High Energy Phenomena in Relativistic Outflows VII (HEPRO VII)

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Facultat de Física, Universitat de Barcelona

Report of Abstracts

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3D numerical study of an anisotropic heat transfer in outer layers of magnetized neutron stars

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Periodic changes in thermal soft X-ray spectra of some single neutron stars indicate a non-uniform distribution of their surface temperature. The possible cause of this phenomenon is a suppression of a heat flux across magnetic field lines in a crust and an envelope of magnetized neutron stars. We calculated the surface temperature distribution, depending on a magnetic field configuration.

We have solved numerically a three dimensional boundary-value problem for a heat transfer equation in a magnetized neutron star crust with an anisotropic (tensorial) heat conductivity coefficient, derived by the Chapman-Enskog method for the Boltzmann equation (G.S.Bisnovatyi-Kogan and M.V.Glushikhina, 2018).

To calculate the envelope surface temperature distribution, we have constructed a local one-dimensional plane-parallel model ("Ts-Tb"-relationship) of a magnetized neutron star envelope and used it as an outer boundary condition for 3D problem in the crust to find a self-consistent solution.

To study possible observational manifestations of thermal spectra from obtained anisotropic temperature distributions we generated light curves with a composite black-body model. Results are discussed.

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5.5 years multiwavelength variability of Mrk 421: evidence of leptonic emission from radio to TeV

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Mrk 421 is a high-synchrotron-peaked blazar featuring bright and persistent GeV and TeV emission. We use the longest and densest ongoing unbiased observing campaign obtained at TeV and GeV energies during 5.5 years with the FACT telescope and the Fermi LAT detector. The contemporaneous multi-wavelength observations were used to characterize the variability of the source and to constrain the underlying physical mechanisms. We study and correlate light curves obtained by nine different instruments from radio to gamma rays and found two significant results. The TeV and X-ray light curves are very well correlated with sub-day lag. The GeV light curve varies independently and accurately leads the variations observed at long wavelengths, in particular in the radio band. We find that the observations match the predictions of leptonic models and suggest that the physical conditions vary along the conical jet, where the emitting region is moving outwards and is becoming first transparent to GeV photons and later to radio.

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A Catalogue of XMM-Newton BL Lacs

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A XMM-Newton catalogue of BL Lac X-ray properties is presented based on the cross-correlation with the 1374 BL Lacs listed in the 13th edition of the Veron-Cetty and Veron (2010) catalogue. X-ray counterparts to these objects are searched in the field of view of around 10000 XMM-Newton pointed observations. The cross-correlation yielded a total of 352 XMM-Newton observations which corresponds to 102 different sources. Data from the three EPIC cameras and OM were homogeneously analysed using the XMM-Newton SAS software. Images, lightcurves and spectral products are produced for those BL Lacs detected in any of the three EPIC cameras. Two different phenomenological models, with different variations of the absorbing column density, are tested: Log-Parabolic and Powerlaw, we determine the best fit model and extract its parameters. The results of the analysis are presented as a catalogue of X-ray spectral properties of the sample in the 0.2 - 10 keV energy band as well as in the V/UV band. Multiwavelength information at radio and gamma-ray energies complete the catalogue.

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A constrained transport method for the solution of Resistive Relativistic plasmas in the PLUTO code

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Resistive plasmas are of fundamental importance in the description of physical phenomena such as magnetic reconnection, which has been recently pointed out as an efficient site for particle acceleration. Here we present a new module for the PLUTO code that solves the Relativistic Resistive MagnetoHydroDynamics (RRMHD) equations using an IMplicit-EXplicit Runge-Kutta (IMEX-RK) method for the evolution of the electric field. The divergence free condition and the conservation of the electric charge are treated using a constrained transport method, where both electric and magnetic fields have a staggered representation.. The solution of the Riemann problem is obtained under the frozen limit condition on the direct combination of two Riemann solvers: one for the outermost electromagnetic waves across which only transverse components of electric and magnetic fields can change, and a second one across the sound waves where only hydrodynamical variables have non trivial jumps.

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A hadronic synchrotron mirror model for blazars - Application to 3C279

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On the 28th of January, an orphan very-high-energy γ-ray flare from 3C279 was detected, not accompanied by flaring in the adjacent GeV gamma-ray regime. Orphan flares have to be caused by different processes than normal γ-ray flares. Specifically, we propose the Hadronic Synchrotron Mirror Model to provide a consistent explanation of this orphan flare. We present analytical estimates of the expected target photon densities in a synchrotron mirror model starting from first principles. The results suggest that the Hadronic Synchrotron Mirror Model may provide a plausible explanation for the vHE γ-ray flare of 3C279. We then present a semi-analytical model which we have developed to represent the Hadronic Synchrotron Mirror Model in a realistic fashion, and discuss the results of its application to the orphan VHE flare of 3C279.

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A mechanism for triple-ridge emission structure of AGN jets

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Recent radio VLBI observations of the relativistic jet in M87 radio galaxy have shown a triple-ridge structure that consists of the conventional limb-brightened feature and a central narrow ridge. Motivated by these observations, we examine a steady axisymmetric force-free model of a jet driven by the central black hole (BH) with its electromagnetic structure being consistent with general relativistic magnetohydrodynamic (GRMHD) simulations, and find that it can produce triple-ridge images even if we assume a simple Gaussian distribution of emitting electrons at the base of the jet. We show that the fluid velocity field associated with the electromagnetic field produces the central ridge component due to the relativistic beaming effect, while the limb-brightened feature arises due to strong magnetic field around the jet edge which also induces the electrons to be dense there. We also show that the computed image strongly depends on the electromagnetic field structure, viewing angle, and parameters related to the electrons' spatial distribution at the jet base. We will also discuss the extension of our force-free model to GRMHD model, which will help constraining the non-thermal electron injection mechanism of BH jets. This study will be complementary to theoretical analyses of the upcoming data of Event Horizon Telescope.

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Acceleration of Relativistic Outflows with Tangled Magnetic Field

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Extracting the rotational energy by magnetic braking is the most promising mechanism driving relativistic outflows of active galactic nuclei, gamma-ray bursts, and pulsar winds, i.e., they must be

Poynting dominated flow at their base.
On the other hand, the observed spectral and dynamical signatures of these relativistic objects infer that the magnetization σ (the ratio of Poynting to particle energy fluxes) of the outflows is much less than unity at a dissipation point.
Many studies intended to accelerate the Poynting dominated outflows by reducing the magnetization have been done, called σ-problem.

Recently, we extended the one-dimensional spherically symmetric steady outflow model by Kennel & Coroniti (1984) by formulating the effects of the turbulent magnetic field in order to resolve the σ-problem of the Crab Nebula (Tanaka et al. 2018).
Here, we will show the results for applications of our model to the relativistic outflows.
Interestingly, even cylindrical jets (e.g., Fanaroff-Riley type II) can be accelerated by the effects of the magnetic turbulence.
Although the magnetic turbulence does not reduce the flow magnetization, the radiative cooling of the relativistic flow accompanied with the dissipation of the turbulent magnetic field leads to further acceleration and reduction of the magnetization.

[1] Kennel C. F., & Coroniti F. V., 1984, ApJ, 283, 694
[2] Tanaka S. J., Toma, K. & Tominaga, N., 2018, MNRAS, 478, 4622

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Analyzing the December 2013 Orphan Gamma-Ray Flare from 3C 279

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Multi-wavelength monitoring of the blazar 3C 279 observed a very bright, 12-hour, orphan gamma-ray flare on 20 Dec 2013 with a uniquely hard FermiLAT spectrum and high Compton dominance. We work with a one-zone, leptonic model with both first- and second-order Fermi acceleration, which now reproduces the unique flaring behavior. We present a simplified analytic electron energy distribution to provide intuition about how particle acceleration shapes multi-wavelength blazar jet emission spectra. The contributions of individual processes in relativistic jets is fundamental to understanding the particle energy budget in the formation and propagation of astrophysical jets. We rule out the possibility that significant acceleration occurs via magnetic reconnection due to the very low magnetization parameter, and is constrained by the maximum Larmor radius for the jet geometry. Our analysis suggests that the flare is initiated by an increase in the particle energies due to shock acceleration, which also increases the stochastic acceleration. The higher energy particle preferentially occupy the outer jet, along the sheath, which decreases the apparent magnetic field and synchrotron radiation, while increasing electron exposure to the BLR photon fields, driving up the external Compton emission.

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Are BL Lac jets weakly magnetised?

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The Spectral Energy Distribution (SED) of BL Lacs is usually modelled assuming that the momentum distribution of the non-thermal particles is isotropic. The modelling of the SED typically suggests the presence of strongly sub-equipartition magnetic fields in the emission region, which contradicts the paradigm of dynamically important magnetic fields in AGN jets. I will argue that the non-thermal electrons responsible for producing the observed radiation are instead primarily accelerated in the direction of the background magnetic field. The key point is that gyroresonant pitch angle scattering, which might isotropize the electron momentum distribution, can be effective only out to some electron energy that is typically smaller than the spectral break due to efficient cooling. I will present a simple phenomenological model that takes this effect into account. Using the new model, the physical properties of the emission region that are inferred from the observed SED change dramatically. In particular, allowing for an anisotropic electron distribution removes the need for strongly sub-equipartition magnetic fields in the emission region.

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Are jets in GRS 1758-258 precessing?

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The large-scale morphology of the radio jets in microquasar GRS 1758-258 has been changing in the last decades. Available radio maps show hints of apparent precession. Here, we fit data with a simple kinematical model and perform an analysis of the possible origins and implications of precession in this system. From our study, that includes an additional observing epoch, we are able to confirm the previous detection of changes in the radio jets of GRS 1758-258 far from the core. However, we tentatively suggest that these changes are more probably due to instabilities instead of jet precession.

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Black Hole High Mass X-ray Binary Microquasars at Cosmic Dawn

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Theoretical models and observations suggest that primordial Stellar Black Holes (Pop-III-BHs) were prolifically formed in HMXBs, which are powerful relativistic jet sources of synchrotron radiation called Microquasars (MQs).

Large populations of BH-HMXB-MQs at cosmic dawn produce a smooth synchrotron cosmic radio background (CRB) that could account for the excess amplitude of atomic hydrogen absorption at z~17, recently reported by EDGES.

BH-HMXB-MQs at cosmic dawn precede supernovae, neutron stars and dust. BH-HMXB-MQs promptly inject into the IGM hard X-rays and relativistic jets, which overtake the slowly expanding HII regions ionized by progenitor Pop-III stars, heating and partially ionizing the IGM over larger distance scales.

