The Fifth Gravi-Gamma-Nu workshop

Report of Contributions

https://agenda.infn.it/e/gravigamma5

Contribution ID: **1** Type: **Contributed talk**

Exploiting the standing accretion shock instability for multi-messenger analysis of core-collapse supernovae

Wednesday, 9 October 2024 17:15 (15 minutes)

Core Collapse supernovae are among the most interesting source of possible multimessenger detections, given the joint production of electromagnetic, neutrino and gravitational waves (GW). In this work we investigate the correlation of SASI structure of neutrino and GW to enhance the GW detection. We compare different search analyses for the case of a benchmark three-dimensional CCSN simulation with zero-age main sequence mass of 24 solar masses. In particular, we build a matched filter analysis which increase detection efficiency of 30% with respect to a standard excess power algorithm for nearby CCSN (less than 1.5 kpc). At further distance we expect that additional work is needed to outline the best strategy for GW detection from CCSN.

Primary author: DRAGO, Marco (Istituto Nazionale di Fisica Nucleare)

Presenter: DRAGO, Marco (Istituto Nazionale di Fisica Nucleare)

Session Classification: Day 1: Latest results

Contribution ID: **2** Type: **Invited talk**

Latest results from the LIGO-Virgo-Kagra fourth observing run

Thursday, 10 October 2024 12:30 (30 minutes)

The fourth observing run (O4) of LIGO-Virgo-KAGRA is ongoing, relying on the most sensitive network of gravitational-wave interferometers to date. In this talk, I will highlight some of the most recent astrophysical findings and their implications (in a multi-messenger context) for massive-star evolution, supernova theory, compact binary populations, and electromagnetic and cosmic-ray counterparts to gravitational-wave sources.

Primary authors: PRINCIPE, Giacomo (Istituto Nazionale di Fisica Nucleare); COLLABORATION, LIGO-Virgo-KAGRA

Presenter: PRINCIPE, Giacomo (Istituto Nazionale di Fisica Nucleare)

Session Classification: Day 2: Latest results

Contribution ID: **3** Type: **Contributed talk**

KM3NeT and the Multi-messenger Astrophysics

Wednesday, 9 October 2024 16:45 (15 minutes)

KM3NeT is a deep-sea telescope aimed at detecting neutrinos. It is composed of two instruments: ARCA and ORCA. ARCA is mainly aimed at searching for astrophysical sources of TeV-PeV neutrinos, while ORCA is mainly dedicated to the study of neutrino oscillations. Despite their different goals, both instruments can participate in a multi-messenger search by providing information about neutrinos in the GeV-PeV range.
Given KM3NeT's large field of view and almost 100% duty cycle, it is ideally suited to distribute alerts to other observatories and to perform follow-up searches on external triggers. KM3NeT's real-time multi-messenger search aims at reconstructing all neutrino events and searching for significant coincidences with alerts coming from other instruments (e.g. gravitational wave and gamma-ray detectors). Moreover, a real-time distribution of alerts in coincidence with detection of neutrinos of interest is under development. It will help in reducing the localization area of poorly-localised triggers, such as gravitational waves, and therefore it will increase the discovery potential to transient sources.
This contribution aims to provide a broad overview of the KM3NeT detector and its ongoing multi-messenger efforts.

Primary author: Dr BADARACCO, Francesca (University of Genova)

Presenter: Dr BADARACCO, Francesca (University of Genova)

Session Classification: Day 1: Latest results

Contribution ID: **4** Type: **Invited talk**

Advanced Virgo plus: current status and future prospects

Thursday, 10 October 2024 12:00 (30 minutes)

On April 10th, 2024 the second part of the fourth observing run (O4b) started with the detectors Advanced LIGO and Advanced Virgo resuming data taking. The run is ongoing and it is currently planned to end in June 2025.

In this talk, I will highlight the series of installed upgrades on Advanced Virgo plus since the end of the O3 observing run in view of O4. Moreover, I will focus on what are the short-term plans to further improve the detector in the two-years break planned between O4 and O5 - currently scheduled to start in June 2027. Finally, I will also briefly describe the longer-term prospects for Advanced Virgo related to the post-O5 period - which will be a bridge between the second and the third generation detectors.

Primary author: AIELLO, Lorenzo (Istituto Nazionale di Fisica Nucleare)

Presenter: AIELLO, Lorenzo (Istituto Nazionale di Fisica Nucleare)

Session Classification: Day 2: Latest results

Contribution ID: **5** Type: **Invited talk**

X-ray quasi-periodic eruptions: where do we stand?

Thursday, 10 October 2024 10:30 (30 minutes)

X-ray Quasi-Periodic Eruptions (QPEs) are high-amplitude bursts of X-ray radiation recurring every few hours and originating near the central black holes in galactic nuclei of low-mass galaxies. So far, only a handful of such events has been found. Some of the latest models suggest that these eruptions are triggered by extreme mass ratio inspirals (EMRIs), in which the secondary body interacts with the accretion flow around the primary. Since EMRIs are GW sources, this would make QPEs their electromagnetic counterparts, opening a new window to the future of multi-messenger astronomy. I will outline the basic observational properties of QPE sources and the current state of the art for their interpretation as EMRIs.

Primary author: ARCODIA, Riccardo (MIT)

Presenter: ARCODIA, Riccardo (MIT)

Session Classification: Day 2: Latest results

Contribution ID: **6** Type: **Contributed talk**

Evolution of massive black hole binaries in gaseous environments

Thursday, 10 October 2024 17:15 (15 minutes)

Understanding the interaction of massive black hole binaries with their gaseous environment is crucial since at sub-parsec scales the binary is too wide for gravitational wave emission to take over and to drive the two black holes to merge.
Furthermore the presence of a gaseous disc around sub-pc massive black hole binaries can trigger electromagnetic emission that can be detected by the Zwicky Transient Facility and the upcoming Vera Rubin Observatory, therefore revealing the presence of hidden binaries.
The outcome of binary-disc interaction in terms of binary evolution remains poorly explored mainly due to numerical limitations and simplistic assumptions in the modelling of these systems.
In this talk I will present our recent results on the evolution of massive black hole binaries embedded in both isothermal and self-gravitating circumbinary discs obtained using hyper-Lagrangian 3D hydrodynamics simulations.
Our approach allows to perfectly resolve the gas dynamics inside the cavity and to therefore measure the torques acting on the binary with high numerical precision. This is crucial in order to infer the correct results in terms of binary parameters evolution. I will discuss how the gas temperature affects the electromagnetic emission, which is crucial in order to pinpoint the origin of the GW sources.
Our results are especially important for massive black hole binaries in the LISA and PTA band.

Primary author: FRANCHINI, Alessia (University of Zurich)

Presenter: FRANCHINI, Alessia (University of Zurich)

Session Classification: Day 2: Latest results

Contribution ID: **7** Type: **Contributed talk**

Theoretical Modeling of Binary Black Hole Merger Light Curves and Observational Follow-Up Using Mount Wendelstein's 2.1m Telescope

Thursday, 10 October 2024 14:45 (15 minutes)

Black hole mergers, involving masses of tens to hundreds of solar masses, are believed to frequently occur within the accretion disks of central supermassive black holes, potentially producing observable electromagnetic counterparts. These counterparts understood as short flares, can last several days to weeks. Here, we present our initial results on the theoretical modelling of light curves from binary black hole merger flares and demonstrate how this model compares with real observational data. Our observations are derived from follow-up campaigns of gravitational wave detections by LIGO/Virgo/KAGRA, using Mount Wendelstein's 2.1 m telescope equipped with the 3KK imager, which captures data in visible to near-infrared bands. This work is a collaboration between the University Observatory Munich at Ludwig Maximilian University (LMU), Carnegie Mellon University (CMU), the Gravitational Wave Multi-Messenger Astronomy Decam Survey (GW-MMADS), and the Dark Energy Spectroscopic Instrument (DESI).

Primary author: SOMMER, Julian (Ludwig-Maximilians-Universität München (LMU))

Presenter: SOMMER, Julian (Ludwig-Maximilians-Universität München (LMU))

Session Classification: Day 2: Latest results

Contribution ID: **8** Type: **Poster**

CTAO sensitivity to axion-like particles

Wednesday, 9 October 2024 16:00 (3 minutes)

Axion-like particles (ALPs) are a common feature in several extensions of the Standard Model, arising, for example, as a solution to the strong CP problem in quantum chromodynamics, or as a prediction of string theories. A significant property for the experimental detection of ALPs is their coupling to photons, which enables ALP-photon conversions in ambient magnetic fields.

