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Livro de Resumos

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Welcome

Autores Jacek Niemiec[1]; Tadeusz Lesiak[2]

[1] *Institute of Nuclear Physics Polish Academy of Sciences*

[2] *Institute of Nuclear Physics PAN (IFJPAN), Kraków*

High energy cosmic rays I / 22

The quest for the sources of Ultra-High Energy Cosmic Rays: experimental results and future perspectives

Autor Antonella Castellina[1]

[1] *INFN & INAF*

The quest for the origin of ultra-high-energy cosmic rays (UHECRs) continues to be an open question in high energy astrophysics. We will give an overview of the current status of the field from an experimental point of view, discussing the most recent results and the information obtained in a multi-messenger approach. The open problems and the perspectives of multi-messenger observatories will be presented, discussing the possible future directions of this field of research.

High energy cosmic rays I / 99

A Review of Cosmic Rays Observations by LHAASO

Autor Shoushan Zhang[1]

[1] *Institute of High Energy Physics*

Large High-Altitude Air Shower Observatory (LHAASO) has one square kilometer array of scintillator detectors and muon detectors (KM2A), 18 Wide Field of View Imaging Atmospheric Cherenkov Telescopes (WFCTA) and a 78,000 square meter Water Cherenkov Detector Array (WCDA). LHAASO is located at very high altitude (around 4410 m a.s.l.) in Haizishan mountain, Daocheng, Sichuan, China. Multi-parameter observation of showers allows to measurement the energy spectrum, elemental composition and anisotropy with high resolution, which give us an excellent opportunity to understand the origin, acceleration and propagation of ultra-high energy cosmic rays. The 1/4, 1/2, 3/4 and full array of LHAASO experiment have started running in September 2019, in January 2020, in December 2020 and July 2021 respectively. Preliminary results and the prospect of the energy spectrum, elemental composition measured by LHAASO experiment will be presented.

High energy cosmic rays I / 57

Cosmic ray measurements with IceCube

Autor Hermann Kolanoski[1]

[1] *Humboldt Universität Berlin and DESY*

In this talk we will report on the investigation of cosmic rays in the energy range between some 100 TeV and about 1 EeV using the IceCube Neutrino Observatory at the South Pole. The IceCube facility combines the in-ice detector with the 1-km^2 surface detector IceTop. The combination offers a unique possibility to study the air shower development at the surface together with the high energy muons and neutrinos generated in the first interactions in the upper atmosphere. This can be exploited for the determination of the mass composition of cosmic rays and for tests of hadronic interaction models which air shower analyses are based on.

We will give an overview of experimental results and will discuss their impact on the understanding of cosmic rays and of hadronic air shower models. This includes: cosmic ray spectrum and mass composition, cosmic ray anisotropy, seasonal variations of atmospheric muon and neutrino rates, muon density at ground level, search for galactic PeV photons, measurements of the moon and sun shadows, neutrino generation in the sun's atmosphere and IceTop's cosmic ray veto for the detection of astrophysical neutrinos. Finally we will discuss the ongoing upgrade activities for the current surface detector and for the future extensions (IceCube-Gen2).

High energy cosmic rays I / 25

Searching for PeV bursts

Autor Roger Clay[1]

[1] *University of Adelaide*

Over the past forty years, there have been occasional reports of the observations of 'bursts' by small air shower arrays operating at energies of about 1 PeV. These would seem to be of astrophysical origin and related to the thrust of studies pursued to the CREDO program. The bursts are rare and few burst searches have extended past a a time required to record more than a handful of potential events. There have also been discussions of the burst data which offer alternative non-astrophysical explanations.

This paper will critically review some of the burst results, which may suggest that interesting burst events have been detected at a rate of ~ 1 per year. If these exist, the astrophysical processes of their origin need to be examined and some possibilities will be discussed in the paper.

High energy cosmic rays I / 23

Unfolding of the High-Energy Interactions in Extensive Air Showers

Autor Lorenzo Cazon[1]

[1] *Laboratory of Instrumentation and Experimental Particle Physics*

In this talk, I will revisit our understanding of the air shower initiated by ultra high energy cosmic rays, focusing on the hadronic core and how macroscopic variables relate with the microscopic variables of the highest energy hadronic interactions therein. Many of those interactions occur at energies and phase-space regions beyond the reach of accelerator experiments. It will be shown how shower observables are being used to constrain hadronic models or directly probe particular aspects of the hadronic interactions. Special attention will be given to muons, which are direct messengers from the hadronic core of the air shower. The status and last advances of the so called "muon puzzle" on air showers will be reported as well as other related measurements.

High energy cosmic rays I / 90

Air shower simulations with CORSIKA 8

Autor Ralf Ulrich[1]

[1] *KIT*

The novel air shower simulation framework CORSIKA 8 is introduced and its main features are highlighted. Detailed comparisons to other codes are shown, which serve both as validation but also as hints to so far poorly known hidden uncertainties in air shower simulations. A focus is made on muon observables in the discussion.

High energy cosmic rays I / 76

The puzzle of cosmic ray muons

Autor Maciej Rybczynski[1]

[1] *Jan Kochanowski University (PL)*

Indications of a discrepancy between simulations and data on the number of muons in cosmic ray showers exist over a large span of investigations. The excess of muon bundles has been observed by the ALICE detector at LHC in its dedicated cosmic ray run (confirming similar findings from the LEP era at CERN) as well as the excess in the muon number in general has been reported by the Pierre Auger Observatory.
We discuss a simple mechanism which can simultaneously increase predicted muon counts for both. Arguing that muonic bundles of highest multiplicity are produced by strangelets, hypothetical stable lumps of strange quark matter infiltrating our universe, we successfully describe data from CERN experiments. Significant evidence for anisotropy of arrival directions of the observed high-multiplicity muonic bundles is found. Estimated directionality suggests their possible extragalactic provenance.
To examine this scenario in the shower development as observed by the Pierre Auger Observatory detailed Monte Carlo simulations had to be carried out. We obtain a rough agreement between the simulations and the data for ordinary nuclei without any contribution of strangelets in primary flux of cosmic rays. Even if the strangelets contribute with small amount in primary flux and generate high multiplicity muon bundles, as we advocate recently, their influence on the average muon content in EAS is negligible.

Gamma ray astronomy I / 41

TeV gamma-ray astronomy

Autor Werner Hofmann[1]

[1] *Max-Planck-Institut für Kernphysik*

The talk aims to introduce the status of the field, discuss key recent results and instruments, as well as future perspectives.

Gamma ray astronomy I / 96

Cherenkov Telescope Array Observatory: the World lagest VHE observatory

Autor Roberta Zanin[1]

[1] *CTA Observatory*

Very-high-energy (VHE) gamma-ray astroparticle physics is a relatively young field, and observations over the past decade have surprisingly revealed almost two hundred VHE emitters which appear to act as cosmic particle accelerators. These sources are an important component of the Universe, influencing the evolution of stars and galaxies. At the same time, they also act as a probe of physics in the most extreme environments known - such as in supernova explosions, and around or after the merging of black holes and neutron stars. However, the existing experiments have provided exciting glimpses, but often falling short of supplying the full answer. A deeper understanding of the TeV sky requires a significant improvement in sensitivity at TeV energies, a wider energy coverage from tens of GeV to hundreds of TeV and a much better angular and energy resolution with respect to the currently running facilities. The next generation gamma-ray observatory, the Cherenkov Telescope Array (CTA), is the answer to this need. In this talk I will present this upcoming observatory from its design to the construction, and its potential science exploitation. CTAO will allow the entire astronomical community to explore a new discovery space that will likely lead to paradigm-changing breakthroughs. In particular, CTA has an unprecedented sensitivity to short (sub-minute) timescale phenomena, placing it as a key instrument in the future of multi-messenger and multi-wavelength time domain astronomy.

Gamma ray astronomy I / 66

The application of SiPMs for Cherenkov light detection in the atmosphere: present and future challenges

Autor Teresa Montaruli[1]

[1] *Universite de Geneve (CH)*

SiPMs are now widely applied for light detection in particle physics and astroparticle. I will focus on Cherenkov light detection from ground and discuss also some space application. Focus will be construction of cameras and challenges for their operation.

Gamma ray astronomy I / 42

Very-High-Energy Astronomy with VERITAS

Autor Binita Hona[1]

[1] *University of Utah (VERITAS Collaboration)*

The Very Energetic Radiation Imaging Telescope Array System (VERITAS) consists of four atmospheric Cherenkov telescopes fully operating in the northern hemisphere since 2007. It is located at Fred Lawrence Whipple Observatory in southern Arizona, USA and is sensitive to gamma rays from 85 GeV to 30 TeV energy range. One of the major focuses of the broad science topics of the multinational VERITAS collaboration is indirect measurements of cosmic rays and their spectra via study of very-high-energy gamma-ray emission. So far, the gamma-ray observation has resulted in detection of 23 galactic and 41 extragalactic sources which include supernovae remnants, pulsar wind nebulae, gamma-ray binaries, active galactic nuclei, gamma-ray bursts, and starburst galaxies etc. VERITAS

participates in multi-wavelength studies with several observatories and maintains an active multi-wavelength campaign with HAWC and LHAASO. Additionally, there is also a multi-messenger program with multiple collaborations to follow up on gravitational waves and high energy neutrino signals originating from the very energetic regions of the Universe. In this presentation, we summarize the recent results from VERITAS in gamma-ray physics along with the multi-wavelength and the multi-messenger efforts.

Gamma ray astronomy I / 44

Latest Results from the HAWC Observatory

Autor Petra Huentemeyer[1]

[1] *Michigan Tech*

In this presentation, I will discuss how the wide field-of-view, high-duty cycle, and excellent sensitivity at energies above 10 TeV make the HAWC Gamma-Ray Observatory a uniquely suited instrument to survey the Northern Hemisphere sky for cosmic-ray acceleration, distribution, and propagation, gamma-ray transients, dark matter signals, and other fundamental physics phenomena. I will present the latest HAWC results and examine their impact on the understanding of our galaxy and beyond. I will conclude with an exploration of the prospects offered by future observations with currently operated and planned TeV survey instruments, including HAWC and SWGO.

Gamma ray astronomy I / 63

Recent science highlights from the Fermi Large Area Telescope

Autor Manuel Meyer[1]

[1] *University of Hamburg*

The Fermi Large Area Telescope has been surveying the gamma-ray sky for more than 13 years. With more than 5,000 detected gamma-ray sources, LAT observations have been instrumental to improve our understanding of particle acceleration and gamma-ray production in astrophysical sources. In this talk, I will review recent science highlights from the LAT. In particular, I will focus on transient phenomena seen with the LAT. This includes the first observation of a giant magnetar flare at GeV energies, as well as the on-going detection of gamma-ray flares of active galactic nuclei (AGN). Gamma-ray flares from AGN can reveal insights on the particle acceleration mechanisms at work. They also provide an essential tool for the search of neutrino counterparts. The new Fermi-LAT light curve repository will greatly simplify the multi-messenger counterpart search.

High energy cosmic rays II / 50

Multi-Messenger Physics with the Pierre Auger Observatory

Autor Karl-Heinz Kampert[1]

[1] *University of Wuppertal*

In this talk, we will review multi-messenger capabilities of the Pierre Auger Observatory involving searches for high energy neutrinos and photons from transient events as well as searches for temporal and/or directional correlations between different messengers including UHECR. Upper bounds on the flux of up-going air showers - of the type that was reported by ANITA - will be presented and used to constrain BSM physics. Finally, we will discuss future prospects, including pushing down the neutrino detection threshold auf the Auger Observatory.

