

**ICRANet Scientific Committee**  
Eighteenth Meeting (e-meeting)  
February 2, 2021

The meeting starts at 11:00 am via GoToMeeting: <https://global.gotomeeting.com/join/750192021>

The following members are present:

Prof. Narek Sahakyan (Armenia)  
Prof. Manuel Malheiro (ad interim, Brazil)  
Prof. Carlo Luciano Bianco (ICRA)  
Prof. Massimo Della Valle (Italy, Chairman)  
Prof. Remo Ruffini (Director of ICRANet)

The additional following persons are present:

Prof. Vladimir Belinski (ICRANet Faculty)  
Prof. Christian Cherubini (ICRANet, University Campus Bio-medico of Rome)  
Prof. Simonetta Filippi (ICRANet, University Campus Bio-medico of Rome)  
Prof. Liang Li (ICRANet Faculty)  
Prof. Rahim Moradi (ICRANet Faculty)  
Prof. Jorge A. Rueda H. (ICRANet Faculty)  
Prof. Gregory Vereshchagin (ICRANet Faculty)  
Prof. She-Sheng Xue (ICRANet Faculty)  
Prof. Cesar Zen Vasconcellos (UFRGS)  
Ms Fatemeh Rastegar Nia (ICRANet)

Absents

Prof. Christopher Fryer (Arizona University)  
Prof. John Mester (Stanford University)  
Prof. Gabriele Gionti, S. J. (Vatican City State)

The meeting is chaired by Prof. Massimo Della Valle and the minutes are taken by the Director.

**Prof. Massimo Della Valle assumes the Chairmanship and invites the Director to present the 2020 ICRANet scientific report to the Scientific Committee. The Director presents the report, in particular Volumes 2 and 3, which are composed as follows:**

Volume 2

- High Energy Gamma-rays from Active Galactic Nuclei (Prof. Narek Sahakyan).....pag. 1-120
- ICRANet-Minsk report (Prof. Gregory Vereshchagin).....pag. 121-140
- ICRANet SDC, Blazar studies, Open Universe Activities (Prof. Paolo Giommi).....pag. 141-168
- Exact solutions of Einstein and Einstein-Maxwell equations (Prof. Vladimir Belinski)..pag. 169-172
- Gamma-Ray Bursts (Prof. Carlo Luciano Bianco).....pag. 173-330
- Theoretical Astroparticle Physics (Prof. Gregory Vereshchagin).....pag. 331-358
- Generalization of the Kerr-Newman solution (Prof. Hernando Quevedo).....pag. 359-422
- Cosmology Group of Tartu Observatory (Prof. Jaan Einasto).....pag. 423-440

- Black Holes and Quasars (Prof. Brian Punsly)..... pag. 441-442
- Electron-positron pairs in physics, astrophysics and cosmology (Prof. Shesheng Xue)...pag. 443-682

Volume 3

- From heavy nuclei to black holes (Prof. Shesheng Xue).....pag. 683-1028
- From Nuclei to Compact Stars (Prof. Jorge A. Rueda H.).....pag. 1029-1132
- Self-gravitating Systems of Dark Matter Particles (Prof. Jorge A. Rueda H.).....pag. 1133-1164
- Supernovae (Prof. Massimo Della Valle).....pag. 1165-1172
- Symmetries in General Relativity (Prof. Donto Bini).....pag. 1173-1286
- Self Gravitating Systems, Galactic Structures and Galactic Dynamics (Prof. Simonetta Filippi).....pag. 1287-1326
- Interdisciplinary Complex Systems (Prof. Christian Cherubini).....pag. 1327-1376

The Director then invites ICRANet scientists to illustrate their respective fields of research:

- Prof. Gregory Vereshchagin presents the report on “*Theoretical Astroparticle Physics*”. This report represents the summary of activities during the last year on this topic by the group including: Carlo Luciano Bianco, Jorge Rueda, Remo Ruffini, Gregory Vereshchagin, Shesheng Xue. Students: Mikalai Prakapenia (ICRANet-Minsk, Belarus), Stefano Campion (IRAP-PhD, Italy), Rafael Ignacio Yunis (Argentina). External collaborators: Alexey Aksenov (ICAD, RAS, Russia), Carlos Arguelles (Instituto de Astrofísica de La Plata, Argentina), Andreas Krut (Germany) and Ivan Siutsou (ICRANet-Minsk, Belarus). This year the group focused on generalization of our method for calculation of collision integrals out of first principles for triple interactions in relativistic plasma. In addition, a new kinematic approach, which improves the scheme performance, has been developed for triple interactions. Results of this work are published in such journals as *Physics of Plasmas*, *Physics Letters A*, and in *European Physics Letters*. New results on photospheric emission from GRBs include identification of several sources where diffusive photospheres could have been observed. The paper is published in *Monthly Notices of the Royal Astronomical Society*. One of the most important results of ICRANet in 2020 has been obtained for self-gravitating systems of dark matter particles. It has been shown that the sole dark matter core, for 56 keV fermions called darkinos, can explain both the multiyear accurate astrometric data of the S2 star orbiting around Sgr A\*, as well as most recent observational data of the G2 object. In the model developed in ICRANet neither drag force nor other external agents are needed, i.e. their motion is purely geodesic. This result is published in *Astronomy and Astrophysics*. A further very interesting consequence of this model is that, a core made of these darkinos, becomes unstable against gravitational collapse into a black hole for a mass of  $10^8$  solar masses. That is, collapsing dark matter cores can provide the seeds for the formation of supermassive black holes in active galaxies (such as M87), without the need of prior star formation, or other black hole seed mechanisms involving super-Eddington accretion rates. Results of these works are published in *Physics of the Dark Universe*, *Journal of Cosmology and Astroparticle Physics*, *Monthly Notices of the Royal Astronomical Society* and *Astronomy and Astrophysics*.

- Prof. Narek Sahakyan, Director of ICRANet-Armenia, illustrates his scientific results on the topic “*High Energy Gamma-rays from Active Galactic Nuclei*” on the main results and activities carried on in ICRANet Seat in Armenia in 2020. He underlines that ICRANet-Armenia is a full member of MAGIC collaboration and takes part in all associated activities. He mentions that the group in 2020 published 22 articles, some of them within MAGIC collaboration. He reports the results obtained from multiwavelength observations of blazar subclasses of Active Galactic Nuclei, in particular highlighting the results from two papers that study the origin of broadband emission from 1ES 1218+304 blazar and from 33 high redshift blazars and which were published in Monthly Notices of the Royal Astronomical Society. He also presents the lepto-hadronic code recently developed in ICRANet Armenia, which can be used to study the hadronic processes in astrophysical sources.
- Prof. Carlo Luciano Bianco presents the scientific results on “*Gamma-Ray Bursts*”. Traditionally, all GRBs phenomenon was attempted to be explained as due to a single physical process taking place within an ultrarelativistic outflow. However, what became clear thanks to the theoretical and observational works of the last years is that a GRB event is formed by a large number of different physical processes taking place inside the progenitor binary system. Some of these processes are only mildly relativistic or nonrelativistic, while some other produce indeed the emission of an ultrarelativistic jet. The role of such an ultrarelativistic jet, however, is limited to specific phases of the GRB event. In 2020 we witnessed a major breakthrough in this new understanding of the physics of GRBs. A novel time-resolved spectral analysis, in a sequence of ever decreasing time intervals, has been applied to the Ultrarelativistic Prompt Emission (UPE) phase of GRB 190114C, GRB 180720, GRB 160509A, and GRB 160625B. This allowed the identification of a self-similar structure in the UPE phase. All previous results have to be reconsidered in view of this new understanding, and this will be one of the main research topics of year 2021.
- The “*ICRANet-Minsk report*” on page 121, presented by Prof. Gregory Vereshchagin, represents the summary of activities during the last year in the ICRANet-Minsk center with the following members: Sergei Kilin (Director), Ivan Siutsou (from January to August – senior research fellow), Mikalai Prakapenia (research fellow), Stanislav Komarov (research fellow), Aksana Kurguzava (graduate student) and Vladislav Stefanov (scientific secretary of the Center). Scientific activities of ICRANet-Minsk center include research in radiation transfer in relativistic plasma, kinetics of relativistic plasma, mechanical and optical evolution of different objects in the vicinity of black hole and effects of gravity in light interaction with quantum systems. The results of research in 2020 were published in four papers in the following journals: Physics Letters A, Physics of Plasmas, International Journal of Modern Physics A and Journal of Applied Spectroscopy.
- Prof. Christian Cherubini, who briefly joins the meeting at 12:30 a.m., reports on “*Interdisciplinary Complex Systems*” and leaves the meeting soon after for overlapping commitments he has. In 2020 the research activities studied aspects of cardiac dynamics with particular attention to the mechanoelectric feedback and to temperature effects. Nonlinear continuum mechanics in union with nonlinear electrodynamics and heat transfer have been combined in this study. Moreover a study on the organization and signaling of cellular

aggregates has been published with particular attention to possible cancer initiation mechanisms.