BH-HMXBs are channels for the formation of Binary-Black-Holes (BBHs). The large masses of BBHs detected by gravitational waves, relative to the masses of BHs detected by X-rays, and the high rates of BBH-mergers, are consistent with high formation rates of BH-HMXBs and BBHs in the early universe.

Recent references on this subject:
Mirabel, I.F. 2017, New Astron. Revs. 78, 1
Mirabel, I.F. 2019, Invited review at IAUS 346: arXiv#1902.00511.pdf

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CTA 102 – year over year receiving you

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The FSRQ CTA 102 (z=1.032) has been tremendously active over the last few years. During its peak activity lasting several months in late 2016 and early 2017, the gamma-ray and optical fluxes rose by up to a factor 100 above the quiescence level. We have interpreted the peak activity as the ablation of a gas cloud by the relativistic jet, which can nicely account for the months-long lightcurve in 2016 and 2017. The peak activity was in the middle of a 2-year-long high-state, which was characterized by increased fluxes and increased rms variability compared to the previous low-states, and which was flanked by two bright flares. In this presentation, we put the cloud-ablation scenario into the broader context of the 2-year-long high-state.

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Calibrating the power of relativistic jets

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There are several methods to calculate the radiative and kinetic power of relativistic jets, but their results can differ by one or two orders of magnitude. Therefore, it is necessary to perform a calibration of the jet power, to understand the reasons for these differences (whether wrong hypotheses or intrinsic source variability), and if it is possible to converge to a reliable measurement of this physical quantity. We present preliminary results of a project aimed at calibrating the power of relativistic jets in active galactic nuclei (AGN) and X-ray binaries (XRB). We started by selecting all the AGN associations with known redshift in the Fourth Fermi LAT Gamma-Ray Catalog (4FGL). We then calculated from available data or extracted from literature the radiative and kinetic powers, in order to compare them with the theoretical expectations of Blandford & Königl (1979).

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Centrifugal acceleration of protons in the vicinity of a supermassive black hole

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TBP

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Chandra Observation of Fast-moving Pulsars

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The supersonic motion of a pulsar in the ambient medium usually renders pulsar wind nebulae with morphologically bow-shaped shocks and/or cometary tails. Chandra, with its unprecedented angular resolution and high sensitivity has proved a great success in the detection and precise characterisation of these fast-moving pulsars. In particular, with an increasing number of detected supersonic pulsar wind nebula (SPWN) systems, an unusual outflow structure misaligned with respect to the pulsar motion has been observed in several cases. Here, recent results from the spatial and spectral analysis of several SPWNe based on Chandra observations are presented.

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Characterising the Long-Term Variability of Blazars in Leptonic Models

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Most research on blazar variability focuses on individual flares to explain acceleration and radiation mechanisms and improve on current models. These short-time events (minutes, hours or days) might not be representative of the underlying mechanisms causing small-amplitude variability and/or continuous emission present most of the time. We therefore investigate long-term (month to years) variability of blazar emission in the framework of current leptonic blazar models. For this purpose, we introduce generated time-dependent parameter variations which are based on typical Power Spectral Densities (PSDs) associated with the variability of accretion flows. The PSDs from the resulting light curves are analyzed and compared to one another as well as the PSD of the input variation. Correlations between light curves are also investigated to aid identification of characteristic variation patterns associated with leptonic models.

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EXTREME REGIMES OF EMISSION IN RELATIVISTIC OUTFLOWS

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In the broad-band spectra of blazars there are two broad and widely separated maxima. According to the existing paradigm, the origin of the lower-frequency maximum is explained by the synchrotron radiation of accelerated electrons, and the higher-frequency maximum is produced via inverse Compton radiation from the same population electrons. This paradigm makes it necessary to adopt such physical parameters in the radiating region (magnetic field energy density, electron acceleration rate, etc.), which differ by orders of magnitude from their natural values dictated by dimensional considerations and comparison with other sources of synchrotron radiation. We analyse the extreme regimes of particle acceleration and radiation, discuss physical limits to the parameters of blazars' emitting zones, and show that in many cases model requirements cannot fit into these fundamental limits.

We also propose another paradigm in which both maxima in blazars' spectra are explained by synchrotron radiation of different populations of particles. The higher-frequency maximum is associated with the emission of primary accelerated particles directly in the acceleration zone, and the lower-frequency maximum with emission of secondary electron-positron pairs, which are produced outside of the acceleration zone. Then the required physical parameters in emitting zones of blazars turn out to be close to their natural values, and the resulting spectra qualitatively agree with the observed ones.

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FRB MULTI-WAVELENGTH AND MULTI-MESSENGER ASTROPHYSICS

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Abstract: Abstract: Fast radio bursts (FRBs), bright millisecond duration radio transients, are quickly becoming a subject of intense interest in time-domain and high energy astrophysics. FRBs have the exciting potential to be used as cosmological probes of both matter and fundamental parameters, but such studies require large populations. Advances in FRB detection using current and next-generation radio telescopes will enable the growth of the population in the next few years from a few dozen to hundreds. Real-time discovery and follow-up, and new studies of the FRB population will provide us with some of the greatest insights in the coming years. I will discuss many observational aspects of the FRB population, including polarisation, searches for multi-wavelength emission, localisation, and repeating FRBs. I will also discuss how multi-wavelength and multi-messenger astrophysics with FRBs can be maximised with future facilities.

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Four Tensors Determining Thermal and Electric Conductivities of Degenerate Electrons in Magnetized Plasma

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A solution to the Boltzmann equation is obtained for a magnetized plasma with strongly degenerate non-relativistic electrons and non-degenerate nuclei. The components of the diffusion, thermal diffusion, diffusion thermoeffect and thermal conductivity tensors in a non-quantizing magnetic field are calculated in the Lorentz approximation without allowance for electron–electron collisions, which is asymptotically accurate for plasma with strongly degenerate electrons. The obtained expressions reveal a considerably more complicated dependence on magnetic field than analogous dependences derived in the previous publications on this subject. The calculated tensors can be used to calculate the heat fluxes and electric current in white dwarfs, on the surfaces and in the crusts of neutron stars, and in magnetized plasma falling onto a neutron star.

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GRMHD SIMULATIONS OF JET FORMATION WITH APPLICATION TO THE EHT ANALYSIS

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Over the last two decades, general relativistic magnetohydrodynamic simulations (GRMHD) have drawn a robust theoretical picture of jet formation in low-luminosity sources. The observations by the Event Horizon Telescope now allow to test these theories at an unprecedented level. I will take this opportunity to review the state-of-the-art in 3D numerical source models. Nowadays, adaptive mesh refinement simulations resolve the black hole engine as well as the jet outflow over several decades. To demonstrate how results compare between different codes, I will also report on the first comprehensive GRMHD code comparison effort of black hole accretion in which nine groups have participated. As an example application, first conclusions drawn from the GRMHD simulation library which was applied to the 2017 EHT observations will be discussed. In particular the jet power derived from GRMHD simulations proved to be very constraining on the source parameters of M87.

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GRS 1758-258 as a winged microquasar

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The large-scale morphology of the prototypical microquasar GRS 1758-258 resembles the Z-shape of the subclass of extragalactic radio sources known as winged radio galaxies. This new quasar-microquasar analogy allows us to study the nature of the origin of this peculiar morphology, which seems to be related to the hydrodynamical back flow. Some other implications could be stated assuming that physical processes at work are similar in Galactic and extragalactic cases

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Gamma-ray Flaring states of Flat Spectrum Radio Quasars: Statistical distribution and Correlations

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We will show the results of the investigation of gamma-ray flaring states of Flat Spectrum Radio Quasars (Paper in preparation). Flaring events were recognized adopting a Scan-Statistic driven clustering method (Pacciani2018) applied to the FERMI-LAT archival data in the energy range 0.3-300 GeV.

We report here:
the statistical distribution of the peak-luminosity and of the duration of flaring activity;
the so-called jet-disk connection for flaring activity;
the photon index correlation with luminosity during flaring states.

We found that the distribution of peak luminosity and flare duration can be described with correlated log-normal or log-gamma distributions. The Fitted model for Flaring activity accounts for ˜75% of the observed catalog source luminosity.
Log-normal and log-gamma distributions are usually invoked to describe turbulent phenomena, when the observed phenomena are the results of chains of events. We argue that the observed correlation among peak luminosity and flare duration can be ascribed to Doppler factor acting both on the apparent source luminosity, both on the flare duration. Finally, we will discuss the constraints that the observed correlations put on the modeling of the high energy spectral distribution of FSRQ jets.

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Gamma-ray bursts associated with BNS mergers

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Based on detection and investigation of well known short duration gamma-ray burst GRB 1170817A associated with LIGO/Virgo GW 170817 we discuss properties of GRBs associating with binary neutron star mergers. In particular we describe variety of light curves and spectra of prompt emission and chance to observe the prompt emission and afterglow.

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Gamma-ray emission from Cyg X-1 and Cyg X-3

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In two recent papers (Zdziarski et al. 2017, 2018), we presented measurements by the Fermi/LAT and theoretical interpretation of the gamma-ray spectra from two Galactic microquasars, Cyg X-1 and Cyg X-3. In both sources, orbital modulation (due to Compton anisotropy of scattered stellar photons from the donor) has been measured, which has allowed us to estimate of the location of the bulk of the gamma-ray emission. The theoretical interpretation of the broad-band spectra (from radio to gamma-rays) is based on extended-jet and accretion models, developed earlier. We have also measured cross-correlations between the gamma-rays and both radio and X-ray emission, which put constraints on the respective emission sites and, in the case of Cyg X-3, implies the presence of extended periods of advection of magnetic fields through the accretion flow. The obtained set of

results allows us to make predictions for the spectra and orbital modulation of those sources when observed by the CTA.

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Gamma-rays and positrons from colliding wind binaries

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Fermi-LAT and HESS detection of η Carinae confirm that diffuse shock acceleration occurs in the complex geometry of the wind collision zone. Hydrodynamic simulations provide a convincing match with the observations if a few percent of the wind mechanical energy dissipated in the shock goes into particle acceleration. The intrinsic π_0 decay spectrum is a complex convolution of the maximum energy, luminosity, particle drift and obscuration. Accelerated particles cool down mainly via inverse-Compton, synchrotron radiation, and photo-pion production. If the final spectra of accelerated electrons from primary side and secondary side overlap significantly and have similar luminosities, the final γ-ray spectra will not present the observed two bumps. High-energy γ-rays interact also with the pool of anisotropic UV photons emitted by both luminous stars, creating $e^{\pm}$ pairs and strongly modifying the observed spectrum. Quick variations of the optical depth are expected along the orbit, due to changes in shape, position, and gas density of the shocked region. Various CTA simulations confirm that flux variabilities down to few days timescale could be detected above 30 GeV. These variations will disentangle the intrinsic particle spectral cut-off from that related to γ-γ opacity and determine the flux of relativistic protons and positrons injected in the interstellar medium, the geometry of the colliding wind region and the magnetic field configuration, as well as the geometrical orientation of the binary system. CTA will also enlighten the nature of the high-energy component, the mechanisms and the percentage of kinetic energy channelled into particle acceleration.

