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Book of Abstracts

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A Unique Multi-Messenger Signal of QCD Axion Dark Matter

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We propose a multi-messenger probe of the natural parameter space of QCD axion dark matter (DM) based on observations of black hole-neutron star binary inspirals. It is suggested that a dense DM spike may grow around intermediate mass black holes. The presence of such a spike produces two unique effects: a distinct phase shift in the gravitational wave strain during the inspiral period and an enhancement of the radio emission from the resonant axion-photon conversion occurring in the neutron star magnetosphere. Remarkably, the observation of the gravitational wave signal can be used to infer the DM density and, consequently, to predict the radio emission. Given a sufficiently nearby detection with the LISA interferometer and next-generation radio telescope Square Kilometre Array, I will show that such observations can explore the QCD axion in the mass range 10^{-7}eV to 10^{-5}eV, potentially providing a striking multi-messenger signature of QCD axion dark matter.

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The Light Dark Matter eXperiment, LDMX

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The constituents of dark matter are still unknown, and the viable possibilities span a very large mass range. Specific scenarios for the origin of dark matter sharpen the focus on a narrower range of masses: the natural scenario where dark matter originates from thermal contact with familiar matter in the early Universe requires the DM mass to lie within about an MeV to 100 TeV. Considerable experimental attention has been given to exploring Weakly Interacting Massive Particles in the upper end of this range (few GeV –~TeV), while the region ~MeV to ~GeV is largely unexplored. Most of the stable constituents of known matter have masses in this lower range, tantalizing hints for physics beyond the Standard Model have been found here, and a thermal origin for dark matter works in a simple and predictive manner in this mass range as well. It is therefore a priority to explore. If there is an interaction between light DM and ordinary matter, as there must be in the case of a thermal origin, then there necessarily is a production mechanism in accelerator-based experiments. The most sensitive way, (if the interaction is not electron-phobic) to search for this production is to use a primary electron beam to produce DM in fixed-target collisions. The Light Dark Matter eXperiment (LDMX) is a planned electron-beam fixed-target missing-momentum experiment that has unique sensitivity to light DM in the sub-GeV range. This contribution will give an overview of the theoretical motivation, the main experimental challenges and how they are addressed, as well as projected sensitivities in comparison to other experiments.

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Why there is no simultaneous detection of Gamma rays and x-rays from x-ray bright galaxy clusters? A hydrodynamical study

on the manufacturing of cosmic rays in the evolving dynamical states of galaxy clusters

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Galaxy clusters are known to be reservoirs of Cosmic Rays (CRs), as inferred from theoretical calculations or detection of CR-derived observables. CR acceleration in clusters is mostly attributed to the dynamical activity that produces shocks. Shocks in clusters emerge out of merger or accretion, but which one is more effective in producing CRs? at which dynamical phase? and why? To this aim, we study the production or injection of CRs through shocks and its evolution in the galaxy clusters using cosmological simulations with the {\sc enzo} code. Particle acceleration model considered here is primarily the Diffusive Shock Acceleration (DSA) of thermal particles, but we also report a tentative study with pre-existing CRs. Defining appropriate dynamical states using the concept of virialization, we studied a sample of merging and non-merging clusters. We report that the merger shocks (with Mach number $\mathcal{M} \sim 2-5$) are the most effective CR producers, while high-Mach peripheral shocks (i.e. $\mathcal{M} > 5$) are mainly responsible for the brightest phase of CR injection in clusters. Clusters once merged, permanently deviate from CR and X-ray mass scaling of non-merging systems, enabling us to use it as a tool to determine the state of merger. Through a temporal and spatial evolution study, we found a strong correlation between cluster merger dynamics and CR injection. We observed that the brightest phase of X-ray and CR injection from clusters occur respectively at about 1.0 and 1.5 Gyr after every mergers. This is the reason for simultaneous non-detection of Gamma rays and x-rays from x-ray bright galaxy clusters.

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Mathematical results on hyperinflation

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Recently, hyperinflationary cosmological model has been proposed. In this model, the target manifold of scalar fields is a hyperbolic space which curvature is negative and slope of the potential does not affect accelerated expansion of the universe. It is interested in mathematical aspects of this model.

Since Penrose has proved a singularity theorem, which states that physically reasonable spacetimes are causally geodesic incomplete, three mathematical conjectures in classical general relativity has been proposed as follows.
(1)Belinskii-Khalatnikov-Lifshitz (BKL) conjecture: Solutions to the Einstein equations should be asymptotically velocity-terms dominated (AVTD) ones near spacetime singularity. In other words, the evolution equations should become ODEs in time near spacetime singularity.
(2)Cosmic no hair (CNH) conjecture: A solution of the Einstein-matter equations with a positive cosmological constant converges to the de Sitter solution at late times in a suitable sense. In particular, the solution is expected to homogenise and isotropise.
(3)Strong cosmic censorship (SCC) conjecture: The maximal Cauchy development of
generic compact or asymptotically flat initial data is locally inextendible
as a regular Lorentzian manifold. In other word, nobody can observe naked singularities.

These concern the global structure of spacetimes and are the most important open problems in mathematical general relativistic cosmology. The aim of our research is to show the validity of the three conjectures by analyzing the Einstein equations with Gowdy symmetry in hypeinflationary cosmological model.

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Cuckoo's eggs in neutron stars: can LIGO hear chirps from the dark sector?

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We explore in detail the possibility that gravitational wave signals from binary inspirals are affected by a new force that couples only to dark matter particles. We discuss the impact of both the new force acting between the binary partners as well as radiation of the force carrier. We identify numerous constraints on any such scenario, ultimately concluding that observable effects on the dynamics of binary inspirals due to such a force are not possible if the dark matter is accrued during ordinary stellar evolution. Constraints arise from the requirement that the astronomical body be able to collect and bind at small enough radius an adequate number of dark matter particles, from the requirement that the particles thus collected remain bound to neutron stars in the presence of another neutron star, and from the requirement that the theory allows old neutron stars to exist and retain their charge. Thus, we show that any deviation from the predictions of general relativity observed in binary inspirals must be due either to the material properties of the inspiraling objects themselves, such as a tidal deformability, to a true fifth force coupled to baryons, or to a non-standard production mechanism for the dark matter cores of neutron stars. Viable scenarios of the latter type include production of dark matter in exotic neutron decays, or the formation of compact dark matter objects in the early Universe that later seed star formation or are captured by stars.

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Lensing of fast radio bursts: future constraints on primordial black hole density with an extended mass function and a new probe of exotic compact fermion/ boson stars

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The discovery of gravitational waves from binary black hole mergers has renewed interest in primordial black holes forming a part of the dark matter density of our Universe. Various tests have been proposed to test this hypothesis. One of the cleanest tests is the lensing of fast radio bursts. In this situation, the presence of a compact object near the line of sight produces two images of the radio burst. If the images are sufficiently separated in time, this technique can constrain the presence of primordial black holes. One can also try to detect the lensed image of the mini-bursts within the main burst. We show that this technique can produce the leading constraints over a wide range in lens masses
$gtrsim\, 2\, M_\odot$ if the primordial black holes follow a single mass distribution. Even if the primordial black holes have an extended mass distribution, the constraints that can be derived from lensing of fast radio bursts will be the most constraining over wide ranges of the parameter space. We also show that this technique can probe exotic compact boson stars and fermion stars and outline the particle physics parameter space which can be probed.

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Potential dark matter signals at neutrino telescopes

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Recent analyses of the diffuse TeV-PeV neutrino flux highlight a tension between different IceCube data samples that suggests a two-component scenario rather than a single steep power-law. Such a tension is further strengthened once the latest ANTARES data are also taken into account. Remarkably, both experiments show an excess in the same energy range (40-200 TeV), whose origin could intriguingly be related to dark matter. In this talk, I describe in a multi-messenger context the allowed features of a potential dark matter signal at neutrino telescopes according to the latest 7.5 years IceCube HESE events making the comparison with previous exclusion limits coming from Fermi-LAT data. Moreover, I discuss whether the Dark Matter hypothesis could be further scrutinized by using forthcoming high-energy gamma-rays experiments.

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Anomalous 21-cm EDGES Signal and Moduli Dominated Era

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The heat transfer between baryons and millicharged dark matter has been considered as a possible explanation for the anomalous 21-cm absorption signal seen by EDGES. It is shown in the literature that the relic density of milli-charged DM obtained by using standard thermal freeze-out mechanism gets overproduced in the range of parameters allowed by EDGES 21-cm signal. Thus, millicharged DM can not successfully explain the EDGES signal unless one invokes new exotic particles or force carriers. We argue that the problem can be evaded if the post inflationary universe undergoes a period of an early matter/modulus domination, which one generally encounters while working in the framework of UV complete theories. Thus, we estimated the relic abundance of millicharged DM by taking the moduli dominated era into account and found that it is possible to obtain the desired fraction of milli-charged DM for a narrow range of requisite parameters by taking modulus mass of the order of several TeV.

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Precision Measurement of Primary Cosmic Rays with Alpha MAgnetic spectrometer on ISS

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We present precision high statistics measurements of primary cosmic ray protons, helium, carbon and oxygen fluxes by Alpha Magnetic Spectrometer in the rigidity range from 2 GV to 3 TV. These measurements are based on 1 billion of protons, 125 million of Helium, 14 million of Carbon and 12 million of Oxygen nuclei collected by AMS during the first 7 years of operation aboard the International Space Station. The properties of these primary cosmic rays will be discussed.
We present precision high statistics fluxes of primary cosmic ray neon, magnesium and silicon measured by Alpha Magnetic Spectrometer in the rigidity range from 3 GV to 3 TV. These measurements are based on 5 million nuclei collected by AMS during the first 7 years of operation aboard the International Space Station. The unexpected new properties of these primary cosmic rays will be shown.

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Properties of Secondary Cosmic Ray Lithium, Beryllium and Boron measured with the Alpha Magnetic Spectrometer on the ISS

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We present precision high statistics fluxes of secondary cosmic rays Lithium, Beryllium and Boron measured by Alpha Magnetic Spectrometer in the rigidity range from 2 GV to 3.3 TV. These measurements are based on 9 million nuclei collected by AMS during the first 7 years of operation aboard the International Space Station. The properties of these secondary cosmic rays as well as high statistics secondary-to-primary flux ratios such as Li/C, Be/C, B/C, Li/O, Be/O and B/O will be discussed.

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The Role of Magnetic Field Geometry in the Evolution of Neutron Star Merger Accretion Disks

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Neutron star mergers are unique multi-messenger laboratories of accretion, ejection, and r-process nucleosynthesis. Theoretically, however, our current understanding of such events is limited, especially of magnetic effects, such as the role the post-merger magnetic field geometry has on the

evolution of merger remnant accretion disks. Through the use of 3D general relativistic magnetohydrodynamic simulations, we investigate such effects while fully capturing mass accretion, ejection, and the production of relativistic jets, over time intervals exceeding several seconds. I will show that not only does an initially poloidal post-merger magnetic field geometry generate relativistic jets, but the more natural, purely toroidal post-merger geometry generates striped jets of alternating magnetic polarity, a result seen for the first time. Our simulated jet energies, durations, and opening angles for all magnetic configurations span the range of sGRB observations. Concurrent with jet formation, sub-relativistic winds, launched from the radially expanding accretion disk, provide efficient collimation of the relativistic jets and an observational window into the observed kilonova. In comparison to GW 170817/GRB 170817A, I will demonstrate that the blue kilonova component, although initially obscured by the red component, expands faster, outrunning the red component and becoming visible to off-axis observers.