In particular, gamma-ray photons could convert into ALPs in the magnetic fields of distant objects and then reconvert in the Milky Way's magnetic field. By eluding absorption by the extragalactic background light (EBL), such a mechanism could produce a hardening in the gamma-ray spectra of these sources. I investigate the capability of the Cherenkov Telescope Array Observatory (CTAO) to detect signals of ALP-photon conversions in the very-high-energy spectra of known blazars at energies above 10 TeV, comparing different magnetic field scenarios.

Primary author: SCHIAVONE, Francesco (Università degli Studi di Bari & INFN Bari)

Co-authors: GIORDANO, Francesco (Istituto Nazionale di Fisica Nucleare); Dr DI VENERE, Leonardo (INFN Bari)

Presenter: SCHIAVONE, Francesco (Università degli Studi di Bari & INFN Bari)

Session Classification: Poster lightning talks

Contribution ID: **9** Type: **Poster**

GRB 221009A: an analytical method for VHE afterglow description and modelling

Wednesday, 9 October 2024 16:06 (3 minutes)

We have witnessed the detection of what has been recorded has the most energetic Gamma-Ray Burst (GRB) ever: GRB 221009A, also known as the B.O.A.T. (brightest of all time, with $E_{iso} \sim 10^{55}$ erg). It spans its emission over the whole electromagnetic spectrum, up to the very high energy (VHE) gamma-ray band: in particular the LHAASO observatory, in China, has been able to detect photons up to energies never detected before from a GRB, reaching ~ 10 TeV and so opening a new era for the observation of this kind of phenomena.
In the work we present here we describe the method we developed to model GRBs afterglow emission through an analytical description of their light curve behaviour, depending on various physical parameters driving the emission, followed by a Markov-Chain Monte Carlo (MCMC), and our particular case study on GRB 221009A.
The dependence on the physical parameters (electron energy fraction, magnetic energy fraction, injected electrons index, initial bulk Lorentz fraction and ISM density) is inferred from the simulations produced with a numerical model based on temporal step-by-step calculation of the evolution of the blast wave and consequent GRB emission through the interaction with the ISM: the behaviour of the light curves is extracted by varying the the parameters, and assuming for them a "modified" smoothed power law shape we inferred a direct dependence on the parameters later used for the MCMC.

Primary author: GASBARRA, Claudio (Istituto Nazionale di Fisica Nucleare)

Co-authors: MORSELLI, Aldo (Istituto Nazionale di Fisica Nucleare); BELARDINELLI, Daniele (ROMA2); RODRIGUEZ FERNANDEZ, Gonzalo (Istituto Nazionale di Fisica Nucleare); FAFONE, Viviana (Istituto Nazionale di Fisica Nucleare)

Presenter: GASBARRA, Claudio (Istituto Nazionale di Fisica Nucleare)

Session Classification: Poster lightning talks

Contribution ID: **10** Type: **Invited talk**

Searching for Binary Supermassive Black Holes via Optical Spectroscopy

Friday, 11 October 2024 10:00 (30 minutes)

In this invited talk I will give an overview of current efforts top detect "long-period"(decades or longer) supermassive black hole binaries using optical spectroscopy. Such objects are interesting for many reasons including, but not limited to, (a) they provide tests of models for galaxy evolution through mergers, (b) they make up the population of supermassive black holes producing the very-low frequency gravitational wave background that the pulsar timing arrays have just detected, (c) they are the counterparts of discrete very-low frequency gravitational wave sources that we expect pulsar timing arrays to detect soon, and (d) some of them will be loud low-frequency gravitational sources detectable by LISA when they do merge. I will begin by describing the physical scenario of the accretion flow onto the two black holes in the binary, which is the basis for predicting the observational signatures that we use. I will then describe how the test is carried out in practice: it is an exercise in patience and persistence. I will conclude by summarizing the status of current searches, presenting some of the latest, more promising results, and discussing the implications.

Primary author: ERACLEOUS, Michael (Penn State University)

Presenter: ERACLEOUS, Michael (Penn State University)

Session Classification: Day 3: Novel simulations and analysis methods

Contribution ID: **11** Type: **Poster**

Evaluation of the CTAO performance to the gamma-ray emission from neutrino sources detectable by the IceCube and KM3NeT neutrino telescopes

Wednesday, 9 October 2024 16:03 (3 minutes)

The simultaneous observation of gamma rays and neutrinos from the same astrophysical source allows us to understand the mechanisms of particle production in the ultra-high energy environments of our Universe.

The Cherenkov Telescope Array Observatory (CTAO) is a new-generation ground-based instrument for very-high-energy gamma-ray astronomy, under construction in the northern and southern hemispheres: CTAO-North will be located on the island of La Palma in the Canary Islands (Spain), while CTAO-South will be located in the Atacama Desert (Chile). CTAO will be the first open ground-based gamma-ray observatory capable of detecting gamma rays in the energy range between 20GeV-300TeV. The KM3NeT collaboration has started building the ARCA neutrino telescope in the Mediterranean Sea. The ARCA detector is optimized to search for high-energy neutrino sources in the Universe. It is being constructed at the Capo Passero site in Italy, 80 km offshore at a depth of 3500 m.

In this contribution, we examine the performance of CTAO as calculated from simultaneous neutrino and gamma-ray simulations for steady-state and transient (TXS flaring-blazar type) sources, assuming that neutrino events are detected by both neutrino telescopes, KM3NeT and IceCube, located in the northern and southern hemisphere, respectively.

Using the open-source python code FIRESONG (FIRst Extragalactic Simulation Of Neutrino and Gamma-ray), a list of neutrino-emitting blazars is generated. Neutrino sources are simulated with different input parameters such as local source density, neutrino luminosity, energy range, and type of stellar evolution model. These simulations are also analyzed and compared with the discovery potentials of neutrino telescopes, to reveal which sources are effectively seen and which are not. In this paper, a preliminary study of the CTAO detection performance of very high-energy gamma-ray counterparts for such neutrino sources is presented.

In particular, we would like to highlight the necessity of implementing the KM3NeT neutrino telescope in the northern hemisphere for the study of transient sources and multi-messenger targets in conjunction with the new CTAO configuration with the implementation of Large Sized Telescopes (LSTs) at the southern site.

Primary author: CICCIARI, Gloria Maria (Istituto Nazionale di Fisica Nucleare)

Presenter: CICCIARI, Gloria Maria (Istituto Nazionale di Fisica Nucleare)

Session Classification: Poster lightning talks

Contribution ID: **12** Type: **Contributed talk**

Constraining the jet shape of HSP blazars with multifrequency polarimetry

In recent years multifrequency polarimetry is emerging as a powerful tool for investigating blazar jets, especially with the advent of the Imaging X-ray Polarimetry Explorer (IXPE) space observatory.
We study the polarization of High-Synchrotron Peaked (HSP) blazars, where both optical and X-ray emission are due to synchrotron radiation from a population of non-thermal electrons. We adopt an axisymmetric stationary Poynting-dominated jet model, where the electromagnetic fields are determined by the jet shape. In particular, the jet geometry is defined by the pressure profile of the external medium which confines the jet. When jets are confined by a windy-like medium, they acquire a quasi-parabolic shape. In this case, the X-ray polarization degree is $\Pi_{\rm X} \sim 15 - 50$ % and the optical polarization degree is $\Pi_{\rm O} \sim 5 - 25$ %. The polarization degree is strongly chromatic, as $\Pi_{\rm X}/\Pi_{\rm O} \sim 2 - 5$. This chromaticity is due to the softening of the electron distribution at high energies, and is much stronger than for a uniform magnetic field. The Electric Vector Position Angle (EVPA) is aligned with the projection of the jet axis on the plane of the sky. These results compare very well with multifrequency polarimetric observations of HSP blazars.
Instead, when the jet is nearly cylindrical, the polarization degree is large and weakly chromatic (we find $\Pi_{\rm X} \sim 70$ % and $\Pi_{\rm O} \sim 60$ %, close to the expected values for a uniform magnetic field. The EVPA is perpendicular to the projection of the jet axis on the plane of the sky. A cylindrical geometry is therefore practically ruled out by current observations.
We also provide analytical approximated formulae (suitable for blazars) for both the polarization degree and the EVPA as a function of the spectral-index. The polarization degree is highly chromatic (Π scales as the square root of a polynomial of degree 4 in the power-law index of the electron energy distribution) unlike the EVPA.
Our model shows that IXPE data may also be compatible with a non stratified emission region and less sensitive to the specific particle acceleration process (e.g., magnetic reconnection or shocks) than previously thought.