High energy cosmic rays II / 40

KASCADE-Grande results and future prospects for the transition energy range of Cosmic Rays

Autor Andreas Haungs[1]

[1] *Karlsruhe Institute of Technology - KIT*

Investigations of the energy spectrum as well as the mass composition of cosmic rays in the energy range of PeV to EeV are important for understanding both, the origin of the galactic and the extragalactic cosmic rays. The multi-detector arrangement of KASCADE and its extension KASCADE-Grande was designed for observations of cosmic ray air showers in this energy range. Most important result from KASCADE is the proof that the knee feature at several PeV is due to a decrease in the flux of light atomic nuclei of primary cosmic rays. Results of KASCADE-Grande have shown two more spectral features: a knee-like structure in the spectrum of heavy primaries at around 90 PeV and a hardening of the spectrum of light primaries at energies just above 100 PeV, meanwhile confirmed by other experiments. In this talk I summarize the scientific results of KASCADE-Grande under the light of using different hadronic interaction models for interpretion. In addition, the KASCADE Cosmic Ray Data Centre (KCDC) is discussed, which is a web-based platform to provide astroparticle physics data for the general public.

High energy cosmic rays II / 52

Origin of Spectral Hardening of Secondary Cosmic-Ray Nuclei

Autor Norita Kawanaka[1]

[1] *Yukawa Institute for Theoretical Physics, Kyoto University*

We discuss the acceleration and escape of secondary cosmic-ray (CR) nuclei, such as lithium, beryllium, and boron, produced by spallation of primary CR nuclei like carbon, nitrogen, and oxygen accelerated at the shock in supernova remnants (SNRs) surrounded by the interstellar medium (ISM) or a circumstellar medium (CSM). We take into account the energy-dependent escape of CR particles from the SNR shocks, which is supported by gamma-ray observations of SNRs, to calculate the spectra of primary and secondary CR nuclei running away into the ambient medium. We find that if the SNR is surrounded by a CSM with a wind-like density distribution, the spectra of the escaping secondary nuclei are harder than those of the escaping primary nuclei, while if the SNR is surrounded by a uniform ISM, the spectra of the escaping secondaries are always softer than those of the escaping primaries. Using this result, we show that if there was a past supernova surrounded by a dense wind-like CSM with $\dot{M} \sim 2.5 \times 10^{-3} M_{\odot}$ yr^{-1}), which happened $\sim 1.6 \times 10^5$ yr ago at a distance of ~ 1.6 kpc, we can simultaneously reproduce the spectral hardening of primary and secondary CRs above 200 GV that have recently been reported by AMS-02.

Gamma ray astronomy II / 24

Recent science results of LHAASO on gamma-ray astronomy

Autor Songzhan Chen[1]

[1] *IHEP, CAS*

LHAASO is a large hybrid extensive air shower (EAS) array being constructed at Haizi Mountain, 4410 m a.s.l., in China. It is composed of three sub-arrays: a 1.3 km array (KM2A) for 100 TeV γ-ray astronomy, a 78000 m water Cherenkov detector array (WCDA) for TeV γ-ray astronomy. A considerable proportion of the LHAASO detectors have been operating since 2019 and the whole array were completed in July 2021. LHAASO is the most sensitive detector for the observation of ultra-high energy gamma-rays in the world. Some important progresses and new discoveries have been made in the ultra-high energy gamma-ray astronomy. In this talk, I will report the status, achieved performances and recent science results of LHAASO on gamma-ray astronomy.

Gamma ray astronomy II / 65

Recent results of the H.E.S.S. Observatory

Autor Rafał Moderski[1]

[1] *Centrum Astronomiczne im. M. Kopernika PAN*

High Energy Stereoscopic System (H.E.S.S.)[1] is a very high energy gamma-ray observatory located in the Khomas Highlands in Namibia. It operates a hybrid set of five imaging atmospheric Cherenkov telescopes, with its one 28 m instrument being the largest in the World. For almost 20 years, since its beginning H.E.S.S. delivers high quality scientific results revolutionizing our understanding of the gamma-ray sky. Some recent highlights from a rich research program of the H.E.S.S. Observatory will be presented with a special emphasis on the multiwavelength and multi-messenger approach. The fate of the H.E.S.S. telescopes in the upcoming era of the Cherenkov Telescope Array will be shortly discussed.

[1]https://www.mpi-hd.mpg.de/hfm/HESS/pages/about/telescopes/

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The MAGIC of acceleration

Autor Julian Sitarek[1]

[1] *University of Łódź*

MAGIC is an array of two 17-m diameter Cherenkov telescopes observing gamma rays in the very-high-energy (VHE; above a few tens of GeV) range. MAGIC is in operation since 2003, leading a successful observational program covering a broad range of scientific topics. Observations of gamma-ray emission from Galactic or extragalactic sources allow us to probe the conditions of acceleration of charged particles in them. We will report the recent highlight results of MAGIC, shedding light on acceleration and radiative cooling processes in cosmic sources. In particular we will discuss the newest member of VHE Flat Spectrum Radio Quasar family: B2 1420+32 during its 2020 flaring state, and the steepest source detected in VHE gamma rays: Geminga pulsar.

Gamma ray astronomy II / 102

The Crab Nebula: an electron PeVatron or a Super-pevatron of Cosmic Rays?

Autor Zhen Cao[1]

[1] *IHEP, China*

Detection of 1.1 PeV photons from the Crab poses challenges to even classical electrodynamic theory and pure magnetohydrodynamics. Or, an accelerator that boosts protons to at highest energy of 30 PeV may be at the center of the nebula? LHAASO has found the most fascinating object, which was recorded as the first recognized supernova by Chinese in Song dynasty, so attractive that it may hint the origin of cosmic rays above the knee. LHAASO's observation in the near future may unveil it.

Gamma ray astronomy II / 6

Stellar Clusters as Major contributors to Galactic Cosmic Rays at PeV Energies

Autor Felix Aharonian[1]

[1] *MPIK Heidelberg*

Massive stars with powerful winds represent alternatives to supernova remnants as major contributors to CRs. Currently, based on the spectral and morphological studies of GeV and TeV gamma-rays, the evidence is mounting that young massive stellar clusters are indeed the highest energy CR factories. The colliding stellar winds and SN explosions can drive superbubbles filled by highly turbulent plasma. Strong shocks or interacting stellar winds can initiate effective particle acceleration. The recent discovery of gamma-rays extending to 1.4 PeV reported by the LHAASO collaboration from the so-called Cygnus Cocoon surrounding Cygnus OB2 implies that clusters of stars can accelerate protons beyond 10 PeV, performing as Super-PeVatrons. The PeV γ-rays are of particular interest. For typical scattering environments, the transport of the parent 10 PeV protons would proceed in the (quasi)ballistic regime producing gamma-rays with a compact image projected on the accelerator. The realisation of this effect would provide unique tools for the localisation and identification of PeVatrons.

Gamma ray astronomy II / 21

Hunting for PeVatrons in the Galaxy

Autor Sabrina Casanova[1]

[1] *IFJ PAN, Krakow, Poland*

The Galaxy hosts sources of cosmic rays up to PeV energies, so called PeVatrons. Gamma-rays at the highest energies turn out to be the most effective tracer of the highest energies cosmic rays in the Galaxy. I will here review current searches for the sources of the highest energy cosmic rays. I will also present prospectives for future gamma-ray observatories.

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Cosmic ray transport near particle accelerators

Autor Martin Pohl[1]

[1] *DESY*

The observational progress from radio to gamma-ray observations reveals more and more morphological features that need to be accounted for when modeling the emission from particle accelerators in the Galaxy. It was recently realised that the cosmic-ray flux outside of such an accelerator cannot be modelled independently of the flux and spectrum of cosmic rays in the interior of the object. Using the time-dependent acceleration code RATPaC that simultaneously solves the transport equations for cosmic rays, magnetic turbulence, and the hydrodynamical flow of the thermal plasma, we can study the formation of extended gamma-ray halos around supernova remnants and the morphological implications that arise when the high-energetic particles start to escape from the SNRs.The simulations span 25,000 years, thus covering the free-expansion and the Sedov-Taylor phase of the SNR's evolution. The morphology of the gamma-ray emission from SNRs at later stages is different for the two main emission processes. At early times, both the inverse-Compton and the pion-decay morphology are shell-like. However, as soon as the maximum-energy of the freshly accelerated particles starts to fall, the inverse-Compton morphology starts to become center-filled, whereas the pion-decay morphology keeps its shell-like structure. Escaping high-energy electrons start to form an emission halo around the SNR at this time. There are good prospects for detecting this spectrally hard emission with the future Cerenkov Telescope Array, as there are for detecting variations in the gamma-ray spectral index across the interior of the SNR. Further, we find a constantly decreasing nonthermal X-ray flux that makes a detection of X-ray unlikely after the first few thousand years of the SNR's evolution. The radio flux is increasing throughout the SNR's lifetime and changes from a shell-like to a more center-filled morphology later on. We discuss the findings in the context of single-source contributions to the cosmic-ray flux at Earth and gamma-ray haloes around other objects.

Gamma ray astronomy II / **27**

The low number of Galactic pevatrons

Autor Pierre Cristofari[1]

[1] *Observatoire de Paris - IJCLab*

Although supernova remnants remain the main suspects as sources of Galactic cosmic rays up to the knee, the supernova paradigm still has many loose ends. The weakest point in this construction is the possibility that individual supernova remnants can accelerate particles to the rigidity of the knee, ~ 106 GV. This scenario heavily relies upon the possibility to excite current driven non-resonant hybrid modes while the shock is still at the beginning of the Sedov phase. These modes can enhance the rate of particle scattering thereby leading to potentially very-high maximum energies. Here we calculate the spectrum of particles released into the interstellar medium from the remnants of different types of supernovae. We find that only the remnants of very powerful, rare core-collapse supernova explosions can accelerate light elements such as hydrogen and helium nuclei, to the knee rigidity, and that the local spectrum of cosmic rays directly constrains the rate of such events, if they are also source of PeV cosmic rays. The implications for the overall cosmic ray spectrum observed at the Earth and for the detection of PeVatrons by future gamma-ray observatories are discussed.

Gamma ray astronomy II / **15**

Gamma-rays from thermal x-ray composites

Autor Vasyl Beshley[1]

[1] *Institute for Applied Problems in Mechanics and Mathematics, NASU*

There are about 300 supernova remnants (SNRs) observed in our Galaxy. They evolve in interstellar medium which is not uniform. SNRs may be classified into a few morphological classes, based on their surface brightness morphologies in different photon energy ranges: shell-like (both in radio and X-rays), centrally-filled (as in radio as in X-rays), thermal X-ray composites (TXCs). The last class often called also mixed morphology SNRs and contains objects which are shell-like in radio and centrally filled in X-rays (which are of the thermal nature). One of the model for the origin of such morphology is interaction of SNRs with dense molecular cloud located on the line of sight. If so then TXCs have to be sources of hadronic gamma-rays. In our talk we explore this idea by performing the 3D MHD simulations of SNRs in a medium with strong gradients of density and magnetic field and synthesizing images of TXCs in different bands from radio- to gamma-rays.

Astrophysical neutrinos I / 36

IceCube: Cosmic Neutrinos and Multimessenger Astronomy

Autor Francis Halzen[1]

[1] *University of Wisconsin-Madison*

Below the geographic South Pole, the IceCube project has transformed one cubic kilometer of natural Antarctic ice into a neutrino detector. IceCube detects more than 100,000 neutrinos per year in the GeV to 10 PeV energy range. From those, we have isolated a flux of high-energy neutrinos of cosmic origin, with an energy flux that is comparable to that of high-energy photons. We have also identified the first source: on September 22, 2017, following an alert initiated by a 290-TeV neutrino, observations by other astronomical telescopes pinpointed a flaring active galaxy, powered by a supermassive black hole. We will review recent progress in measuring the cosmic neutrino spectrum and in identifying its origin.

Astrophysical neutrinos I / 45

Highlights from the ANTARES neutrino telescope

Autor Giulia Illuminati[1]

[1] *INFN-Bologna*

ANTARES is a high-energy neutrino telescope running since 2007 below the surface of the Mediterranean Sea with the main aim of identifying the sources of the astrophysical neutrinos. The location of ANTARES allows for an advantageous view of the Southern Sky, in particular for neutrino energies below 100 TeV. This feature, combined with a very good angular resolution, makes the telescope an excellent tool to test for the presence of neutrino sources, especially of Galactic origin. Besides looking for a diffuse flux or individual sources of astrophysical neutrinos produced in cosmic-ray interactions, ANTARES can also investigate the presence of dark matter in massive celestial objects by searching for neutrinos as final annihilation/decay products of dark matter particles. Moreover, ANTARES is involved in a rich multi-messenger program which includes searching for neutrinos in coincidence with promising transient astrophysical events, as well as triggering electromagnetic follow-up observations of interesting neutrino candidates by sending alert messages to the Astronomical community. In this talk, the latest results from the ANTARES telescope will be presented, ranging from searches for diffuse fluxes and point-like sources of neutrinos, to dark matter and multi-messenger analyses.