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Dependence of accessible dark matter annihilation cross sections on the density profiles of dSphs

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Dwarf spheroidal galaxies (dSphs) are good target to search for dark matter annihilation signals with gamma-ray observations. For WIMPs lighter than $m_{\rm DM} \sim calO(10)$ GeV, the strongest constraints are obtained by Fermi's observation of dSphs. In the near future, our accessibility to WIMPs heavier than $m_{\rm DM} \sim calO(1)$ TeV should be significantly enhanced with Cherenkov Telescope Array (CTA). The importance of the dark matter spatial distribution in dSphs increases because the angular resolution of CTA facilities are much finer than the typical size of dSphs. We evaluate how our accessibility to WIMP depends on the models of dark matter distribution in dSphs and discuss the implications.

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Ways of Seeing: Finding BSM physics at the LHC

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Searches for beyond-Standard Model physics at the LHC have thus far not uncovered any evidence of new particles, and this is often used to state that new particles with low mass are now excluded. Using the example of the supersymmetric partners of the electroweak sector of the Standard Model, I will present recent results from the GAMBIT collaboration that show that there is plenty of room for low mass solutions based on the LHC data, including a low mass dark matter particle. I will then present a variety of methods for designing new LHC analyses that can successfully target those solutions.

Parallel / 19

Probing the Early Universe with Axion Physics

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Axions and axion-like particles are excellent dark matter candidates, spanning a vast range of mass scales from the milli- and micro-eV for the QCD axion, to 10^{-22} eV for ultralight axions, to even lighter candidates that make up the "axiverse". In some scenarios, inhomogeneities in the axion density lead to the formation of compact structures known as axion "miniclusters" and axion stars. Topological defects in the early universe might also contribute the energy density of axions and generate primordial gravitational waves that can possibly be detected in future experiments. I will first discuss astrophysical and cosmological constraints on axions at either end of this spectrum, using data from the cosmic microwave background anisotropies and the effects of miniclusters on the gravitational microlensing and on direct detection. I will then assess the formation and the evolution of axion stars in various astrophysical regimes.

Parallel / **21**

Evidence the 3.5 keV line is not from dark matter decay

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X-ray observations of nearby clusters and galaxies have reported an unexpected X-ray line around 3.5 keV. This line has received significant attention due to its possible explanation through decaying dark matter; in particular, decaying sterile neutrino models, with a sterile neutrino mass around 7 keV, provide a good fit to the available data. We use over 30 Ms of XMM-Newton blank-sky observations to search for evidence of the 3.5 keV line consistent with arising from decaying dark matter within the ambient halo of the Milky Way. We find the strongest limits to-date on the lifetime of dark matter in this mass range, strongly disfavoring the possibility that the 3.5 keV line originates from dark matter decay.

Parallel / **22**

Global study of effective Higgs portal dark matter models using GAMBIT

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In this talk, I'll present results from a global analysis of effective Higgs portal dark matter (DM) models in frequentist and Bayesian statistical frameworks. We use the GAMBIT software to determine the preferred mass and coupling ranges for vector, Majorana and Dirac fermion DM models. We also assess the relative plausibility of all four (including scalar DM) models using Bayesian model comparison. Our analysis includes up-to-date likelihood functions for the DM relic density, invisible Higgs decays, and direct and indirect searches for WIMP DM, and includes the latest XENON1T data. We also account for important systematic uncertainties arising from the local DM density and velocity distribution, nuclear matrix elements relevant for direct detection, and Standard Model masses and couplings.

From our global analysis, we find the parameter regions that can explain all of the DM and give a good fit to the observed data. The case of vector DM requires the most tuning and is thus slightly disfavoured from a Bayesian point of view, whereas the fermionic DM case requires a strong preference for including a CP-violating phase due to respective suppression of direct detection limits. Finally, we present DDCalc 2.0.0, a tool for calculating direct detection observables and likelihoods for arbitrary non-relativistic effective operators. All of our results and samples are publicly available via Zenodo.

Parallel / **23**

Angular power spectrum analysis on current and future high-energy neutrino data

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To constrain the contribution of source populations to the observed neutrino sky, we consider isotropic and anisotropic components of the diffuse neutrino data. We simulate through-going muon neutrino events by applying statistical distributions for the fluxes of extra-galactic sources and investigate the sensitivities of current (IceCube) and future (IceCube-Gen2 and KM3NeT) experiments. I will show that the angular power spectrum is a powerful probe to assess the angular characteristics of neutrino data and demonstrate that we are already constraining rare and bright sources with current IceCube data.
In addition, I will investigate the decay and annihilation of very heavy dark matter as a potential neutrino source, as suggested by the observed excess in the High-Energy Starting Event dataset. We apply our angular power spectrum analysis to this HESE data for different channels, allowing us to interpret the observed neutrino sky and perform a sensitivity forecast.

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Testing the EWPT of 2HDM at future lepton Colliders

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A successful electro-weak baryongenesis calls for a strong first order electro-weak phase transition (SFOEWPT), which is unavailable in the Standard Model (SM). Some degree of modification on Higgs potential at electro-weak temperature is required to develop an energy barrier, and the property of Higgs at zero temperature is also changed accordingly. In this work we study the realization of SFOEWPT in type-I and type-II two Higgs doublet model (2HDM), and changes of Higgs couplings in SFOEWPT satisfied parameter regions. A global fit to various search channels at future electron colliders is performed to obtain the 95% C.L. limits on parameter space. Our results shows that future

electron colliders are capable of excluding most SFOEWPT parameter region in type-I and type-II 2HDM.

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The Pierre Auger Observatory Upgrade

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The scientific results of the Auger Observatory have been many and of great impact in the field of cosmic ray physics, but there are still many unknowns about the mass composition and the cosmic accelerators at the highest energies.
In this context, an upgrade project called "AugerPrime" is underway to obtain more detailed information regarding the mass composition and the origin of the high-energy flux suppression.
The AugerPrime upgrade contains many improvements to the Pierre Auger Observatory including the installation of a new Surface Scintillator Detector (SSD) above each of the existing water-Cherenkov detectors (WCDs), new surface detector stations electronics to process both WCD and SSD signals, the installation of the underground scintillator muon detector AMIGA, and the addition of sensors to each WCD to measure the radio waves generated by the extensive air showers.
AugerPrime will be described, with particular attention to the electronics and the expected performance of the upgraded Observatory.

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A peek to GRB emission at VHE through 10 years of Fermi-LAT observations

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Very High Energy (VHE) emission is the next frontier of exploration of the extreme physics of Gamma-Ray Bursts (GRBs). Thanks to its wide field of view the Large Area Telescope (LAT) on board of the Fermi satellite is a continuous probe of the VHE component of GRBs. A systematic search spanning the first 10 years of the Fermi-LAT data results in the detection of 186 GRBs vith energies >30MeV. The Fermi-LAT wealth of bursts provides a sample to study the VHE properties of GRBs with and unprecedented coverage. Furthermore the recent contemporaneous detections of two GRBs by Fermi-LAT and respectively H.E.S.S (GRB180720B). and MAGIC (GRB190114C) enrich our collection of two important events. In this contribution we present the features of this extreme emission emerging from the study of more of 10 years of data and of the two recent breakthrough in the GRB field. We will finally discuss the models to interpret the GRB VHE emission and the prospectives opened for future detections by VHE instruments.

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Cosmic-ray dark matter in simplified models

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Cosmic rays propagating in the galaxy could potentially scatter on the dark matter halo. This scattering will impart significant energy to the dark matter, creating a small population of 'cosmic-ray dark matter' particles. This population of cosmic rays could be observed in ordinary dark matter and neutrino detectors if the dark matter is sufficient light. In this talk I will review the formalism of cosmic-ray dark matter and then describe improvements and extensions that we are making to the formalism. Notably, this includes applying the formalism to simplified models of dark matter, which are more suitable in the regime under consideration (where we have relativistic, strongly interacting dark matter). Using these simplified models we find large departures from the previously calculated bounds.

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Primordial Black Holes as Silver Bullets for New Physics at the Weak Scale

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Observational constraints on gamma rays produced by the annihilation of weakly interacting massive particles around primordial black holes (PBHs) imply that these two classes of Dark Matter candidates cannot coexist. In this talk, I will show that the successful detection of one or more PBHs by radio searches (with the Square Kilometer Array) and gravitational waves searches (with LIGO/Virgo and the upcoming Einstein Telescope) would set extraordinarily stringent constraints on virtually all weak-scale extensions of the Standard Model with stable relics, including those predicting a WIMP abundance much smaller than that of Dark Matter. Upcoming PBHs searches have in particular the potential to rule out almost all of the favorable parameter space of popular theories such as the minimal supersymmetric standard model and scalar singlet Dark Matter.

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The atmospheric muons flux measured with the Large Volume Detector for 24 years

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The Large Volume Detector, hosted in the INFN Laboratori Nazionali del Gran Sasso, is triggered by atmospheric height energy muons (E_μ>1 TeV), which are produced in the decay of short-lived charged mesons in the extensive air showers, at a rate of $\sim 0.1\tilde{}$Hz.
The data collected over almost a quarter of century (1994-2017), the longest ever exploited by a single instrument, allows for the accurate long-term monitoring of the muon intensity underground. This is relevant as a study of the background in the Gran Sasso Underground Laboratory (minimal depth

3100 m w.e.), which hosts a variety of long-duration and low-background detectors aimed to search for rare events as supernova neutrinos and dark matter.

The muon flux intensity measured with LVD, $\mathrm{I}_{\mu} = (3.35 \pm 0.0005^{\mathrm{stat}} \pm 0.03^{\mathrm{sys}}) \times 10^{-4}\ \mathrm{m}^{-2}\mathrm{s}^{-1}$, is modulated with the effective temperature due to seasonal temperature variations in the stratosphere. We quantify such correlation, $\alpha_{\mathrm{T}} = 0.94 \pm 0.01^{stat} \pm 0.01^{sys}$, by using temperature data from the European Center for Medium-range Weather Forecasts for the LNGS Laboratory in agreement with other measurements at the same depth. We also investigated the spectral content of the time series by means of the Lomb-Scargle and Singular Spectrum Analysis techniques. This yields the clear evidence of a 1-year periodicity, as well as the indication of others, both shorter and longer, suggesting that the series, as expected, is not a pure sinusoidal wave.

In this contribution we will report on the results of the time series analisys and we will describe the methods to select muon-like events, to compute the effective temperature and to calculate the detector exposure.