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Gamma-rays from large-scale outflows in starburst galaxies

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The combined effects of supernova explosions and stellar winds produce a hot bubble in the central regions of starburst galaxies. As the bubble expands, it can outbreak into the galactic halo driving a superwind that transports hot gas and fields to the intergalactic space. I present estimates of cosmic ray generation and gamma-ray emission in this large-scale wind.

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Generalized Fermi acceleration

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The present paper proposes a generalized description of Fermi-type acceleration processes, by following the momentum of the particle through a continuous sequence of accelerated frames, defined in such a way that the electric field vanishes at each point along the particle trajectory. This unified description of Fermi acceleration applies equally well in sub- and ultra-relativistic settings, in Cartesian or non-Cartesian geometries, flat or non-flat space- time.

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High-energy neutrino and gamma-ray emission from AGN-driven winds

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Various observations are revealing the widespread occurrence of fast and powerful winds in active galactic nuclei (AGN) that are distinct from relativistic jets, likely launched from accretion disks. On sufficiently large scales, they are expected to interact with the gas of their host galaxies, leading to strong shocks that can accelerate nonthermal particles to high energies. Such winds have been suggested to be responsible for a large fraction of the observed extragalactic gamma-ray background (EGB) and the diffuse neutrino background, via the decay of neutral and charged pions produced in pp interactions between protons accelerated by the forward shock and the ambient gas. Taking into account processes such as adiabatic losses that were not properly included in earlier studies, we evaluate the production of gamma rays and neutrinos by AGN-driven winds in detail by modeling their hydrodynamic and thermal evolution. We find that they can only account for less than ˜30% of the EGB flux, as otherwise the model would violate the independent upper limit derived from the diffuse isotropic gamma-ray background. We also identify ranges of parameters such as the spectral index for which AGN winds may still make an important contribution to the diffuse neutrino flux. Furthermore, we discuss the possibility of neutrino production via p-gamma interactions in the inner regions of the wind near the nucleus.

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IMAGING SUPERMASSIVE BLACK HOLES WITH THE EVENT HORIZON TELESCOPE

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The Event Horizon Telescope (EHT) has captured the first image of a black hole. The central compact radio source in the radio galaxy M87 has been resolved out into an asymmetric bright emission ring with a diameter of 42 uas, which is circular and encompasses a central depression in brightness with a flux ratio >10:1. The emission ring is recovered using different calibration and imaging schemes, and remains stable over four different observations carried out in different days. We compare our images to an extensive library of ray-traced GRMHD simulations showing that they are consistent in size and shape with the lensed photon orbit encircling a dark shadow caused by photon capture at the event horizon of a 6.5 billion solar masses black hole, as predicted by general relativity. Our EHT observations thus provide confirmation for the presence of supermassive black holes powering active galaxies, and present a new tool to explore gravity in its most extreme limit via repeated astronomical observations.

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Inclination dependence of the time-lag – photon-index correlation in BHXRBs and its explanation with a simple jet model

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It is widely accepted that the power-law X-ray spectra of black-hole X-ray binaries (BHXRBs) are produced by inverse Compton scattering in a corona, which is typically taken to be the hot inner flow around the black hole or the base of the jet. However, if a photon finds itself in the hot inner flow or the base of the jet, nothing prevents it from traveling higher up in the body of the jet. In other words, Comptonization in the hot inner flow and the base of the jet is, by necessity, followed by Comptonization in the body of the jet, because the jet is fed by the hot inner flow and lies above and below the hot inner flow. Over the years, we have demonstrated with a simple jet model that Comptonization in the body of a jet can explain not only the spectrum from radio to hard X-rays, but also the evolution of the photon index and the time (phase) lags as functions of Fourier frequency, the correlation between time lag and photon index (in Cyg X-1, in GX 339-4, and in the class of BHXRBs as a whole), and the correlation between time lag and cut-off energy in GX 339-4. Here we demonstrate observationally that the time-lag – photon-index correlation is different for systems with different inclinations. We also demonstrate theoretically, with Comptonization in the jet, that the same jet model reproduces nicely the inclination dependence of the correlation. Photons escaping the jet at different viewing angles obey different time-lag – photon-index correlations. The time lag is due to the random walk of the photons in the body of the jet.

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Kinetic Simulations of Relativistic Radiative Steady-State Magnetic Reconnection

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We will present the results of kinetic simulations of relativistic magnetic reconnection including synchrotron radiation reaction in a domain with open boundaries. In such configuration, reconnection produces steady relativistic outflows that involve chains of plasmoids with well-defined statistical characteristics (Sironi et al. 2016). Due to the stochasticity of plasmoids chains, the plasmoid reconnection offers an attractive scenario for the multi-timescale and multi-wavelength variability of high-energy non-thermal sources, in particular those associated with relativistic magnetized jets, e.g., blazars (Christie et al. 2019). However, the effects of radiative cooling on the evolution of plasmoid properties have not been investigated yet. By means of particle-in-cell (PIC) simulations using the Zeltron code that includes synchrotron radiation reaction, a strong cooling efficiency regime

is achieved, with typical synchrotron cooling length scales of the order of the physical size of our computational domain. As has been noted before, the evolution of individual plasmoids depends fundamentally on their size, e.g. the bulk acceleration length scale is shorter for small plasmoids, and small plasmoids are responsible for the most rapid variability of the emitted radiation. We find that small plasmoids are able to radiate away a large fraction of their thermal energy within the domain boundaries, and hence their contribution to the observed light curves can be accurately described by the results of our simulations.

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- Sironi, L., Giannios, D. & Petropoulou, M. 2016, MNRAS, 462, 48

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Laboratory simulation of jet propagation in ambient medium with Plasma Focus facilities

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Plasma focus (PF) facilities have proved to be an effective tool in the modeling of outflows from compact astrophysical objects [1]. The specific feature of the experimental scheme with PF is the possibility to study the propagation of plasma flows over long distances, while we are able to change the parameters of the ambient medium. The talk provides a brief overview of the latest experiments on the PF-3 (NRC "Kurchatov Institute", Moscow) and PF-1000 (IPPLM, Warsaw) facilities. The main emphasis is made on the simulation of the bow shock wave. The effect of pre-ionization of background gas by the radiation of the plasma flow is shown. The effects of radiation cooling and magnetic fields on the collimation and stability of the plasma flow are analyzed. The results of experiments with an external poloidal field are presented. The increase in both the poloidal and toroidal components of the captured magnetic field is shown. This effect may be due to the rotation of the plasma flow.

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Localisation of the gamma-ray emission zone in narrow-line Seyfert-1 galaxies with Cherenkov Telescope Array simulations

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The location of the gamma-ray emitting region in jetted sources is one of the currently open issues that can be efficiently tackled by future observations with the Cherenkov Telescope Array (CTA). For transients/flaring events (time-scales of ˜1 day or shorter) CTA will be at least two orders of magnitude more sensitive with respect to Fermi-LAT in the overlapping energy range above 25 GeV, allowing an unprecedented opportunity to investigate flaring gamma-ray emitting narrow-line Seyfert 1 galaxies (g-NLS1) galaxies.
In a recent work, we considered the prospects for observations of a sample of 20 g-NLS1s taking into account the effect of both the extragalactic background light in the propagation of gamma-rays and a simplified analytical modelling of the intrinsic absorption components.
Motivated by our results, we now consider the most promising sources, SBS 0846+513, PMN J0948+0022, and PKS 1502+036, and simulate their spectra by adopting more physical broad-line region (BLR) absorption models. In particular, we consider the detailed treatment of gamma-gamma absorption in the radiation fields of the BLR of these g-NLS1s as a function of the location of the gamma-ray emission region as proposed by Böttcher & Els (2016, 2018). These detailed models allow us to put tight constraints on the location of the gamma-ray emitting region in this extreme class of jetted sources.

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Lorentz factors of compact jets in black hole X-ray binaries

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Compact, continuously launched jets in black hole X-ray binaries (BHXBs) produce radio to optical–infrared (OIR) synchrotron emission. These jets are launched in the hard X-ray state, and are quenched in the soft state. They are not spatially resolved except in a few cases using VLBI radio observations. One of the basic properties of these jets is the bulk Lorentz factor, which defines how fast and how relativistic these jets are. The bulk Lorentz factor is notoriously difficult to measure, with to date only weak constraints for a few BHXBs. Here, we adopt simple models to constrain the Lorentz factor of the compact jets in several BHXBs using the amplitude of the jet fade and recovery at infrared (IR) wavelengths over state transitions. We investigate why some BHXBs have prominent IR excesses and some do not, quantified by the amplitude of the IR quenching or recovery over the transition from/to the hard state. Using the amplitude of the IR fade/recovery, known orbital parameters and simple analytical models, we constrain for the first time the Lorentz factor of compact jets in several BHXBs. We also find that the very high amplitude IR fade/recovery seen repeatedly in GX 339−4 requires a much lower inclination angle than previously expected. Our results are strongly supportive of the IR excess being produced by synchrotron emission in a relativistic outflow, and demonstrates how useful OIR monitoring of BHXB is for studying jet properties.

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MHD Accretion Disk Winds and the Blazar Sequence

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Fermi telescope has detected a significant number of AGNs to allow statistical treatment of their properties. Among others, it confirmed the "Blazar Divide" in FSRQs and BL Lacs according to their gamma-ray spectral index and luminosity. We investigate this classification by proposing a model which reproduces in detail the broadband blazar spectra and their statistical properties based on the physical parameters of their MHD accretion disk winds. This model describes the distribution of matter and magnetic fields in AGN at least over 5 decades in radius and it provides the vestiges of an account of the observed blazar classification in terms of a single parameter, their mass accretion rate.

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MHD Simulation of Laboratory Jets

Olga Toropina[None]

We performed numerical MHD simulation of the laboratory experiment for creating plasma jets on a NEODIM laser installation. In this experiment, the plasma ejection is formed as a result of the action of a powerful laser on the target. To describe these processes and simulate plasma flow, we chose a numerical method, boundary and initial conditions. We investigated the picture of the flow and compared it with the experiment. We found the distribution of the density of matter at various distances from the target and at different time and investigated the possible structures of matter on the surface of the detector.

