Markarian Multiwavelength Data Center (MMDC – https://mmdc.am/), supported by the Higher Education and Science Committee of the Ministry of Education, Science, Culture, and Sport of the Republic of Armenia. The MMDC, operational since February 2024, is an innovative platform that facilitates comprehensive blazar research by constructing and analyzing multiwavelength Spectral Energy

Distributions. The MMDC provides open access to infrared, optical, ultraviolet, X- and gamma-ray data from blazar observations, analyzed daily at the ICRANet Armenia servers. It provides novel methods for modeling observational data using artificial intelligence. This capability distinguishes MMDC as a leading tool for blazar studies. During February-May 2024, the MMDC had about **600** accesses worldwide to download or fit data (Fig. 7).

ICRANet promotes international conferences involving the astronomy and astrophysics community. The best example is the Marcel Grossman (MG) Meeting, co-organized with ICRA and internationally supported. It is held every three years in a different place in the world and has been successfully running **since 1975**. In addition to meetings in Italy, there have been meetings from Asia to Eurasia to the Americas, including China, USA and Europe. The MG17 will be held in Pescara from July 7 to 12, 2024 with already **more than 700 registered participants from 52 countries**. In addition, ICRANet has started the 6 Galileo-Xu Guangqi (GX) Meetings, the 18 Italian-Korean Symposium and the 5 Zeldovich Meetings focus on strategic exchanges between Eastern and Western in relativistic astrophysics at the highest level. These meetings serve as bridges for our communities and have an ever-increasing participation. The GX6 meeting was carried out jointly with The Annual Meeting of the Division of Gravitation and Relativistic Astrophysics of the Chinese Physical Society, was held in Hengyang, Hunan Province, China, on April 19 to 24, 2024, and counted with more than **700** participants.

Future Directions

Consolidating ICRANet science

ICRANet will consolidate its leadership in astrophysics topics such as black holes physics and astrophysics. Along this line, it is worth recalling that ICRANet professors (J. A. Rueda and R. Ruffini) have been invited by *Physics Reports* to write the review article "*The role of neutron stars, black holes, and supernovae in short and long gamma-ray bursts*", which will be a worldwide reference text on the state-of-the-art and future research avenues in the comprehension of GRBs after 50 years since their discovery and first theoretical works. ICRANet will continue investing in its traditional successful topics as per ICRANet Scientific Committee directives, including relativistic astrophysics plasmas, white dwarfs, neutron stars, supernovae, dark matter, cosmology, high-energy astrophysics (e.g., GRBs, blazars, neutrinos, cosmic rays), general relativity, and astrophysical probes for alternative theories.

Expanding scientific boundaries

ICRANet aims to expand its research to include emerging areas. For instance:

- ICRANet has started promoting the use of artificial intelligence (AI) applications in astrophysics. In a collaboration, ICRANet uses deep learning networks to simulate, analyze, and interpret vast amounts of astronomical data from large facilities. ICRANet researchers have recently introduced the use of state-of-the-art fine-tuning large language models in astrophysics, such as GPT and LLaMA. The AI integration in astrophysics can handle multidisciplinary data, driving discoveries and enhancing the depth and precision of research. An excellent example is the MMDC developed by ICRANet-Armenia. Combining AI and big data relies heavily on international collaboration. ICRANet scientists are working

with Chinese scientists to use deep learning to process data from the Large High Altitude Air Shower Observatory (LHAASO), Earth's most sensitive ultra-high-energy particle detector.

- ICRANet plans to promote the interplay between relativistic astrophysics and biology and astrobiology, one of the astrophysics branches with the most rapid growth. For instance, in the search for the processes leading to the onset of DNA and life all over the Universe, understanding the essential role of high-energetic sources like GRBs.

- After identifying seven different physical emission episodes in these extragalactic sources, ICRANet researchers have found they fulfilled new physical laws unknown in terrestrial laboratories. ICRANet has partnered with the world's largest and most advanced high-power laser, the Extreme Light Infrastructure (ELI), promoting the diagnostics of GRB-related phenomena by the most potent earth-based laboratories.

- Multimessenger astrophysics is a rapidly evolving field that utilizes diverse cosmic messengers, such as neutrinos, photons, and gravitational waves, to study astrophysical objects. Considering the number of currently operating and planned new instruments and advancements in neutrino detectors, multimessenger astrophysics will progress significantly in the next few years. ICRANet aims to enhance research in this field by identifying new multimessenger sources and developing sophisticated theoretical models, including artificial intelligence methods for localizing and analyzing the emission from photons, neutrinos, and gravitational waves. Indeed, the MG17 meeting in Pescara from 7-12 July 2024, which will count more than **700 registered participants from 52 countries**, will have **seven plenary talks and five parallel sessions devoted to gravitational waves**. **Two plenaries** will be delivered by the **LIGO-Virgo-Kagra (LVK) Collaboration** and the **Einstein Telescope**. For **MG17 details, see the conference website: 17th Marcel Grossmann Meeting (7-12 July 2024). Following Prof. Ruffini's recent lecture at Princeton University on May 17, 2024 (presentation link), perspectives of further scientific collaboration with Princeton University and the University of Cornell have been open to progress on the understanding of the emission processes of Gravitational Waves radiations and their detection on our planet.**

Increasing support for research and training

ICRANet will consolidate its position as a global network leader in relativistic astrophysics that facilitates scientific cooperation and interaction among institutions and researchers worldwide and inclusive education in astrophysics at the highest level.