Opening / **31**

Oppening address

Parallel / **33**

The Migdal effect and bremsstrahlung in effective field theories of dark matter scattering

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Creative ideas for extending the reach of large scale dark matter direct detection experiments to low mass WIMPs include exploiting inelastic detection channels. Two examples are the Migdal effect (atomic ionization) and photon bremsstrahlung from the recoiling nucleus. We calculated these effects for a variety of momentum- and spin-dependent dark matter interactions described by non-relativistic effective field theories. In addition we have calculated these effects for coherent neutrino-nucleus scattering, we compare these rates with the elastic nuclear and electronic scattering rates. Lastly, I will show detailed detector simulations of the Migdal effect that will be used to faithfully evaluate the effects impact on future experiments.

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Filtered Dark Matter

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We describe a new mechanism of dark matter production that employs a first order cosmological phase transition to suppress the dark matter relic abundance. While the mechanism can be applied generally, we study it specifically in a toy model consisting of a single real scalar field and a Dirac fermion (which will constitute the dark matter). During the cosmological phase transition the scalar field obtains a vev. If the dark matter particles then acquire a significant mass, it is energetically disfavoured for them to enter the bubbles. Instead, most dark matter particles are reflected from the bubble wall and annihilate into the thermal bath. This suppresses their relic abundance within the bubbles, which eventually merge as the phase transition is completed.

Parallel / **35**

Probing Blazar Emission Processes with Optical/gamma-ray Flare Correlations

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Even with several thousand Fermi-LAT blazar detections, the high-energy jet emission mechanism is poorly understood. Although popular models point towards leptonic processes, the recent possible neutrino association with a γ-ray flare challenges our understanding of these processes implicating a hadronic contribution to the high energy emission of blazar jets. I will discuss our recent efforts to address the distinction between leptonic and hadronic models by exploring the temporal relation and correlated flux variations between optical and γ-rays for the largest sample of γ-ray blazars analyzed to this date, as well as the first attempt to quantify the fraction of orphan γ-ray flares in the Fermi light curves.

Parallel / **36**

Probing Ultralight Dark Matter using Galactic Kinematics

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Dark matter candidates exist over a mass range spanning greater than 70 orders of magnitude. At one end of this spectrum, Ultralight Dark Matter (ULDM) posits particles so light that their de Broglie wavelength can be as large as several kpc, giving rise to gravitational dynamics that can be very different from models with heavier candidates. Examples of such dynamics include dynamical heating of stellar populations through fluctuation of the wave-like ULDM field, and formation of a large

central soliton in galaxies (predicted by ULDM simulations). In this talk, I will show how existing kinematic data in galaxies can probe several orders of magnitude in ULDM parameter space. The resulting constraints hold even in the absence of any non-gravitational coupling of dark matter to the Standard Model, potentially closing part of the 70 order-of-magnitude window in a model-independent way.

Parallel / **37**

A frequentist analysis of three right-handed neutrinos with GAMBIT

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The lightness of the three active neutrinos can be explained by the existence of an equal number of exotic heavy neutral fermions, with a mass ranging from a few MeV to around a TeV. Constraints from different sources such as direct detection, lepton flavour violation and electroweak precision observables, impose strong upper limits on their mixing of these sterile neutrinos to the active neutrinos. We present here the results of a global fit using the GAMBIT tool of a model with three heavy right-handed neutrinos, combining all experimental constraints from collider, precision and cosmological origin.

Parallel / **38**

Radiative Signatures of Relativistic Reconnection in Blazar Jets

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Relativistic magnetic reconnection, a process which converts magnetic energy to particle acceleration, is an ideal mechanism for the multi-wavelength spectral and temporal variability observed in blazar jets. By coupling recent two-dimensional particle-in-cell simulations of relativistic reconnection with a time-dependent radiative transfer model, we compute the non-thermal emission from a chain of plasmoids, namely quasi-spherical blobs of plasma containing relativistic particles and magnetic fields formed during a reconnection event. Here, I will show that our derived photon spectra display characteristic features observed in both BL Lac sources and flat spectrum radio quasars. A differentiation in modeling the two subclasses is achieved by varying the strength of the photon fields external to the jet, the jet magnetization, and the number of electron-positron pairs per proton

contained within. Additionally, I will present several 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.

Parallel / 39

Probing Seesaw Mechanisms at Future Lepton Colliders

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A future lepton collider is expected to be able to measure the cross section of the Higgsstrahlung process to sub-percent level precision. In this talk, it is argued that this will provide an opportunity to indirectly probe models which incorporate the seesaw mechanism to generate small Majorana masses for neutrinos. The expected corrections to selected Standard-Model observables, which are measured to high precision, are quantified by means of effective field theory. The obtained bounds on specific parameter combinations in the respective models are compared to other constraints from electroweak precision measurements.

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Seeking Meaning in Mystery: Modeling the TeV Gamma Rays towards HESS J1804-216

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The High Energy Stereoscopic System (HESS) has discovered numerous Galactic TeV gamma-ray sources. HESS J1804-216 is one of the brightest and most mysterious sources discovered and is currently classified as an unidentified source, as no clear counterpart has yet been identified. It is vital to have an understanding of the gas surrounding a source, as it can lead to constraining the nature of the source. Therefore, the morphology of interstellar gas which surrounds HESS J1804-216 is investigated using data from the Mopra Southern Galactic Plane CO Survey and Southern Galactic Plane Survey of HI. In this contribution, the results of the gas surveys will be summarised and possible scenarios of gamma-ray production will be discussed.

Parallel / 42

Gamma Ray Diffuse Emission from the Galactic Plane with HAWC Data

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The Galactic gamma-ray diffuse emission (GDE) is the extended radiation from the Galactic plane produced by the interaction of background cosmic rays (CRs) with ambient gas and radiation fields. Studying this radiation helps us to understand particle transport and distribution in the Galaxy. The HAWC (High Altitude Water-Cherenkov) observatory is an instrument that detects CRs and gamma-rays from 300 GeV to more than 100 TeV by observing the Cherenkov light produced by the air-shower particles into the water of the detector. We will present the analysis of HAWC data from the Galactic plane to measure the spectrum and the angular distribution of the diffuse emission from the Galactic plane. This measured GDE includes the emission induced by the CR sea but also an unavoidable contribution from unresolved gamma-ray sources and thus our results will provide upper limits to the GDE. We will use these HAWC measurements to constrain particle transport properties in different regions of the Galactic plane, such as the region close to the Galactic center, comparing them to the predictions of transport models implemented with the DRAGON code.

Parallel / **43**

The Peanut Shaped Fermi Galactic Centre Excess

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The Fermi Large Area Telescope (LAT) has observed an excess of GeV gamma rays coming from Galactic Centre. The two main competing explanations are an unresolved population of millisecond pulsars or self-annihilating dark matter. One distinguishing feature of these two explanations is that in the annihilating dark matter case the excess is predicted to be very close to spherically symmetric. While in the millisecond pulsar case, the excess is expected to trace the stellar mass of the bulge which has a boxy/peanut shape. Previous studies have shown that the excess is better described by a boxy morphology compared to a spherical morphology. I will present new results showing that the excess actually has more of a peanut like (double bump) shape as opposed to a boxy shape. We demonstrated this by non-parametrically constructing a template of the Galactic bulge stellar distribution from the Vista Variables in the ViaLactea (VVV) infrared data. We then found that this peanut-shaped template provides a significantly better fit to the Galactic Centre excess.

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Carbon Monoxide in Our Galactic Centre: Implications for Understanding Gamma-Ray Emission

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Using the Mopra Southern Galactic Plane Carbon Monoxide Survey: Galactic Centre dataset, comparisons between high resolution molecular gas and current HESS observations of Very High Energy (VHE) gamma-ray sources are presented. Similar comparisons will be able to be made in the future when CTA provides higher resolution gamma-ray maps, with a greater sensitivity that is expected to detect more diffuse VHE gamma-ray emission. Multiwavelength analysis will be necessary to understand the origin of potentially extremely widespread emission.

Parallel / 46

Thermal leptogenesis from a low-scale seesaw.

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The implications of requiring the necessary generation of the baryon asymmetry via the decay of heavy sterile neutrinos on the parameter space of the Inverse Seesaw (ISS) and Linear Seesaw (LSS) is explored. Often in such low-scale seesaw scenarios a natural mass degeneracy occurs resulting in a relatively small mass splittings amongst sterile neutrinos, allowing for a resonant enhancement in the amount of asymmetry generated per sterile decay.

Simple scenarios of these low-scale seesaws are considered as well as scenarios where a particular lepton flavour symmetry ansatz is adopted. Additionally, motivated by the fact that the Dirac phase in the PMNS matrix is the only CP-violating parameter in the leptonic sector that can be measured in neutrino oscillation experiments, we examine the possibility that it is the dominant source of CP violation in these scenarios.

Parallel / 47

Synchrotron and synchrotron-self-Compton mechanisms for VHE emission from GRBs

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Recent detection of very high energy (VHE, > 100 GeV) gamma rays from GRBs has opened a possibility to test emission mechanisms late in the afterglow phase. Synchrotron radiation from a decelerating blast wave is a widely accepted model of optical to X-ray afterglow emission from GRBs. GeV gamma rays detected by the Fermi Large Area Telescope (LAT) and the duration of which extends beyond the prompt gamma-ray emission phase, is also compatible with broad features of the afterglow emission. VHE gamma-ray detection therefore can be used for testing the synchrotron-self-Compton (SSC) emission mechanism, which is a natural extension of the synchrotron mechanism. We have developed an SSC model for emission from a decelerating blast wave in various scenarios, such as adiabatic or radiative fireball in constant density or wind-type environment. Here we report on modeling of multiwavelength afterglow data from a few bright GRBs. In the VHE range we compare and contrast SSC emission mechanism with the proton-synchrotron emission mechanism.

Parallel / 48

A new constraint on the origin of Galactic Center positrons

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Positron annihilation has been observed toward the center of the Galaxy for around 50 years, via the detection of gamma-rays produced in positron-electron co-annihilation. However, the origin of these positrons remains uncertain, and proposed sources include the annihilation or decay of Dark Matter. Constraining the injection energy of the positrons allows us to constrain the origin of the positrons. The in-flight annihilation of positrons with kinetic energies >1 MeV results in the emission of excess continuum emission above 511 keV. I present a novel analysis of almost 2 decades of INTEGRAL telescope gamma-ray data and a new constraint on the injection energies and sources of the positrons observed to annihilate toward the Galactic center.

Parallel / **49**

Imaging Observation for Cosmic MeV Gamma Background and Galactic Diffuse MeV Gamma by SMILE2+ balloon-bore experiment

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The evolution of Active Galactic Nuclei is one of most significant issues of Astrophysics, and both the spectrum and distribution of Cosmic MeV gamma Background (CMGB) are considered strongly to reflect the differences in theoretical models. However, until now only COMPTEL provided only the spectrum of CMGB measured from the wide sky area from 9years observation, although it included large statistical and systematic errors due to severe background radiation in space.
In 2018, we (SMILE-project in Comic-ray Group of Kyoto University) have observed MeV gamma rays for the southern hemisphere by Electron Tracking Compton Camera (ETCC) using JAXA one-day flight balloon at Australia (SMILE2+ Project). By measuring all parameters of Compton scattering in each gamma, ETCC has achieved to measure the complete direction of MeV gammas same as optical telescopes, and to distinguish signal gammas completely from huge background gammas. In this observation, ETCC observed MeV gammas in 02-5MeV from 3/5 of the southern hemisphere including galactic center and Crab, and we successfully obtained pure cosmic gammas by reducing background by near 3 orders, which is clearly certificated by an obvious enhancement in the light curve with ˜30% during the galactic center passing through the FoV. This enhancement is consistent to the ratio of CBMG and Galactic Diffuse MeV gamma rays (GDMG), which ensures that ˜70% of detected gammas are CBMG and only a few 10% are backgrounds. Thus, several of 10ˆ4 gammas of CMBG are detected with quite low noise level, which is surely a first reliable data for discussing the above issue. Here we will present new Spectrum of CMGB and maybe its distribution. In addition, 511keV line gammas and GDMG are detected with ˜5 and 11sigmas, respectively, which are surely very important for indirect search for light DMs and Cosmic-ray physics.