Primary author: BOLIS, Filippo (INAF-OAB and Università dell'Insubria)

Co-authors: Dr SOBACCHI, Emanuele (GSSI); Dr TAVECCHIO, Fabrizio (INAF-OAB)

Presenter: BOLIS, Filippo (INAF-OAB and Università dell'Insubria)

Session Classification: Day 2: Latest results

Contribution ID: **13** Type: **Poster**

Anomaly Detection with Machine Learning on Time Series Data from the Fermi Anti-Coincidence Detector

Wednesday, 9 October 2024 16:09 (3 minutes)

Multimessenger astrophysics relies on multiple observational data channels, requiring efficient methods to analyze events of astrophysical origin. Given the increasing volume and complexity of data from modern observatories, machine learning techniques have become essential for efficiently identifying signals.

This project applies machine learning techniques to time series data from the Anti-Coincidence Detector (ACD) on the Fermi Gamma-ray Space Telescope, with the aim of improving the detection of high-energy transient events such as Gamma-Ray Bursts. The presentation begins by introducing the concept of time series and the ACD and satellite data itself. A feed-forward neural network (FFNN) is employed to learn temporal patterns in the time series and predict the background. This is followed by the implementation of a triggering algorithm for anomaly detection, which identifies significant deviations from the background, signaling the presence of astrophysical transients.

This tool can be adapted for various signals, making it applicable across different contexts in multimessenger studies.

Primary author: ADELFIO, Andrea (INFN Perugia)

Co-authors: CUTINI, Sara (Istituto Nazionale di Fisica Nucleare); LONGO, Francesco (Istituto Nazionale di Fisica Nucleare); MALDERA, Simone Paolo (Istituto Nazionale di Fisica Nucleare)

Presenter: ADELFIO, Andrea (INFN Perugia)

Session Classification: Poster lightning talks

Contribution ID: **14** Type: **Invited talk**

The gamma-ray analysis and modelling of the BOAT GRB 221009A

Wednesday, 9 October 2024 11:45 (30 minutes)

The brightest of all time (BOAT) GRB 221009A has been observed across all the electromagnetic spectrum. The observations of the BOAT in the MeV gamma-rays have revealed a presence of a new feature in the spectrum of the prompt emission - a narrow and variable MeV line. The early GeV and TeV observations have allowed for the detailed characterisation of the afterglow radiation of the BOAT. In this talk I will summarise the observations of the BOAT in the MeV-TeV gamma-rays. The new theoretical insights into the physics of the prompt and the afterglow radiation will be drawn from the unique data set of GRB 221009A.

Primary author: OGANESYAN, Gor (GSSI)

Presenter: OGANESYAN, Gor (GSSI)

Session Classification: Day 1: Latest results

Contribution ID: **15** Type: **Contributed talk**

Estimation of joint detection probabilities of Gamma-Ray Burst and Gravitational Waves produced by NSBH binary mergers

Wednesday, 9 October 2024 15:45 (15 minutes)

Black hole-neutron star (NSBH) coalescence events are regarded as highly significant phenomena within the current multimessenger framework of gravitational waves,
and they are poised to assume an increasingly prominent role in the foreseeable future. To date, only a handful of such events have been observed,
with GW200105 and GW200115 being the most noteworthy among them. However, with the forthcoming upgrades to the LIGO-Virgo-Kagra (LVK) interferometers,
and particularly with the prospective implementation of next-generation instruments such as the Einstein Telescope (ET), we anticipate a substantial increase
in the detection rate of these events, potentially by orders of magnitude.

The study of NSBH coalescences, alongside neutron star binary (BNS) mergers, is pivotal due to their status as prime multimessenger candidates capable of producing
a wide range of electromagnetic counterparts, including Gamma-ray Bursts (GRBs) and Kilonovae. By conducting joint analyses of both the gravitational and electromagnetic signals,
it becomes feasible to derive more precise insights into the properties of the involved celestial objects and the myriad processes occurring during and subsequent to the merger,
including the neutron star's stiffness and the mechanisms underlying GRB generation and beam structure.

This work provides an estimation of the combined detection capability for gravitational signals and GRBs originating from NSBH events,
considering the anticipated upgrades to existing instruments and the deployment of next-generation facilities. In assessing the gravitational wave detectors,
we compare the LVK interferometers with ET employing the GWFish software, while for evaluating the detectability of GRBs, particularly focusing on the afterglow component,
we primarily reference Fermi and the prospective CTA array telescope. By utilizing state-of-the-art models for beam formation and propagation, we investigate how the goodness
of information derived from these events is contingent upon the instruments utilized and the inherent characteristics of the coalescence itself.

Primary authors: Mr MATCOVICH, Tobia (Istituto Nazionale di Fisica Nucleare); GERMANI, Stefano (Istituto Nazionale di Fisica Nucleare); CUTINI, Sara (Istituto Nazionale di Fisica Nucleare); Dr BAWAJ, Mateusz (University of Perugia); BROZZETTI, Maria Lisa (Istituto Nazionale di Fisica Nucleare)

Presenter: Mr MATCOVICH, Tobia (Istituto Nazionale di Fisica Nucleare)

Session Classification: Day 1: Latest results

Contribution ID: **16** Type: **Contributed talk**

The luminosity of the darkness – Schechter function in GW cosmology

Thursday, 10 October 2024 16:45 (15 minutes)

The gravitational-wave (GW) cosmology community has been developing techniques and methodologies to infer the cosmological parameters and investigate the black hole population with Compact Binary Coalescences (CBCs) without an electromagnetic counterpart, commonly referred to as dark sirens.

In this study, our focus lies on the method based on galaxy catalogs such as GLADE+, a composite catalog whose completeness varies across the sky. Galaxy catalogs typically suffer from significant incompleteness after redshift z = 0.1. To date, most of the sources of GW detections have originated from larger distances, and with Einstein Telescope (ET) this trend is destined to continue, potentially extending detection capabilities to redshift as high as z = 10.

Hence, to infer cosmological parameters it is necessary to estimate the luminosity of galaxies beyond the detection threshold of electromagnetic telescopes –"the luminosity of the darkness" . This estimation currently relies on the Schechter function. Empirical evidence points towards an evolution of the Schechter function as a function of the redshift, however, this effect is not yet accounted for in the cosmological analysis. We will show how the redshift dependency can impact the line of sight (LOS) redshift prior and subsequently the posterior distribution of H0 due to the evolving Schechter function.

Primary author: BROZZETTI, Maria Lisa (Istituto Nazionale di Fisica Nucleare)

Co-authors: GOSH, Archisman; TURSKI, C.; PUNTURO, Michele (Istituto Nazionale di Fisica Nucleare)

Presenter: BROZZETTI, Maria Lisa (Istituto Nazionale di Fisica Nucleare)

Session Classification: Day 2: Latest results

Contribution ID: **17** Type: **Invited talk**

Quasi Periodic Eruptions from EMRI-disc crossings

Friday, 11 October 2024 09:30 (30 minutes)

Quasi-periodic eruptions (QPEs) are recurrent X-ray bursts observed in active galactic nuclei, characterized by regular flares followed by periods of quiescence. One potential explanation for these eruptions involves extreme mass ratio inspirals (EMRIs), where a stellar-mass compact object, such as stellar mass black hole, spirals into a supermassive black hole (SMBH). During it orbit, the EMRI periodically impacts the inner accretion disk surrounding the SMBH. These disk impacts can generate shock waves, releasing energy in the form of X-ray bursts, potentially explaining the observed QPE behavior. The connection between EMRIs and QPEs provides a promising avenue to study both SMBH environments and EMRI dynamics through their electromagnetic signatures.

Primary author: BONETTI, Matteo (University of Milano-Bicocca)

Presenter: BONETTI, Matteo (University of Milano-Bicocca)

Session Classification: Day 3: Novel simulations and analysis methods

Contribution ID: **18** Type: **Contributed talk**

Search for VHE Short-Timescale Variability in PG1553+113

Thursday, 10 October 2024 15:15 (15 minutes)

PG 1553+113 is a high-frequency peaked BL Lac object with a redshift of 0.433, detected by the current generation of Imaging Atmospheric Cherenkov Telescopes up to approximately 1 TeV. Interestingly, the continuous gamma-ray light curve recorded by Fermi-LAT since 2008 has shown a periodic modulation of 2.18 ± 0.08 years at energies above 100 MeV and 1 GeV. Additionally, the source displays clear variability on a day-scale across all bands. Recent XMM-Newton data revealed rapid variability in the X-ray band down to 40.01±11.67 min. Periodicity and intra-day variability have not yet been detected at very high energies (VHE) i.e. above 100 GeV.