Budgetary constraints limit the potential impact of ICRANet research exchanges and academic programs because of the limited number of professors it can support. A primary mid-term strategic goal is to increase the funding of these activities from the current **12%** to **20%** of the overall ICRANet budget. This goal's achievement needs to raise the base annual budget from Member States' contributions by approximately **150 kEUR**. These funds are essential for safeguarding the ICRANet Faculty and promoting possibly **two** junior Faculty to protect against the "*brain drain*" phenomenon that has already affected ICRANet.

Future hiring will be pivotal in shaping the institute's research trajectory. The selection process for new positions will carefully consider the candidates' research fields and CVs,

ensuring alignment with ICRANet's strategy. Additionally, bibliometric indicators will be used to assess the candidates' scientific impact and contributions objectively. This approach will ensure that ICRANet attracts new talents to drive forward its mission of scientific excellence and international collaboration.

ICRANet is committed to identifying partners and funding opportunities to support more projects, e.g., applying to the European Research Council (ERC) grants. Following this view, ICRANet will promote the formation of an international, inter-sectoral, and interdisciplinary Consortium of doctoral training, leading to a joint doctoral degree, to participate in the Doctoral Networks Call of the Marie Skłodowska-Curie Actions 2024 within the Horizon Europe Framework Programme.

ICRANet plans to enhance its educational offerings through digital platforms and outreach initiatives to underserved regions in an inclusive approach to science dissemination.

Expanding international cooperations and memberships

ICRANet will increase its participation in international collaborations following the successful participation in the MAGIC Telescopes Collaboration. The proficuous cooperation with Argentina, Brazil, and Colombia suggests joining the Cherenkov Telescope Array (CTA), the Pierre Auger Observatory, and the Vera Rubin Observatory, but not limited to.

Bilateral agreements with universities and research institutions drive ICRANet's activities worldwide. ICRANet will continue its expansion and inclusive policy by renewing and signing new agreements with institutions in partnered countries to consolidate our collaboration (e.g., Argentina, Brazil, China, Colombia, Estonia, France, Germany, Kazakhstan, Italy, and South Korea) and expanding into countries where it has yet to establish partnerships.

ICRANet plans to strengthen its relations with Eurasian and Middle Eastern countries. Scientific results have been presented in the series of Zeldovich meetings, which have had strong revitalizing effects in the area. Scientists from 38 countries, including 5 scientists from Ukraine (Bohdan Novosyadlyj, Oleg Zaslavskii, Alexander Zhuk, Volodimir Pelykh, and Elena Panko), participated in the meetings. Prof. Ruffini has been invited to deliver a plenary talk at the XXIV Gamow International Astronomical Conference, which will be held from August 19 to 23, 2024, in Odessa, Ukraine. In 1978, Prof. Ruffini was invited to Iran to deliver lectures. He visited the University of Shiraz and met Prof. Yousef Sobouti. Despite the many political changes, ICRANet has kept close contact with the ABS Institute for Advanced Study, collaborating with students and professors and reaching important scientific results, including the recently published book "*ICRANet-Isfahan Astronomy Meeting: From Ancient Persian Astronomy to Recent Developments in Theoretical and Experimental Physics, Astrophysics and General Relativity*" with Cambridge Scientific Publishers, which has been presented at the 35th Tehran International Book Fair (TIBF), which took place from May 8 to 18, 2024 in Teheran (Iran). The contact with Israel has been kept active in all these activities: the 8th Marcel Grossmann meeting was held in Jerusalem at the Hebrew University at Jerusalem, where

all Einstein manuscripts are kept. Scientific daily exchanges occur between Prof. Ruffini and Prof. Tsvi Piran from the Hebrew University. There is also an ongoing project to open an ICRANet center in the Armenian quarter of Jerusalem, a few hundreds meters away from the seat of the Hebrew University.

ICRANet does not plan to play any role in solving political affairs. Still, it can help by informing the Member States as well as the Member Institutions about fundamental scientific advances, guaranteeing the connection through the 86 agreements with leading scientists worldwide, and fostering their sensible and constructive actions to support peace as well as scientific and technological progress in this phase of rebuilding the normal peaceful activities on planet Earth.

ICRANet is committed to expanding Institutional and State memberships. It has recently received a manifestation of interest from the University of Tartu from the Republic of Estonia to join ICRANet as a Member Institution. This membership may be pivotal for Estonia's entrance as a Member State in ICRANet. The increased cooperation with Latin American universities suggests having a regional ICRANet coordinating center. In this regard, ICRANet has started a dialogue with the Universidad Industrial de Santander (UIS) in Colombia, based on the long-standing cooperation, its leadership in Colombia, and increasing regional role to promote and drive the creation of such a center and the adhesion of Colombia into ICRANet as a Member State.

This action will likely include the participation of Princeton and Cornell Universities, following the ongoing activities and strengthening of the ICRANet relations with Stanford University through the results of the Fermi satellite, which gives daily fundamental data to ICRANet scientists to build detailed GRB models. Similarly, the University of Arizona in Tucson is performing the world's most advanced data analysis of the largest black holes of billion solar masses observed close to the Big Bang, which is essential for theoretical work on dark matter made at ICRANet.

Conclusion

ICRANet has been pivotal in advancing our understanding of the Universe while fostering a global community that values and supports scientific discovery. Through its commitment to research excellence, comprehensive education, and public engagement, ICRANet continues to inspire and nurture future generations of astrophysicists.