Parallel / **50**

A New Method for an Untriggered, Source Stacking Search for Neutrino Flares

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Recent results from IceCube regarding TXS 0506+056 suggest that it may be useful to test the hypothesis of multiple neutrino flares, where each flare is not necessarily accompanied by a corresponding gamma-ray flare. An untriggered, time-dependent, source-stacking search would be ideal for testing this hypothesis. Previous methods fit only the largest untriggered flare in the data, however a significant improvment in discovery potential can be achieved by fitting all the flares in the sample simultaneously. In this talk, we introduce a new method specifically tailored to this purpose. This method has the additional benefit of returning a neutrino flare curve, describing the temporal structure of the neutrino data associated with a particular source. We show results of this method applied across 8 years of northern sky IceCube data for a catalog of Fermi 3LAC blazars, as well as a "self-triggered" style catalog consisting of high energy IceCube events.

Parallel / **51**

Probing Quadratic Gravity with Binary Inspirals

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We study gravitational waves generated by binary systems within an extension of General Relativity which is described by the addition of quadratic in curvature tensor terms to the Einstein-Hilbert action. Treating quadratic gravity as an effective theory valid in the low energy/curvature regime, we argue that reliable calculations can be performed in the early inspiral phase, and furthermore, no flux of additional massive waves can be detected. We then compute massive dipole (-1PN), and Newtonian (0PN) leading corrections to the post-Newtonian (PN) expansion of the standard waveform. By confronting these theoretical calculations with available experimental data, we constrain both unknown parameters of quadratic gravity.

Parallel / **52**

New results from the CUORE experiment

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The Cryogenic Underground Observatory for Rare Events (CUORE) is the first bolometric experiment searching for neutrinoless double-beta decay ($0\nu\beta\beta$) that has been able to reach the one-ton scale. The detector, located at the Laboratori Nazionali del Gran Sasso in Italy, consists of an array of 988 TeO_2 crystals arranged in a compact cylindrical structure of 19 towers. The construction of the experiment was completed in August 2016 with the installation of all towers in the cryostat. CUORE achieved its first physics data run in 2017 corresponding to a TeO_2 exposure of 86.3 kg·yr and a median statistical sensitivity to a ^{130}Te $0\nu\beta\beta$ half-life of 7.0×10^{24} yr. Following multiple optimization campaigns in 2018, CUORE is currently in stable operating mode and has accumulated data corresponding to a TeO_2 exposure approaching 500 kg·yr. In this talk, we present the updated $0\nu\beta\beta$ results of CUORE, as well as review the detector performance. We finally give an update of the CUORE background model and the measurement of the ^{130}Te two neutrino double-beta decay ($2\nu\beta\beta$) half-life.

Parallel / **53**

H.E.S.S. observations following multi-messenger alerts in real-time

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The H.E.S.S. Imaging Air Cherenkov Telescope system is, due to its fast reaction time and its comparably low energy threshold, very well suited to perform follow-up observations of detections at other wavelengths or other messengers like high-energy neutrinos and gravitational waves. These advantages are utilized optimally via a fully automatized system reacting to alerts from various partner observatories covering various wavelengths and astrophysical messengers.

In this contribution we'll provide an overview and present recent results from H.E.S.S. programs to follow up on multi-wavelength and multi-messenger alerts. To illustrate the capabilities of the system we will present several real-time ToO observations searching for high-energy gamma-ray counterparts to gravitational waves, high-energy neutrinos and Fast Radio Bursts.

Parallel / **54**

Photo-hadronic neutrino production in blazars: Cascading constraints and effects of anisotropies

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The 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, 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.

Parallel / **55**

Electron injection in merger shocks of galaxy clusters

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Radio and X-ray observations of so-called radio relics indicate electron acceleration at merger shocks in galaxy clusters. These large-scale shocks are also candidate sites for ultra-high-energy cosmic ray production. Merger shocks have low Mach numbers and propagate in high beta plasmas, $\beta \gg 1$. Particle acceleration and in particular electron injection mechanisms are poorly understood in such conditions. Here we report results of our large-scale 2D particle-in-cell simulations of cluster shocks that allow the development of multi-scale turbulence in the shock transition, including ion-scale shock rippling modes. We show that the presence of turbulence in multi scales is critical for efficient electron pre-acceleration. The main injection process is stochastic Shock Drift Acceleration, in which electrons are confined in the shock region by pitch-angle scattering off magnetic turbulence and gain energy from motional electric field. Wide-energy non-thermal electron distributions are formed both upstream and downstream of the shock. We demonstrate that the downstream electron spectrum has a power-law form with index $p = 2.4$, in agreement with observations. Pre-acceleration to very high energies occurs that should lead to electron injection to Diffusive Shock Acceleration processes in the presence of long-wave MHD upstream turbulence.

Parallel / **56**

Highlights from the H.E.S.S GRB observation program

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The emission at very-high energies (VHE, >100 GeV) from gamma-ray burst (GRBs) - the most luminous explosions in the universe - remained elusive for long time. After almost a decade of efforts by current Imaging Atmospheric Cherenkov Telescopes (IACTs), within the last two years the detection of three GRBs at VHEs has been confirmed, one with the MAGIC telescopes and two with H.E.S.S. In this contribution we present the H.E.S.S. GRBs observation programme and some of its highlight results including the VHE detection of the extremely bright GRB 180720B, remarkably achieved over 10 hours after the end of the prompt emission, when the X-ray flux had already decayed by four orders of magnitude. We will show this VHE detection in context with the multi-wavelength data, discuss the possible emission mechanisms at work and underline their implications on the GRB detection estimates for future VHE observatories.

Parallel / **57**

What a decade of multi-wavelength observations can tell us about the nature of blazars? The case of 1ES 1215+303

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Blazars are known for their variability on a wide range of timescales at all wavelengths. Their classification into flat spectrum radio quasars, low-, intermediate- or high-frequency-peaked BL Lac (FSRQ, LBL, IBL, HBL, respectively) is based on broadband spectral characteristics that do not account for possible different activity states of the source. Recently, it was proposed that blazars could be classified according to the kinematics of their radio features. Most studies of TeV gamma-ray blazars focus on short timescales, especially during flares, due to the scarcity of observational campaigns or due to the relatively young existence of specialized, sensitive enough detectors.

Thanks to a decade of observations from the Fermi-LAT and VERITAS, we present an extensive study of the long-term multi-wavelength variability of the blazar 1ES 1215+303. This unprecedented data

set reveals multiple strong gamma-ray flares and a long-term increase in the gamma-ray and optical flux baseline of the source over the ten-year period, which results in a linear correlation between these two energy bands over a decade.
Typical HBL behaviors were identified in the radio morphology of the source. However, analyses of the broadband SED at different flux states, unveils an extreme shift in energy of the synchrotron peak frequency from IR to soft X-rays. This evidences that the source exhibits IBL characteristics during quiescent states and HBL behavior during high states. A two-component synchrotron self-Compton model is used to describe this dramatic change.

The different methods applied and presented in this work provide a complete and detailed panorama of the intricate nature of blazars, and possibly even challenge our current classification scheme. Moreover, this work demonstrates the rewarding potential of blazars long-term studies that will be accessible, and potentially improved, thanks to future imaging atmospheric instruments, such as the Cherenkov Telescope Array (CTA).

Parallel / **58**

Cosmic-ray acceleration and escape from post-adiabatic Supernova remnants

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Supernova remnants are known to accelerate cosmic rays on account of their non-thermal emission observed at radio, X-ray and gamma-ray energies. Although there are many models for the acceleration of cosmic rays in Supernova remnants, the escape of cosmic rays from these sources is yet understudied.

We use our time-dependent acceleration code RATPaC to study the acceleration of cosmic rays and their escape in post-adiabatic Supernova remnants and calculate the subsequent gamma-ray emission.

We performed spherically symmetric 1-D simulations in which we simultaneously solve the transport equations for cosmic rays, magnetic turbulence, and the hydrodynamical flow of the thermal plasma in the test-particle limit. Our simulations span 100,000 years, thus covering the free-expansion, the Sedov-Taylor, and the beginning of the post-adiabatic phase of the remnant's evolution.

At later stages of evolution a considerable amount of cosmic rays with a wide range of energis can reside outside of the remnant. This leads to spectra softer than predicted by standard diffusive shock acceleration which feature breaks in the 10 - 100 GeV range. The total spectrum of cosmic rays released into the interstellar medium has a spectral index of s˜2.4 above roughly 10 GeV which is close to that required by Galactic propagation models. We further find the gamma-ray luminosity to peak around an age of 4,000 years for inverse-Compton-dominated high-energy emission. Remnants expanding in low-density media reach higher inverse-Compton peak-luminosities matching the fact that the brightest known supernova remnants - RCW86, Vela Jr, HESSJ1721-347 and RXJ1713.7-3946 - are all expanding in low density environments.

Parallel / **59**

Understanding the multiwavelength observation on Geminga's TeV halo in the context of anisotropic diffusion

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Recently, the HAWC experiment revealed an extended multi-TeV emission (so-called TeV halo) around several tens of parsecs around Geminga, implying an inefficient diffusion zone in that region. On the other hand, the TeV-emitting electrons are supposed to give rise to X-ray as well via synchrotron radiation in the ISM magnetic field. We perform a X-ray analysis on the region around Geminga but did not detect significant X-ray signal. This result translates to an upper limit of of 1μG for the magnetic field in the TeV halo. Either the small diffusion coefficient or the weak magnetic field is quite puzzling in the context of isotropic particle diffusion. We propose that both X-ray and TeV observations can be explained in the context of anisotropic diffusion without invoking extreme parameters for the surrounding ISM.

Parallel / **60**

An improved model of UHECR nuclei photomeson interactions

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The case for cosmic ray nuclei at the highest energies has become stronger with recent composition results from the Pierre Auger Observatory and Telescope Array. To understand the origin of these nuclei we need more reliable models of their interactions with photons. The currently used photomeson treatment underestimates the nuclear disruption and overestimates the photoproduction of pions when compared to experimental data. Our new photomeson model improves on these aspects and predicts lighter cosmic ray composition and reduced neutrino fluxes in the sources. These effects are relevant for environments where the photomeson interaction rates dominate at the highest cosmic ray energies. The impact of the model is illustrated in examples of TDEs and GRBs which satisfy this condition. An open source code has been made available which helps implementing the model in other frameworks used by the community.