Astrophysical neutrinos I / 95

Baikal-GVD: status and first results

Autor Dmitry Zaborov[1]

[1] *INR (Moscow)*

Baikal-GVD is a cubic kilometer neutrino detector currently under construction in Lake Baikal, Russia. We review the current status of Baikal-GVD and first results obtained using data from the partially complete instrument.

Astrophysical neutrinos I / 54

The Trinity VHE Neutrino Observatory

Autor David Kieda[1]

[1] *University of Utah*

The recent detection of potential point sources of astrophysical neutrinos by the IceCube observatory has led to renewed interest in developing next-generation techniques for very to ultra-high-energy neutrino astronomy. The Trinity Observatory, employing an optical technique for detecting tau-air showers induced by Earth-skimming PeV neutrinos, is proposed to fill in the energy gap between the IceCube observatory and UHE radio neutrino detectors. The full-scale Trinity Observatory will use a network of wide Field of View (FoV) telescopes located on high prominence mountain tops to observe tau-neutrinos passing through the Earth's crust. In this talk, we describe the Trinity concept, including optics, electronics, and site considerations, and present the expected sensitivity of the observatory. We describe the capability of enormous Trinity detector volume to explore the origin of 1-10^4 PeV energy astrophysical neutrinos, and synergies with future radio and in-ice optical neutrino observatories. This talk concludes with a discussion of the Trinity Demonstrator Prototype detector, which is under construction for deployment at the top of Frisco Peak, Utah, USA, in Fall 2022.

Astrophysical neutrinos I / 10

A very high energy neutrino telescope on-board the EUSO-SPB2 mission

Autor Mahdi Bagheri[1]

[1] *Georgia Institute of Technology*

We present the status of the development of a Cherenkov telescope to be flown on an ultra-long-duration balloon flight, the Extreme Universe Space Observatory Super Pressure Balloon 2 (EUSO-SPB2). EUSO-SPB2 is an approved NASA balloon mission that is planned to fly in 2023 from Wanaka, New Zealand and is a precursor for future space-based missions to detect astrophysical neutrinos. The objective of this mission is to classify known and unknown sources of background, make the first observation of cosmic rays via Cherenkov technique from suborbital altitude and target of opportunity search in response to international multi-messenger alerts. Furthermore, we will use the Earth-skimming technique to search for Very-High-Energy (VHE) tau neutrinos below the Earth's limb (E > 10 PeV). The 0.785 m^2 Cherenkov telescope is equipped with a 512-pixel SiPM camera, covering 12.8° x 6.4° (Horizontal x Vertical) field of view, that utilizes novel stereo optical system. The camera signals are digitized with a 100 MS/s readout system. In this talk, we discuss the status of the telescope development, the camera integration, and simulation studies of the camera response.

Particle acceleration I / 43

Nonthermal particle accelerator of magnetic reconnection

Autor Masahiro Hoshino[1]

[1] *The University of Tokyo*

The nonthermal particle acceleration during magnetic reconnection has remained a fundamental topic in many astrophysical phenomena such as solar flares, pulsar wind, and magnetars and so on for more than half a century, and one of the unresolved questions is the efficiency of the nonthermal particle acceleration. Recently, nonthermal particle acceleration mechanisms during reconnection have been extensively studied by particle-in-cell simulations and hybrid simulations, yet it is an intriguing enigma as to how the magnetic field energy is divided into the thermally heated plasmas and the nonthermal particles. Here we study both non-relativistic and relativistic magnetic reconnections using a large-scale particle-in-cell simulation for a pair plasma, and show that the production of the nonthermal particle becomes efficient with increasing the plasma temperature. In the relativistic hot plasma case, we find that the heated plasmas by reconnection can be approximated by a kappa distribution function with the power-law index of about 2, and the nonthermal energy density of reconnection reaches about more than 95% of the total heated plasma.

Particle acceleration I / 46

PIC Simulations of Particle Acceleration in Magnetized Relativistic Shocks

Autor Masanori Iwamoto[1]

[1] *Kyushu University*

Relativistic magnetized shocks are ubiquitous in the universe. High energy astrophysical objects such as active galactic nuclei, gamma ray burst, and pulsar wind nebula are usually associated with the shocks as a consequence of the interaction between relativistic plasma outflow and interstellar medium. The nonthermal emission from these objects are generally modeled as synchrotron radiation and inverse Compton scattering of relativistic electrons, which are believed to be generated in relativistic magnetized shocks. Relativistic magnetized shocks are assumed to be an efficient particle accelerator and are often invoked for the source of ultra-high-energy cosmic rays. However, the detailed acceleration mechanism is far from understood.
Particle-in-cell (PIC) method is a first-principles model of collisionless plasmas and a central tool to simulate relativistic maetized shocks. Numerous PIC simulations of relativistic magnetized shocks are so far conducted to explore particle acceleration. They demonstrate that many kinetic plasma instabilities such as Weibel instability, synchrotron maser instability, and parametric decay instability can develop depending on physical parameters and these instabilities plays a significant role for particle acceleration. In this talk, we will review the recent progress in PIC simulations of magnetized relativistic shocks and discuss our new particle acceleration mechanism.

Particle acceleration I / 8

Electron injection at shocks: Transition from stochastic shock drift acceleration to diffusive shock acceleration

Autor Takanobu Amano[1]

[1] *University of Tokyo*

The acceleration of high-energy particles is common both in heliophysics and astrophysics. The diffusive shock acceleration (DSA) process has been the standard mechanism for particle acceleration at collisionless shock waves. It is, however, well known that DSA cannot explain the acceleration of low-energy electrons because of the lack of efficient scatterers. We have proposed stochastic shock drift acceleration (SSDA) as a plausible mechanism to resolve the problem of electron injection [Katou & Amano, 2019]. The energy gain mechanism of SSDA is essentially the same as the conventional shock drift acceleration (SDA), but the presence of stochastic pitch-angle scattering makes the acceleration more efficient. Good agreements between theoretical predictions based on SSDA and in-situ observations by Magnetospheric MultiScale (MMS) spacecraft have been reported [Amano et al. 2020]. Furthermore, electron acceleration signatures found in fully kinetic Particle-In-Cell (PIC) simulations have also been found [Matsumoto et al. 2017, Kobzar et al. 2021]. Motivated by these previous studies, we have developed a theory that can consistently predict the energy spectrum for sub-relativistic and relativistic energy ranges. We find that the spectrum at the sub-relativistic energy produced by SSDA is steeper than the standard DSA prediction. As the particle energy increases, the particle acceleration mechanism may smoothly transition from SSDA to DSA. We find that the electron injection scheme through SSDA occurs preferentially at shocks with higher Alfven Mach numbers defined in the Hoffmann-Teller frame.

Particle acceleration I / **18**

Electron acceleration at supernova remnants

Autor Artem Bohdan[1]

[1] *Deutsches Elektronen-Synchrotron DESY*

Supernova remnants (SNRs) are believed to produce the most part of the galactic cosmic rays (CRs). SNRs harbor non-relativistic collisionless shocks responsible for acceleration of CRs via diffusive shock acceleration (DSA), in which particles gain their energies in repetitive interactions with the shock front. As the DSA theory involves pre-existing mildly energetic particles, a means of pre-acceleration is required, especially for electrons. Electron injection remains one of the most troublesome and still unresolved issues and our physical understanding of it is essential to fully comprehend the physics of SNRs. To study any electron-scale phenomena responsible for pre-acceleration, we require a method capable of resolving these small kinetic scales and Particle-in-cell (PIC) simulations fulfill this criterion. Here I report about the latest achievements on kinetic simulations of non-relativistic high Mach number shocks. I discuss how the physics of SNR shocks depends on the shock parameters (e.g., the shock obliquity, Mach numbers, the ion-to-electron mass ratio), which processes are responsible for the electron pre-acceleration and how these shocks can be studied using in-situ satellite measurements. Finally, I outline future perspectives of the electron injection problem and other complementary ways to solve it.

Particle acceleration I / **51**

Particle Acceleration at Weak Shocks Induced by Mergers of Galaxy Clusters

Autor Hyesung Kang[1]

[1] *Pusan National University*

Low Mach number shocks with M~2-3 are induced in the hot tenuous intracluster medium (ICM) by mergers of galaxy clusters. Cosmic ray (CR) protons are expected to be accelerated mainly at quasi-parallel shocks, whereas CR electrons are expected to be accelerated preferentially at quasi-perpendicular shocks. Microinstabilities excited by reflected protons and electrons, and the ensuing self-excitation of plasma waves are critical in the energizaion of background thermal populations. Moreover, scattering of backstreaming particles back to the shock by those upstream waves play important roles in particle injection to the Fermi-I process and the further acceleration to relativistic energies. We review these kinetic processes operating in such ICM shocks.

Particle acceleration I / 56

Electron acceleration at rippled low-Mach-number shocks in high-beta cosmic plasmas: role of the pre-shock conditions

Autor Oleh Kobzar[1]

[1] *Faculty of Materials Engineering and Physics, Cracow University of Technology*

Shock waves in cosmic plasmas are the places of the electromagnetic turbulence generation and acceleration of particles. They can be found in a big number of astrophysical objects on different scales, e.g. Earth's bow shock, solar flares, supernova remnant (SNR) shocks, merger shocks in galaxy clusters. In the latter case, X-ray and radio observations indicate the efficient electron acceleration. Merger shocks are found to have low Mach numbers (Ms « 10) and propagate in hot plasma with β » 1. The mechanisms of the particle acceleration at such conditions are poorly known yet, however recent studies indicate that electron energization can be provided by shock drift acceleration (SDA) accompanied by the particle-wave interaction. In the current work we investigate the role of the multi-scale wave structures, especially the ion-scale shock rippling modes, in the electron acceleration at low-Mach-number hi-beta shocks, using the large-scale 2D Particle-In-Cell (PIC) simulations. We showed that efficiency of the electron acceleration increases sufficiently after the appearance of rippling modes, and the main mechanism of the electron acceleration at such conditions is stochastic SDA (SSDA). The electrons gain energy from the motional electric field, being confined in the shock transition region by pitch-angle scattering off magnetic turbulence. Investigation of the multi-scale turbulence appearance at the different pre-shock conditions indicate the crucial role namely of the shock rippling modes in the electron generalization via SSDA.

Laboratory astroplasma physics / 35

Transport of Charged Particles through Spatially Intermittent Turbulent Magnetic Fields

Autor Gianluca Gregori[1]

[1] *Oxford University*

Galaxy clusters are filled with hot, diffuse X-ray emitting plasma, with a stochastically tangled and intermittent magnetic field whose energy is close to equipartition with the energy of the turbulent motions. In the cluster cores, the temperatures remain anomalously high compared to what might be expected considering that the radiative cooling time is short relative to the Hubble time. While feedback from the central active galactic nuclei is believed to provide most of the heating, there has been a long debate as to whether conduction of heat from the bulk to the core can help the core to reach the observed temperatures, given the presence of tangled magnetic fields. To address the problem of thermal conduction in a magnetized and turbulent plasma, we have created a replica of such a system at the National Ignition Facility laser, the largest laser laboratory in the world. Our data show a reduction of local heat transport by two orders of magnitude or more. While the diffusive transport of the highest energy charged particles appears to be unaffected by the spatial intermittency of the magnetic field, the diffusion of lower energy electrons is, instead, better described in terms of percolation. This, together with a cooling instability, leads to strong temperature variations on small spatial scales, as also observed in the intergalactic plasma.