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MULTIWAVELENGTH PROPERTIES OF AGN JETS

Relativistic jets in AGN emit radiation at all wavelengths,
from radio to TeV gamma-rays. The main source of their power seems the rotation of the black hole. Their radiation mechanisms however remains elusive. I will review the current status and some recent observations which are challenging
common views, in particular about variability, location of the gamma-ray emitting regions, particle acceleration and main emission mechanisms among different classes of sources.

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Magnetically arrested disks around black hole, and jet formation

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Synchrotron origin of the radiation from extragalactic disks indicate to important role of the magnetic field in their formation and collimation. Jets from AGN show their close connection with supermassive black holes. Large magnetic fields around BH are formed during an accretion of matter with large-scale magnetic field. Approximate solutions describing such accretion lead to conclusion of formation of an accretion disk around BH supported by magnetic field against gravity, instead of a centrifugal force in the keplerian disk. The efficiency of this regime of accretion may reach 0.5Mc2. The properties of such disk had been studied it the middle of 70s, and much later is was named as

"magnetically arrested disk". Different models of jet origin from such disk had been studied in approximate way. 2-and 3 d numerical simulations had been performed during last years, confirming efficiency of jet formation, especially from the disks around rapidly rotating BH.

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Magnetorotational supernovae and gravitational waves

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Co-author(s): G. S. Bisnovatyi-Kogan

We consider magnetorotational(MR) core-collapse supernova explosion mechanism.
Numerical simulations show that the shape of the MR explosion depends on the initial configuration of the magnetic field. The explosion can develop preferably near equatorial plane (quadrupole-like field) or as a mildly collimated jet (dipole-like field). We have estimated the dimensionless amplitude of the gravitational wave with a frequency ˜ 1300 Hz, radiated during the collapse of the rotating core of a pre-supernova with a mass of 1,2Msun. This estimate agrees well with many other calculations that have been done in 2D and 3D settings and which rely on more exact and sophisticated calculations of the gravitational wave amplitude.

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Modelling flux variability from internal shocks in relativistic jets

Andreas Zech[1]

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Particle acceleration at stationary and moving internal shocks is one of the principal mechanisms to explain the variable synchrotron emission, seen from the radio to the X-ray band, from relativistic jets in radio-loud active galactic nuclei. To reproduce the light curves associated with these shocks, we perform SRMHD simulations of magnetised relativistic
transverse-structured jets using the AMRVAC code.
Perturbations are injected at the base of a jet that carries stationary shocks, to study the interaction between the moving and the stationary shocks. Synchrotron emission and radiative transfer are simulated in post-treatment. The model is applied to the radio core and inner jet of the radio-galaxy M87 to study the multi-wavelength flux evolution from such perturbations and compare it against archival data.

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Modelling the Spectral Energy Distribution and Polarisation of Blazars

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The optical radiation emitted from most blazars is contributed by synchrotron radiation from their jets, as well as thermal radiation emitted by the accretion disc and host galaxy towards the high and low frequency ends of the optical spectrum, respectively. With the central engine being directly visible in blazars, the accretion disc radiation usually dominates over the host starlight. Thermal radiation from the accretion disc is expected to be unpolarised and thereby it dilutes the polarization from the dominant synchrotron radiation in the optical/UV regime. The accretion disc therefore presents itself as a decrease of the polarization degree towards higher optical/UV frequencies in spectropolarimetry observations of blazars. Optical/UV spectropolarimetry of gamma-ray blazars is conducted through a Southern African Large Telescope (SALT) target-of-opportunity programme. A model is constructed to simultaneously fit the spectral energy distribution and the degree of polarisation observations in the optical/UV regime. This model constrains the accretion disc spectrum and thereby the mass of the supermassive black hole. Furthermore, the model retrieves the electron distribution, the photon spectral indices of the synchrotron radiation profile, the ordering of the magnetic field of the jet and the accretion disc luminosity. The model is applied to fit the observations of the flat spectrum radio quasar, 4C+01.02 (z = 2.1), in its flaring and quiescent states, for which the mass of the supemassive black hole is obtained as ˜4·10ˆ8 M_⊙.

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Monte Carlo Simulations of Compton Polarization of Astrophysical Sources

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The spectral energy distributions (SEDs) and variability of astrophysical sources can be modeled in many different ways, in particular the production of X-rays and γ-rays in the SEDs of blazars. Other spectral features, for instance, the soft X-ray excess (Big Blue Bump) in the SEDs of some blazars are poorly understood, and can be modeled with different mechanisms. Polarization carries important, additional information on the astrophysical environment of astrophysical sources such as the geometry and orientation of the magnetic field, the location of the emitting region, and the emission mechanism. Compton scattering can both produce or reduce the degree of polarization of γ-rays, with the magnitude of the effect depending on the geometry of the source. In this project, Monte Carlo methods are used to simulate the anisotropic Compton scattering of thermal and a power-law tail of non-thermal electrons, in order to study the high-energy polarization, and make predictions for various models for the Big Blue Bump feature in blazars and the high-energy emission from gamma-ray bursts.

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Neutrinos from TXS 0506+056

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We used archival data to perform a detailed analysis
of the time evolution of the jet of TXS 0506+056.
In this talk we will discuss the specifics of the jet
kinematics and in particular its possible relation to
neutrino emission.
A paper describing the results has just been submitted.

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Non-thermal emission from a supernova explosion within an extragalactic jet

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Extragalactic jets are launched from the innermost regions of galaxies, near the central supermassive black hole. As they propagate, they must cross the whole galaxy, and in this process they interact with a variety of obstacles (e.g., gas clouds, stars). As populations of stars reside within the jet at all times, it is also possible that one of them explodes as a supernova (SN), introducing a SN remnant within the jet, arguably the largest effective internal obstacle that extragalactic jets can encounter. This remnant is then shocked by the jet ram pressure, expanding and accelerating, potentially leading to particle acceleration and non-thermal emission. We have explored the possibility SNe taking place within extragalactic jets, studying the dynamical evolution of the remnant and its generated gamma-ray emission, as well as the likelihood of these events taking place. Our results show that this interaction can lead to significant, prolonged gamma and X-ray emission both in nearby radio galaxies and moderate redshift blazars.

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Observations of the accreting X-Ray pulsar GX 301-2 with the X-Calibur Hard X-ray polarimetry mission

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Measurements of polarization of the X-ray emission in accreting neutron stars probe the particle acceleration region and can distinguish between fan-beam and pencil-beam approximations of the geometry of the accretion column.
In Dec 29th 2018, NASA's hard X-ray polarimetry mission X-Calibur was launched on a 2.5-day stratospheric balloon flight from McMurdo station in Antarctica. During the campaign, X-Calibur observed the high-mass X-ray binary GX 301-2 in a rare flaring state at orbital phase ˜0.35, close to apastron, resulting in a clear detection of GX 301-2 in the hard X-ray band. The ability of X-Calibur to measure the azimuthal scattering angle of the incoming X-rays resulted in a measurement of a 22% +/- 14% polarization fraction of the hard X-ray emission form GX 301-2 during the main peak of its 685s-long pulse profile. The measured polarization agrees better with fan-beam emission predictions (˜20%) than pencil beam scenarios (˜0%).
We will report on the results of the X-Calibur observations of GX 301-2 including a 15-60 keV light curve, hard X-ray energy spectrum, phase-resolved analysis, and constraints on linear polarization. We will also present contemporaneous observations of GX 301-2 in the soft X-ray band with the Neil Gehrels Swift observatory and NICER X-ray telescope that show significant variability of the shape of the pulse profile during the flaring event. We will conclude with a discussion of how neutron star, accretion, and fundamental physics can be constrained with future deeper polarimetric observations of accreting X-ray pulsars.

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Off-axis synchrotron light curves from full-time-domain moving-mesh simulations of jets from massive stars

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We present full-time-domain, moving-mesh, relativistic hydrodynamics simulations of jets launched from the centers of massive stars and compute the resulting synchrotron light curves for observers at a range of viewing angles. We follow jet propagation from the stellar center, through propagation in the stellar envelope and breakout from the stellar surface, then through the coasting and deceleration phases as the jet compresses into a thin shell, sweeps up the circumstellar medium, and eventually enters the Newtonian phase. The jets naturally develop angular and radial structure due to hydrodynamical interaction with surrounding gas. Synchrotron light curves cover the observed temporal range of prompt to late afterglow phases of long gamma-ray bursts (LGRBs). The on-axis light curves exhibit an early emission pulse originating in shock-heated stellar material followed by a shallow decay and a later steeper decay. The off-axis light curves rise earlier than previously expected based on top-hat models, rising on a time scale of seconds to minutes after breakout, and decaying afterwards, sometimes with later re-brightening components that can be contemporaneous with SNe Ic-bl emission. We calculate the detection rate of LGRB afterglows in the optical and X-ray bands based on the results of our simulations, and find that the average time for afterglows to remain above a given detection threshold is shorter than found in previous estimates. Our calculations are consistent with detection rate results from past optical and X-ray surveys of orphan afterglows, and may shed light on the structure of GRB outflows in the afterglow stage.

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On the interaction of pulsar winds and clumpy stellar winds

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TBD

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On the minimum jet power of TeV BL Lac objects in the p-gamma model

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We study the requirement on the jet power in the conventional p-gamma models (photo pion production and Bethe-Heitler pair production) for TeV BL Lac objects. We select a sample of TeV BL Lac objects whose SEDs are difficult to be explained by the one-zone leptonic model. Based on the relation between the p - gamma interaction efficiency and the opacity of absorption, we find that detection of TeV emission poses upper limits on the p - gamma interaction efficiencies in these sources and hence minimum jet powers can be derived accordingly. We find that the obtained minimum jet powers exceed the Eddington luminosity of the supermassive black holes. Implications for the accretion mode of the supermassive black hole in these BL Lac objects and the origin of their TeV emissions are discussed.

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Optical study of TeV sources

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About forty (Mrk 421, Mrk 501, 1ES 1959+650, PG 1553+113 and others) northern TeV extragalactic sources have been discovered during last twenty five years. Most of them (2/3) we are monitoring in Abastumani Observatory during 20 years using 125-cm and dedicated 70-cm meniscus telescopes. All observations (over 3500 nights) have been conducted with Apogee Ap6E and SBIG ST-6 CCD cameras in BVRI bands. The frames have been reduced using Daophot II and homogenous light curves have been constructed. The amplitudes of long-term variability are within 0.3-1.5 magnitudes. Few sources show Intra-day variability within 0.05-0.15 magnitudes, while intra-night/micro-variability is below 0.05 magnitudes. The extensive multi-wavelength campaigns with Whipple, VERITAS, HESS and MAGIC have also been conducted.