Parallel / **61**

A two-zone model for blazar emission: implications for TXS 0506+056 and the neutrino event IceCube-170922A

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A high-energy muon neutrino event, IceCube-170922A, was recently discovered in both spatial and temporal coincidence with a gamma-ray flare of the blazar TXS 0506+056. It has been shown, with standard one-zone models, that neutrinos can be produced in the blazar jet via hadronic interactions, but with a flux which is mostly limited by the X-ray data. In this work, we explore the neutrino production from TXS 0506+056 by invoking two physically distinct emission zones in the jet, separated by the broad line region (BLR). Using the Doppler-boosted radiation of the BLR as the target photon field, the inner zone accounts for the neutrino and gamma-ray emission via p-gamma interactions and inverse Compton scattering respectively, while the outer zone produces the optical and X-ray emission via synchrotron and synchrotron self-Compton processes. The different conditions of the two zones allow us to suppress the X-ray emission from the electromagnetic cascade, and set a much higher upper limit on the muon neutrino flux than in one-zone models. We compare, in detail, our scenario with one-zone models discussed in the literature, and argue that differentiating between such scenarios will become possible with next generation neutrino telescopes, such as IceCube-Gen2.

Parallel / 62

Smoking Gun Signatures of Microscopic Black Holes at Neutrino Telescopes

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Large Extra Dimensions have been proposed as a compelling solution to the hierarchy problem, with a 'true'Planck scale that can be as low as a few TeV. In such scenarios, high-energy collisions can lead to the creation of microscopic black holes, which have been sought in cosmic ray interactions and at colliders. Future neutrino telescopes such as IceCube Gen2, km3Net, RNO and GVD have the potential to probe energies beyond the reach the next generation of colliders. I will describe the conditions to create and observe microscopic black holes at such telescopes, effects they may have on apparent unitarity violations in the flavor mixing matrix, as well as new, unique signatures in event topology and Cherenkov light timing. Taken together, these provide a clear prescription for identifying black holes on an event-by-event basis and a unique opportunity to discover physics beyond the Standard Model.

Plenary / 63

Linking TeV and THz astronomy (gamma-ray and radio astrophysics connections)

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Astrophysical gamma-ray sources are sites of extreme particle acceleration. For gamma-ray sources in our galaxy, a key ingredient in understanding the nature of the underlying particles (leptons

and/or hadrons) is knowledge of the interstellar gas (neutral and ionised), often traced by high frequency radio telescopes. For example, this gas can act as a target for cosmic ray collisions. In this talk, I will review what we have learned so far by comparing the gamma-ray emission and interstellar gas for a number of gamma-ray sources (e.g. supernova remnants and pulsar-wind nebulae). I will also look at the latest interstellar gas surveys and how they will impact the gamma-ray science to come from the next generation observatories, like the Cherenkov Telescope Array.

Parallel / 64

Science at the very high energy with the ASTRI mini-array

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The ASTRI Project aims at the design and development of a technologically innovative solution for small (4 m diameter) and large field of view (about 10 degrees) telescopes, of the same class of the Small-Sized Telescopes (SSTs) of the Cherenkov Telescope Array (CTA) devoted to cover the energy band up to 100 TeV and beyond. In the first phase of the project, an ASTRI prototype in a dual-mirror Schwarzschild-Couder (SC) configuration has been installed in Mt. Etna (Italy) and proposed as a CTA SST. The prototype, called the ASTRI-Horn telescope (in honor of the Italian-Jewish astronomer Horn D'Arturo, inventor of the tessellated mirror solution for astronomical telescopes), has started its scientific operation in fall 2018 and has provided the first detection of very high-energy (VHE) gamma-ray emission from the Crab Nebula by a Cherenkov telescope in dual mirror configuration. A camera based on SiPM sensor and CITIROC read-out electronic has been specifically developed for the scopes. As a continuation of the project, a mini-array of 9 (up to 12) ASTRI dual-mirror telescopes is currently being implemented. It will be deployed at the Observatorio del Teide, in the Canary Island of Tenerife, in collaboration with IAC. Thanks to its expected overall performance, better than current Cherenkov telescopes' arrays for energies above ˜10 TeV and up to ˜100 TeV, and its wide field of view, the ASTRI mini-array will be an important instruments to perform soon deep observations of the Galactic and extra-Galactic sky at the TeV energy scale and beyond. Important synergy with already existing Imaging Atmospheric Cherenkov Telescopes and Water Cherenkov facilities in the both northern and southern hemisphere are also foreseen. The ASTRI mini-array will also pave the way to the highest energy observations to be done with CTA southern site.
In this contribution, we introduce the ASTRI concept in the context of the CTA Observatory and discuss the scientific prospects of the mini-array in the fields of Galactic and extra-Galactic astrophysics, and fundamental physics.

Parallel / 65

Constraints on high energy particle interactions with the Pierre Auger Cosmic ray detectors

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High energy cosmic rays can interact in our atmosphere with energies up to 10^{20} eV. At these extreme energies, the high energy hadronic interaction models are not able to describe the observed properties in air showers. In this presentation, we will present a comparison of observations from the Pierre Auger Observatory and expectations according to high energy hadronic interaction models.

Parallel / 66

Reviving Millicharged Dark Matter for 21-cm Cosmology

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The existence of millicharged dark matter (mDM) can leave a measurable imprint on 21-cm cosmology through mDM-baryon scattering. However, the minimal scenario is severely constrained by existing cosmological bounds on both the fraction of dark matter that can be millicharged and the mass of mDM particles. We point out that introducing a long-range force between a millicharged subcomponent of dark matter and the dominant cold dark matter (CDM) component leads to efficient cooling of baryons in the early universe, while also significantly extending the range of viable mDM masses. Such a scenario can explain the anomalous absorption signal in the sky-averaged 21-cm spectrum observed by EDGES, and leads to a number of testable predictions for the properties of the dark sector. The mDM mass can then lie between 10 MeV and a few hundreds of GeVs, and its scattering cross section with baryons lies within an unconstrained window of parameter space above direct detection limits and below current bounds from colliders. In this allowed region, mDM can make up as little as 10^{-8} of the total dark matter energy density. The CDM mass ranges from 10 MeV to a few GeVs, and has an interaction cross section with the Standard Model that is induced by a loop of mDM particles. This cross section is generically within reach of near-future low-threshold direct detection experiments.

Parallel / 67

Recent results on gamma-ray observations from the Tibet AS gamma experiment

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The Tibet air shower array has been observing high-energy cosmic rays and gamma rays at the altitude of 4,300 m in Tibet, China, since 1990.
Its sensitivity toward gamma rays above 10 TeV has been dramatically improved by the underground water-Cerenkov-type muon detector array added in 2014, which discriminates gamma rays from background cosmic-ray nuclei based on the number of muons in their air showers and thus suppresses > 99.9% of background events above 100 TeV.
In this presentation we report the recent results on gamma-ray observations with the Tibet air shower array combined with the muon detector array.

Parallel / 69

A two source population fit to ultrahigh-energy cosmic ray data

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We fit ultrahigh-energy cosmic ray spectrum and composition data from the Pierre Auger Observatory using two populations of astrophysical sources. One population, accelerating dominantly protons, follows typical cosmological evolution similar to luminous astrophysical sources; while another, mostly nearby, population of astrophysical sources accelerate light-to-heavy nuclei. We compute expected cosmogenic neutrino flux in such a hybrid source population scenario and discuss possibilities to detect these neutrinos by upcoming detectors to shade lights on the sources of ultrahigh-energy cosmic rays.

Parallel / 70

Optimization of the Southern Wide Field-of-view Gamma-ray Observatory (SWGO)

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Ground-based, wide field of view instrumentation in gamma-ray astronomy such as HAWC and LHAASO is currently limited to the northern hemisphere and hence, lack sensitivity to our Galactic Center and the rest of the southern sky. A Gamma-ray Observatory comprising an array with a high fill factor (> 70 %) of primarily modular and scalable Water Cherenkov Detector (WCD) units in the Southern Hemisphere between latitudes of -10 to -30 degrees and above an altitude of 4.4 km would provide 100% duty cycle, steradian field of view, and cover an energy range from 100s of GeV to 100s of TeV. In this contribution, we present the current status of the research and development phase of the project, developments towards a common framework for simulation and analysis and initial optimization studies with a candidate double-chambered WCD array.

Parallel / 71

Energy dependent morphology of the pulsar wind nebula HESS J1825-137 in the GeV domain

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HESS J1825-137 is the archetypal example of energy-dependent morphology within a pulsar wind nebula. In a deep analysis with ten years of Fermi-LAT data, we measure continued energy dependence into the GeV regime. Combining GeV and TeV data yields new insights into the evolutionary history of the system. We use a multi-zone model to reproduce simultaneously the spectral and morphological properties of the nebula.

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The fraction of TeV Halos in gamma-ray bright pulsar wind nebulae

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The recent detection of extended gamma-ray emission around the local pulsars Geminga and PSR B0656+14 has led to the suggestion of TeV halos as a separate source class, phenomenologically distinct from pulsar wind nebulae. Defining halos as regions where the pulsar no longer dominates the dynamics of the interstellar medium, yet an over-density of relativistic electrons is present, we assess the current TeV source population in terms of size and particle energy density. We find that the known population is comprised mainly of pulsar wind nebulae, with halos unlikely to contribute significantly to the total gamma-ray luminosity of our Galaxy. However, it seems likely that a significant number of low flux diffuse halos around older pulsars will be discovered by the next generation of gamma-ray instruments.

Parallel / 73

Properties of Elementary Particle Fluxes in Primary Cosmic Rays Measured with the Alpha Magnetic Spectrometer on the ISS

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The fluxes and flux ratios of charged elementary particles in cosmic rays are presented in the absolute rigidity range from 1 up to 2000 GV. Of particular interest is the energy dependance of the positron flux, which clearly shows the existence of the new source of high energy cosmic ray positrons. In the absolute rigidity range ~60 to ~500 GV, the antiproton, proton, and positron fluxes are found to have nearly identical rigidity dependence and the electron flux exhibits different rigidity dependence

Parallel / **74**

A study of gamma-rays from local Giant Molecular Clouds and its implications on the cosmic-ray flux

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The spectral properties of the cosmic-ray (CR) spectrum in the interstellar medium can be understood by comparing the results of gamma-ray observation with the direct local CR measurements. Among the best candidates for such studies are giant molecular clouds (GMCs) of the Gould Belt star formation region, since these clouds are usually located outside of the Galactic plane where associated γ-ray emission can be easily discriminated from the Galactic diffuse emission.
Based on Fermi-LAT and HAWC data, we report the average CR spectrum of seven nearby GMCs using the Planck dust opacity map as a spatial template. We find that this spectrum in Fermi-LAT's 3-1000 GeV range is well described by a power-law with a spectral index of 2.70±0.01 and the normalization of the spectrum is slightly higher than one expected from direct measurements of local CRs by the AMS02 experiment, which can imply non-homogeneous distribution of CRs at least within 1 kpc of the Local Galaxy. In addition to this, we also present combined limits in HAWC's 1-100 TeV energy range with 95% C.I. using ˜3 years of data.