Short-timescale (sub-hour) variabilities are key observables to probe the small spatial structures of the jet, e.g., constraining the size of the photon-emitting region in the jet. The first Large-Sized Telescope (LST-1) of the Cherenkov Telescope Array Observatory, located on Roque de los Muchachos in La Palma, Spain, provides a unique opportunity to study such phenomena due to its high sensitivity at low energies and low energy threshold (down to about 20 GeV). In April 2023, a very bright flare from PG 1553+113 triggered LST-1 and multi-wavelength observation campaigns. In this study, we present the results of these observations, with a focus on the search for short-timescale variability in the VHE range. We characterize the variations in the observed flux of PG 1553+113 during a 4-hour observation conducted by LST-1, with hints of the presence of intra-day variability.

Primary author: LUCIANI, Helena (Istituto Nazionale di Fisica Nucleare)

Co-authors: RUINA, Arshia (Istituto Nazionale di Fisica Nucleare); PRANDINI, Elisa (Padova University and INFN)

Presenter: LUCIANI, Helena (Istituto Nazionale di Fisica Nucleare)

Session Classification: Day 2: Latest results

Contribution ID: **19** Type: **Contributed talk**

Multi-Wavelength Study of GRB Afterglows: Exploring Double-Peaked Spectral Distributions and Anomalies.

The detection of a double-peaked broadband spectral energy distribution in the long GRB 190114C highlights the need for a systematic study of Gamma-Ray Burst (GRB) temporal and spectral evolution. This study will examine multi-wavelength observations of GRB afterglows, analysing their spectral evolution across seven orders of magnitude in energy, ranging from 0.3 keV to 107 keV. The sample includes 12 GRBs detected by the Fermi Large Area Telescope (30 MeV - 300 GeV) between 2008 and 2018 with test statistics (TS) greater than 20, which also have simultaneous observations from the X-ray Telescope (0.3 - 10 keV) onboard the Neil Gehrels Swift Observatory. Our analysis reveals that 5 GRB afterglows including anomalies such as flares and plateaus, exhibit double-peaked spectral energy distributions, while 7 are consistent with the single synchrotron radiation model. These findings support previous research and highlight the significance of very high-energy (VHE) observation in better understanding the acceleration processes in relativistic shocks. GRB physics. The talk will present the multi-wavelength spectral properties of standard afterglow and anomalies such as flares and plateaus and their theoretical implications.

Primary author: TIWARI, Pawan (Gran Sasso Science Institute)

Presenter: TIWARI, Pawan (Gran Sasso Science Institute)

Session Classification: Day 1: Latest results

Contribution ID: **20** Type: **Contributed talk**

Sensitivity of the Cherenkov Telescope Array Observatory to the gamma-ray emission from neutrino sources detected by IceCube

Wednesday, 9 October 2024 17:00 (15 minutes)

Gamma-ray observations of astrophysical neutrino sources are fundamentally important for understanding the underlying neutrino production mechanisms. We investigate the Cherenkov Telescope Array Observatory (CTAO) prospects for detecting the very-high-energy (VHE) gamma-ray counterparts to neutrino-emitting extragalactic sources. The performance of CTAO under different configurations (including the so-called "Alpha" and "Omega" configurations) is computed based on neutrino and gamma-ray simulations of steady sources and of flaring blazars, assuming that the neutrino events are detected with the IceCube neutrino telescope. The detection probability for CTAO is calculated for both the North and South sites, taking into account visibility constraints. We find that, under optimal observing conditions, within 30 minutes of observation, CTAO could detect the VHE gamma-ray emission associated with at least 3 neutrino events per year. We investigate the detectability of the blazars given either 1 or 5 hours CTAO observation windows.

Primary authors: ROSALES DE LEON, Alberto; BROWN, Anthony M.; TUNG, Chun Fai; FIORILLO, Damiano; CICCIARI, Gloria Maria; TABOADA, Ignacio; SATALECKA, Konstancja; MALLAMACI, Manuela; SERGIJENKO, Olga

Presenter: SERGIJENKO, Olga

Session Classification: Day 1: Latest results

Contribution ID: **21** Type: **Invited talk**

Pulsar Timing Arrays on the edge of detection

Wednesday, 9 October 2024 10:15 (30 minutes)

The main goal of the Pulsar Timing Array is to regularly monitor tens of millisecond pulsars in the radio band to detect dynamic perturbations of the space-time metric, such as those caused by the passage of gravitational waves. So far, pulsar networks are the only way to detect gravitational wave emission in the nanohertz frequency range. The talk will discuss the current status of Pulsar Timing Arrays, focusing on the EPTA results, and the future goals of the project. Special attention will be given to the possible nature of the signal obtained in recent data from six international collaborations. Both traditional astrophysical interpretations and more unconventional scenarios will be considered.

Primary author: PORAYKO, Nataliya (University of Milano Bicocca)

Presenter: PORAYKO, Nataliya (University of Milano Bicocca)

Session Classification: Day 1: Latest results

Contribution ID: **22** Type: **Contributed talk**

Search for gravitational waves from individual supermassive black hole binaries in MeerTime data

Wednesday, 9 October 2024 15:30 (15 minutes)

Although the recent evidence presented by Pulsar Timing Arrays (PTAs) is that for a stochastic Gravitational Wave Background (GWB), which was most likely produced by the superimposition of several GW signals, simulations of the merger history of supermassive black hole binaries (SMBHBs) suggest a narrow possibility of the detection of some of the most massive or fortunately located individual Continuous Gravitational Wave (CGW) sources in the highest precision PTA datasets that are currently being generated. The detection of CGW sources in the nHz regime would confirm the existence of sub-parsec SMBHBs, can probe their dynamics and evolution history, as well as provide several tests of fundamental physics.

In this talk, I will present the results of a search for CGWs in the first 4.5 years of data from the MeerTime Pulsar Timing Array (MPTA), which consists of ultra-precise Time Of Arrivals (TOAs) from 88 Millisecond Pulsars (MSPs). In particular, I focus on searching for CGWs from known sources, building a catalog with the best sources from the literature to initiate a targeted search. MeerTime is a large survey project of MeerKAT, one of the most sensitive radio telescopes and a precursor to the Square Kilometer Array (SKA) in South Africa.

Primary author: MORESCHI, Beatrice Eleonora (University of Milano-Bicocca)

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Presenter: MORESCHI, Beatrice Eleonora (University of Milano-Bicocca)

Session Classification: Day 1: Latest results

Contribution ID: **23** Type: **Contributed talk**

Neutron star accretion events in AGN discs: mutimessenger implications

Wednesday, 9 October 2024 17:30 (15 minutes)

We investigates the accretion of neutron stars (NSs) in active galactic nucleus (AGN) accretion discs. We classify potential accretion modes of NSs in AGN discs, proposing a hierarchical model of NS accretion: accretion flow from the Bondi sphere to accretion columns. The accretion of NSs in AGN discs differs from that of BHs, especially within the scale of the NS's magnetosphere due to its hard surface and magnetic field. As the accretion flow approaches the magnetosphere, the magnetic fields guide the accretion flow to form accretion columns, primarily dominated by neutrinos. While neutrinos generated from single NS accretion may not have observable effects, considering the all-sky background, they contribute to the neutrino background in the sub-MeV energy range comparable to that of supernova explosions. NS accretion may also lead to the generation of mass quadrupole moments, consequently generating gravitational waves (GWs). The GWs, which exhibit characteristic effects like periodic modulations and echoes, could be observed by third-generation GW detectors. The emission of neutrinos and GWs carries away energy and angular momentum brought by accretion, reducing the feedback effect on the AGN disc. This results in an exceptionally high NS accretion rate, leading to a collapse time-scale shorter than the migration-merge time-scale, making it less likely that binary NS mergers originate from AGN discs.

Primary author: ZHANG, Shurui (UNIFE & USTC)

Presenter: ZHANG, Shurui (UNIFE & USTC)

Session Classification: Day 1: Latest results

Contribution ID: **24** Type: **Contributed talk**

Realistic simulations of resolved binaries in pulsar timing array datasets

Wednesday, 9 October 2024 15:15 (15 minutes)

Pulsar Timing Array (PTA) experiments use well-timed pulsars to probe the gravitational universe at frequencies down to a few nanohertz. This band is populated by gravitational waves emitted by binary systems of supermassive black holes (SMBHBs). The most common signal sought by PTA experiments is a stochastic gravitational wave background generated by the superposition of hundreds of thousands of these waves arriving from a large population of SMBHBs. However, it is very likely that we will be able to detect one or more nearby and massive binaries as singularly resolved sources. By analysing realistic simulations of PTA datasets, I have compared the performance of different single-source models in reconstructing the parameters of the binary. The performance of the best model is also tested in the case where the resolved source is present on top of a stochastic background, which is the most likely scenario for single source detection. In particular, I will discuss possible biases in the sky localisation of the source and the possibility of constraining the binary's luminosity distance and chirp mass, which are key parameters in the search for the resolved system's electromagnetic counterpart.