Laboratory astroplasma physics / 82

Exploring the current filamentation/Weibel instability in laboratory scenarios with relativistic beams

I will present some recent analytical and numerical results on the current filamentation instability/Weibel instability, with a focus on conditions relevant for planned/future experiments with relativistic beams. Results on the long time behavior of the instability will also be discussed with a focus on observables (such as beam/cloud slowdown) and expected magnetization. Astrophysical scenarios where these findings can be of relevance will also be discussed.

Gamma ray astronomy III / 97

Jets in microquasars

Autor Andrzej Zdziarski[1]

[1] *N. Copernicus Astronomical Center, Warsaw, Poland*

I will review our current knowledge about jets in accreting X-ray binaries. I will concentrate on three well-studied systems, namely MAXI J1820+070, Cyg X-1, and Cyg X-3. The compact objects in the first two are black holes, while it is likely but not certain in Cyg X-3. Thanks to an extensive multiwavelength campaign during the recent outburst of MAXI J1820+070, the structure of its compact jet emitting in radio to optical frequencies is now very well understood. The relatively long time lags measured between various radio and sub-mm frequencies prove that emission is formed at distances several orders of magnitude higher than the gravitational radius. We determine the jet opening angle, the location of the onset of the emission, the magnetic field strength and the electron distribution, and put constraints on the bulk Lorentz factor, the content of electron-positron pairs and the jet power. Then, I will compare those jet parameters with those in Cyg X-1 and Cyg X-3, both of which emit high-energy gamma rays.

Gamma ray astronomy III / 98

Recent progress in GRB studies

Autor Bing Zhang[1]

[1] *University of Nevada, Las Vegas*

I will present an overview of some recent progress in the GRB field. The topics include discovery and implications of TeV emission in GRB afterglows, new events that point to special progenitor channels, as well as theoretical models that help to diagnose the jet composition and central engine of both long and short GRBs.

Gamma ray astronomy III / 74

Probing particle acceleration at relativistic shocks with GRBs

Autor Brian Reville[1]

[1] *MPIK*

Until recently, questions on the maximum particle energy produced by GRBs was primarily int he context of UHECRs. However, the recent spate of TeV gamma-ray measurements bring the question of maximum electron energies into focus. Here I will review the current status of particle acceleration at relativistic shocks, how the theoretical predictions stand up to the recent observations, and what might be the possible implications for UHECR production.

Particle acceleration II / 85

Nonthermal emission from relativistic reconnection

Autor Lorenzo Sironi[1]

[1] *Columbia University*

Relativistic jets of blazars and magnetized coronae of highly accreting black holes routinely display non-thermal emission signatures, including fast and bright flares of high-energy emission. Yet, the "engine" responsible for accelerating the emitting particles to ultra-relativistic energies is still unknown. With fully-kinetic particle-in-cell (PIC) simulations, we will argue that relativistic magnetic reconnection — where the magnetic energy of annihilating field lines is even larger than the particle rest mass energy — offers an intriguing explanation for (1) high-energy flares in blazar jets, and associated rotations in the optical polarization vector; and (2) the hard-state spectra of black hole X-ray binaries and Active Galactic Nuclei.

Particle acceleration II / 68

Magnetic reconnection in relativistic jets

Autor Krzysztof Nalewajko[1]

[1] *Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences*

Relativistic jets are produced by certain accreting black holes where accumulation of magnetic fields leads to relativistic magnetizations. Magnetic reconnection is one of the most promising mechanisms of energy dissipation and particle acceleration that may operate in the relativistic jets. Magnetic reconnection may be triggered instabilities, in particular the current and pressure driven modes in the presence of toroidal magnetic fields. Relativistic reconnection and instabilities in relativistic jets have been investigated extensively by means of kinetic particle-in-cell simulations. These studies have demonstrated that relativistic jets can be very efficient particle accelerators.

Particle acceleration II / 75

Full lepto-hadronic radiative treatment of GRBs in the internal shock scenario and application to Fermi-LAT detected events

Autor Annika Rudolph[1]

[1] *DESY Zeuthen*

Gamma-Ray Bursts (GRBs) are long-standing cosmic-ray source candidates. It is however unclear how large the fraction of energy transferred to non-thermal protons (often dubbed baryonic loading) can be in order to be still compatible with observed photon spectra. Using the internal shock model for the dynamic evolution of the outflow, we perform self-consistent lepto-hadronic radiation models of the GRB prompt phase. Our description allows to calculate both time-dependent observables like the light curve as well as time-integrated photon and neutrino spectra. First turning to an educative example, we scrutinize the impact of modeling choices such as the mean Lorentz factor of the outflow, the fraction of energy transferred to the magnetic field and the baryonic loading. We find that for large baryonic loadings, secondary cascades largely impact the spectrum around the sub-MeV peak and may outshine the primary electron emission. From the simple, educative example we move to prototypes that reproduce the main observables (light curve structure, observed fluence and peak energy) of Fermi-LAT detected events and show that their simulated properties depend similarly on modeling choices.

Gravitational waves / 71

Gravitational waves and multi-messenger astronomy: results and prospects

Autor Barbara Patricelli[1]

[1] *EGO and INFN - Sezione di Pisa*

The era of Gravitational Wave (GW) Astronomy started on 2015, with the first observation of GWs from the merger of a binary black hole (BBH) system by Advanced LIGO. Two years later, the detection of GWs from a binary neutron star (BNS) merger by the Advanced LIGO and Advanced Virgo network and of the associated electromagnetic (EM) signals marked the birth of multi-messenger astronomy with GWs, opening a new chapter in the study of the universe. Besides these two ground-breaking discoveries, the LIGO, Virgo and KAGRA collaborations reported the detection of many other GW events during the first three observing runs and, thanks to their increasing sensitivity, more GW and joint GW and EM detections are expected in the near future. This talk will give an overview of the GW and multi-messenger observations so far, their astrophysical implications and the prospects for the upcoming years.

Gravitational waves / 20

On the origin of the gravitational wave sources

Autor Tomasz Bulik[1]

[1] *University of Warsaw and Astrocent CAMK*

Recent years have brought us a great development in the gravitational wave astronomy with many new sources discovered by LIGO and Virgo. I will summarize the properties of the objects discovered and listed in the recent GWTC-3 catalog, and provide a summary of the models of their origin. Each of these models has specific predictions. I will review these predictions and confront them with the properties of the observed gravitational wave sources.

Gravitational waves / 47

Jets and winds from gamma ray bursts

Autor Agnieszka Janiuk[1]

[1] *Center for Theoretical Physics, PAS*

The electromagnetic radiation emerging from jets in gamma rays is modulated on timescales driven by the magnetirotational instability. Shorter, free-fall timescales, are relevant for the state of magnetically arrested accretion, when the interchange instabilities regulate the excess of magnetic flux on the black hole horizon region. On the other hand, the uncollimated outflows accretion disk may contribute to the subrelativistic neutron-rich material, which is responsible for blue and red kilonova, accompaning some short GRBs. I will discuss the properties of these different types of outflows launched from gamma ray bursts, and focus on the role of accretion disk in their origin.

Gamma ray astronomy IV / 17

Multi-wavelength and multi-messenger observations of blazars and theoretical modeling

Autor Markus Boettcher[1]

[1] *North-West University*

This talk will review recent advances in multi-wavelength observations of blazars as well as indications of associations of very-high-energy neutrino events with blazars. Physics constraints that may be drawn from such associations will be reviewed. Recent work on consistent particle acceleration and time-dependent radiation transfer modeling in mildly relativistic shocks in blazar jets will also be highlighted.

Gamma ray astronomy IV / 87

Some Recent Observational Constraints on the Magnetization and Energy Dissipation in AGN Jets

Autor Łukasz Stawarz[1]

[1] *Astronomical Observatory, Jagiellonian University*

In this talk I will briefly discuss some recent observational constraints on the magnetization of relativistic jets in AGN jets, and the related issue of the energy dissipation and acceleration of the jet particles to ultra-relativistic energies. I will focus predominantly on the structures beyond the jet formation site, i.e. on the large-scale portions of the outflows, the jet termination shocks, and the extended radio lobes. The observational constraints follow from the detailed analysis of the radio and X-ray data for the selected objects, in particular from imaging and spectral analysis of the quasar jets with the Chandra X-ray Observatory, as well as from the radio and gamma-ray population studies, in particular with the Fermi-LAT. Those results, when augmented by simple models of the jet evolution and MHD structure, seem to suggest that the jet magnetization at large scales is typically low, in a sense that the ratio of the total particle energy flux to the jet Poynting flux, is always less than unity. At the same time, however, the internal structure of the jets and lobes may be rather inhomogeneous, so that the magnetic pressure may still dominate over particle pressure for certain ranges of the jet radius, or for particular segments of the lobes. The implication for the energy dissipation and particle acceleration at the jet termination shocks, and within magnetic filaments of the lobes, are briefly summarized.

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It's a Blazar… It's a Radio Galaxy… It's PKS 0625-354!

Autores Alicja Wierzcholska[1]; Dorit Glawion[None]

[1] *The Henryk Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences*

The catalogue of TeV gamma-ray emitting objects includes about 90 extragalactic sources, among which only a few belong to the class of radio galaxies or misaligned blazars. This smaller class includes PKS 0625-354, a source detected as TeV gamma-ray emitter already in 2012. Here, we report H.E.S.S. observations of this active galaxy performed in November 2018. The classification of the object is still a matter of debate in the context of blazar and radio galaxy scenarios. With the recent H.E.S.S. observations, supported with multi-wavelength observations collected with Fermi-LAT, Swift-XRT, and Swift-UVOT, we report the detection of TeV gamma-ray variability of the sources. Ten days of H.E.S.S. observations revealed an outburst observed on November, 1st followed by a decrease of the gamma-ray flux. In this talk, I report the result of H.E.S.S. and multi-wavelength observations of PKS 0625-354. I also discuss the possible interpretation of the broadband spectral energy distribution of the source and the implication of the TeV gamma-ray variability detected.

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A possible association of a Fermi-LAT flaring activity with a blazar candidate behind the Large Magellanic Cloud

Autor Natalia Zywucka[1]

[1] *North-West University*

We present the results of a preliminary investigation of a potential association of a blazar candidate behind the Large Magellanic Cloud (LMC) and a gamma-ray transient object. The indication of gamma-ray flaring activity in the Fermi-LAT data was detected at the position (RA, decl.) ~(86.60 deg,-69.02 deg), while the J0545-6846 blazar candidate is located at (RA, decl.) = (86.47 deg, -68.77 deg). J0545-6846 is characterised by a particularly large radio flux of 176.3 mJy at 843 MHz, a high value of the radio-loudness parameter R=6900, and an integrated gamma-ray flux >1 GeV of ~9.6 × 10^(-12) erg cm^(-2) s^(-1). We have analysed the Fermi-Large Area Telescope (LAT) data from the LMC region in order to verify the flaring activity detected in July/August 2008 and later in April 2015 at MeV and GeV energies, using the latest Fermi-LAT point source catalogue. The unbinned maximum likelihood analysis performed took into account the positions of all known point-like sources, diffuse emission as well as the advanced gas modelling from the region investigated. Our preliminary analyses indicate positional consistency between J0545-6846 and the flaring activity in both periods. This suggests that the observed transient activities are related to the same blazar.

Gamma ray astronomy IV / 16

Characterizing optical and gamma-ray variability properties of blazars

Autor Gopal Bhatta[1]

[1] *Nuclear Institute of Physics PAN, Poland*

Blazars, a subset of powerful active galactic nuclei, feature relativistic jet which shine in a broadband electromagnetic radiation, e. g. from radio to TeV emission. Here we present the results of the studies that explore gamma-ray and optical variability properties of a sample of gamma-ray bright sources Several methods of time-series analyses are performed on the decade-long optical and Fermi/LAT observations. The main results are as follows: The sources are found highly variable in both the bands, and the gamma-ray power spectral density is found to be consistent with flicker

noise suggesting long-memory processes at work. While comparing two emission, not only the overall optical and the γ-ray emission are highly correlated but also both the observation distributions exhibit heavy tailed log-normal distribution and linear RMS-flux relation. Similarly, non-linear time series analysis suggested the presence of deterministic nature of the underlying dynamical processes. In addition, in some of the sources indications of quasi-periodic oscillation were revealed with similar characteristic timescales in the both the bands. We discuss the results in light of current blazar models with relativistic shocks propagating down the jet viewed close to the line of sight.