Parallel / **75**

Recent results and status of the Telescope Array experiment

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The Telescope Array (TA) is a cosmic-ray observatory of the largest exposure in the northern hemisphere, and is operational since 2008. In this talk I will present the data analysis results using the 11-year data of TA and discuss the energy spectrum, mass composition, and arrival direction distribution of ultra-high energy cosmic rays. I will also present the status of TA extensions of TA, i.e. TAx4 to enlarge the exposure for highest energy cosmic rays, and TALE as a low-energy extension aiming at finding a transition energy of cosmic rays of galactic or extra-galactic origins.

Parallel / **76**

Magnetic-field models and constraints on axion-like paricles from the lack of irregularities in high-energy spectra

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Photons may convert to axion-like particles (ALPs) in external magnetic fields. Under certain conditions, this effect should result in irregular features in observed spectra of astrophysical sources. Lack of such irregularities in particular spectra was used to constrain ALP parameters, with two most popular sources being the radio galaxy NGC 1275 and the blazar PKS 2155-304. The effect and, consequently, the constraints, depend on the magnetic fields through which the light from the source is propagated. Here, we revisit ALP constraints from gamma-ray observations of NGC 1275 taking into account the regular magnetic field of the X-ray cavity observed around this radio galaxy. This field was not accounted for in previous studies, which assumed a model of purely turbulent fields with coherence length much smaller than the cavity size. For the purely regular field, ALP constraints are relaxed considerably, compared to the purely turbulent one. Similar arguments hold also for PKS 2155-304. While the actual magnetic field around a source is an unknown sum of the turbulent and ordered components, the difference in results gives an estimate of the theoretical uncertainty of the study and calls for detailed measurements of magnetic fields around sources used to constrain ALP properties in this approach.

Parallel / 77

Sub-PeV gamma-ray astronomy with Carpet

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Carpet is an air-shower array at Baksan, Russia, equipped with a large-area muon detector, which makes it possible to separate primary photons from hadrons. We report results of the search for primary photons with energies E>300 TeV, including diffuse and point-source fluxes or limits, in particular for gamma rays associated with the IceCube neutrino flux. Final data obtained with Carpet-2 (175 square-meter muon detector) as well as the sensitivity and first light of Carpet-3 (410 square-meter muon detector) will be presented.

Parallel / 78

Dark Matter searches towards the WLM dwarf irregular galaxy with H.E.S.S

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In the indirect dark matter (DM) detection framework, the DM particles would produce some signals by self-annihilating and creating standard model products such as γ rays, which might be detected by ground-based telescopes. Dwarf irregular galaxies represent promising targets for the search for DM as they are assumed to be dark matter dominated. These dwarf irregular galaxies are rotationally supported with relatively simple and well measured kinematics which lead to small uncertainties on their dark matter distribution profiles. In 2018, the H.E.S.S. telescopes observed the irregular

dwarf galaxy Wolf-Lundmark-Melotte (WLM) for 18 hours. These observations are the very first ones made by an imaging air Cherenkov telescope toward this kind of objects. We search for a DM signal looking for excess of γ rays towards WLM dwarf galaxy. We perform the first analysis of this source in stereoscopy using the data taken by the five H.E.S.S. telescopes. We present the new results on the observations of WLM interpreted in terms of velocity-weighted cross section for DM self-annihilation ⟨σv⟩ as a function of DM particle mχ mass for eight annihilation channels: bb, W+W−, τ+τ−, Z+Z−, e+e−, μ+μ−, tt as continuum spectra and the prompt emission γγ.

Parallel / **79**

Latest results on high-energy cosmic neutrinos with the ANTARES neutrino telescope

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The ANTARES neutrino telescope is located in the Mediterranean Sea at a depth of 2.5 km, 40 km off the Southern coast of France, and is operational since more than 10 years. The transparancy of the seawater allows for a very good resolution in the reconstruction of the incoming direction of neutrinos of all flavours. The ANTARES location in the Northern Hemisphere is optimal for the observation of the Southern Sky, including most of the Galactic Plane and the Galactic Center.
The latest ANTARES results will be presented. These include measurements of diffuse fluxes, various searches for point-like and extended neutrino sources and searches for neutrinos from dark matter annihilation, some of which are performed in combination with IceCube. ANTARES has an extended multi-messenger program, and results are presented from analyses of triggers generated by ANTARES, as well as analyses of the ANTARES data collected during transient events triggered by others, in particular by gravitational wave interferometers.

Parallel / **80**

Statistics of the subhalo population in the Milky Way for the detection of dark matter point sources

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It is known that cold dark matter form structures on scales much smaller than the size of typical galaxies. This clustering translates into a very large population of subhalos in the Milky Way. Analyzing Fermi-LAT data and/or using numerical simulations, several studies have investigated the possibility that among the 1525 unassociated point sources identified by the collaboration (4FGL catalog), some of them be DM subhalos. I present a new statistical analysis for the detectability of DM clumps as point sources within the framework of a semi-analytical model to describe the subhalo population. This approach not only allows to consistently and analytically compute the detection probability of point subhalos but also gives information on the most visible ones (i.e. their position, mass and concentration) and can be used to make predictions for the next generation of telescopes (e.g. CTA).

Parallel / 81

Improved upper limits on the WIMP annihilation cross section from dwarf spheroidal satellite galaxy observations with the MAGIC telescopes

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The Major Atmospheric Gamma Imaging Cherenkov (MAGIC) telescopes, located on the Canary Island of La Palma, play an important role in the detection of VHE gamma rays resulting from the annihilation or decay of WIMP dark matter. Dwarf spheroidal satellite galaxies (dSphs) are among the best candidates to search for DM, having the highest known mass-to-light (M/L) ratios and being free of gamma-ray emitting sources in the foreground. In 2011, the MAGIC collaboration started a program on DM indirect detection in dSphs. The observations presented no hint of signals, implying strong upper limits on the velocity-averaged cross section of WIMP annihilation from the observations of Segue 1 and Ursa Major II dSphs. To avoid a possible bias on the target selection, to improve the previous results, and to reduce their associated systematic uncertainties, a diversification of the observation strategy has been carried out over the past years through a multi-year dSphs observation campaign. We present here new MAGIC results obtained from 60h of observation of the Draco dSph in 2018 and 50h of the Coma Berenices dSph in 2019. Since no signal has been detected from these targets, the individual limits and their combination with the previous results, using a total of 380 hours of good quality data, will be shown.

Parallel / 82

Development of photosensor and inner detector in DarkSide-20k experiment

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DarkSide-20k experiment utilizes 20 tonnes of 39Ar-depleted argon as fiducial mass in a dual-phase Time Projection Chamber (TPC) to search for dark matter signals. In this talk, I will present the development of Silicon Photomultipliers (SiPMs) based photosensors, specifically for liquid argon detector. I will also present the design and prototyping of the inner detector, with an emphasis on the program ongoing at CERN towards the Darkside-20k inner detector cryogenics construction and test, and the operation of a series of prototype detectors for the finalization of the DarkSide-20k TPC design.

Parallel / 83

Searching for Dark Matter annihilation with a combined analysis of dwarf spheroidal galaxies data from Fermi-LAT, HAWC, H.E.S.S., MAGIC and VERITAS

Authors: Daniel Kerszberg[1]; Celine Armand[2]; Eric Charles[3]; mattia di mauro[4]; Chiara Giuri[5]; J. Patrick Harding[6]; Tjark Miener[7]; Emmanuel Moulin[8]; Louise Oakes[9]; Vincent Poireau[10]; Elisa Pueschel[5]; Javier Rico[1]; Lucia Rinchiuso[11]; Daniel Nicholas Salazar-Gallegos[None]; Kirsten Anne Tollefson[12]; Benjamin Zitzer[13]; for the Fermi-LAT, HAWC, H.E.S.S., MAGIC and VERITAS collaborations.[None]

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Dwarf spheroidal galaxies (dSphs) are among the most dark matter (DM) dominated objects with negligible expected astrophysical gamma-ray emission. This makes nearby dSphs ideal targets for indirect searches for a DM particle signal. The accurate knowledge of their DM content makes it possible to derive robust constraints on the velocity-weighted cross section of DM self-annihilation. In the past years, separate limits have been produced by the Fermi-LAT, HAWC, H.E.S.S., MAGIC, and VERITAS collaborations. We will report on an initiative aiming at combining data from these five experiments in order to maximize the sensitivity of DM searches towards dSphs, using a common maximum likelihood approach. This approach includes a uniform description of the DM content, quantified through the J-factor, and its statistical uncertainty. Preliminary results of the combination constraining the DM annihilation cross section will be presented spanning a range of DM masses from 10 GeV to 100 TeV.

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Status and commissioning of the Large Size Telescopes of the Cherenkov Telescope Array

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The Cherenkov Telescope Array (CTA) will be the next generation ground-based observatory for gamma-ray astronomy and will consist of Imaging Atmospheric Cherenkov Telescopes (IACTs) distributed over two sites, one in the northern and one in the southern hemisphere. CTA will detect

gamma rays from 20 GeV to 300 TeV by means of three different telescope sizes. The sub-arrays of four Large Size Telescopes (LSTs) that will be installed on both sites aim at detecting gamma rays at the lower energies, especially between 20 GeV and 100 GeV. The first LST (LST-1) was completed in 2018 at the CTA-North site at La Palma (Spain) and three more will be built in the next three years. In this presentation we will report on the status of the LSTs as well as the commissioning of the LST-1. In particular we will report on the status of: the drive system able to move the structure that supports a 23 m diameter dish anywhere in the sky in 20 seconds for Gamma Ray Burst follow-up, the Active Mirror Control in charge of shaping the reflective surface made of 198 individual mirrors, and the camera made of 1855 PMTs with high quantum efficiency and fast embedded readout electronics allowing a data acquisition rate up to at least 15 kHz.

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Search for Lorentz invariance violation using observations of GRB 190114C with the MAGIC telescopes

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On the night of January 19, 2019, the Major Atmospheric Gamma Imaging Cherenkov (MAGIC) telescope detected GRB 190114C above 0.2 TeV with very high significance, recording by far the most energetic photons ever observed from a gamma-ray burst (GRB). Observations of GRBs can be used to probe an energy dependence of the speed of light in vacuo for photons (in-vacuo dispersion) as predicted by several quantum-gravity models. For the arrival time of high-energy photons from cosmological origin, such a violation of Lorenz Invariance (LIV) could lead to an observably large effect. This makes such observations a rare opportunity to test a relevant parameter space of quantum-gravity predictions. Making use of a set of conservative assumptions on the possible GRB-intrinsic spectral and temporal-evolution and exploiting on a probabilistic basis the full information content of the background-contaminated data set from GRB 190114C, we search for delay of arrival time scaling linearly or quadratically with the energy of the photon.