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Optical variability modelling of newly identified blazars and blazar candidates behind Magellanic Clouds

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We present results of optical variability study of 44 newly identified blazars and blazar candidates behind the Magellanic Clouds (Żywucka et al. 2018). The sample contains 27 flat spectrum radio quasars (FSRQs) and 17 BL Lacertae objects (BL Lacs), but only nine of them are recognized as blazars, while the classification of 35 objects is still uncertain. All objects possess high photometric accuracy and infrequently sampled optical light curves (LCs) from the long-term ($\sim$2 decades) monitoring conducted by the Optical Gravitational Lensing Experiment in V and I filters. The LCs were modelled with the Continuous-time Auto-Regressive Moving Average (CARMA) process using the publicly available Markov Chain Monte Carlo sampler described by Kelly et al. (2014) and with the Lomb-Scargle (LS) periodogram.

The CARMA models allow to investigate variability features of irregularly sampled LCs, especially their power spectral density (PSD), to determine variability-based classification of astrophysical objects and to detect quasi-periodic oscillations (QPOs). We found that some of the examined objects require high-order fits, implying a deviation from the simple single-Lorentzian PSD.

The power law PSD is indicative of a self-affine stochastic process characterised by the Hurst exponent H, underlying the observed variability. An estimation of the H values was performed with a wavelet lifting transform (Knight, Nason & Nunes 2017). We find that most objects have $H \leq 0.5$, indicating short-term memory, but four BL Lacs and two FSRQs have $H > 0.5$, implying long-term memory.

The power law PSDs of blazars are thought to be the result of synchrotron, synchrotron self-Compton and external Compton emission. The higher-order CARMA fits suggest there are additional variations present in blazar jets and/or accretion discs that affect both the overall shape of the PSD, and can give rise to QPOs. The non-power law features are also visible in some of the LS periodograms, and signs of flattening of the PSD at low frequencies observed in some of the CARMA fits hints at the blazar nature of the objects.

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PLASMA INJECTION AND HIGH-ENERGY EMISSION IN BLACK HOLE MAGNETOSPHERES

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Plasma injection and magnetic field dissipation are two key issues in the theory of black hole jets. Pair production in either starved magnetospheric regions or dissipative boundary layers can supply the plasma required for black hole activation. These processes naturally produce rapidly
varying VHE emission. In the first part of the talk I shall discuss pair creation in a starved BH magnetosphere and present recent GRPIC simulations of a spark gap. In the second part I will present results of recent force-free
simulations of magnetic loops accretion into a Kerr black hole, and show that in such configurations rapid dissipation occurs in the current sheets of interacting loops, that can give rise to TeV emission and consequent pair creation.

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PRESENT STATUS OF PARTICLE ACCELERATION IN RELATIVISTIC OUTFLOWS

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Relativistic outflows are ubiquitous in high-energy cosmic phenomena. Whether their reservoir of free energy at launch is in the form of bulk kinetic, magnetic or gravitational, it is ultimately channeled into energetic particles and non-thermal radiation. A key question is to understand how this transfer operates efficiently and under which conditions. In this talk, I will review some of the recent developments in the modeling of three particle acceleration processes, namely relativistic diffusive shock acceleration, relativistic magnetic reconnection and collisionless turbulence. These results will be discussed in the context of pulsars and pulsar wind nebulae, black hole magnetospheres and relativistic jets.

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PROBING BLAZAR PHYSICS WITH ASTROPHYSICAL NEUTRINOS

Maria Petropoulou[1]

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Astrophysical neutrinos, the "ghost particles of the Cosmos", are unique probes of the physical conditions in their sources, as they can escape from them and reach Earth almost unimpeded due to their extremely weak interactions with matter and radiation. High-energy neutrinos, which are mainly produced by inelastic collisions of relativistic protons or heavier nuclei with radiation or matter, can be used to trace the elusive sources of cosmic rays and to shed light on the underlying particle acceleration mechanisms. The recent discovery of a high-energy neutrino coincident with an electromagnetic flare from a blazar (TXS 0506+056) offers a unique opportunity to probe the physics of these powerful extragalactic sources using multiple messengers (i.e., photons and neutrinos). In this talk, I will review the lessons learned and the challenges created from the first high-energy neutrino source association to date.

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PROPAGATION AND STABILITY OF RELATIVISTIC JETS

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Particle acceleration in relativistic jets to very high energies occurs at the expense of the dissipation of magnetic or kinetic energy. Therefore, understanding the processes that can trigger this dissipation is key to the characterization of the energy budgets and particle acceleration mechanisms at action in active galaxies. Instabilities and entrainment are two obvious candidates to trigger dissipation. On the one hand, supersonic, relativistic flows threaded by helical fields, as expected from the standard formation models of jets in supermassive black-holes, are unstable to a series of magnetohydrodynamical instabilities, such as the Kelvin-Helmholtz, current-driven, or possibly the pressure-driven instabilities. Furthermore, in the case of expanding jets, the Rayleigh-Taylor and centrifugal instabilities may also develop. With all these destabilizing processes at action, a natural question is how can some jets keep their collimated structure along hundreds of kiloparsecs. On the other hand, the interaction of the jet with stars and clouds of gas that cross the flow in their orbits around the galactic centers provides another scenario in which kinetic energy can be efficiently

converted into internal energy and particles can be accelerated to non-thermal energies. In this talk, I will review the conditions under which these processes occur and their role both in jet evolution and propagation and energy dissipation.

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Photo-hadronically produced neutrinos from blazars

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The tentative identification of the gamma-ray bright BL Lac object TXS 0506+05 with very-high-energy neutrinos detected by IceCube triggered a large number of works on the physics implications of neutrino production in blazar jets. Most of these works agree that GeV - TeV gamma-rays are unlikely to be produced by the same hadronic processes generating the IceCube neutrinos in the same emission region. In previous work, we had developed a method to derive general constraints on the physical conditions in the neutrino emission region and multi-wavelength electromagnetic signatures expected to go in tandem with such neutrino production. Our main conclusion is that, in order to produce IceCube neutrinos at the level of the 2014-15 neutrino flare from the direction of TXS 0506+056 (accompanied only by a slightly harder Fermi-LAT spectrum, but no flux enhancement), an intense UV - soft X-ray radiation field external to the jet is required as target photon field for photo-pion interactions. This result necessitates the proper treatment of anisotropies of the target photon field in the frame of the emission region. In this talk, we will briefly summarize previous work and present first results of our study of the effects of anisotropies on the resulting neutrino yield and electromagnetic signatures.

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Pitch-angle Diffusion and Bohm-type Approximations in Diffusive Shock Acceleration

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The problem of accelerating cosmic rays is one of fundamental importance, particularly given the uncertainty in the conditions inside the acceleration sites. In this talk, I describe our work in which we examine diffusive shock acceleration in arbitrary turbulent magnetic fields, constructing a new model that is capable of bridging the gap between the very weak ($\delta B/B\_0 \ll 1$) and the strong turbulence regimes. To describe the diffusion we provide a quantitative analytical description of the "Bohm exponent" in each regime.
I show that our results converge to the well known quasi-linear theory in the weak turbulence regime. In the strong regime, we quantify the limitations of the Bohm-type models. Furthermore,

our results account for the anomalous diffusive behavior which has been noted previously. Finally, I will discuss the implications of our model in the study of possible acceleration sites in different astronomical objects.

Poster session / 203

Precise spectrometry in the cutoff region as a key for the understanding of radiation processes in flaring AGN

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We present results of spectrometric studies based on the observations of very strong AGN flares in high and very-high-energy bands and discuss their implications regarding the origin of radiation mechanisms.

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Probing the dynamics of AGN jets with advanced semi-analytical modelling

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The jets launched by accreting super-massive black holes can be some of the brightest sources in the high-energy sky. However, despite being discovered decades ago, their physics and energetics are still poorly understood. The past decade has seen a dramatic improvement in the quality of available multi-wavelength data, particularly in the X-ray and γ-ray bands. However, the semi-analytical modelling of jets has advanced slowly, and simple one-zone models are still the preferred method of interpreting data, in particular for AGN jets. These models can roughly constrain the properties of jets but they can not unambiguously couple their emission to the launching regions and internal dynamics, which are usually probed with simulations. On the other hand, simulations are not easily comparable to observations because they cannot yet self-consistently predict spectra. I will discuss our group's ongoing efforts to develop a more advanced semi-analytical model which accounts for the dynamics of the whole jet, starting from a simplified parametrization of Relativistic Magnetohydrodynamics in which the magnetic flux is converted into bulk kinetic energy. We apply our model to state-of-the-art datasets, including recent observations taken during the Event Horizon Telescope multi-wavelength campaign, which combine combine multi-wavelength SEDs and direct

VLBI imaging of the jet. Thanks to the quality of our data we are able to conduct a thorough exploration of parameter space. Compared to previous modelling efforts this approach produces some of the best SED fits for these sources to date and provides stronger constraints on jet internal properties physics.

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RELATIVISTIC OUTFLOWS FROM COMPACT GALACTIC SOURCES

Relativistic jets are ubiquitous phenomena present in a variety of galactic sources. These jets can carry a significant fraction of the system's energy reservoir up to distances of a few tens of parsecs. Particle acceleration along the jets or at the interaction sites with the surrounding medium leads to the production of copious non-thermal emission, which is observed in a broad energy range, from radio to very-high-energy gamma-rays. While powerful galactic jets are typically associated to accretion processes in BH/NS X-ray binaries, jet-like features have recently been imaged also from isolated systems, most notably from young pulsars moving at high-speeds through the interstellar medium. In this talk I will review recent findings related to some of the most extreme examples of galactic jets, discussing the implications these findings have in our understanding of jet formation and propagation mechanisms.