Gamma ray astronomy IV / 19

An expanding one-zone model for studying blazars emission

Autor Stella Boula[None]

Blazars have their jet pointing towards us and are known for their emission that covers practically all electromagnetic spectrum frequencies. These sources, in some cases, exhibit a correlation between γ-ray and radio emission, especially during flaring episodes. Adopting the hypothesis that high-energy photon emission by relativistic electrons occurs close to the central black hole, we study the evolution of this population of particles as they move along the jet and lose energy by radiation and adiabatic expansion. In this scenario, γ-rays are produced early on, when the electrons are still very energetic, while radio emission at a later time when the emission region becomes optically thin to synchrotron self-absorption due to expansion. We develop an expanding one-zone code to calculate the emitted spectrum by simultaneously solving the kinetic equations of particles and photons. We will discuss the parameters entering our calculations, like the magnetic field strength, the density of relativistic electrons, etc., in connection to the observational data by applying our results to the case of Mrk421.

Young Scientists' Session / 67

Non-thermal features from broad-line region clouds

Autor Ana Laura Müller[1]

[1] *ELI Beamlines, Institute of Physics, Czech Academy of Sciences*

Active galactic nuclei show in their spectra broad-emission lines that are considered to be created by clouds orbiting close to the central black hole. The motion of these clouds is predominantly Keplerian, consistent with the scenario described by the Failed Radiatively Accelerated Dusty Outflow (FRADO; Czerny & Hryniewicz 2011). In this talk, we discuss the non-thermal signatures that can arise from the inflow motion of the clouds and their interaction with the accretion disk according to the FRADO model. We show that significant non-thermal radiation can be produced, especially in the hard X- and gamma-ray bands displaying the spectral energy distributions similarities to the gamma emitter narrow-line Seyfert 1 galaxies spectra.

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Transition from low to high activity states in gamma-ray emitting NLS1 galaxies

Autor Anna Luashvili[1]

[1] *Observatoire de Paris*

Gamma-ray-emitting narrow-line Seyfert 1 galaxies (NLS1) constitute an intriguing small population of Active Galactic Nuclei (AGN) with debated fundamental properties, unexpected gamma-ray emission and anomalous variability features, possessing properties similar to low power flat-spectrum radio quasars (FSRQ). They are jetted, gamma/radio-loud Seyfert galaxies, with relatively low BH masses, accreting at exceptionally high, near-Eddington rates. Two bona-fide NLS1 1H 0323+342 and PMN J0948+0022, and one intermediate object between NLS1 and FSRQ sub-classes B2 0954+25A are considered in this work. We analyzed quasi-simultaneous multiwavelength data for two gamma-ray activity states. Two different scenarios are discussed, in the framework of a one-zone leptonic model, where the high energy emission is due to the inverse Compton scattering of BLR or torus photons by energetic electrons of the jet. Using a maximum number of physical constraints such as the jet opening angle, causality and energetic arguments, we show that the transition from low to high state is well described by minimal changes in the jet parameters, favoring the stationary shock scenario at the origin of the particle acceleration. The intrinsic nature of these sources and their place in the AGN classification are discussed.

Young Scientists' Session / 78

A connection between TeV gamma-ray flux and cosmic rays in the Seyfert galaxy 1068

Autor Rodrigo Sasse[1]

[1] *Federal University of Latin American Integration - UNILA*

Hadronic interactions in cosmic-ray propagation can produce charged and neutral pions. The neutron pion decays into photons, while positrons and electrons are produced due to the decay of charged pions. The basic mechanisms that can produce gamma-ray fluxes associated with jets of cosmic rays are the decay of neutral pions electron/positron bremsstrahlung, and inverse Compton scattering. These cascade processes show a correlation between the upper limit on the integral GeV - TeV gamma-ray flux and the ultra-high energy cosmic rays (UHECR) luminosity. We calculate the UHECR cosmic-ray luminosity for the 1068 galaxy using the upper limits on TeV gamma-ray flux by H.E.S.S. and MAGIC Observatories. We compare our neutrino flux to current estimates of NGC 1068 neutrino flux.

Young Scientists' Session / 55

Understanding the Spectrum of Gamma-Ray Burst 190114C

Autor Marc Klinger[1]

[1] *DESY Zeuthen*

The recent very-high-energy (VHE) gamma-ray observations of gamma-ray bursts (GRBs) in their afterglow phase motivate a review of the established fireball model in which a relativistic blast wave accelerates electrons in the forward shock, which then radiate via the synchrotron process and inverse Compton scattering on these synchrotron photons (synchrotron self-Compton). We use the rich observations of GRB 190114C ranging from X-ray (keV) to VHE gamma-rays (TeV) to investigate the properties of the radiating electron distribution assuming a single emitting zone. We present preliminary modeling considering the landscape of solutions finding consistency with the multi-wavelength observations, and consider the implications of these different solution groups.

Young Scientists' Session / 32

A marginally fast-cooling proton-synchrotron model for prompt GRBs

Autor Ioulia Florou[1]

[1] *National & Kapodistrian University of Athens*

A small fraction of GRBs with available data down to soft X-rays (~0.5 keV) have been shown to feature a spectral break in the low energy part of their prompt emission spectrum. The overall spectral shape is consistent with optically thin synchrotron emission from a population of marginally fast cooling particles. In this work we firstly consider that the radiating particles are hadrons and investigate the idea that the prompt emission originates from relativistic protons that radiate synchrotron in the marginally fast cooling regime. We compute the source parameters required for such a scenario to work and investigate analytically and numerically how additional processes, namely photohadronic interactions and gamma-gamma pair production, contribute to the overall spectrum. We show that this idea is physically disfavored and readdress the one zone electro synchrotron scenario, which has been already been studied in previous works. We seek the initial source parameters that could explain the production of the GRB spectra taken from the sample presented by Oganesyan et al 2019.

Young Scientists' Session / 31

Flare echos from relaxation waves in perturbed relativistic jets

Autor Gaëtan Fichet de Clairfontaine[1]

[1] *Laboratoire Univers et Théorie, Observatoire de Paris, Université PSL, Université de Paris, CNRS, F-92190 Meudon, France*

Multi-wavelength flux variabilities observed in relativistic jets are most often attributed to the diffusive acceleration of a population of relativistic electrons on internal shocks. The shortest observed variability time scale changes over several orders of magnitude between the radio and X-ray band. We simulate relativistic jets with the SR-HD code AMRVAC. Non-thermal particle distributions are injected at standing and moving shocks. We follow the propagation of a moving shock wave that can interact with a structure of standing recollimation shocks in the jet. Synchrotron emission and radiative transfer are calculated in post-processing for given observation angles and frequencies, assuming a turbulent magnetic field. Our study shows the emergence of flare events over a large frequency range with varying time scales due to moving and standing shocks interactions. We highlight the additional emission signature from relaxation waves forming and propagating due to the jet relaxation. Emission from this region can dominate the flux or lead to a flare echo ». Impact on flare morphology by time delay effect will be discussed for observation angle close and equal to 90°.

Young Scientists' Session / 12

Ultra-high energy cosmic rays luminosity from multi-messenger analysis

Autor Adriel Gustavo Bartz Mocellin[1]

[1] *Neusa Bartz Mocellin*

Ultrahigh energy cosmic rays (UHECRs) are probably originated from extragalactic sources as, e.g., Starburst, Radio Galaxies, and Active Galactic Nuclei (AGNs). In the present work, we obtain the upper limits of the cosmic-rays luminosity of Starburst galaxies. The method described in (Supanitsky

2013 and Anjos 2014) is a productive tool for the obtainment of the upper limits of the cosmic-rays luminosity and illustrates techniques to study the origin of UHECR from gamma-rays at GeV-TeV. The method has been used with the upper limit on the GeV-TeV gamma-ray flux measured by space and ground instruments, as FERMI-LAT, VERITAS, H.E.S.S, and MAGIC and connects a measured upper limit on the integral flux of GeV-TeV gamma-rays and the UHECR cosmic-ray luminosity of a point source.

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3D PIC Simulations for Relativistic Jets with a Toroidal Magnetic Field

Autor Kenichi Nishikawa[1]

[1] *Alabama A&M University*

The properties of relativistic jets, their interaction with the ambient environment, and particle acceleration due to kinetic instabilities are studied self-consistently with Particle-in-Cell simulations. An important key issue is how a toroidal magnetic field affects the evolution of a pair and an electron - proton jet, how kinetic instabilities such as the Weibel instability (WI), the mushroom instability (MI) and the kinetic Kelvin-Helmholtz instability (kKHI) are excited, and how such instabilities contribute to particle acceleration. In this work we use a new jet injection scheme where an electric current is self-consistently generated at the jet orifice by the jet particles. We perform four different simulation runs. We inject pair and electron - proton unmagnetized and magnetized jets into unmagnetized ambient plasmas with same species, the latter with a toroidal magnetic field (with a top-hat jet density profile), and for a sufficiently long time in order to examine the non-linear effects of the jet evolution. We show that WI, MI and kKHI excited at the linear stage, generate a quasi-steady x-component of electric field which accelerates and decelerates electrons. Despite the weakness of the initial magnetic field, we observe significant differences in the structure of the strong electromagnetic fields that are driven by the kinetic instabilities. We find that the two different jet compositions (pair and electron - proton) showcase different instability modes respectively. Moreover, the magnetic field in the non-linear stage generated by different instabilities becomes dissipated and re-organized into a new topology. The 3 dimensional magnetic field topology indicates possible reconnection sites as the particles are significantly accelerated in the non-linear stage by the dissipation of the magnetic field or probably reconnection.

High energy cosmic rays III / 62

Results from the Telescope Array

Autor John Matthews[1]

[1] *University of Utah*

The Telescope Array is a hybrid cosmic ray detector consisting both of fluorescence telescopes and an array of scintillator surface detectors. It is the largest cosmic ray detector in the northern hemisphere. It is presently expanding from 700 sq km to 2800 sq km. The status of spectral, composition, and source search measurements will be presented in addition to an update on the deployment of the TAx4 detector.

High energy cosmic rays III / 79

Digital Radio Arrays for Ultra-High-Energy Cosmic Particles

Autor Frank Schröder[1]

[1] *University of Delaware / Karlsruhe Institute of Technology*

Digital radio arrays have become an effective tool to measure air showers at energies around and above 100 PeV. Compared to optical techniques, the radio technique is not restricted to clear nights. Thanks to recent progress on computational analysis techniques, radio arrays can provide an equally accurate measurement of the energy and the depth of the shower maximum. Stand-alone radio arrays offer an economic way towards huge apertures, e.g., for the search for ultra-high-energy neutrinos, but still require technical demonstration on large scales. Hybrid arrays combining radio antennas and particle detectors have already started to contribute to cosmic-ray physics in the energy range of the presumed Galactic-to-extragalactic transition. In particular, the combination of radio and muon detectors can pave a path to unprecedented accuracy for the mass composition of cosmic rays. This talk review recent developments regarding the radio technique and highlight selected running and planned antennas arrays, such as GRAND, the SKA, the AugerPrime Upgrade of the Pierre Auger Observatory, and IceCube-Gen2.

High energy cosmic rays III / 26

Direct cosmic ray measurements: status and perspectives

Autor Stephane Coutu[1]

[1] *Penn State University*

Recent instruments deployed in space or on stratospheric balloons are targeted at the study of a variety of energetic cosmic particles, including protons and nuclei, electrons, antimatter particles, secondary nuclei (including isotopes), ultraheavy nuclei, all complementing gamma-ray studies. Thus a new wealth of data is providing fresh insights on high-energy phenomena in the Galaxy. The instruments are large and deployed for long exposures, providing for an energy reach that permits direct cross-comparisons with ground-based measurements. We briefly review the state of the field, focusing on present and near future efforts.