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STACEX: RPC-based detector for a multi-messenger observatory in the Southern Hemisphere

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Extensive Air Shower (EAS) arrays are survey instruments able to monitor continuously all the overhead sky.
Their wide field of view (about 2 sr) is ideal to complement directional detectors by performing unbiased sky surveys, by monitoring variable or flaring sources, such as AGNs, and to discover transients or explosive events (GRBs).
With an energy threshold in the 100 GeV range EAS arrays are transient factories.
All EAS arrays presently in operation or under installation are located in the Northern hemisphere.
A new survey instrument located in the Southern Hemisphere should be a high priority to monitor

the Inner Galaxy and the Galactic Center.
STACEX is the proposal of a hybrid detector with ARGO-like RPCs coupled to Water Cherenkov Detectors (WCDs) mainly to lower the energy threshold at 100 GeV level.
In this contribution we introduce the possibility of improving the low energy sensitivity of survey instruments by equipping RPCs, which were proved to be optimal detectors at 100 GeV energies by the ARGO-YBJ Collaboration, with WCDs.
An EAS detector with high sensitivity between 100 GeV and 1 TeV would be a valuable complementary transient detector in the CTA era.

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UHECR and neutrino production in GRB multi-collision models

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In this talk I will dicuss the production of multiple messengers in multi-collision models of gamma-ray bursts (GRBs). In the internal shock model for GRBs, their prompt emission is generated by collisions of regions with different Lorentz factors in the GRB jet (shells). Multi-collision models take the full dynamic of the jet into account generating a range of collisions happening at different radii. This separates the production of different messengers: While neutrinos are dominantly produced at small radii, ultra-high energy cosmic rays (UHECRs) escape mostly at intermediate radii. This can significantly reduce the neutrino flux from GRBs compared to the simpler one-zone models of GRBs.

I will explain the impact of two important model assumptions - the two-shell-collision dynamics and initial engine setup - on the ejected spectra of UHECRs and neutrinos. I will also dicuss the requirements for fitting the UHECR spectrum and composition within this model while taking into account neutrino constraints.

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Reproducing the spectral Energy Distribution of HESS J1825-137 and HESS J1808-204

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As of 2018, the High Energy Stereoscopic System (H.E.S.S.) has observed over 75 objects. Two of these objects include HESS J1825-137, a bright and extensive Pulsar Wind Nebula, and Super Massive Cluster CL 1806-20. Using SED models, cosmic ray propagation and acceleration will be investigated to identify the origin of the gamma-ray flux towards these objects.

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First search for a remnant of GW170817 using convolutional neural networks

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We present the results of the first-ever search for gravitational waves from a remnant of binary neutron star merger GW170817 using convolutional neural networks (CNNs). Analyzing one week of data after GW170817 for signals lasting about one hour did not return any viable candidates. We describe the search pipeline in detail, showing that the CNNs are used to trigger possible interesting times/frequencies to be followed up by another method to estimate parameters. Furthermore we explain some specific aspects of the CNNs used in this search, namely (1) how we trained them, (2) how we minimized their false alarm probability through an appropriate use of a threshold (our detection statistic) on their output, and (3) how we ensured their robustness towards signals that deviated from the model on which they were trained. Finally we show that our upper limits on a gravitational wave signal from a post-merger remnant are comparable to those obtained in previous LIGO/Virgo searches.

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Towards the SM Neff

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We revisit the SM calculation of Neff, motivated by results discrepant with the canonical value of $N_{\mathrm{eff}} = 3.044$ (Gariazzo, S. et al., 2019). We show that the discrepancy (which gave $N_{\mathrm{eff}} = 3.052$ (Grohs, E. et al. 2015)) stems from a misunderstanding of the interactions that take place in the plasma at finite temperature.

After clarifying common pitfalls, we follow this up by including previously ignored charge screening effects that lead to a decrease of $\delta N_{\mathrm{eff}} = -0.001$. This gives a change to N_{eff} that is around the same size as including neutrino oscillations and non-instantaneous decoupling has been shown to give (Gariazzo, S. et al., 2019). We argue that our findings should be included, therefore, in a full calculation of N_{eff}.

We finish by re-estimating the electron neutrino decoupling temperature using the optical theorem at finite temperature in a self-consistent way, finding our results ($T_d = 1.42$ MeV) to be in agreement with the existing literature. We use this to argue that the formalism may be used to include higher order weak effects, which may lead to a further change in N_{eff}.

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Global fit of pseudo-Nambu-Goldstone Dark Matter

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We perform a global fit of the pseudo-Nambu-Goldstone (pNG) dark matter (DM) that arises in a complex scalar singlet model with a softly broken global U(1) symmetry. The resulting pNG boson is massive and serves as a viable DM candidate. More importantly, as the pNG DM-nucleon cross-section is momentum-suppressed at tree-level, it provides a natural way of explaining the null results from current direct detection experiments. In our fit, we include constraints from perturbative unitarity, DM relic density, Higgs invisible branching ratio, electroweak precision observables, and latest Higgs searches at colliders in order to explore the viable regions of the model parameter space. We present our results in both frequentist and Bayesian statistical approaches. In addition, our post-processed samples are confronted against strong indirect detection limits from Fermi-LAT dwarf spheroidal galaxies

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Inefficient Cosmic-Ray Diffusion around Vela X: Constraints from H.E.S.S. Observations of Very High-energy Electrons

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Vela X is a nearby pulsar wind nebula (PWN) powered by a $\sim 10^4$ year old pulsar. Modeling of the spectral energy distribution of the Vela X PWN has shown that accelerated electrons have largely escaped from the confinement, which is likely due to the disruption of the initially confined PWN by the supernova remnant (SNR) reverse shock. The escaped electrons propagate to the earth and contribute to the measured local cosmic-ray (CR) electron spectrum. We find that the escaped CR electrons from Vela X would hugely exceed the measured flux by HESS at $\sim$ 10 TeV if a standard diffusion coefficient for the interstellar medium (ISM) is used.
We propose that the diffusion may be highly inefficient in the vicinity of Vela X and find that a spatially-dependent diffusion can lead to CR flux consistent with the HESS constraint. Assuming a two-zone geometry for the diffusion region around Vela X, we find that the diffusion coefficient in an inner region of a few tens of pc should be < $10^{28}\mathrm{cm}^2\mathrm{s}^{-1}$ for $\sim$ 10 TeV CR electrons, which is about two orders of magnitude lower than the standard value for ISM.
Such an inefficient diffusion around Vela X resembles the case of the Geminga PWN, which suggests that inefficient diffusion regions may be common around PWNe with a wide range of ages.

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Gamma-ray from Dark Matter Annihilation in Three-loop Radiative Neutrino Mass Generation Models

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We study the Sommerfeld enhanced Dark Matter (DM) annihilation into gamma-ray for a class of three-loop radiative neutrino mass models with large electroweak multiplets where the DM mass is in the TeV range. We show that in this model, the DM annihilation rate becomes more prominent for larger multiplets, and it is already within reach of the currently operating Imaging Atmospheric Cherenkov telescopes (IACTs), High Energy Stereoscopic System (H.E.S.S.). Furthermore, we investigate the prospect of constraining such model with very high energy gamma-ray observation from the Galactic center with future Cherenkov Telescope Array (CTA) which will have improved sensitivity by a factor of $\mathcal{O}(10)$ compared to present IACTs. We find that the CTA will exclude a large portion of the parameter space of the three-loop radiative neutrino mass model with larger electroweak multiplets. This result implies that the only viable option for the model is the lowest electroweak multiplet, i.e. the singlet of $SU(2)_L$ where the DM annihilation rate is not Sommerfeld enhanced, and hence it is not yet constrained by the indirect detection limits from H.E.S.S. or future CTA. (Based on Physics Letters B, Vol. 782, pp. 215-223 (2018) and arXiV:1710.xxxxx)

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Using Minkowski Functionals to analyze CMB weak lensing

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Minkowski Functionals are a set of descriptors, which can be used to describe the morphological structures of a map. Unlike the power spectrum, they intrinsically contain higher order correlations information. CMB weak lensing, a powerful probe of the early universe and cosmological parameters. Imprinting projective information of large-scale structures all the way back to the last scattering surface. In this talk, I will discuss the feasibility of Minkowski Functionals to constrain cosmological parameters, when apply them on CMB lensing potential maps.

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Fitting Function for Quintessence Dark Energy

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The true nature of dark energy remains largely unknown. In search of an alternative to the cosmological constant, several classes of theoretical models utilise scalar fields in an attempt to achieve accelerated expansion of the universe. On the experimental front, upcoming large scale structure surveys, such as Euclid and SKA, will provide high precision power spectrum data on a wide range of length scales. The challenge now is how to analyse and fit the data. To avoid the enormous computational overhead of N-body simulations, we constructed a fitting function for dark energy. In this work, we follow the RelFit formalism presented by Hannestad and Wong (2019), demonstrating that

it can be applied to a large class of scalar field dark energy models. Ultimately this allows MCMC analysis to be done without the need for large computation facilities.

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Cosmology as a search for neutrinos and new light particles

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Cosmological measurements are becoming sensitive enough to provide the first-ever measurement of the neutrino masses, and to search for completely new particles suggested by recent experiments. I will discuss the effects of these light, fast particles on the formation of large-scale cosmic structure, as well as my recent constraints on them. Then I will describe ongoing work to tackle one of the most difficult problems in theoretical cosmology, the prediction of the non-linear clustering of massive neutrinos, which will be essential for making full use of next-generation cosmic surveys as probes of fundamental physics.

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Scalar spectral index in the presence of Primordial Black Holes

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We study the possibility of reheating the universe in its early stages through the evaporation of Primordial Black Holes (PBHs) that are formed due to the collapse of the inhomogeneities that were generated during inflation. By using the current results of the baryon-photon ratio obtained from BBN and CMB observations, we impose constraints on the spectral index of perturbations on those small scales that cannot be estimated through CMB anisotropy and CMB distortions. The masses of the PBHs constrained in this study lie in the range of 10^9 and 10^{11}g, which corresponds to those PBHs whose maximal evaporation took place during the redshifts $10^6 < z < 10^9$. It is shown that the upper bound on the scalar spectral index, n_s can be constrained for a given threshold value, ζ_{th}, of the curvature perturbations for PBHs formation. Using Planck results for cosmological parameters we obtained $n_s < 1.309$ for $\zeta_{th} = 0.7$ and $n_s < 1.334$ for $\zeta_{th} = 1.2$ respectively. The density fraction that has contributed to the formation of Primordial Black Holes has also been estimated.

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Combined searches for light supersymmetry at the LHC with GAMBIT

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Searches for electroweak production of neutralinos and charginos (electroweakinos) at the LHC have revealed a series of excesses over the predicted Standard Model background. GAMBIT analyses show that although the excesses are inconsistent in terms of simplified models, taken together within the framework of a non-simplified electroweakino effective field theory, searches with 36 fbˆ-1 of data constitute a self-consistent, approximately 3 sigma local excess. A subset of the preferred models are also fully consistent with all dark matter searches. I will describe the GAMBIT joint analysis of 12 different 36 fbˆ-1 ATLAS and CMS searches for electroweakinos, as well as some additional supporting and preliminary results based on both Run I and full Run II datasets, and their implications for preferred models.

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Unresolved gamma-ray sources.

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The contribution of unresolved gamma-ray point sources to the
extragalactic gamma-ray background has been recently measured through
analyses employing the statistical properties of observed gamma-ray counts.
The contribution from each
specific source class to the source-count distribution, such as blazars,
misaligned Active Galactic Nuclei, or Star Forming Galaxies is affected by
significant uncertainties, in particular in the unresolved flux regime.
In this contribution we exploit the statistics of photon counts and the anisotropies of more than
10 years of Fermi-LAT data to probe extra-galactic gamma-ray source
populations in different energy bands. We additionally discuss some results of the application of our statistical tool to galactic dark matter annihilating into gamma rays.