Poster Session / 136

Radiation-driven outflows in AGNs: Revisiting feedback effects of scattered and reprocessed photons

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Based upon our previous large scale numerical simulation of radiation-driven outflow in active galactic nuclei (AGNs), we have improved and extended the calculation of the radiation force. In this study, we present two-dimensional, time-dependent hydrodynamical simulations of slowly rotating accretion flows around supermassive black holes with the mass M_{BH} = 2 \times 10^{8} M_{\odot}, from 0.01-7 pc. To evaluate the radiation force, we assume the central AGN consists of two different components including a spherical hot corona plus an extended disc. We consider the corona is contributed to the radiation force only due to electron scattering which is responsible for ionizing the gas to the high ionization state. Also, the disc radiation force is due to both electron scattering as well as line force. Compared to our previous work, we revisit feedback effects of scattered and reprocessed photons, i.e., the effects of locally produced photons via absorption and scattering process. We include both the Eddington forces due to the UV and X-Ray photons to calculate the total radiative force. Moreover, we do some modifications in calculating the radiation flux as well as re-radiation force. We find that these improvements can significantly change the outflow properties such as outflow velocity and the energy fluxes of the wind. Our new results show that the outflow starts from 2 \times 10^{3} Schwarzschild radius with velocity about 0.03 c. The average mass outflow rate and kinetic power of the wind at the outer boundary are evaluated as 0.2\, M_{\odot}, yr^-1 and \dot{E}*{k} \sim 7 \times 10^{43} erg s^{-1}, respectively. The effects of the high gas temperature (T*{0} = 2 \times 10^{7}K) at the outer boundary is also investigated. Unlike our previous results, the emitted luminosity of the accretion flow does not show any oscillations for high outer boundary temperature. These results agree reasonably well with the recent observations of ultrafast outflows (UFOs). Based on these results, we can rule out the line-driven outflow model as the origin of UFOs.

Poster Session / 145

Radiative Signatures of Relativistic Reconnection in Blazar Jets

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Relativistic magnetic reconnection, a process which efficiently converts magnetic energy to non-thermal particle energy, is an ideal mechanism for explaining the multi-wavelength spectral and temporal variability observed in blazars. By coupling recent two-dimensional particle-in-cell simulations of relativistic reconnection with a time-dependent leptonic radiative transfer code, we compute the non-thermal emission from a chain of plasmoids, namely quasi-spherical blobs of plasma containing relativistic electron-positron pairs and magnetic fields formed during a reconnection event. We present broadband photon spectra, light curves, and other observational signatures of our model including the statistical properties of plasmoid-powered flares, the correlation of flaring events in multi-wavelength bands, and the power-spectral density of our reconnection-driven light curves.

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Reconnection and Associated Flares in Global Relativistic Jets Containing Helical Magnetic Fields with PIC Simulations

Kenichi Nishikawa[None]

In the study of relativistic jets one of the key open questions is their interaction with the environment on the microscopic level. Here, we study the evolution of both electron–proton and electron–positron relativistic jets containing helical magnetic fields, focusing on their interaction with an ambient plasma. We have performed simulations of "global" jets containing helical magnetic fields in order to examine how helical magnetic fields affect kinetic instabilities such as the Weibel instability, the kinetic Kelvin-Helmholtz instability (kKHI) and the Mushroom instability (MI) using a large jet radius. In our simulation study these kinetic instabilities are excited and new types of jet evolution takes place. In the electron-proton jet simulation a recollimation-like instability occurs near the center of jet. In the electron-positron jet simulation mixed kinetic instabilities grow and the jet electrons are accelerated. The evolution of electron-proton jets shows that helical magnetic fields are untangled and electrons are accelerated in turbulent magnetic field further. We also investigate mechanisms of flares possibly due to rapid acceleration.

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Relativistic Jet of Markarian 421: Observational Evidences of Particle Acceleration Mechanisms

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Markarian 421 is one the most extreme blazars characterized by complex, unpredictable timing/spectral variability, exclusively strong X-ray flares in some epochs, very broad, nonthermal spectral energy distribution (SED) extending over 19 orders of the frequency and showing a typical two-"hump" structure. The lower-energy component, ranging from the radio to X-rays, is widely accepted to be a synchrotron radiation emitted by ultra-relativistic electrons/positrons/protons, while the origin of higher-energy emission (the MeV-TeV range) still remains controversial (synchrotron self-Compton, external Compton, hadronic etc.). All these mechanisms need the presence of highly-relativistic particles in the jet, to be initially accelerated via the Blandford-Znajek mechanism and magneto-hydrodynamic processes in the vicinity of the central super-massive black hole. However, particles loose the energy, sufficient for emitting the KeV photons, very quickly and the source can maintain its flaring state on the daily-weekly timescales if some additional acceleration mechanisms are continuously at work. According to different studies and simulations, the particles can gain a tremendous energy due to the propagation of relativistic shocks through the jet: by means of first-order Fermi mechanism at the shock front, or they undergo an efficient stochastic (second-order Fermi) acceleration close to the shock, in the turbulent jet medium. Our intense X-ray spectral study of Mrk 421 has revealed the dominance of these processes in different epochs: while the spectral curvature and photon index show a positive cross-correlation during some flares (expected in the framework of energy-dependent acceleration probability scenario: a particular case of first-order Fermi mechanism), other epochs clearly demonstrate the observables of the stochastic (second-order Fermi) acceleration (low spectral curvature; anti-correlation between the spectral curvature and the position of the synchrotron SED peak). During several X-ray flares, the source also showed hard power-law spectra, expected in the case of relativistic magnetic reconnection.

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Relativistic Jets from black hole accretion disc

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Astrophysical jets from AGNs and microquasars are often relativistic and collimated. We study magnetic and radiative driving of jets to address these issues. The plasma is described by relativistic equation of state which depends on the composition. We show that the matter content may not affect the streamline of magnetically driven jets, but the poloidal velocity and temperature distribution strongly depend on composition of the jet. We also discuss the salient features of radiatively driven jets. Although consensus in the community precludes radiation driving to be effective acceleration mechanism, we show that is certainly not the case. For black holes surrounded by luminous discs, jets may be accelerated up to few Lorentz factors for baryon dominated jets. Interestingly, the terminal Lorentz factor may reach to a value of few tens for lepton dominated jets. We also show internal shock driven by radiation is also possible for jets. Moreover, consideration of temperature dependent scattering cross-section can produce relativistic jets which stats with very low speed and quite moderate temperatures which are expected in the inner region of the accretion discs. Although we have studied magnetic driving and radiative driving separately, but it is apparent that both the processes should be incorporated in order to solve collimation and acceleration enigma of astrophysical jets.

Poster Session / 146

Relativistic reconnection in pair-proton plasmas and application to AGN jets

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Magnetic field dissipation via reconnection is a promising process for explaining the non-thermal signatures from a variety of relativistic astrophysical outflows, such as pulsar wind nebulae (PWNe) and jets of active galactic nuclei (AGN). In most relativistic astrophysical outflows reconnection proceeds in the so-called relativistic regime in which the Alfven velocity of the plasma approaches the speed of light. In contrast to PWNe, where the outflow is composed of relativistic pairs, in AGN jets the composition of the plasma is largely unknown. Our goal is to study the general properties of relativistic reconnection in the unexplored regime of plasmas with mixed particle composition. We focus on pair-proton plasmas, as they bridge the gap between the pair plasma and electron-proton plasma cases that have been extensively studied in the past. We perform a suite of 2D PIC simulations using the realistic proton-to-electron mass ratio (m_i/m_e=1836) while varying three physical parameters, namely the plasma magnetization, the plasma temperature, and the pair multiplicity. We study, for the first time, the energy distributions of accelerated particles, the inflows and outflows of plasma in the reconnection region, and the energy partition between pairs, protons, and magnetic fields, as a function of the pair multiplicity in the regime where protons dominate the rest mass energy of the plasma. We finally discuss our results in the context of non-thermal emission from AGN jets.

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Resolving a decades-long transient: an orphan long gamma-ray burst or a young magnetar nebula?

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The source FIRST J1419+3940 was recently discovered as a slow transient that has been fading for the last 30 years. The radio light-curve is consistent with an orphan long gamma-ray burst. However, our interest arises when comparing its host to the one where the Fast Radio Burst FRB 121102 is located: inside a low-metallicity star-forming region in a dwarf galaxy. Both sources show comparable compact radio emission and similar environments. We thus believe that FIRST J1419+3940 can be a potential host for FRBs, and could make a connection between long GRBs and FRBs. In this talk we present the results from observations conducted with the European VLBI Network (EVN) which allowed us to study the compactness of the source to unveil its origin. These results allowed us to discard several scenarios for the fading source, and to establish comparisons with the persistent counterpart of FRB 121102.

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SUPER-EDDINGTON LUMINOSITIES

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SUPERFAST AGN VARIABILITY

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We compare the energy requirements of different scenarios that allow addressing ultrafast gamma-ray variability recently reported by the MAGIC collaboration from two extragalactic sources, IC 310 and NGC 1275. Currently, the following three models are accepted as a feasible explanation for minute-scale variability: (i) external cloud in the jet, (ii) relativistic blob propagating through the jet material, and (iii) production of high-energy gamma rays in the magnetosphere gaps. Our
analysis shows that the first two scenarios are not constrained by the flare luminosity. On the other hand, there is a robust upper limit on the luminosity of flares generated in the black hole (BH) magnetosphere (MSph). The maximum luminosity of magnetosphere flares depends weakly on the mass of the central BH and is determined by the accretion disk magnetization, viewing angle, and the pair multiplicity. For the most favorable values of these parameters, the luminosity for 5-minute flares are limited by 2*10ˆ43 erg/s, which excludes a BH MSph origin of the flare detected with MAGIC from IC 310, and NGC 1275. In the scopes of scenarios (i) and (ii), the jet power, which is required to explain the flares detected from these sources, exceeds the jet power estimated based on the radio data. To resolve this discrepancy in the framework of the scenario (ii), it is sufficient to assume that the relativistic blobs are not distributed isotropically in the jet reference frame. A realization of scenario (i) demands that the jet power during the flare exceeds by a large factor, 100, the power of the radio jet relevant on a timescale of 10ˆ8 years.

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Searching for gamma-ray binaries using GOSC and Gaia DR2

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Gamma-ray binaries, which contain a massive star and a compact object, are very interesting astrophysical laboratories because particle acceleration and radiation/absorption mechanisms are modulated by the orbital phase. However, only 7 of such sources are currently known: 2 composed of an O-type star and 5 of a Be-type star, being the systems with an O-type star runaways with respect to their environment. Gaia DR2 provides us with useful information of positions, proper motions and distances for 1332 million sources. To search for new gamma-ray binaries we have studied a sample of 370 O-type stars from the GOSC catalog. Since Gaia DR2 does not fit the 7 orbital parameters for binaries, we could expect bad astrometric fits for some gamma-ray binaries. Among the 370 O-type stars we have found 36 with bad astrometric fits. We have also computed the peculiar velocities of the remaining 334 O-type stars and found 74 runaways, some of which could be part of new gamma-ray binaries. We conclude with a short discussion and an outlook of future work.