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Recent very-high-energy (VHE) results on pulsars and pulsar wind nebulae (PWN)

Autor Christo Venter[1]

[1] *North-West University*

For many years, high-energy pulsar models were rather uncertain as to the expectations of detectable pulsed TeV spectral components from pulsars. Surprisingly, MAGIC announced the detection of pulsations from the Crab pulsar up to 25 GeV in 2008, followed by the VERITAS pulsed detection up to 400 GeV, and finally MAGIC's detection up to 1.5 TeV. This opened a new window into pulsar science. H.E.S.S.-II next detected pulsed emission from the Vela pulsar in the sub-20 GeV to 100 GeV range, with their latest observations unveiling pulsed emission at a few TeV. Additionally, H.E.S.S.-II detected pulsed emission from PSR B1706-44 in the sub-100 GeV energy range, and MAGIC detected pulsed emission from the Geminga pulsar between 15 GeV and 75 GeV. These new detections open up questions as to the origin and nature of the VHE pulsed spectra from pulsars, challenging theorists to rethink established theoretical frameworks. Additionally, these new constraints naturally feed into the study of VHE pulsar wind nebulae (PWNe) that surround the energetic pulsars. In 2018, H.E.S.S. released a PWN VHE catalogue based on their 9-year Galactic Plane Survey, revealing new correlations and spurring on theoretical progress. HAWC has furthermore detected spatially extended

TeV sources (pulsar halos) surrounding two middle-aged pulsars, opening questions regarding PeV accelerators. In this talk, I will discuss some recent progress in the field and assess the theoretical progress that has been made. I will also mention the questions that the Cherenkov Telescope Array (CTA) will be able to tackle.

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Interpreting the GeV and TeV pulsar emission

Autor Constantinos Kalapotharakos[1]

[1] *University of Maryland / NASA GSFC*

Fermi-LAT observations have provided a wealth of data in the GeV band. Moreover, recent observations from ground-based imaging atmospheric Cherenkov telescopes have revealed multi-TeV pulsed emission. The consensus from the latest theoretical modeling is that the high-energy pulsar emission is produced in the equatorial current sheet outside the light cylinder. I will discuss how the observational data along with theoretical considerations constrain the various emission processes (curvature, synchrotron, inverse Compton). I will show that the entire Fermi pulsar population (young and millisecond pulsars) lies on a Fundamental Plane that connects the total gamma-ray luminosity, the cut-off energy, the spin-down power, and the stellar surface magnetic field, which is consistent with curvature radiation emission. Nonetheless, synchrotron radiation can reproduce the lower energy (up to infrared) segment of the pulsar spectrum, while its photons can serve as the seeds that produce emission up to multi-TeV radiation in IC interactions with the high-energy curvature emitting electrons. Finally, I will present our innovative kinetic PIC models of global pulsar magnetospheres that validate the above description.

Gamma ray astronomy IV/Heliophysics / 73

Unresolved questions about the heliosphere

Autor Romana Ratkiewicz[1]

[1] *Space Research Center PAS*

Over the course of more than six decades numerous and sophisticated models of the interaction of the solar wind (SW) with the Local Interstellar Medium (LISM) have been developed. As a result of this interaction, the heliosphere was formed. Understanding of the heliosphere and surrounding it region is necessary to enable future investigations, aimed for example at exploring the structure and evolution of other astrospheres. Between many unresolved science questions on the nature of the heliosphere two are fundamental: "how does the heliosphere look like?" and "where is the nose of the heliospfere"? The aim of this presentation is to try to answer these questions.

Dark matter / 58

Overview of dark matter searches

Autor Marcin Kuźniak[1]

[1] *AstroCeNT / CAMK PAN*

Dark matter accounts for 23% of the mass-energy density of the Universe, however, its nature and origins remain the most important open questions in physics. The search for Weakly Interacting Massive Particles (WIMPs), one of the leading dark matter particle candidate, is now in a decisive phase. This talk will present the status of the leading experimental searches and summarize constraints on the main theoretical models. Special attention will be given to detectors based on liquefied noble gases: xenon and, in particular, argon. Finally, perspectives and limitations for future dark matter searches with very large next generation detectors will be discussed.

Dark matter / 80

ALICE at the LHC, neutron stars and indirect dark matter searches

Autor Laura Šerkšnytė[1]

[1] *Technische Universitaet Muenchen (DE)*

In recent years, the ALICE Collaboration carried out dedicated measurement campaigns to advance the understanding of the physics of neutron stars and indirect dark matter searches and provided new input for the nuclear physics underlying these astrophysics phenomena. The study of the internal structure of neutron stars relies on the knowledge of two- and three-body strong interaction for hadrons containing light quarks (u, d and s). The study of particle correlations in momentum space (femtoscopy) performed by ALICE provided results with unprecedented precision for the strong interaction between all the hadron pairs of interest for the physics of neutron stars. The measurements of the p-Lambda, p-Sigma, p-Xi, p-phi as well as p-p-p and p-p-Lambda correlations will be discussed in the context of the equation of state of neutron stars containing nucleons and strange hadrons.
The second research area connected to astrophysics focuses on the study of the formation mechanisms of light antinuclei and their interaction with ordinary matter. Indeed, antinuclei can either be produced by high-energy cosmic rays or dark matter annihilations in our galaxy and the indirect dark matter searches need a microscopic understanding of the antinuclei properties which can be studied at accelerators. In this context, we will discuss the differential measurements of antideuterons and antihelium-3 and the study of their annihilation cross sections in the context of antinuclei detection in the Earth's proximity.

Dark matter / 38

Direct searches for cold dark matter in DarkSide-20k

Autor Malgorzata Haranczyk[1]

[1] *Jagiellonian University*

Many astronomical observations indicate that the known matter accounts only for a small fraction of the observed gravitational matter of the Universe. The remaining mass, called dark matter, could be explained by weakly interacting particles with properties different from ordinary matter. Direct detection of that dark matter would be a changing discovery in the history of science and would open a gateway for further investigation of a major part of our Universe. A leading candidate for dark matter are weakly interacting massive particles, WIMPs, a relic of the Big Bang with mass in the GeV/c2 - TeV/c2 range.
In the talk the current status of the DarkSide-20k experiment will be presented. DarkSide-20k is a low-energy-threshold liquid argon based detector (TPC containing 50 tons of LAr, 20 tons fiducial) capable of identifying nuclear recoils from WIMP over the course of a very large exposure. Due to its unique light emission properties and pulse shape discrimination abilities, liquid argon can provide excellent sensitivity for WIMP collisions and strong background suppression. The DarkSide-20k experiment will reach the cross section vs. mass range in the search for dark matter of 4.6 x 10^{-48} cm^2 for the 90% C.L. exclusion and 1.5x 10^{-47} cm^2 for the 5 discovery significance for a 1 TeV/c2 WIMP after a 500 t yr exposure. It is well beyond any current or presently funded experiments.

This will allow us to discover, confirm or exclude the WIMP dark matter hypothesis down to the level where atmospheric neutrinos induce an irreducible background, the so-called neutrino floor. Unique features of DarkSide-20k is usage of depleted LAr (1500 lower specific activity of Ar-39 with respect to normal argon) and large-surface array of low-background SiPMs for scintillation light detection.

Dark matter / 7

Dark Matter Searches Through Multi-Messenger Observations of Compact Stars

Autor David Alvarez-Castillo[1]

[1] *Institute of Nuclear Physics PAS*

The purpose of this talk is discuss the possibility of detection of dark matter through multiple observations of compact stars and related phenomena. Recent scientific and technological developments have allowed for a better study of the nature of these astrophysical objects, in particular of the equation of state (EoS). As we advance on the quest for clarification of the neutron star internal content, we will be able to reveal or discard the existence of dark matter in the corresponding stellar environments. In one hand, new channels of multi-messenger observations like gravitational radiation from merger events of binary systems of compact stars or radio and X-ray signals from isolated pulsars have revealed the most their most basic structural properties like mass, radius, compactness, cooling rates and compressibility of their matter. In the other hand, nuclear measurement and experiments have narrowed the EoS uncertainty in the lowest to intermediate density range. Importantly, there exist several types of violent, transient energetic emissions associated not only with the strong magnetic fields and extreme gravity in the proximity of these objects but with explosive, evolutionary stages often triggered by mass accretion from companion stars. Therefore, we expect that the presence of dark matter will leave an imprint in the many kinds of detected signals from compact stars.

Astrophysical neutrinos II / 88

The Status of DUNE

Autor Andrzej Michal Szelc[1]

[1] *University of Edinburgh (GB)*

Long-baseline neutrino oscillations hold the key to understanding the crucial open questions in neutrino physics: what is the neutrino mass ordering and is the Charge-Parity(CP) symmetry violated in the lepton sector. The Deep Underground Neutrino Experiment (DUNE) is being constructed at the Sanford Underground Research Facility (SURF) in South Dakota to adress these very questions. It will employ 70 kTons of liquid argon to detect neutrinos travelling a distance of 1300km from Fermilab, near Chicago. The liquid argon time projection chamber (LArTPC) technology will also enable a broad range of non-beam physics, such as measurements of atmospheric and astrophysical neutrinos. In this talk, I will present the the status of the DUNE experiment and its sensitivity to beam and non-beam neutrino physics.

Astrophysical neutrinos II / 14

The latest T2K neutrino oscillation results and the future of the T2K experiment

Autor Marcela Batkiewicz-Kwaśniak[1]

[1] *IFJ PAN*

T2K is an accelerator neutrino experiment conducted in Japan, which studies of oscillations from muon (anti)neutrinos disappearance and electron (anti)neutrinos appearance at a distance of 295 km between the set of near detectors (at J-PARC) and the far detector SuperKamiokande (SK, at Kamioka). It has already provided world-leading measurements of the two oscillation parameters: θ23 mixing angle and δCP phase, describing the CP symmetry conservation/violation for neutrinos, as well as many cross-section measurements of muon and electron neutrino and antineutrino interactions.
Currently, T2K is heading towards phase II of the experiment (T2KII), which involves major upgrades of the neutrino beamline and the ND280 near detector. The goal of T2KII is to confirm CP symmetry violation in the neutrino sector at over the 3σ level. The successor of the T2K experiment will be the Hyper-Kamiokande (HK) experiment. It will use the same beamline and set of the near detectors, but as a far detector it will use the Hyper-Kamiokande detector, which will be eight times more sensitive than SK. The HK experiment physics program includes confirmation of CP violation at the 5σ level, searching for proton decay and cosmic neutrino studies, including Supernova Relic Neutrinos and Solar Neutrinos. The start of T2KII and HK is scheduled for 2023 and 2027, respectively.
I will show the latest T2K neutrino oscillation results and the status of the work performed for the second phase of the T2K experiment and the Hyper-Kamiokande experiment, as well as their physics program.

Astrophysical neutrinos II / 64

Experimental detection of the CNO cycle

Autor Marcin Misiaszek[1]

[1] *Jagiellonian University*

The Borexino has recently reported the first experimental evidence of neutrinos from the CNO cycle. Since this process accounts only for about 1% of the total energy production in the Sun, the associated neutrino flux is extremely low as compared with the one from the pp-chain, the dominant process of hydrogen burning. This experimental evidence of the CNO neutrinos was obtained using the highly radio-pure liquid scintillator of Borexino. Improvements in the thermal stabilization of the detector over the last five years enabled us to exploit a method to constrain the rate of Bi-210 background. Since the CNO cycle is dominant in massive stars, this result gives the first experimental proof of the primary mechanism for stellar conversion of hydrogen into helium in the Universe.

