EP 11: Astroparticles: From the source to the detector (joint session EP/T)

Time: Thursday 16:15–18:30 Location: EP-H1

EP 11.1 Thu 16:15 EP-H1

Multi-messenger studies with gravitational waves and neutrinos — •Tista Mukherjee for the IceCube-Collaboration — Institute for Astroparticle Physics (IAP), Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

IceCube is a neutrino observatory located in Antarctica. Since its discovery of a high-energy neutrino (IC170922A) from the blazar TXS0506+056 in 2017, neutrino astronomy has been established as a viable option to probe the high-energy Universe. Neutrinos can carry undistorted information about their respective astrophysical sources, thus can serve as a cosmic 'messenger' to us. There are other potential messengers as well, e.g. gravitational waves (GW) and cosmic rays other than the traditional photons of various wavelengths. Combining interesting signals of such messengers available from different observatories leads us towards multi-messenger searches, allowing us to address many of the so far unanswered questions about the fundamentals of this Universe, such as the origin of ultra-high-energy cosmic ray sources. So far, we have the knowledge of detecting electromagnetic signal in multiple wavelengths, spatially and temporally correlated with GW and high-energy neutrinos, as two separate events. However, there is still a missing link as we have not been able to correlate GW with neutrino signals. The aim of my work is to contribute in this aspect, searching for Virgo detected GW counterparts of neutrino events detected by IceCube, including low-energy neutrinos as well as sub-threshold GW events in our analysis. The work plan and initial results will be discussed in this talk.

EP 11.2 Thu 16:30 EP-H1

Multi-messenger characterization of Mrk501 during historically low X-ray and gamma-ray activity — •Lea Heckmann[1], David Paneque[1], Sargis Gasparyan[2], Matteo Cerruti[3], Narek Sahakyan[2], and Axel Arbet-Engels[1] for the Multi-wavelength collaborators and the MAGIC and Fermi-LAT-Collaboration — [1]Max-Planck-Institut für Physik, D-80805 München, Germany — [2]ICRANet-Armenia, Marshall Baghramian Avenue 24a, Yerevan 0019, Armenia — [3]Institut de Ciències del Cosmos (ICCUB), Universitat de Barcelona (IEEC-UB), Martí i Franquès 1, 8 E08028 Barcelona, Spain

Blazars are the most numerous very-high-energy (>0.2 TeV, VHE) gamma-ray emitters, due to their continuous and very luminous emission; but they are far from being understood.

In this contribution we describe the multi-wavelength behavior of Mrk501, one of our closest and therefore brightest blazars, from 2017 to 2020. Alongside the dense monitoring campaign over this four years, three long observations with NuSTAR were conducted displaying various low-activity flux levels for the hard X-ray emission. This very comprehensive data set reveals a historically low X-ray and VHE gamma-ray emission period lasting two years. Using the low-activity broadband spectral energy distribution (SED) and data published by IceCube, we investigate the nature of the low state. Additionally, we try to explain the evolution of the broadband SED data during the low state to evaluate its potential of being the baseline emission of Mrk501 that is usually outshone by more dominant and variable components.

EP 11.3 Thu 16:45 EP-H1

Hadronic models of active galaxies to constrain cosmic-ray acceleration — •Xavier Rodrigues — DESY Zeuthen

In a new era of multi-messenger observatories, numerical models can help shed light on what are the sources of the astrophysical neutrinos and the ultra-high-energy cosmic rays. In this talk I discuss recent results on active galactic nuclei (AGN) as multi-messenger sources, based on numerical simulations of photonuclear cosmic-ray interactions. Assuming AGN jets can reaccelerate cosmic rays up to the EeV regime, I will show that an AGN population may in fact dominate the observed flux and chemical composition of ultra-high-energy cosmic rays. Under certain conditions, the accompanying neutrino flux may be observable by future EeV neutrino telescopes, while respecting the current IceCube limits at PeV energies.