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Spectral ageing in powerful radio galaxies

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Relativistic radio jets create large-scale lobes – the extragalactic footprints of accretion onto supermassive black holes, central to radio-loud active galaxies. In these dynamic and energetic structures, the phenomenon of spectral ageing occurs – the progressive steepening of the radio spectrum in the lobes due to radiative losses. Recent advances in computing capabilities have enabled this physical process to become a tool that can be used to calculate the age of radio galaxies – an important parameter used to determine their jet power (the time averaged kinetic feedback into the environment). In building the jet power function for all radio galaxies, accurate sources ages are required. Spectral ages, however, are almost always underestimated relative to the dynamical ages
of radio galaxies. In this talk I will present a detailed investigation of spectral and dynamical ages of two powerful cluster-centre radio galaxies, using broad-band VLA data at multiple frequencies, and deep X-ray observations with Chandra and XMM-Newton of the shocked medium being driven by the central radio source. We find that the use of broad-band radio data can give a close agreement between spectral and dynamical ages, which is rarely found. These observational results are repeated when analytically modelling the radio sources and their X-ray environments. These findings will be key to building future tools to determine jet powers of all radio-loud AGN, which will be observed in the dawn of deep radio surveys such as the SKA, and will lead to information on the total power output of radio galaxies over all cosmic time.

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Stability analysis of two–component magnetized astrophysical jets

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Astrophysical jets are observed as stable structures, extending in lengths several times their radii. The role of various instabilities and how they affect the observed jet properties has not been fully understood. Using the ideal relativistic MHD equations to describe jet dynamics we aim to study the stability properties through linear analysis. Our jets consist of two components, a fast light inner spine engulfed by a slower heavier outer sheath. In order to find the growth rates for the instabilities we solve numerically the perturbed system. We seek to find any connection between growth rates and various characteristic parameters such as the magnetization and the pitch angle. Finally, we conduct a series of MHD simulations for the two–component configuration, and check whether there is correlation between the linearised system results and the numerical solution of the full problem.

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Structure of a collisionless pair jet in a magnetized electron–proton plasma: flow-aligned magnetic field

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Accreting black holes can eject jets that are composed of electrons, positrons and ions. Electromagnetic emissions by such jets reveal the presence of strong coherent magnetic fields, of hot plasma and relativistic leptons. Several mechanisms contribute to the magnetic field of the jet: magnetic field transport by the jet, the amplification of the ambient magnetic field by shocks and collisionless plasma instabilities. The latter two have been studied with particle-in-cell simulations. Collisionless shocks, which develop between plasma clouds with the same particle composition that collide at a relativistic speed, are mediated by magnetic fields that are driven by the filamentation (beam-Weibel) instability.
We present results from a particle-in-cell simulation that models the interaction between a spatially localized pair cloud and a magnetized electron-proton plasma. The pair cloud has the temperature 400 keV and mean speed 0.9c. Its mean velocity vector is aligned with the background magnetic field that permeates the electron-proton plasma. A jet forms in time. Its outer cocoon consists of jet-accelerated ambient plasma and is separated by an electromagnetic piston from the jet material. This piston is the counterpart of a hydrodynamic contact discontinuity in collisionless plasma. Its coherent magnetic field enwraps the pair jet and its thickness is comparable to the thermal gyroradius of the relativistic jet particles. This piston constitutes a novel plasma structure that could contribute to the radio emissions of jets. A beam of electrons and positrons moves along
the jet spine at its initial speed. Its electrons are slowed down and some positrons are accelerated as they cross the jet's head. The latter escape upstream along the magnetic field, which yields an excess of MeV positrons ahead of the jet. Some of the protons, which were located behind the electromagnetic piston at the time it formed, are accelerated to MeV energies.

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Study of Bright FERMI-LAT Blazars in optical band

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To study optical variability of extragalactic sources during last twenty years we are conducting in Abastumani Observatory a long-term monitoring campaign using dedicated telescopes, which allowed collecting 320000 CCD frames during ~3500 nights. This extensive monitoring campaign a few dozen blazars first five years was carried out in BVRI bands and later on from 2002 mainly in R band using the 70-cm meniscus (f/3, SBIG ST6 and Apogee Ap6E) and 125-cm Ritchey-Chretien (f/13, Apogee Ap6E) telescopes. Most dense coverage of selected LAT brightest sources (3C 454.3, 3C 279, PKS 1510-089, S5 0716+710, 4C 71.07 and others) has been undertaken after lunch of FERMI satellite in 2008. The frames have been reduced using Daophot II and homogenous sample of light curves have been constructed. Most sources show wide range of variability (long-term up to six magnitudes, IDV and micro-variability). We present optical light curves of these most well sampled sources.

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Study of the wind properties in the structure of supercritical accretion flows

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We solve the two-dimensional radiation-hydrodynamic (RHD) equations of supercritical accretion flows in the presence of radiation force and outflow by using self similar solutions in spherical coordinates. Compare with the pioneer works, here we consider power-law function for mass inflow

rate as $\dot{M} \propto r^s$. Our purpose is to investigate the influence of the outflow on the dynamics of the accretion flow.

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Synchrotron maser from weakly magnetised neutron stars as the emission mechanism of fast radio bursts

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The origin of Fast Radio Bursts (FRBs) is still mysterious. All FRBs to date show extremely high brightness temperatures, requiring a coherent emission mechanism. Using constraints derived from the physics of one of these mechanisms, the synchrotron maser, as well as observations, we show that accretion induced explosions of neutron stars with surface magnetic fields of B_*<10^{11} G are favoured as FRB progenitors.

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THE FLARING CRAB NEBULA: CURRENT UNDERSTANDING AND FUTURE OBSERVATIONS

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Flaring activity above 100 MeV was serendipitously detected from the Crab nebula by Agile and Fermi-LAT in 2010 . Since then, a tens of flaring events have been observed by Fermi-LAT showing different spectral and flux behaviours within each other. In the attempt of identifying the exact site of this enhanced emission observations by high-resolution lower-frequency instruments were triggered, although all unsuccessful so far. In this talk I will review the results of the observed Crab flares obtained by Fermi-LAT, and the subsequent multi-wavelength campaigns. These results will be discussed in the light of the state-of-the-art theoretical models. I will conclude by discussing the capabilities of future instruments to constrain the origin of these still enigmatic phenomena.

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THE INTERACTION OF JETS WITH OBSTACLES

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Extragalactic jets are launched from the innermost regions of galaxies, near the central supermassive black hole. As they propagate, they must cross the whole galaxy, and in this process they interact with a variety of obstacles; including gas clouds, populations of stars or even supernova

remnants. The interaction between jets and penetrating obstacles has been studied as a possible method for jet mass-loading and deceleration, as well as of production of gamma-ray emission, through non-thermal particles accelerated in shocks. Interaction with individual objects, such as stars or gas clouds, can explain both rapid variability in blazars, and gamma-ray flares. Interaction with whole populations of obstacles, however, may lead to the production of persistent gamma-ray emission.

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THE PHYSICS OF GAMMA-RAY BURSTS

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I will review several open questions in GRB physics as well as how latest observational data shed light into them. The topics include jet composition, energy dissipation mechanism, radiation mechanism, progenitors, and central engine. The exciting aspects of gravitational wave - GRB associations will be discussed, with GW170817/GRB 170817A as an example.

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THE THEORY OF PULSAR WIND NEBULAE: RECENT PROGRESS

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Pulsar Wind Nebulae are highly intriguing astrophysical objects in many respects. They are the brightest and closest class of relativistic sources, and hence the ultimate laboratory for the physics of relativistic plasmas: several processes observed (or inferred to occur) in other classes of relativistic sources can here be studied with unique detail, like the acceleration and collimation of relativistic outlfows, or the acceleration of particles at relativistic shocks.

I will review the current status of our theoretical understanding of Pulsar Wind Nebulae in light of the most recent 2D and 3D MHD modeling of these sources. I will discuss how these studies are taking us to the point when we can reliably use multi-wavelength observations of these nebulae as a diagnostics of the hidden physics of the pulsar wind and of the mechanism(s) through which particles are accelerated at the highly relativistic shock that terminates the wind. Finally I will briefly discuss the role of Pulsar Wind Nebulae as sources of cosmic ray leptons.

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THE TRANSIENT HIGH-ENERGY SKY AND EARLY UNIVERSE SURVEYOR (THESEUS)

The Transient High-Energy Sky and Early Universe Surveyor (THESEUS) is a space mission concept currently under Phase A study by ESA as candidate M5 mission, aiming at exploiting Gamma-Ray Bursts for investigating the early Universe and at providing a substantial advancement of multi-messenger and time-domain astrophysics. Through an unprecedented combination of X-/gamma-rays monitors, an on-board IR telescope and automated fast slewing apabilities, THESEUS will be a wonderful machine for the detection, characterization and redshift measurement of any kind of GRBs and many classes of X-ray transients. In addition to the full exploitaiton of high-redshift GRBs for cosmology (pop-III stars, cosmic re-ionization, SFR and metallicity evolution up to the "cosmic dawn"), THESEUS will allow the identification and study of the electromagnetic counterparts to sources of gravitational waves which will be routinely detected in the late '20s / early '30s by next generation facilities like aLIGO/aVirgo, LISA, KAGRA, and Einstein Telescope (ET), as well as of most classes of transient sources, thus providing an ideal sinergy with the large e.m. facilities of the near future like LSST, ELT, TMT, SKA, CTA, ATHENA.

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TeV and X-ray emission from the 50-year period binary PSR J2032+4127/MT91 213 during periastron passage

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We report on the observations of the pulsar/Be binary system PSR J2032+4127/MT91 213 which was recently discovered at TeV and X-rays energies with MAGIC, VERITAS and Swift-XRT. This is the second gamma-ray binary in which the nature of the compact object is known. The system was detected at TeV energies during the periastron passage, which took place in November 2017. This observation was a once-in-a-lifetime opportunity due to the 50-year orbital period of the pulsar around the Be star. Our observations covered from 18 months prior to periastron passage to one month after. This allowed to study not only the pulsar/Be interaction but also the extended source TeV J2032+4130, most likely a PWN potentially associated with the pulsar. The observations revealed a cut-off in the TeV spectrum of the binary and high flux variability on a daily basis. The X-ray observations also revealed strong variability. Significant revision of the existing models is required to explain the detected TeV emission.

Multiwavelength and multi-messenger aspects / 141

The Impact of Plasma Instabilities on the Constraints on the Intergalactic Magnetic Field

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A relativistic electron–positron pair beam can be produced in the interaction between TeV photons from a blazar and extragalactic background light. The relativistic e ± pairs lose energy through inverse-Compton scattering (ICS) photons of the cosmic microwave background or plasma instabilities. The dominant energy-loss process is under debate. Based on the assumption that the dominant energy-loss process is ICS, the resulting cascade GeV radiation is usually used to constrain the intergalactic magnetic field (IGMF). Here, we include the energy-loss due to plasma oblique instability in the calculation of cascade gamma-ray flux, and investigate the impact of the plasma instability on the constraint of IGMF. Up-to-date GeV data and archival TeV data of the blazar 1ES 0229+200 are used. The results indicate that even if the oblique instability cooling is dominating ICS cooling, the cascade flux could still be used to constrain the IGMF.