Primary author: FERRANTI, Irene (Istituto Nazionale di Fisica Nucleare)

Co-authors: SESANA, Alberto (University of Milano-Bicocca); Dr CHALUMEAU, Aurelien (ASTRON, Netherlands Institute for Radio Astronomy); Dr SHAIFULLAH, Golam ('G. Occhialini' Dipartimento di Fisica, Università degli Studi di Milano-Bicocca)

Presenter: FERRANTI, Irene (Istituto Nazionale di Fisica Nucleare)

Session Classification: Day 1: Latest results

Contribution ID: **25** Type: **Poster**

Artificial neural network classification of the Fermi-LAT catalog blazars of unknown type and unidentified sources

Thursday, 10 October 2024 15:54 (3 minutes)

In 14 years of operation the *Fermi*-LAT detected more than 7000 γ-ray sources, of which one third are still not associated with counterparts in other wavelengths, and approximately one fifth are associated with blazar of unknown type. We developed a machine learning method based on an artificial neural network trained with multi-wavelength data which we used to classify blazars of unknown type as either BL Lacs or Flat Spectrum Radio Quasars. Then we considered all the possible multi-wavelength counterparts of the unidentified γ-ray sources, and we implemented another neural network to identify which counterpart was the best candidate and to classify the unidentified sources accordingly.

Primary authors: CASINI, Francesco (Istituto Nazionale di Fisica Nucleare); CUTINI, Sara (Istituto Nazionale di Fisica Nucleare); GERMANI, Stefano (Istituto Nazionale di Fisica Nucleare)

Presenter: CASINI, Francesco (Istituto Nazionale di Fisica Nucleare)

Session Classification: Poster lightning talks

Contribution ID: **26** Type: **Contributed talk**

Multi-wavelength view and modeling of the blazar B2 1811+31 in flaring state

Thursday, 10 October 2024 15:00 (15 minutes)

Intermediate synchrotron-peaked BL Lacs (IBLs) are quite rare sources in the TeV gamma-ray sky. The IBL B2 1811+31 (z = 0.117) underwent a period of flaring activity in 2020. Detailed characterization of the broad-band emission of the source was achieved thanks to a multi-wavelength (MWL) campaign triggered by the Large Area Telescope (LAT) on board the Fermi satellite in the high-energy gamma-ray band (HE; 100 MeV < E < 100 GeV). The observational campaign was joined by the MAGIC telescopes in the very-high-energy (VHE; 100 GeV < E < 100 TeV) gamma-ray band, leading to the first detection of the source in this energy range. At lower frequencies, the XRT and UVOT instruments onboard the Neil Gehrels Swift Observatory partecipated to the campaign, as well as several ground-based optical and radio telescopes. An extensive MWL dataset spanning over 15 years was employed to put the high state activity observed in 2020 into the context of the source long-term emission.
In this contribution, we report on the MWL characterization of B2 1811+31, focusing on the 2020 high state. We discuss a leptonic interpretative model for the source high state and propose a self-consistent scenario for the emission regions responsible for the flare.

Primary authors: CERASOLE, Davide (Istituto Nazionale di Fisica Nucleare); PAVLETIĆ, Lovro (Faculty of Physics, University of Rijeka); LOPORCHIO, Serena (INFN Bari)

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Presenter: CERASOLE, Davide (Istituto Nazionale di Fisica Nucleare)

Session Classification: Day 2: Latest results

Contribution ID: **27** Type: **Contributed talk**

Probing the early X-ray afterglow of short Gamma-Ray Bursts in the Multi-Messenger Era

Thursday, 10 October 2024 17:00 (15 minutes)

The joint detection of a gravitational wave (GW) signal and a short Gamma-Ray Burst (GRB) from a binary neutron star merger in 2017 proved that short GRBs are multi-messenger sources. It is thus fundamental to understand and model the afterglow emission of short GRBs in order to improve our follow-up strategies for detecting the electromagnetic counterparts of GW events. It is widely accepted that the afterglow radiation of GRBs comes from electrons cooling via synchrotron and inverse Compton processes at the forward shock. However, a consistent fraction of short GRBs presents some features in the early X-ray light curves, such as steep declines and plateaus, which cannot be explained within the standard afterglow model. It is then crucial to model these features in order to predict the early X-ray counterparts of GWs, detectable by the recently launched wide-field X-ray instruments, such as Einstein Probe. In this talk, I will present a systematic analysis of early X-ray afterglows of short GRBs, including their temporal and spectral evolution. I will also discuss the preliminary results from the modelling of the features in the X-ray emission. Finally, I will present predictions for future observations of short GRBs with the current wide-field X-ray cameras.

Primary author: IERARDI, Annarita (Gran Sasso Science Institute)

Co-authors: OGANESYAN, Gor (Gran Sasso Science Institute); BRANCHESI, Marica (Gran Sasso Science Institute); ASCENZI, Stefano (Gran Sasso Science Institute)

Presenter: IERARDI, Annarita (Gran Sasso Science Institute)

Session Classification: Day 2: Latest results

Contribution ID: **28** Type: **Poster**

Systematic time-resolved analysis of Gamma-Ray Bursts detected by Fermi-GBM

Thursday, 10 October 2024 15:45 (3 minutes)

The Fermi Gamma-Ray Space Telescope has been operational for almost 16 years. During this period, the Fermi Gamma-Ray Burst Monitor (GBM) has been the most prolific Gamma-Ray Burst (GRB) detector ever, with more than 3700 observed GRBs to date. Tens of dedicated single-GRB publications and several general catalogs helped shedding light on the temporal and spectral characteristics of these fascinating events.
Here we present a systematic analysis of a subsample of bright GRBs, focusing on the evolution of the fitting model parameters during each event. Light Curves are binned using the Bayesian Blocks method, and the time-resolved analysis is performed by means of the newly developed GBM Data Tools. We applied five different spectral models to each time bin, and selected the best one through specific statistical criteria. We find that the best fit parameters distributions confirm the dominance of the Comptonized model. Finally, our goal is to implement the current pipeline for a future comprehensive and systematic analysis of a broader GRB sample.

Primary author: DEPALO, Davide (Istituto Nazionale di Fisica Nucleare - Sezione di Bari)

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Presenter: DEPALO, Davide (Istituto Nazionale di Fisica Nucleare - Sezione di Bari)

Session Classification: Poster lightning talks

Contribution ID: **29** Type: **Contributed talk**

Gamma-ray burst prompt emission spectra in the high energies.

Wednesday, 9 October 2024 17:45 (15 minutes)

Prompt emission of GRB is believed to be produced from electrons accelerated up to non thermal energies in the internal shocks. This emission peaks in the keV-MeV energy band, but a high energy (HE, 0.1 < E <100 GeV) component is theoretically expected. While photons in the very high energy (VHE; E > 20GeV) domain have been detected by Imaging Atmospheric Cherenkov Telescopes in recent years, prompt-related VHE photons have not been observed yet. Their detection would be crucial for the understanding of the physics related to the prompt emission.
In the last 15 years of LAT operation, many GRBs showed HE gamma-ray emission temporally coincident with prompt emission phase, but with different spectral properties. This GeV emission has been interpreted by several authors as mostly dominated by the afterglow. I will present new results based on a systematic study of GRBs with an early GeV emission detected by Fermi/LAT. This study uses a physical model to explain the prompt emission. The systematic temporal and broad-band keV-GeV spectral analysis reveals that in many cases the GeV radiation is part of the main spectral component of the prompt emission. In contrast, in some other cases, these GeV photons are related to a second spectral component, which might peak at VHE gamma rays. I will discuss the physical origin of the GeV photons and the possible implications of a second spectral component in light of the upcoming CTA.

Primary author: MACERA, Samanta (Gran Sasso Science Institute)

Presenter: MACERA, Samanta (Gran Sasso Science Institute)

Session Classification: Day 1: Latest results

Contribution ID: **30** Type: **Invited talk**

AI for cosmic ray detection in space at high-energy frontier

Friday, 11 October 2024 12:30 (30 minutes)

We will dive into recent AI advancements for data reconstruction and analysis with spaceborne instruments at the mult-TeV energies. First, we will briefly describe the DAMPE and HERD missions - state-of-the-art spaceprobes for high-energy cosmic rays and gamma-ray physics. Then we will discuss how modern Deep Learning methods broaden the science program of such experiments and even facilitate new kinds of measurements. In conclusion, we will give an overview of the physics results achieved so far thanks to AI techniques.