EP 11.4 Thu 17:00 EP-H1

Neutrino Emission during Supermassive and stellar mass Binary Black Hole Mergers — •Ilja Jaroschewski[1], Julia Becker Tjus[1], and Peter L. Biermann[2,3] — [1]Theoretische Physik IV, Ruhr-Universität Bochum — [2]MPI for Radioastr., Bonn — [3]Dept. of Phys. & Astron., Univ. Alabama, Tuscaloosa, AL, USA

Ever since the discovery of a diffuse astrophysical neutrino flux by IceCube, the question arose which sources contribute most. With several neutrino-blazar associations since the first high-probability association of such a neutrino to the blazar TXS 0506+056 in 2017, there is an indication that at least a non-negligible part of this diffuse neutrino flux emerges from blazars.

As over ninety stellar mass binary black hole mergers were already detected via gravitational waves (GWs), with more to come, there are strong indications that supermassive black holes (SMBHs) in galaxy centers, and thus blazars, also merge and have had at least one merger in their lifetime. Such a merger is almost always accompanied by a change of observable jet direction, leading to interactions of a preceding jet with surrounding molecular clouds and neutrino productions.

By creating a connection between neutrinos and GWs, we set limits on how much energy can be emitted in form of neutrinos in each merger of binary SMBHs and stellar mass black holes and estimate their contributions to the diffuse neutrino flux that is measured by IceCube. As neutrino production is directly connected to high energy cosmic ray interactions, the contribution of these sources to the cosmic ray injection rate is established.

EP 11.5 Thu 17:15 EP-H1

Search for high-energy neutrinos from blazars with IceCube — •Cristina Lagunas Gualda for the IceCube-Collaboration — DESY Zeuthen

The IceCube Neutrino Observatory is the world's largest neutrino telescope, instrumenting one cubic kilometre of Antarctic ice. IceCube started its operation with full configuration in 2011 and a diffuse flux of neutrinos was discovered in 2013. To this day the sources of those neutrinos are still largely unknown. One of the most promising neutrino source candidates is blazars, Active Galactic Nuclei with jets aligned towards Earth.

In 2018 IceCube reported the first clearly identified observation of an astrophysical high-energy neutrino, IC170922A, in spatial and temporal coincidence with blazar TXS 0506+056. Other examples of coincidences that have been observed with lower significance are, but not limited to, IC190730A with blazar PKS 1506+012 and IC141209A with blazar GB6 J1040+0617. What these have in common is that they involve a blazar and a high-energy neutrino with a high probability of being astrophysical in origin (neutrino alert). These coincidences can be combined to calculate a global p-value by performing a stacking analysis. Here we present the results obtained with the Fourth Catalog of Active Galactic Nuclei detected by Fermi-LAT (4LAC-DR2, for Data Release 2) and neutrinos detected by IceCube between 2011 and 2020 that would have passed the neutrino alert criteria.

EP 11.6 Thu 17:30 EP-H1

Comparison of Models for Predicting Periodic Gamma-Ray & Neutrino Emissions From Blazars — •Armin Ghorbanietemad, Ilja Jaroschewski, and Julia Becker Tjus — Theoretische Physik IV, Ruhr-Unviersität Bochum

There are several indications that electromagnetic emissions from blazars have quasi-periodic variability, ranging from minutes to years. The long-term periodicity in the span of years is particularly evident in gamma-ray observations with the Fermi LAT instrument. Two separate high probability associations of neutrinos, detected by IceCube in 2014/15 and 2017, to the blazar TXS0506+056 further indicate that blazars are neutrino emitters. These two flares can be interpreted as a possible periodicity. It is the aim of this work to develop a general set of models that can explain the periodic gamma-ray and neutrino emissions from blazars.

In this talk, we present models with single supermassive black holes as well as supermassive binary black hole mergers at the centers of blazers. Our focus lies on supermassive binary black hole mergers, due to them radiating gravitational waves which could be detectable by the Laser-interferometer Space Antenna (LISA). The binary systems are characterized by the change of jet direction accompanied by jet precession close to an imminent merger. This allows predictions of possible neutrino and gravitational wave emissions from blazars with quasi-periodic behavior.