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The New Relativistic Hydrodynamic Code for Numerical Simulation of Jet Galaxy Formation

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The talk presents a new relativistic hydrodynamic code based on a two-level adaptive nested mesh technology. The numerical method implemented in the code is based on a combination of the Godunov method and Piecewise-Parabolic on Local Stencil method. The Parallel implementation is based on the idea of distributed computing. A hydrodynamic evolution of astronomical objects is performed on the architecture with shared memory. When reaching critical values of temperature and density, a new sub-grid problem is launched on the distributed memory architecture. In can be achieved up to six orders relative to computational domain on high-end supercomputers. The results of mathematical modeling of relativistic hydrodynamics of jet galaxy formation are presented in the talk. The analytical model of hydrogen ionization is constructed. A study of Ionization processes of neutral atomic hydrogen during the evolution of jet galaxy was performed experimentally.

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The Pulsar Sequence

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A decade of Fermi-LAT operations has provided a wealth of observational data that shifted the study of gamma-ray pulsars from discovery to astronomy. Moreover, recent observations from ground-based imaging atmospheric Cherenkov telescopes has 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 with magnetic-field-line dependent particle injection. I will show not only how our simulations validate the above description but also how the particle population, which is injected near the separatrix that separates the open from the closed field lines, regulates the Fermi-LAT gamma-ray emission. Our simulations, more accurately than ever before, reproduce the observed Fermi gamma-ray phenomenology of the millisecond and young pulsars for the entire range of spin-down powers.

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The extreme character of our closest VHE blazars, Mrk421 and Mrk501

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Owing to their brightness and proximity (z=0.03), Mrk 421 and Mrk 501 are among the blazars that can be studied with the greatest level of detail; and hence a sort of astrophysical laboratories to study the blazar's phenomena. In the conference I will show that these two objects can change their personality from one season to the next, sometimes showing a remarkably extreme character in the broadband SED, as well as in the variability and Doppler factors that are measured or inferred from the data. I will report detailed observational and theoretical results related to the 2-week long highest X-ray activity in Mrk501 observed with Swift-XRT since its launch 14 years ago, which suggests the presence of narrow spectral components at TeV energies. And I will also show an unprecedented correlation study of VHE gamma-rays and X-rays for Mrk421, revealing a large degree of complexity in these relations when quantified on different temporal and energy bins, and supporting the presence of multiple components in the X-ray and VHE gamma-ray emission. These multi-instrument observations on Mrk421 and Mrk501 have yielded thought-provoking results, and demonstrate the importance of performing a continuous monitoring over multi-year timescales to fully characterise the dynamics of blazars.

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The onset of Supercriticality in expanding sources

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Hadronic models of high energy emission from compact astrophysical objects are becoming more and more relevant the recent years. An overlooked property of these models is that they become supercritical by abruptly transforming the energy stored in the relativistic protons into radiation. Supercriticality manifests itself when the proton density exceeds a critical value. We seek to map the complete parameter space of this behaviour in cases where the source is expanding so adiabatic losses become important. We assume that the energy injected in the source is deposited into a Maxwellian distribution of relativistic protons connected to a power law extended to high energies. Given a set of initial parameters we follow the expansion of the source and search for those values that lead the system to a supercritical regime, giving emphasis for those closely related to GRBs.

Poster session / 201

The problematic connection between gamma-ray bursts (GRBs) and ultra-high energy cosmic rays (UHECR)

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The acceleration site for UHECR is still an open question despite extended research and GRBs are considered one of the most promising source candidates. Under the likely assumption that electrons are also accelerated at the UHECR acceleration site, synchrotron emission from these co-accelerated electrons is inevitable. We characterize this synchrotron emission and compare it to observed GRB spectra and find that for standard parameters, the synchrotron flux from these electrons would be much too luminous. This result challenges both high- and low-luminosity GRBs as accelerators of UHECR. A detailed discussion on
GRB 060218 as UHECR source is also presented.

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Tidal disruption events with an on-beam or off-beam relativistic jet

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A star or sub-stellar object will be destroyed by tidal forces when it passes close enough by a supermassive black hole (SMBH). These events known as TDEs are expected to produce luminous flare emission in the UV to X-ray band. The observations of Sw J1644+57, in particular, suggest that at least some TDEs can launch an on-beam relativistic jet. A common speculation is that these rare events are related to rapidly spinning BHs. We constrained the BH spin parameter by using the available data, and found that the BH indeed carries a moderate to high spin, suggesting that BH spin is likely the crucial factor behind the Sw J1644+57-like events. Other observational evidences include the rough 2.7 day periodicity in X-ray dips and 200s QPO, which we interpret as due to spin-induced precession. In addition, Sw J2058+05 and Sw J1112.2-8238 are also thought to be a TDE with an on-beam relativistic jet. It is natural to expect that there should be some events with off-beam ones. We found that IGR J12580+0134 in the nucleus of NGC 4845 is likely such a case.

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Time variability of low angular momentum accretion flows around black hole.

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Observations show the emission of hard and soft photons at high energies (X-ray or gamma ray) in the black hole accretion flow's spectra. These hard photons are observed at very high frequency which implies that they are produced near black hole horizon. As the quality and quantity of the high energy observations improved over the years, evidence mounted showing that photons must be created in a hot, tenuous, advection dominated region called the corona. This corona, boiling violently above the comparatively cool disk, is very close to the event horizon of the black hole. A relativistic fluid flowing into the black hole must have a varying adiabatic index rather than a constant one throughout the accretion disk.

Our recent work present the relativistic 2D simulation of such axisymmetric, inviscid, hydrodynamic accretion flows in a fixed Kerr black hole gravitational field. The flow is considered to have low angular momentum with respect to Keplerian one. In quasi-spherical, transonic accretion flow, occurrence and location of shock and sonic points depends on the parameters of the flow. Studying the evolution of this kind of flow with time shows oscillation of shock position in response to pressure against rotational force for some particular parameter space. I will talk about such oscillatory behavior of shock position and respective effect on mass accretion rate and frequency with varying adiabatic index. I will also discuss the relevance of our results with the observed phenomenon - QPO's (Quasi periodic oscillations) from galactic black holes and micro-quasars.

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Time-Dependent, Multi-Wavelength Models for Active Flares of Blazars

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Jets in blazars are an excellent forum for studying acceleration at relativistic shocks using the highly-variable emission seen across the electromagnetic spectrum. Our recent work on combining multi-wavelength leptonic emission models with complete simulated distributions from shock acceleration theory has resulted in new insights into plasma conditions in blazars. This has demonstrated the ability to infer the cyclotron frequency, the plasma density and thus also the Alfven speed, thereby determining the rapidity of particle energization. An important inference was that MHD turbulence levels decline with remoteness from jet shocks. In this paper, we deliver new results from our recent extension of this program to a two-zone, time-evolving construction, modeling together both extended, enhanced emission states from larger radiative regions, and prompt flare events from compact acceleration zones. These are applied to flares in the LBL blazar 3C 279 monitored by Fermi-LAT. With impulsive injection episodes from the shock zone, as the acceleration first proceeds and then abates, the radiative simulations obtain spectral hysteresis in the hardness-flux diagram in all wavebands that differs between flares. For 3C 279, while model radio and X-ray synchrotron flares a temporally correlated, there is a lag in both bands relative to GeV gamma-rays and optical emission on timescales of several hours. This is governed by the short cooling time associated with the bright external Compton signal. The results are interpreted in the light of the shock acceleration paradigm, identifying potential observational diagnostics.

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UHE COSMIC RAYS AND AGN JETS

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AGN are believed to be potential sites of ultra-high energy (UHE) cosmic ray acceleration. I will highlight observational findings as well as requirements on source energetics, and then discuss the relevance of different acceleration sites and mechanisms, such as black hole gap or large-scale jet shear acceleration.

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Unraveling the complex nature of the very high-energy gamma-ray blazar PKS 2155-304

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PKS 2155-304 is a blazar located in the Southern Hemisphere, monitored with the High Energy Stereoscopic System (H.E.S.S.) at very high energy (VHE) gamma rays every year since 2004. Thanks to the large data set collected in the VHE range and simultaneous coverage in optical, ultraviolet, X-ray and high energy gamma-ray ranges, this object is an excellent laboratory to study spectral and temporal variability in blazars. However, despite many years of dense monitoring, the nature of the variability observed in PKS 2155-304 remains puzzling.

In this presentation, I will discuss the complex spectral and temporal variability observed in PKS 2155-304. I will focus on the VHE gamma-ray data collected with H.E.S.S. starting in 2013, and which is complemented with multi-wavelength observations from Fermi-LAT, Swift-XRT, Swift-UVOT, SMARTS, the Steward Observatory, and the ATOM telescope. I will also discuss the complexity of the temporal evolution of the broadband emission with a special focus on the presence of different kinds of flaring activity, including orphan outbursts. The theoretical implications are manifold, ranging from acceleration and emission processes to different locations of the emission regions. I will also demonstrate the importance of dense, multi-wavelength monitoring that is needed to fully characterize the behaviour of PKS 2155-304.

Particle acceleration and Radiation processes / 160

Weibel Mediated Shocks Propagating into the Inhomogeneous Media

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The Weibel instability occurs in collisionless plasma with the temperature anisotropy. It is thought to be important for particle acceleration and generation of magnetic fields in relativistic shocks. Observations of afterglows of gamma ray bursts (GRBs) suggest that magnetic fields are amplified in the large downstream regions of relativistic shocks. However, the magnetic field produced by the Weibel instability decays rapidly, which cannot explain the observed properties of afterglows of GRBs. The nonlinear evolution of the Weibel instability has been studied in uniform plasmas so far. In reality, there must be density fluctuations in interstellar or circumstellar medium. We performed two-dimensional particle-in-cell simulations of relativistic shocks propagating to the inhomogeneous electron-positron plasmas. We found that, for the no-uniform case, the downstream magnetic field keeps a higher amplitude and larger length-scale than that for the uniform case. Furthermore, there is a much larger temperature anisotropy in the far downstream region than that for the uniform case. The downstream temperature anisotropy results from the downstream sound waves excited by an interaction of incident waves with shock waves. The observed temperature anisotropy is sufficiently large to generate the magnetic field required by the GRB observations. We could expect that the upstream inhomogeneity is crucial role for the generation of magnetic field and particle acceleration in relativistic collisionless shocks.