Primary author: TYKHONOV, Andrii (University of Geneva)

Presenter: TYKHONOV, Andrii (University of Geneva)

Session Classification: Day 3: Novel simulations and analysis methods

Contribution ID: **31** Type: **Invited talk**

X-ray polarimetry: a new window to the multimessenger Universe

Thursday, 10 October 2024 10:00 (30 minutes)

Polarimetry is a very important probe of the high-energy processes in the Universe. In December 2021 NASA launched the Imaging X-ray Polarimetry Explorer - IXPE, offering us a completely new window to the Universe, and the tools to study astrophysical systems from a radically different perspective. I will discuss the lessons learned from IXPE's two-year nominal mission and the implications for the multimessenger emission from candidate neutrino sources.

Primary author: LIODAKIS, Ioannis (Institute of Astrophysics - FORTH)

Presenter: LIODAKIS, Ioannis (Institute of Astrophysics - FORTH)

Session Classification: Day 2: Latest results

Contribution ID: **32** Type: **Invited talk**

An overview of EHT results sub specie ”variabilitatis”

Wednesday, 9 October 2024 12:15 (30 minutes)

By releasing the first image of the black hole shadows of M87*and Sgr A*, the EHT Collaboration has achieved one of the most illustrious scientific results of the last few years. Beyond the formidable technical accomplishment, the two images had a fundamental impact on our understanding of the physics of black holes and AGNs, and provided a further striking confirmation of general relativity. The outcome of the EHT project, however, is not limited to these famous images and their direct implications; numerous interesting results have been reached through the data collected by the collaboration. In this talk, I will mainly focus on the variability of M87*and Sgr A*, and show how a factor of significant complication for the calibration of the data could become a source of essential information for our understanding of the environment around supermassive black holes.

Primary author: MARCHILI, Nicola (INAF - Istituto di Radioastronomia)

Presenter: MARCHILI, Nicola (INAF - Istituto di Radioastronomia)

Session Classification: Day 1: Latest results

Contribution ID: **33** Type: **Contributed talk**

Long term multi-wavelength analysis of the flat spectrum radio quasar OP 313

Thursday, 10 October 2024 15:30 (15 minutes)

The flat spectrum radio quasar OP 313 showed extremely intense γ-ray activity from November 2023 to March 2024, as observed by the Large Area Telescope on board the Fermi Gamma-ray Space Telescope. This initiated a large number of follow-up campaigns at all wavelengths, resulting in a confirmation of the increase of the source activity from the radio to very high energy (VHE) bands. Remarkably, it also led to the first detection of the VHE emission from OP 313 by the Large-Sized Telescope (LST-1) of the Cherennkov Telescope Array Observatory at La Palma and it is also the most distant Active Galactic Nuclei detected at these energies.

We present a multi-wavelength analysis covering 15 years of Fermi-LAT observations, from August 2008 to March 2024. From the Fermi-LAT study of the 15-year light curve, we identify different periods of activity, called flaring periods, and quiescent states of the source. The γ-ray lightcurve is then compared with the data available from other instruments. We include X-ray and ultraviolet data collected by the Neil Gehrels Swift Gamma Ray Burst Explorer instruments XRT and UVOT. The optical dataset is from different projects: Catalina Real-Time Transient Survey (CRTS), Katzman Automatic Imaging Telescope (KAIT), Tuorla telescope, ATLAS, and Palomar ZTF data. The radio data in the different frequencies include the FERMI-GST AGN Multi-frequency Monitoring Alliance (F-GAMMA) public data from 2.64 to 14.60GHz, the MOJAVE public data at 15GHz, the Submillimeter Array (SMA) public data at 300 and 353GHz, Metsähovi data at 37GHz and the VLBA-BU-BLAZAR data at 43GHz. Using this wide multi-wavelength dataset and studying the kinematics of the jet, we want to find the mechanisms that are producing the flaring activity of the galaxy. This approach helps us to understand the mechanisms involved in particle acceleration inside the jet, and how radiation in different wavelengths is connected in OP 313.

Primary author: BARTOLINI, Chiara (Istituto Nazionale di Fisica Nucleare)

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Presenter: BARTOLINI, Chiara (Istituto Nazionale di Fisica Nucleare)

Session Classification: Day 2: Latest results

Contribution ID: **34** Type: **Invited talk**

Deep Learning Models to Analyze Gamma-ray Images and Time Series for Space and Ground-Based High-Energy Facilities.

Friday, 11 October 2024 11:30 (30 minutes)

In this contribution, we present several Deep Learning (DL) models developed for high-energy astrophysics to detect and localize gamma-ray transient sources, such as gamma-ray bursts (GRBs). These models were applied to high-energy projects including AGILE, COSI, and CTAO.

AGILE is a high-energy astrophysics space mission launched in 2007, which concluded operations in 2024. Its payload includes, among others, the Gamma-Ray Imaging Detector (GRID) and an Anti-Coincidence System (ACS). We developed the first DL-based method to detect and localize GRBs in the GRID sky maps above 100 MeV, successfully detecting 21 GRBs in the AGILE archive. Additionally, we implemented a method using anomaly detection on time series data generated by AGILE/ACS (50-200 keV), which detected 72 GRBs, including 15 new detections in AGILE data. The final model for AGILE uses a deep neural network to predict the expected background count rates of the ACS based on the satellite's orbital and attitude parameters. By comparing the predicted and acquired count rates, the model detected 39 GRBs, four of which are new to the AGILE data. We calculated the p-value distribution for all DL models to evaluate the statistical significance of the detected GRBs.

From the knowledge gained with AGILE, we are also developing a DL model for the COSI soft gamma-ray survey telescope (0.2-5 MeV) to localize GRBs using the count rates of the BGO shield panels. Localization can be further improved by including the count rates of the germanium detectors.

The Cherenkov Telescope Array Observatory (CTAO) aims to advance ground-based very-high-energy gamma-ray astronomy, featuring the Science Alert Generation (SAG) system as part of the Array Control and Acquisition (ACADA) system. We developed an anomaly detection autoencoder to improve the CTAO capability of detecting GRBs in real time, using energy-dependent light curves as multi-variant time series data. This DL model aims to achieve faster detections without a minimum photon count as constrained by standard analysis. Additionally, we developed two Convolutional Neural Network (CNN) prototypes to enhance the scientific analysis of CTAO data in real-time: an autoencoder for subtracting background noise from observation counts maps and a regressor for extracting the coordinates of the brightest source. Using the current ACADA/SAG pipelines as a reference, the autoencoder showed a minimal source count loss with a mean difference of about 2 counts (±8 at the 1σ level), while regressor tests indicated a 68% containment radius 0.07° compared to the of 0.04° achieved with the current standard analysis. Both CNN models, though, operate without prior knowledge of target position, background templates, or instrument response functions (IRFs), opposite to the standard analysis.

Finally, we are developing Quantum Deep Learning (QDL) models to compare them with classical models. The goal is to explore how quantum computing features can enhance the training process and improve results obtained with DL models.

Primary authors: Dr PARMIGGIANI, Nicolò (INAF/OAS Bologna); Dr BULGARELLI, Andrea (INAF/OAS Bologna); Dr BARONCELLI, Leonardo; Prof. BENEVENTANO, Domenico (Università di Modena e Reggio Emilia); Dr CASTALDINI, Luca (INAF/OAS Bologna); CAVAZZUTI, Elisabetta (T); CIABATTONI, Alex (Università di Bologna, INAF OAS Bologna); Dr DI PIANO, Ambra (INAF/OAS

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Presenter: Dr PARMIGGIANI, Nicolò (INAF/OAS Bologna)

Session Classification: Day 3: Novel simulations and analysis methods

Contribution ID: **35** Type: **Contributed talk**

Fermi-LAT detection of the low-luminosity radio galaxy NGC 4278 during the LHAASO campaign

Thursday, 10 October 2024 17:30 (15 minutes)

Compact symmetric objects (CSOs) are sources with radio lobe emission on both sides of an active nucleus and an overall size of less than one kpc.
From the detection of 3 CSOs by the Large Area Telescope (LAT) on board the Fermi Gamma-ray Space Telescope, we know that the emission from these objects can extend into the GeV band. Surprisingly, the first LHAASO catalog reported a TeV source, 1LHAASO J1219+2915, detected up to 25 TeV and tentatively associated with the CSO NGC 4278.
In this contribution, we present the analysis of the LAT data in the region of 1LHAASO J1219+2915 at the time of the LHAASO detection. Our analysis revealed evidence for a new point-like source, detected at a statistical significance of TS~29, spatially consistent with the LHAASO detection and the radio position of NGC 4278. We observed a hard spectrum in the Fermi-LAT band, with two very high-energy (VHE) photons (~100 GeV) associated with NGC 4278 with a probability exceeding 99%.
Our results provide further support to the association between the LHAASO source and the CSO NGC 4278, posing new challenges for our understanding of the physical processes acting in relativistic jets.