- Prof. Simonetta Filippi presents her report on “*Self Gravitating Systems, Galactic Structures and Galactic Dynamics*”. In 2020 the collaboration with several ICRANet scientists continued. The studies on the relevance of black holes immersed in uniform at infinity magnetic fields (Wald Field) continued with particular attention to GRBs. In particular the problem of the electric-charge distribution in a Kerr black hole magnetosphere has been studied. Another study instead, based on non relativistic theory of self-gravitating configurations is still under study.
- Prof. Shesheng Xue illustrates the recent results on “*Electron-positron pairs in physics, astrophysics and cosmology: from heavy nuclei to black holes*”. One of most important issue in physics is the dynamics of electron-positron-photon plasma. This has been a traditional ICRANet research topic, initiated by Profs R. Ruffini and S.-S. Xue in collaboration with Key researchers J. Wislon and J. Salmonson from US national Livermore laboratory. The fundamental results were published in 1999, A&A, 350, 334, and 2000, A&A, 359, 855. Since then this topic has been well developed in ICRANet and detailed report has been published in Physics Report 487, 1 (2010) for consultancy and convenience of worldwide researchers who are working on this issue. The new application of such electron-positron-photon plasma dynamics in the presence of baryon matter leads to the explanation of GRBs thermal spectrum and cutoff power laws observed. This topic now becomes very urgent, in view of discovery of self-similarity phenomenon, for details see Carlo Bianco’s report. In astrophysical systems, there can possibly exist nucleons and quark matters of large charge number  $Z$  and atomic number  $A$ , such as udQM nuggets, strangelets, and strangeon nuggets. We study electron-positron production in such dense matter by applying the Thomas-Fermi model of highly degenerate electrons and the Schwinger model of vacuum polarisation in strong Coulomb fields. The results are relevant for the observed phenomena and have been published in Physics Review D 101, 103031, 2020. The excess of events from recoil electrons is recently reported the XENON1T collaboration (Italian National INFN Laboratory at Gran Sasso). This implies the signal from dark matter (DM) particles, which makes up 85% of the matter in the universe. We study this experimental result by considering sterile neutrinos as warm DM particles, which are well motivated from astrophysical and cosmological point of view. It is shown that sterile neutrinos with masses around 90 keV and specific effective coupling can fit well with the XENON1T data where the best fit points preserving DM constraints. This result is consistent with the nature of dark matter particles as a fermion with the mass in keV range from the analysis of the rotation curves of the Milky Way, made by ICRANet member in the case of the S2 and G2 orbits around the Galactic center. These studies may shed light on the dark matter nature. The results have been published in JHEP 12 (2020) 194.
- Prof. Jorge A. Rueda H. reports on the topic “*From Nuclei to Compact Stars*”. In this report we present results obtained by ICRANet scientists, in collaboration with international peers, on these topics (but not limited to): nuclear and atomic physics applied to the structure of compact stars, e.g. white dwarfs and neutron stars; relativistic systems such as compact-object binaries and the cataclysmic events they are associated with. These include supernovae and gamma-ray burst physics, mechanisms of radiation (electromagnetic, gravitational waves, neutrinos, etc),

accretion processes, binary coalescences, compact object magnetospheres, among others. We also apply exact solutions of the Einstein-Maxwell equations to describe some of these systems, and study the role of non-linear electrodynamics. In 2020, our group has reached very important results in these fields, published in five articles and two contributions as chapter of books. The major results are:

1. We have given strong evidence in two articles of the multipolar structure of the magnetic field of neutron stars. The first evidence was obtained in an article that analyses the X-ray data from the Chandra satellite of a pulsar in our Galaxy. In a different article, we obtained a similar conclusion but from extragalactic sources, namely from the analysis of the X-ray lightcurves of gamma-ray burst afterglows. Based on the binary-driven hypernova model recently introduced in ICRANet, we went even further by inferring the magnetic field strength and the rotation rate of the neutron star born at the center of the supernovae associated with these sources.
2. We have set the theoretical basis of the “inner engine” paradigm for the explanation of the high-energy emission of gamma-ray bursts. We have introduced a novel concept in black hole physics and astrophysics: the “blackholic quantum”. It was there presented a new mechanism able to extract the rotational energy of a spinning black hole when it is surrounded by a magnetic field and ionized matter. This novel and efficient mechanism, which makes use of a purely general relativistic effect, *gravitomagnetic interaction*, in conjunction with electrodynamics, is able to power the high-energy radiation (GeV energies) of gamma-ray bursts and active galactic nuclei, and ultrahigh-energy cosmic rays. An efficient, astrophysical viable mechanism of black hole energy extraction has been sought for nearly 50 decades since the beginning of black hole astrophysics started with the article by R. Ruffini and J. A. Wheeler “Introducing the black hole”.
3. We have introduced the study of the microscopic phenomenon of neutrino flavor oscillations (conversion of some neutrino species into another) in the processes of accretion around neutron stars and black holes. This leads to consequences in gamma-ray burst models based on electron-positron production from neutrino-antineutrino annihilation, as well as in the production of heavy (r-)elements synthesized in accretion outflows.

Two additional articles have been submitted for publication, one on the proton-proton interactions occurring in binary-driven hypernovae and leading to neutrino emission, and a second one on the application of the “inner engine” paradigm to the analysis of GRB 190114C. We expect them to be accepted for publication soon and include them in the 2021 Scientific Report.

- Prof. Massimo Della Valle presents his report mainly focused on the observations of Supernovae, Novae and Kilonovae. He also describes the new spectrograph SOXS (SO of X Shooter) that will equip the 4m class telescope NTT at the European Southern Observatory (ESO). This instrument is supported by a large international collaboration including: INAF (Ita), Weizmann Institute (Israel), Queen University of Belfast (UK), University of Turku (FINCA,- Finland), Millennium Institute of Astrophysics (MAS-Chile), Tel-Aviv University (TAU-Israel), Cosmic Dawn Center and Aarhus University (Denmark). It will allow to carry out (from ~ June 2022) the optical follow-up of hundreds of transients per year that will be discovered by the Large Synoptic Survey Telescope (LSST). This scientific activity has produced in the last year (2020), 33 papers published on the main international scientific journals.

**The Chairperson invites the Director to illustrate the second item on the Agenda: Discussion with scientists from the 9 Institutes with ongoing collaboration agreement in Brazil.**

The Chairman as well as the Director welcomes Prof. Cesar Zen Vasconcellos (UFRGS) and Prof. Manuel Malheiro (ITA) who joined the meeting from Brazil. The Director recalls to the Scientific Committee the relevance of the renewed cooperation agreement signed with Instituto Tecnológico de Aeronáutica (ITA), on September 22, 2020 as well as the ongoing process for the renewal of the collaboration agreement with the Universidade de Brasília (UnB) in Brasilia and with the Centro Brasileiro de Pesquisas Físicas (CBPF) in Rio De Janeiro. The Director also informs the Committee about the contacts taken with the Universidade Federal do Rio Grande (FURG) in order to establish a new collaboration agreement with that Institute.

The Scientific Committee unanimously approves the Report and warmly congratulates with the Director for the achievements of ICRANet in 2020.

The meeting ends at 17:15 pm on February 2, 2021.

The Scientific Committee agrees that the draft minutes of the meeting will be sent to all of them by email and, then, everyone could send them back with eventual comments within Thursday, February 4, 2021.

Prof. Manuel Malheiro  
Representative of Brazil



Prof. Carlo Luciano Bianco  
Representative of ICRA



Prof. Massimo Della Valle  
Representative of Italy, Chairman



Prof. Jorge A. Rueda H. on behalf of Chris Fryer  
Representative of the Arizona University



Prof. Remo Ruffini  
Director of ICRANet



Prof. Narek Sahakyan  
Representative of Armenia