EP 11.7 Thu 17:45 EP-H1

First science results from the X-ray telescope STIX on Solar Orbiter — •Alexander Warmuth, Frederic Schuller, and Gottfried Mann — Leibniz -Institut für Astrophysik Potsdam (AIP)

The ESA mission Solar Orbiter was successfully launched in 2020, with the main goal of improving our understanding of how the Sun creates and controls the heliosphere. The Spectrometer/Telescope for Imaging X-rays (STIX) is one of six remote-sensing instruments on board and provides imaging spectroscopy of solar flares in the energy range of 4 to 150 keV. Thus, STIX is able to measure quantitatively both the parameters of the hot flare plasma and the characteristics of the accelerated electrons. Together with the other instruments on Solar Orbiter as well as with other space-borne and ground based observational assets, STIX studies energy release and particle acceleration in solar flares. This talk will be focused on the first science results obtained during the cruise phase of Solar Orbiter (2020 and 2021). This includes observations of microflares, constraints on flare energetics, collaborative studies of gamma-ray flares together with Fermi, and the investigation of flare-associated solar energetic particle events.

EP 11.8 Thu 18:00 EP-H1

Unfolding the muon neutrino energy spectrum from 10 years of IceCube data with DSEA+ — •Leonora Kardum, Karolin Hymon, Johannes Werthebach, Pascal Gutjahr, Tim Ruhe, and Jean-Marco Alameddine for the IceCube-Collaboration — Astroparticle Physics WG Rhode, TU Dortmund University, Germany

Neutrinos, the most elusive particles in the Standard Model, can travel tremendous distances unaffected by magnetic fields or encountered particles from distant sources in the Universe. As this makes them perfect information carriers, many attempts at uncovering their properties are made. The IceCube Neutrino Observatory, a cubic kilometer detector embedded in the South Pole ice, is capable of detecting neutrinos from several GeV up to PeV energies enabling precise reconstruction of the neutrino spectrum. Determining the accurate spectrum is of great importance to neutrino physics, especially in differentiating the three predicted components - prompt, conventional, and astrophysical, of which only the latter two have been detected so far. The Dortmund Spectrum Estimation Algorithm (DSEA+) is a novel approach to unfolding the energy spectrum from measured experimental quantities that effectively translates ill-posed problems to multinomial classification solvable using readily available machine learning tools. The current status of applying DSEA+ on 10 years of IceCube data will be presented.

EP 11.9 Thu 18:15 EP-H1

Recent solar and geoneutrino results from Borexino — •Sindhujha Kumaran for the Borexino-Collaboration — Forschungszentrum Jülich - Institute for Nuclear Physics, IKP-2, Jülich, Germany — III. Physikalisches Institut B, RWTH Aachen University, Aachen, Germany

Borexino is a 280-ton liquid scintillator experiment which ran from May 2007 until October 2021 at the Laboratori Nazionali del Gran Sasso (LNGS), Italy. The main goals of Borexino include the measurement of solar neutrinos and geoneutrinos. The extreme radiopurity and thermal stability of the detector have proven to be valuable assets in achieving these goals. Borexino has not only performed a complete spectroscopy of the dominant pp-chain solar neutrinos but has also provided the first direct experimental evidence of the rare CNO-cycle neutrinos. These measurements have several implications for solar and stellar Physics and further improvements are envisioned using the full dataset. In addition, it has recently presented the first directional measurement of sub-MeV solar neutrinos using the subdominant Cherenkov light, through a novel technique called Correlated and Integrated Directionality (CID). This method can be further combined with a typical spectral fit and can also prove valuable for next-generation liquid scintillator detectors. The latest geoneutrino measurement from Borexino included a substantial improvement in the precision as well as the rejection of the no-mantle signal with a high significance. This group report will summarize all these recent solar and geoneutrino results of Borexino.