Primary author: BRONZINI, Ettore (University of Bologna - INAF/OAS)

Co-authors: Dr TORRESI, Eleonora (INAF-OAS); Dr GRANDI, Paola (INAF-OAS); Prof. BUSON, Sara (University of Wurzburg & DESY)

Presenter: BRONZINI, Ettore (University of Bologna - INAF/OAS)

Session Classification: Day 2: Latest results

Contribution ID: **36** Type: **Invited talk**

Observational constraints on the dependence of the stochastic X-ray flux variations on black hole mass and Eddington ratio

Thursday, 10 October 2024 11:30 (30 minutes)

The radiation produced by the accretion of matter onto supermassive black holes exhibits stochastic flux variations across a range of timescales. These fluctuations offer critical insights into the geometry and physical conditions of the accretion flow as well as the interplay between the different energy emitting regions. In this presentation I will focus on the X-ray flux variability of AGN and its dependence on the physical parameters of the active black hole, such as mass and Eddington ratio. Instead of studying individual sources, I will highlight the power of ensemble variability studies, leveraging large samples to uncover average trends. Multi-epoch eROSITA All Sky Survey data and archival XMM observations of tens of thousands of SDSS QSOs are used to characterise the ensemble X-ray variability in bins of black hole mass and Eddington ratio. The analysis employs new Bayesian methods that correctly account for the Poisson nature of X-ray observations and allow maximal information extraction from the multi-epoch observations. The results include evidence of an anti-correlation between X-ray variability and black hole mass or Eddington ratio, but also an intriguing reversal of this trend for the fastest accreting black holes. These results will be discussed in the context of different physical models for the feeding and feedback cycle of the accreting supermassive black holes.

Primary author: Dr GEORGAKAKIS, Antonis (National Observatory of Athens)

Presenter: Dr GEORGAKAKIS, Antonis (National Observatory of Athens)

Session Classification: Day 2: Latest results

Contribution ID: **37** Type: **Poster**

Chaotic dynamics around black holes

Thursday, 10 October 2024 15:48 (3 minutes)

I will explore the dynamics of objects orbiting black holes, focusing on when these dynamics remain regular and when they transition into chaotic behavior. The phenomenon of chaotic dynamics around black holes presents rich and complex behavior, which I will discuss across various scenarios, including both general relativity and modified gravity theories [1,2]. While point-particle dynamics provide a useful baseline, the emphasis of this presentation will be on macroscopic objects and their unique chaotic characteristics in strong gravitational fields.
Additionally, I will discuss potential observational signatures of chaotic dynamics, ranging from gravitational wave signals to electromagnetic detections, offering insights into how these phenomena might be identified experimentally. This study will cover both theoretical foundations and current proposals for detecting such chaos, aiming to shed light on this captivating aspect of black hole physics.
1. Chaotic dynamics of a spinless axisymmetric extended body around a Schwarzschild black hole. Ricardo A. Mosna, Fernanda F. Rodrigues, Ronaldo S. S. Vieira. Phys. Rev. D 106, 024016 (2022)
2. Chaotic dynamics of pulsating spheres orbiting black holes. Fernanda F. Rodrigues, Ricardo A. Mosna, Ronaldo S. S. Vieira. GRG (2024)

Primary author: RODRIGUES, Fernanda (Institute of High Energy Physics)

Presenter: RODRIGUES, Fernanda (Institute of High Energy Physics)

Session Classification: Poster lightning talks

Contribution ID: **38** Type: **Contributed talk**

Latest results from the DAMPE space mission

Thursday, 10 October 2024 18:00 (15 minutes)

The Dark Matter Particle Explorer (DAMPE) is a satellite-based detector designed for precise Galactic cosmic ray studies and indirect dark matter search. Since its launch in December 2015, DAMPE has been continuously collecting data on high-energy cosmic particles, with excellent statistics and particle identification capabilities, thanks to a large geometric factor and a good energy resolution. Its deep calorimeter allows for the detection of electron-positron and gamma-ray spectra up to 10 TeV, and cosmic ray nuclei up to hundreds of TeV. In this contribution, a general overview of the DAMPE space mission will be presented, highlighting its main scientific results and ongoing activities.

Primary author: CASILLI, Elisabetta (Istituto Nazionale di Fisica Nucleare)

Presenter: CASILLI, Elisabetta (Istituto Nazionale di Fisica Nucleare)

Session Classification: Day 2: Latest results

Contribution ID: **39** Type: **Invited talk**

Observing GRB 221009A at very-high energy

Wednesday, 9 October 2024 12:45 (30 minutes)

The observation by the LHAASO Collaboration of the gamma-ray burst GRB 221009A at energies up to (13-18) TeV challenges conventional physics. This GRB originated at redshift z = 0.151, whence emitted photons at energies above 10 TeV are hardly observable on Earth due to their interaction with the extragalactic background light (EBL) photons. Indeed, if the most recent and accurate EBL model to date by Saldana-Lopez et al. is considered, we show that the LHAASO Collaboration should not have detected photons from GRB 221009A with energies above 10 TeV. Therefore, the Universe is too opaque, and a higher Universe transparency appears as necessary. We also demonstrate that the inclusion of the interaction of photons with axion-like particles (ALPs) solves the problem reducing the effective EBL absorption to a level able to explain the LHAASO detection. ALPs are particles predicted by string theory and among the best candidates for dark matter. In the presence of external magnetic fields ALPs produce spectral and polarization effects on astrophysical sources. The explanation of the GRB 221009A detection thanks to the photon-ALP interaction inside the encountered magnetized media represents a strong indication of ALP existence in addition to two previous hints arising from blazars, which are a class of active galactic nuclei. A final answer about ALP existence will be obtained in the near future thanks to new data from observatories such as ASTRI Mini-Array, CTAO, LHAASO and like AMEGO, COSI, IXPE.

Primary author: GALANTI, Giorgio (INAF, Osservatorio Astronomico di Brera)

Presenter: GALANTI, Giorgio (INAF, Osservatorio Astronomico di Brera)

Session Classification: Day 1: Latest results

Contribution ID: **40** Type: **Contributed talk**

Multi-messenger studies with the Pierre Auger Observatory

Thursday, 10 October 2024 17:45 (15 minutes)

Photons, neutrinos, gravitational waves and cosmic rays may originate from the same source regions, so a multi-messenger approach is crucial for a better understanding of the physics behind the production and propagation of these messengers. In this context, the Pierre Auger Observatory plays a key role to investigate the highest-energy primary particles, given its ability to distinguish extensive air showers generated by ultra-high-energy photons and neutrinos from hadronic showers above 10^{17} eV. The latest results in the search for diffuse fluxes and point-like sources of neutrinos and photons will be discussed in this contribution together with follow-up analyses. Results on photon fluences from a selection of gravitational wave sources detected by LIGO/Virgo and results of the search for ultra-high-energy neutrinos from binary black hole mergers will also be presented.

Primary author: DE VITO, Emanuele (Istituto Nazionale di Fisica Nucleare)

Co-author: AUGER COLLABORATION, Pierre

Presenter: DE VITO, Emanuele (Istituto Nazionale di Fisica Nucleare)

Session Classification: Day 2: Latest results

Contribution ID: **41** Type: **Poster**

HYPERION: a Normalizing Flow based pipeline for the rapid parameter estimation of eccentric Close Encounters

Thursday, 10 October 2024 15:51 (3 minutes)

Among astrophysical gravitational waves sources yet undetected, of great interest are the binary close encounters involving black holes and/or neutron stars. These systems are characterized by high orbital eccentricities and form via dynamical interactions in dense stellar environments, like globular clusters or Active Galactic Nuclei disks. Their detection could shed light on the different formation channels and could allow tests of General Relativity in the strong field regime as well as multimessenger observations.