Astrophysical neutrinos II / 100

Search for Neutrinoless Double Beta Decay of 76Ge with GERDA - final latest results

Autor Grzegorz Zuzel[1]

[1] *Jagiellonian University*

The GERDA experiment, located in the underground Laboratori Nazionali del Gran Sasso in Italy, has been designed to search for the neutrinoless double-beta (0vbb) decay in 76Ge. It used in different stages of the project up to 44 kg of high purity germanium (HPGe) detectors enriched up to about 86% in the isotope 76Ge. The bare detectors were operated in liquid argon, which served in the first phase as a passive, and later, in the second phase of the experiment, also as an active shield. The combination of powerful background suppression techniques (liquid argon veto and pulse shape discrimination) together with excellent energy resolution of HPGe detectors allowed GERDA to be the first background-free (less than 1 background event expected in the region of interest) 0vbb decay experiment. After about 5 years of data taking together in Phase I and Phase II more than 100 kg*yr of data has been accumulated, as foreseen in the original proposal. Combining all available data no signal has been observed, and a lower limit on the half-life of the 0νββ decay in 76Ge is set at T1/2 > 1.8 x 10^{26} yr at 90% C.L, which is presently the strongest limitation. It may be translated into an upper limit of the effective neutrino mass of mee < (79 - 120) meV, depending on the used matrix elements. In the talk the design of the experiment and details of the data analysis will be presented. A prospect for the successor Legend-200 experiment will be outlined as well.

Young Scientists' Session: Dark matter and astrophysical neutrinos / 28

Investigating the effect of dark matter component on neutron star equation of state using the gravitational wave observation from binary neutron star merger GW170817

Autor Arpan Das[1]

[1] *Institute of Nuclear Physics Polish Academy of Sciences Krakow*

We investigate the effect of a dark matter component inside a neutron star using gravitational wave constraints coming from binary neutron star merger. We consider the nuclear matter using the relativistic mean-field model including $\sigma - \omega - \rho$ meson interaction. We study fermionic dark matter interacting with nucleonic matter via the Yukawa interaction inside the neutron star. We show that admixture of dark matter inside the neutron star softens the equation state which gives rise to a lower value of the tidal deformability. Gravitational-wave observation GW170817 puts a constraint on the upper bound on the tidal deformability of a binary neutron star. Such gravitational wave observation puts a stringent constraint on the nuclear equation of state. We investigate any physical implication of such an observational constraint coming from the gravitational wave observation on the dark matter admixed neutron stars. We argue that in the presence of a dark matter component even the stiff equation of state, e.g. the Walecka model with NL3 parameterization satisfy the tidal deformability bound coming from the gravitational wave observation.

Reference: This abstract is based on our works, Phys. Rev. D 99, 043016 (2019) and arXiv:2011.01318

Young Scientists' Session: Dark matter and astrophysical neutrinos / 9

The ICARUS detector for the Short-Baseline Neutrino (SBN) experiment at Fermilab

Autor Marta Babicz[1]

[1] *IFJ-PAN*

ICARUS is one of three liquid argon time projection chambers (LArTPCs) of the Short-Baseline Neutrino (SBN) Program at FNAL. SBN's purpose is to address the observed neutrino measurement anomalies seen by experiments such as LSND and MiniBooNE, and the potential existence of sterile neutrinos. ICARUS underwent an overhaul at CERN and has now been transferred to FNAL where ICARUS will serve as the far detector in a physics run for the SBN Program. ICARUS resides in the Booster Neutrino Beam (BNB), and is currently ready for physics data taking (Run1) by the end of the year. This talk will present the current status of the ICARUS detector and its physics goals.

Young Scientists' Session: Dark matter and astrophysical neutrinos / 70

Method for simulation of light propagation in water for large-scale underwater Cherenkov telescopes

Autor Wojciech Noga[1]

[1] *The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences*

Large-scale neutrino telescopes, such as Baikal-GVD or ORCA, require calibration and testing of the optical modules. Calibration methods typically use laser and LED-based systems to not only test the telescope's response to light, but also to monitor optical parameters of water, such as absorption and scattering lengths, which show seasonal changes in natural water bodies. In addition, the high-energy laser is a strong light source that can cause damage to the optical modules under some conditions, hence the need to simulate the light distribution in the telescope volume as quickly as possible, taking into account the varying conditions of the medium and the configuration of the telescope components. In this work we show an efficient/fast tool for the simulation of laser light propagation in the active volume of neutrino telescope. Fast simulations may be used to choose the correct and safe parameters of the light source, like energy, intensity, direction, thus can improve the calibration procedure. The cross-check of our simulation results, such as arrival time and expected signal recorded by the optical modules with Geant4 simulations has been also presented.

Young Scientists' Session: Dark matter and astrophysical neutrinos / 53

VERITAS follow-up observations of dwarf nova MASTER OT J030227.28+191 as a possible neutrino counterpart

Autor Maria Kherlakian[1]

[1] *DESY*

A dwarf nova, MASTER OT J030227.28+191754.5, was detected as a possible counterpart of the astrophysical neutrino candidate IceCube-211125A. Follow-up observations by the VERITAS instrument of the nova location resulted in no detection for an exposure of 5.5 h. The nova was seen as a 10 mag outburst by the MASTER-Tavrida auto-detection system in temporal coincidence with the neutrino. Moreover, a possible blazar, 4FGL J0248.0+2232, lies within the the 90% localization region of the neutrino. A further combined analysis with 1h exposure on 4FGL J0248.0+2232 still yielded no detection. In this presentation we discuss the flux upper limits obtained from the analysis of the VERITAS data and the gamma and neutrino emission mechanisms from novae.

Young Scientists' Session / 94

Numerical study of orbital and statistical behaviors of galactic cosmic rays invading into the heliosphere

Autor Kotaro Yoshida[1]

[1] *Interdisciplinary Graduate School of Engineering Science, Kyushu University*

We have studied the transport process of galactic cosmic rays invading into the heliosphere using test particle simulations embedded in global MHD simulation of the heliosphere. The heliosphere was reproduced by an MHD simulation under the assumptions that the solar wind is steady with northward solar magnetic polarity and zero tilt angle. Motions of a number of test particles (=galactic cosmic rays) in and near the virtual heliosphere are solved to analyze their detailed orbits and statistics as well focusing especially on the effects of heliospheric boundary structures.

Young Scientists' Session / 92

Galactic magnetars as transient ultra high energy cosmic ray sources

Autor Vadym Voitsekhovskyi[1]

[1] *Astronomical Observatory of Kyiv National University*

Search for sources of ultra high energy cosmic rays (UHECRs, $E > 10^{18}$ eV) remains one of the main unsolved problems in modern astrophysics. Galactic magnetars are potential candidates for the UHECR accelerators due to their ability to generate relativistic plasma flows and shock waves during magnetar giant flares. Favorable conditions for UHECR acceleration also occur during a Supernova ejecta energisation and a magnetar wind nebula (MWN) formation by newborn millisecond magnetars. In both cases, typical signatures of hadronic and leptonic CR acceleration are neutrino and broad-band (from the radio to gamma-ray) non-thermal emission. In this work we show that Galactic magnetar SGR1900+14 is a potential transient source of UHECRs. Detected by Auger and Telescope Array positionally coincident triplet of UHECRs with $E > 10^{20}$ eV can be accelerated in the giant flare of the SGR1900+14. Moreover, high-energy and very high-energy gamma-ray emission from magnetar SGR1900+14 outskirts (Fermi-LAT 4FGL J1908.6+0915e, H.E.S.S. HESS J1907+089, and HAWC 3HWC J1907+085 sources) can be explained by the acceleration of CRs in a magnetar-connected Supernova remnant and/or MWN. Necessary energy reserve of the SGR1900+14 progenitor can be provided by the newborn millisecond magnetar with initial rotational energy $W_{rot} \sim 10^{52}$ erg.

Young Scientists' Session / 34

Cosmic rays acceleration in SN 1006

Autor Roberta Giuffrida[1]

[1] *Università degli studi di Palermo - Osservatorio Astronomico di Palermo*

Supernova remnants are expected to be the main source of Galactic cosmic rays up to energies of about 3 PeV, provided that they transfer a significant fraction of their kinetic energy to the particles. The bilateral supernova remnant SN 1006 shows bright synchrotron X-ray emission from ultrarelativistic electrons accelerated at the shock front in its northeastern and southwestern limbs. If efficient hadron acceleration occurs in these regions, we expect that it affects the shock dynamics by enhancing the shock compression ratio above the canonical value of 4. We performed a spatially resolved spectral analysis of Chandra and XMM-Newton observations of SN 1006 by measuring the density of the shocked ambient medium in narrow regions between the shock front and the contact discontinuity. Our results show an increase of the compression ratio up to ~ 7 in northeastern and southwestern limbs, i.e. in regions where the ambient magnetic field is almost parallel to the shock velocity. We conclude that an efficient particle acceleration causes shock modification in quasi-parallel shocks in SN 1006. By comparing our results with state-of-the-art models, we find that SN 1006 is transferring a significant fraction of its kinetic energy to hadrons.

Young Scientists' Session / 77

A spatially resolved study of hard X-ray emission in Kepler's SNR: indications of different regimes of particle acceleration

Autor Vincenzo Sapienza[1]

[1] *INAF-OAPa*

Synchrotron X-ray emission in young supernova remnants (SNRs) is a powerful diagnostic tool to study the population of high energy electrons accelerated at the shock front and the acceleration process. We performed a spatially resolved spectral analysis of NuSTAR and XMM-Newton observations of the young Kepler's SNR, aiming to study in detail its non-thermal emission in hard X-rays. We selected a set of regions all around the rim of the shell and extracted the corresponding spectra. Then the spectra were analyzed by adopting a model of synchrotron radiation in the loss-limited regime, to constrain the dependence of the cutoff energy of the synchrotron radiation on the shock velocity. We identify two different regimes of particle acceleration, characterized by different Bohm factors. In the north, where the shock interacts with a dense circumstellar medium (CSM), we found a more efficient acceleration than in the south, where the shock velocity is higher and there are no signs of shock-cloud interaction. Our results suggest an enhanced efficiency of the acceleration process in regions where the shock-cloud interaction generates an amplified and turbulent magnetic field. By combining hard X-ray spectra with radio and gamma-ray observations of Kepler's SNR, we propose that the observed gamma-ray emission is mainly hadronic and originates predominantly in the northern part of the remnant.

Young Scientists' Session / **33**

PIC simulations of SNR's shock waves with a turbulent upstream medium

Autor Karol Fułat[1]

[1] *University of Potsdam*

Investigation of astrophysical shocks has a major importance in understanding physics of the cosmic rays acceleration. Electrons to be accelerated at shocks must have an injection energy, which implies that they should undergo some pre-acceleration mechanism. Many numerical studies examined possible injection mechanisms, however most of them considered homogenous upstream medium, which is unreal assumption for astrophysical environments. We will to investigate electron acceleration at high Mach number and low plasma beta shocks using 2D3V particle-in-cell simulations with a turbulent upstream medium. Here we discuss method of generation of the compression-dominated turbulence. It is sufficiently long-living to be inserted into a shock simulation, as well as their parameters represent the high Mach number and low beta regime.

Young Scientists' Session / **89**

Hydrodynamics and radiation from colliding pulsar and stellar winds in a high-mass binary system

Autor Gabriel Torralba Paz[1]

[1] *IFJ PAN*

X-ray binaries are systems consisting on a massive star and a compact object. If the compact object is a pulsar, both the star and the pulsar will have their own winds. When both winds clash, they produce a contact discontinuity which creates shocked flows that go away from the binary and are affected by the orbital motion of the system. These flows are a plasma made by charged particles and

it is assumed to be ideal and in adiabatic conditions. Under these assumptions we can compute the hydrodynamic properties in particular of the shocked pulsar wind as well as its radiation by inverse Compton scattering. The model tries to explain the hydrodynamics and radiation close to the binary system, called the ”inner region”, and in the ”outer region” up to a certain distance from the star. The results show a shocked wind that bends as a spiral with a decreasing pressure, density and specific enthalpy as the shocked wind goes further away, while the Lorentz factor starts increasing but ends up decreasing. This, as well as the Doppler boosting, affects the observer luminosity along the orbit. The variation of the luminosity over a whole orbit gives us information about the inclination, the processes involved in the shocked pulsar wind and its emission, and the properties of both the massive star and the compact object.