The expected gravitational wave emission from these events differs from standard coalescences, being instead characterized by repeated short duration bursts emitted at each periastron passage of the two objects. The burst nature of the signal paired with the expected low signal-to-noise ratio makes them a challenging source either for detection or parameter estimation with traditional data anaysis approaches. We present HYPERION ("HYP-er fast close EncounteR Inference from Observation with Normalizing-flows"): a novel data analysis pipeline based on probabilistic machine learning and normalizing flows to infer Bayesian posterior. We show that our method is very promising since it can make inference several orders of magnitude faster than traditional techniques while maintaining high accuracy on the parameters, thus showing how machine learning could help in studying these sources.

Primary author: DE SANTI, Federico (Università di Pisa and INFN Pisa)

Co-author: RAZZANO, Massimiliano (University of Pisa and INFN-Pisa)

Presenter: DE SANTI, Federico (Università di Pisa and INFN Pisa)

Session Classification: Poster lightning talks

Contribution ID: **42** Type: **Invited talk**

Multi-wavelength data analysis with the threeML framework

With an increasing number of observatories making their data publicly available, we have truly reached the era of multi-wavelength astronomy. Combining gamma-ray data from multiple instruments as well as with measurements at other wavelengths is needed to unlock the data's full potential. However, lack of standardization as well as unique challenges of each instrument can make combining data from multiple instruments a challenging and time-consuming task.
ThreeML, the multi-mission maximum likelihood framework, is a python-based software package for multi-wavelength data analysis with a special focus on high-energy astronomy. Its flexible, plugin-based structure enables the inclusion of data from many different observatories in their diverse native formats without much additional effort by the user. ThreeML relies on astromodels, a flexible modeling framework, for the description of astronomical sources. Source modeling and data access are thus separate from likelihood optimization, and can be combined in a flexible manner. In addition to the (frequentist) maximum likelihood analysis, threeML also allows for Bayesian analysis via sampling of the posterior distribution. I will report on the current status of threeML and astromodels, and show some examples for joint likelihood fits using threeML.

Primary author: OMODEI, Nicola (Stanford University/KIPAC)

Co-author: DI LALLA, Niccolo' (Stanford University)

Presenter: OMODEI, Nicola (Stanford University/KIPAC)

Session Classification: Day 3: Novel simulations and analysis methods

Contribution ID: **43** Type: **Invited talk**

Searching for long faint astronomical high energy transients: a data driven approach

Friday, 11 October 2024 10:30 (30 minutes)

I will present a novel framework designed to assess the background count rate for spaceborne high-energy detectors—a critical step in identifying faint astrophysical transients. The approach integrates a neural network to estimate background light curves across various timescales and leverages a rapid change-point and anomaly detection technique, Poisson-FOCuS, to flag statistically significant excesses in observed counts. We've tested this methodology using archival data from NASA's Fermi Gamma-ray Burst Monitor (GBM), which shares similar parameters with the HERMES Pathfinder. Our results confirm several known events, including solar flares and gamma-ray bursts from the Fermi-GBM catalog, while also identifying previously unreported events potentially linked to solar flares, terrestrial gamma-ray flashes, gamma-ray bursts, and galactic X-ray flashes. I'll discuss the performance of the neural network under different solar activity conditions and share insights from a deeper analysis of seven newly identified events, including localization estimates and tentative classifications.

Primary author: Dr CRUPI, Riccardo (Intesa Sanpaolo / Università degli Studi di Udine)

Presenter: Dr CRUPI, Riccardo (Intesa Sanpaolo / Università degli Studi di Udine)

Session Classification: Day 3: Novel simulations and analysis methods

Contribution ID: **45** Type: **Poster**

testing

gbhvg

Primary author: PESCE-ROLLINS, Melissa (Istituto Nazionale di Fisica Nucleare)

Presenter: PESCE-ROLLINS, Melissa (Istituto Nazionale di Fisica Nucleare)

Session Classification: Day 1: Latest results

Contribution ID: **46** Type: **Poster**

More tests

fgdg

Primary author: PESCE-ROLLINS, Melissa (Istituto Nazionale di Fisica Nucleare)

Presenter: PESCE-ROLLINS, Melissa (Istituto Nazionale di Fisica Nucleare)

Session Classification: Day 2: Latest results

Contribution ID: **47** Type: **Invited talk**

The search for binary supermassive black holes in large time-domain electromagnetic surveys

Friday, 11 October 2024 12:00 (30 minutes)

Supermassive black hole binaries are thought to be an inevitable product of the prevailing galaxy evolution scenarios where most massive galaxies host a central black hole and undergo mergers over cosmic time. The early stages of this process have been observed in the form of interacting galaxy pairs and widely separated dual quasars, but the close, gravitationally bound binaries that are expected to follow have proven elusive. One approach to finding them has been to search large-area electromagnetic surveys for candidates based on the expected time-domain signatures of binarity. In this invited talk, I will review these signatures, their implementation in current and upcoming industrial scale surveys, and the complications that arise from regular quasar variability.

Primary author: Prof. RUNNOE, Jessie (Department of Astronomy & Physics Vanderbilt University)

Presenter: Prof. RUNNOE, Jessie (Department of Astronomy & Physics Vanderbilt University)

Session Classification: Day 3: Novel simulations and analysis methods

Contribution ID: **48** Type: **Invited talk**

Constraints on ultralight dark matter with the European Pulsar Timing Array

Wednesday, 9 October 2024 10:45 (30 minutes)

Pulsar Timing Array experiments can probe the presence of possible scalar or pseudoscalar ultralight dark matter particles through decade-long timing of an ensemble of galactic millisecond radio pulsars. If dark matter interacts only gravitationally with ordinary baryonic matter, our findings show that ultralight particles with masses $10^{-24.0}$ eV $\leq$ m $\leq 10^{-23.3}$ eV can have at most local density $\rho \leq 0.3$ GeV/cm^3. A conformal coupling of the dark matter scalar to gravity, instead, would mediate an effective coupling between pulsars and dark matter. In turn, this would produce a periodic modulation of the pulsar rotational frequency. We present constraints on the coupling of dark matter, improving on existing bounds.

Primary author: SMARRA, Clemente (SISSA)

Presenter: SMARRA, Clemente (SISSA)

Session Classification: Day 1: Latest results

Contribution ID: **49** Type: **Invited talk**

High-energy Neutrinos from Blazars

Wednesday, 9 October 2024 14:45 (30 minutes)

Cosmic rays prove that our Universe hosts elusive astrophysical ”monsters”capable of continuously and efficiently accelerate particles at extreme energies. High-energy photons and neutrinos may provide the ultimate key to decipher the mystery of cosmic rays. Amongst the most promising neutrino candidate sources of high-energy neutrinos there are blazars, active galactic nuclei hosting a relativistic jet pointed towards us. However, to date there is neither a consistent picture for the physical mechanism nor a theoretical framework capable of convincingly explain the full set of multi-messenger observations. This contribution presents initial encouraging steps in one of the foremost challenges in the astrophysics and multi-messenger fields, i.e. identifying the sources of extragalactic neutrinos, and discusses the latest status of the field.

Primary author: BUSON, Sara (Univ. of Wuerzburg)

Presenter: BUSON, Sara (Univ. of Wuerzburg)

Session Classification: Day 1: Latest results

Contribution ID: **50** Type: **Invited talk**

Summary on lessons learned from IXPE observations of AGN

Thursday, 10 October 2024 09:30 (30 minutes)

I will present a summary of observations of active galaxies from the Imaging X-ray Polarimetry Explorer (IXPE). For radio quiet AGN such as NGC 1068 and the Circinus Galaxy, X-ray polarization results from scattering from the corona above the disk or from the inner wall of a molecular torus. Blazars whose synchrotron spectra peak at high frequencies (in or near the X-ray band), denoted as HBLs, are generally found to be polarized at the 10-30% level. Examples include Mk 501 and Mk 421. They can have quite variable polarization both in degree and position angle – likely related to the jet on parsec scales. Optical polarization is much lower than the X-ray polarization in these cases, supporting a model where electrons are accelerated in shocks travel downstream to regions of increasingly disordered field. By contrast, for blazars with low frequency synchrotron emission (LBLs), such as 3C 273, 3C 279, and 3C 454.3, have X-ray spectra dominated by Compton upscattered photons. X-ray polarization has not been detected in LBLs at levels of 10% or less. For these sources, we favor models where the X-ray band is dominated by unpolarized photons upscattered by relativistic electrons in relativistic jets. The parameter space for hadronic models is severely constrained. The IXPE observations have been critically supported by contemporaneous multiwavelength polarization campaigns, required for a holistic view of blazar emission.

Primary author: MARSHALL, Herman (MIT Kavli Institute)

Presenter: MARSHALL, Herman (MIT Kavli Institute)

Session Classification: Day 2: Latest results