Young Scientists' Session / 60

Jump Conditions for a Relativistic Shock Propagating in a Resistive Medium

Autor Argyrios Loules[1]

[1] *National and Kapodistrian University of Athens*

Relativistic shocks possess a central role in energetic astrophysical phenomena, with gamma-ray bursts (GRBs) being a prominent example. This has led to the extensive investigation of the properties of shocks propagating in both non-magnetized and magnetized fluids characterized by infinite electrical conductivity. The derivation of the jump conditions for a relativistic shock propagating in a finite conductivity medium is presented. By the assumption of a relativistic equation of state for the shocked gas, its Lorentz factor in the unshocked medium's comoving frame may be determined and consequently its density, pressure, and electromagnetic field. Finally, the effects of the shocked medium's conductivity on its hydrodynamic quantities and electromagnetic field are investigated.

Young Scientists' Session / 84

Stability analysis of relativistic magnetised astrophysical jets: a hyper-unstable solution

Autor Charalampos Sinnis[1]

[1] *National Kapodistrian University of Athens*

Astrophysical jets are considered among the most stable structures throughout the cosmos, as they are able to propagate to distances many times their initial radii. In this context we conduct a linear stability analysis on astrophysical outflows, for which the dynamics are described by the relativistic magnetohydrodynamics. A new peculiar solution emerged, having instabilities' growth timescales comparable to the light crossing time. These time intervals are extraordinarily small compared to values already found in the literature, hence we name the mode as hyper–unstable. We study and find the jet physical parameters affecting the new mode, and the parameters' range for which these hyper–unstable solutions are present. The mode is characterised as local, due to the fact that it is developed mainly at the boundary of the jet. In addition, we run a series of simulations in order to study the non–linear evolution of this mode. The simulations verify the analytical results and showcase a new specific configuration established. A really interesting trait of this new configuration is the creation of vortices which do not dissipate and travel with relativistic velocities for timescales of several hundred jet light crossing times.

High energy particle physics / 59

Probing the QCD phase diagram with HBT femtoscopy

Autor Sandor Lokos[1]

[1] *Institute of Nuclear Physics Polish Academy of Sciences (PL)*

The first observation of intensity correlation between bosons, namely photons was observed in the field of radio astronomy by Hanbury Brown and Twiss, hence such quantumstatistical correlations usually referred as HBT correlations. Quantumstatistical correlations were also observed in particle physics, firstly by Goldhaber, Goldhaber, Lee and Pais among same charged pions. They could explain the measured data by took into account for the Bose-Einstein symmetrization of the wave function of indistinguishable bosonic particles. Nowadays, HBT or Bose-Einstein correlations are widely used technique to measure the spatio-temporal properties of the particle emitting source but their importance are not solely given by their direct relation to the source size but their possible connections to underlying processes such as partially coherent particle production, in-medium mass modification or critical phenomena.
With limited statistics, the Gaussian shape of the correlation function was assumed but recent measurements have revealed a more detailed structure of the correlation functions. By employing Levy-type of correlation functions a new parameter, the Levy-index is introduced which could indicate several physical processes. It also gives statistically acceptable description of the measured data. In the special case, when the Levy-index is equal to 2 it restores the Gaussian distribution, when equal to 1, restores the Cauchy distribution. Interstitial values could be explained by anomalous diffusion, QCD jets, vicinity of the hypothetical critical point on the QCD phase diagram. These possibilities could mean motivation to perform precise HBT measurements to clarify the physical meaning of the Levy-index. Its possible relation to critical phenomena could make the measurements of the Levy-index a good tool to investigate the phase diagram of the strongly interacting matter. The precise measurements of the strength of the correlation, however, could give an insight to the particle production.
In my presentation I will review the theoretical background of the Levy HBT correlation measurements and then will give an overview results from BNL (PHENIX and STAR) and from CERN (CMS and NA61).

Young Scientists' Session / 83

Non-boost-invariant description of polarization within hydrodynamics with spin

Autor Rajeev Singh[1]

[1] *Institute of Nuclear Physics Polish Academy of Sciences*

Abstract: Space-time evolution of spin polarization within the framework of hydrodynamics with spin based on de Groot - van Leeuwen - van Weert forms of energy-momentum and spin tensors is studied. Due to the non-boost invariant flow in the system the spin polarization components couple to each other implying some effects on the spin polarization observables. We study transverse-momentum and rapidity dependence of mean spin polarization vector for Lambda hyperons. Our results show qualitative agreement for rapidity dependence of the global spin polarization with the experiments and other models. The quadrupole structure of the longitudinal component at midrapidity is not found, however, as compared to the results for Bjorken expansion, some non-trivial signal at forward rapidities is observed. (Based on https://arxiv.org/abs/2112.01856)

Young Scientists' Session / 11

Separation of Quark and Gluon Jets using Angularities

Autor Petr Baron[1]

[1] *IFJ Pan Krakow*

As a result of hadronization, the partons (quarks and gluons) are being observed via objects called jets which represent energy deposits in clustered calorimeters with associated jet reconstruction algorithm. This study investigates the determination of the initial parton from which the jet evolved based on five variables called angularities. Having a discriminant on an event-by-event basis could enhance the reach for Beyond Standard Model since most of the signal regions are being dominated by quarks and on the other hand in the Standard Model signal regions are populated mostly by gluons. The results provide an evaluation of the most suitable angularity with respect to the jet radius, beam energy, and trimming techniques, which can be the starting point for novel measurement at the Large Hadron Collider at CERN.

Young Scientists' Session / 13

Double-parton Scattering at LHCb and Pythia Tunings

Autor Saliha Bashir[1]

[1] *AGH University of Science and Technology (PL)*

High energy proton-proton and proton-lead collisions may proceed via double-parton scattering. In addition, soft interactions accompany any hard process. To describe these processes, Pythia parameters are revised and constantly tuned to match Run 2 LHC data and to make better predictions that would fit the astrophysics data. In this presentation, the recent LHCb results on double-parton scattering are described. The study how tunes of the Pythia parameters in simulation influence the hadron multiplicities in proton-proton collisions at 14 TeV center-of-mass-energy will also be presented.

Young Scientists' Session / 29

Early charm physics at Belle II

Autor Sanjeeda Bharati Das[1]

[1] *Malaviya National Institute of Technology Jaipur*

Analyses of D meson yields as functions of decay time provide access to fundamental standard model parameters and probe natural non-SM scales at 10-100 TeV energies. Outstanding vertexing performances are key enablers of this program. We prove the capabilities of the Belle II detector by measuring the lifetimes of the D0 and D+ mesons. The results are the most precise to date, owing to a vertexing resolution 2x better than that of Belle and BaBar. Perspectives on the sensitivity to the main observables in charm physics. First results obtained on relevant channels with early data sets are shown.

Young Scientists' Session / 37

Strong evidence of the rho(1250) from a unitary multichannel reanalysis of elastic scattering data with crossing-symmetry constraints

Autor Nadine Hammoud[1]

[1] *IFJ, PAS*

We present an analysis of elastic P-wave $\pi\pi$ phase shifts and inelasticities up to 2 GeV, in order to identify the corresponding $J^{PC} = 1^{--}$ excited ρ resonances and focusing on the $\rho(1250)$ vs.\ $\rho(1450)$ controversy. In our approach we employed an improved parametrization in terms of a manifestly unitary and analytic three-channel S-matrix with its complex-energy pole positions. The included channels were $\pi\pi$, $\rho 2\pi$, and $\rho\rho$. The improvement with respect to prior work amounts to the enforcement of maximum crossing symmetry through once-subtracted dispersion relations called GKPY equations. A clear picture emerges from this analyses, identifying five vector ρ states below 2~GeV which are $\rho(770)$, $\rho(1250)$, $\rho(1450)$, $\rho(1600)$, and $\rho(1800)$, with $\rho(1250)$ being indisputably the most important excited ρ resonance.

Young Scientists' Session / 39

Second Generation Machine Learning based Algorithm for Long-lived Particles Reconstruction in Upgraded LHCb Experiment.

Autor Sabin Hashmi[1]

[1] *AGH University of Science and Technology Krakow*

Large Hadron Collider- beauty (LHCb) is one of the four large experiments operating currently at Large Hadron Collider(LHC) it is designed to study New Physics phenomena in the heavy flavor quarks sector and perform precise measurements of CP symmetry violation in beauty and charm quarks sector. At present, the detector is undergoing a major upgrade with respect to its original design. In order to filter out the data produced by each proton-proton interaction, it requires a robust trigger system. In the upgraded system, the hardware trigger that worked based on information from Calorimeters and Muon Systems is completely removed instead a flexible fully-software trigger will be used. Machine Learning based Long-lived particle reconstruction algorithm is a part of this new upgraded system. It will apply a cascade of filters to remove fake tracks and improve both the efficiency and purity of the final track samples. The machine learning models make the decisions based on the data. The performance of the data pipeline will be highly optimized without the limitations of having a Hardware Trigger System. LHCb experiment collected during Run 1 and Run 2 a data sample corresponding to integrated luminosity of 9 fb-1, whilst after Run 3 and Run 4 the integrated luminosity should reach at least 50 fb-1. Thus this approach is vital for the upgrade to remove rigid cuts on measurable parameters, avoid the limitations of hardware degradations and replacements by making the entire system more complex and help us understand the Physics that we never knew before.

Young Scientists' Session / 48

Event reconstruction in MUonE experiment at SPS accelerator

Autor Izabela Juszczak[1]

[1] *Polish Academy of Sciences (PL)*

The MUonE experiment planned to be operating at the SPS accelerator in 2021-2022 (pilot run) and 2023-26 provides a great potential to search for New Physics in the sector o of the anomalous muon magnetic moment a_μ. The discrepancy between the most accurate determination of a_μ and the Standard Model predictions is about 4 standard deviations, and an analogous improvement is required in precision of theoretical prediction, dominated by uncertainty related to hadronic contribution, expected to be the main limitation of eventual discovery. MUonE experiment will allow for a precise measurement of hadronic contribution to a_μ employing the measurement of shape of differential cross section for the μe -> μe elastic process. This would help to increase the significance of observed discrepancy to the level of 7 standard deviations. The crucial issue in this kind of study is the development of the event reconstruction procedures, allowing for reduction the systematic effects, and at the same time to achieve high angular resolution, together with very good precision and efficiency of the track and vertex reconstruction.

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Charmonium as a probe of hot quark matter in nuclear collisions in ALICE at the LHC

At extremely high temperatures and densities, hadronic matter undergoes a phase transition to a state of deconfined quarks and gluons known as quark-gluon plasma (QGP). It is believed that our universe had been in such deconfined state just after the big bang when the temperature was of the order of several thousand billion degrees. Such state of matter might be also present in the inner core of Neutron Stars (NSs), where nuclear matter can reach extremely high densities. Ultrarelativistic nuclear collisions offer an opportunity to study the properties of QGP by achieving such extreme conditions in the laboratory. Charmonia, bound states of charm and anti-charm quarks, serve as an efficient probe of the QGP in nuclear collisions.
In this contribution, recent charmonium measurements performed by the ALICE collaboration in Pb–Pb collisions, will be shown. In particular, observables that are especially sensitive to the properties of the QGP, such as nuclear modification factors (RAA) and elliptic flow (v2) of inclusive J/ψ meson in Pb–Pb collisions at collision energy of 5.02 TeV, will be presented. The comparison of results with available theoretical model calculations will also be discussed.

High energy cosmic rays I / 30

Study of galactic cosmic rays with the DAMPE space mission

Autor Ivan De Mitri[1]

[1] *Gran Sasso Science Institute (GSSI) and INFN*

DAMPE (DArk Matter Particle Explorer) is a satellite-born experiment smoothly taking data since its launch in december 2015. The detector features (good resolutions, large geometric factor, etc.) allow measuring the energy spectra of galactic cosmic rays (electrons/positrons , protons and single nuclear species) up to hundreds of TeV (few TeV in case of electrons/positrons). A first direct evidence of a cutoff of the all-electron spectrum was evidenced at about 1 TeV, while new features on proton and He nuclei spectra were detected at few tens of TeV. A review of the lastest mission results will be given.