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Mining the High-Energy Gamma-Ray Sky

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The Large Area Telescope (LAT) on board the Fermi satellite conducted the deepest all-sky survey in gamma rays so far. Despite outstanding achievements in assigning source types, a large number of

sources in the various Fermi-LAT source catalogs remains without plausible associations. Previous machine learning strategies to assign source types were based solely on properties extracted from gamma-ray observations. The extension to multi-wavelength information provides additional source type-specific characteristics for a better classification. At the same time, it offers the possibility to determine the most likely corresponding counterpart. In this contribution, the wavelength-dependent machine learning method is described, and the results of its application are discussed. Furthermore, this investigation serves as a proof of concept for source and counterpart associations of future Big Data experiments like the Cherenkov Telescope Array (CTA) or the Square Kilometre Array (SKA), where conventional methods are no longer sufficient.

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Search for extended gamma-ray emission around the Geminga pulsar with H.E.S.S.

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The Geminga pulsar is one of the closest pulsars to Earth and as such is a potential local source of cosmic ray positrons and electrons. TeV emission around the Geminga pulsar has been detected by HAWC and MILAGRO, and found to be significantly extended. This makes detection of the gamma-ray emission challenging for IACTs due to their limited field of view. HAWC observations of the Geminga and Monogem regions found a low diffusion coefficient in the immediate pulsar environment, challenging the local source hypothesis.

We present a search for extended gamma-ray emission in the Geminga region with H.E.S.S. using a variety of analysis and observation strategies.

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ALPACA : A new air shower array experiment to explore 100TeV gamma-ray sky in Bolivia

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Andes Large area PArticle detector for Cosmic ray and Astronomy (ALPACA) is a new air shower experiment to be constructed near the Chacaltaya mountain in Bolivia at altitude of 4740 m. A conventional surface array with 401 scintillation counters covers 83,000 m^2 to detect cosmic rays and cosmic gamma rays above 10TeV. Total 5400 m^2 of water Cherenkov muon detector is constructed 2.2 m underground that enables to discriminate between cosmic-ray and gamma-ray initiated showers to enhance the sensitivity to gamma rays. ALPACA explores the southern gamma-ray sky at 100TeV for the first time and reveals the accelerators of galactic cosmic rays called PeVatrons. A prototype array called ALPAQUITA covering 20% of the full ALPACA area with 1000 m^2 muon detector is

now funded and under construction. Scientific targets and sensitivity of ALPACA together with the current status of ALPAQUITA are presented.

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Constraining Electroweak Baryogenesis at Colliders

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We examine the collider phenomenology of two standard model extensions relevant to electroweak baryogenesis. Firstly we study the hypercharge-zero SU(2) triplet scalar extended standard model, a common component of multi-step electroweak phase transition models. Secondly, we examine a model with vector-like lepton doublets and scalar singlets. We show that both of these models are constrained by existing multilepton searches at the LHC. We argue that with the advent of run 3 analyses and the high luminosity LHC these models, and similar electroweak multiplet scalar extensions relevant to electroweak baryogenesis, will be very strongly constrained.

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MAGIC Detection of the Geminga Pulsar at the Very High Energies

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With an estimated age of approximately $3{\cdot}10^5$ years and at the distance of 250 pc, Geminga (PSRJ0633+17) is an old nearby pulsar and the prototype of the gamma-ray loud and radio-quiet pulsars.

The Large Area Telescope (LAT) onboard the Fermi Gamma-ray Space Telescope has continuously observed Geminga over its eleven years of operation characterizing its doubly peaked pulsed emission and spectrum. Due to the small collection area of LAT, observations of Geminga above 20 GeV quickly become statistically limited.
On the other hand, the energy threshold of MAGIC, when using the stereo Sum-Trigger-II, is reduced to $\sim$ 20 GeV, thus further enabling for the observation of very soft sources such as pulsars, high redshift AGNs and GRBs.

Employing the Sum-Trigger-II system, the MAGIC Telescopes have observed the Geminga Pulsar between 2017 and 2019. We report the detection of the pulsed signal, with a significance above 6 sigma, and a spectrum well represented by a single power-law from 20 GeV to 80 GeV. A combined MAGIC and Fermi-LAT fit disfavors a pure exponential cut-off model.

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Gamma-ray heartbeat powered by the microquasar SS 433

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Microquasars, the local siblings of extragalactic quasars, are binary systems comprising a black hole of several to tens of solar masses and a companion star. By accreting matter from their companions, microquasars launch powerful winds and jets, influencing the interstellar environment around them. Steady gamma-ray emission is expected to rise from their central objects, or from interactions between their outflows and the surrounding medium. The latter prediction was recently confirmed with the detection at the highest (TeV) energies of SS 433, one of the most interesting microquasars known. We analyzed more than ten years of Fermi-LAT gamma-ray data on SS 433. Detailed scrutiny of the data reveal emission associated with a terminal lobe of one of the jets and with another position in the SS 433 vicinity, co-spatial with a gas enhancement. Both gamma-ray sources are relatively far from the central binary, and the latter shows evidence for a periodic variation at the precessional period of SS 433, linking it with the microquasar. This result challenges obvious interpretations and is unexpected from any previously published theoretical models. It provides us with a chance to unveil the particle transport from SS 433 and to probe the structure of the local magnetic field in its vicinity.

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Particle escape in middle-aged SNRs and related gamma-ray signatures

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The escape process of particles accelerated at supernova remnant (SNR) shocks is one of the poorly understood aspects of the shock acceleration theory. In this talk I will describe a phenomenological approach to study the particle escape and its impact on the gamma-ray spectrum resulting from hadronic collisions both inside and outside of a middle-aged SNR. Under the assumption that in the spatial region immediately outside of the remnant the diffusion coefficient is reduced with respect to the average Galactic one, I will show that a significant fraction of particles are still located inside the SNR long time after their nominal release from the acceleration region. This fact results into a gamma-ray spectrum that resembles a broken power law, similar to those observed in several middle-aged SNRs. Above the break, the spectral steepening is determined by the diffusion coefficient outside of the SNR and by the time dependency of the maximum energy. Consequently, the comparison between the model prediction and actual data will contribute to determining these two quantities, the former being particularly relevant within the predictions concerning the gamma-ray emission from the halo of escaping particles around SNRs which could be detected with future Cherenkov telescope facilities.

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High School Students'Water Cherenkov Detector

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We report progress on applying water Cherenkov detection technique to a robust, inexpensive cosmic ray detector to be deployed at high school as part of an outreach effort to allows students to experience what it is like to be a true cosmic ray physicist.
The Cherenkov radiation will be detected by a 4X4 SiPM matrix covering a 24X24 mm2 area.

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GUM: GAMBIT Universal Model

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GUM is a new feature of the GAMBIT global fitting software framework, which provides a direct interface between Lagrangian level tools and GAMBIT. GUM automatically writes GAMBIT routines to compute observables and likelihoods for physics beyond the Standard Model. I will describe the structure of GUM, the tools (within GAMBIT) it is able to create interfaces to, and the observables it is able to compute.

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Mimicking alternatives to inflation with interacting spectator fields

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It has been argued that oscillatory features from spectator fields in the primordial power spectrum could be a probe of alternatives to inflation. In view of the future prospects for detecting oscillatory signals in the Cosmic Microwave Background, it is important to clarify whether those associated with alternative scenarios could be mimicked by non-trivially interacting spectator fields in an inflationary setting. In this talk, I show that the frequency and amplitude dependence of the patterns appearing in alternatives can be mimicked by field interactions during inflation. Therefore, the claim that oscillatory features in the primordial power spectrum can be used to distinguish between inflation and alternatives is softened. The degeneracy of the frequency holds for the n-point correlation functions, while the degeneracy of the amplitude is broken at the level of non-gaussianities.

Parallel / 111

Latest results from XENON1T and status of the XENONnT expriment

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The XENON program aims at finding direct evidence for the existence of Weakly Interacting Massive Particles (WIMPs) using the dual-phase xenon time projection chamber technology. The XENON1T experiment was the first ton-scale detector searching for Dark Matter via nuclear recoils and constrained the Spin Independent interaction to the world's best limit. To further increase the WIMP discovery potential, the XENON collaboration is building the XENONnT detector with a target xenon mass of about 8 tons. The large target mass combined with an approximately 10×lower background than in its predecessor XENON1T, will increase the sensitivity by an order of magnitude, to 2·10ˆ{−48}cmˆ{2} for a spin-independent WIMP-nucleon cross-section.

This talk will report on the most recent analysis efforts the XENON1T collaboration is making, which further exploits the exposure of 1 tonne x year in ultra-low background conditions. The improvement to the XENONnT system and the XENONnT physics program will be also presented.

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3D modeling of the Galactic Center explaining the diffuse gamma-ray emission

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The origin of high-energy of cosmic-rays (CRs) is yet not completely solved. Due to the accessibility, Galactic sources give us opportunities to investigate the ambient condition of potential sources.
The Galactic Center, on the one hand, shows a peculiar non-thermal emission. On the other hand, the crowded and emissively active vicinity makes modeling more challenging. Previous works discussed the origin of the diffuse γ-ray emission detected by H.E.S.S. without considering the magnetic field, although, the impact on the CR spatial profile is significant.
In this work, we use for the first time collective and recently developed 3D models of the ambient condition, including the magnetic field configuration, mass distribution, and the photon field. In doing so and using the propagation tool CRPropa, we can involve all relevant interaction processes in the TeV- PeV regimes such as hadronic pion production, inverse Compton scattering, and γ-ray attenuation by electromagnetic pair production.
In order to identify the real source, we further present five different source set-ups based on observational hints. Hereafter, we compare our results with the measured spatial as well as energy spectra.

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Radiation modeling in high- and low-luminosity GRBs

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We model Gamma-Ray Burst (GRB) prompt spectra in the fireball internal shock scenario. This theoretical model assumes particles to be accelerated in collisions of plasma blobs in the optically thin regime. Usually, the observed prompt emission is attributed to synchrotron emission from accelerated electrons. Additional processes like inverse Compton scattering and photon-photon annihilation can shape the spectra, where inverse Compton emission might introduce an extra component at high energies. We model GRB spectra and light curves with AM3, a time-dependent radiative code. A special focus will be on high-energy emission in low-luminosity GRBs (LL GRBs) which might be observable with the future Cherenkov Telescope Array (CTA).

Parallel / 114

The impact of the circumstellar magnetic field on the observed gamma-ray spectrum from supernova remnants

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Supernova remnants (SNRs) are widely believed to be one of the main candidates for the origin of Galactic cosmic rays. Very-high-energy gamma-ray emission observed from a number of SNRs suggests that particles are indeed accelerated to high energies by shock in remnants. However, it is extremely difficult to discriminate which particles are responsible for this emission as both protons (through hadronic interactions and subsequent pion decay) and electrons (through inverse Compton scattering on ambient photon fields) can potentially generate gamma-ray photons. Recent detection of the abrupt cut-off at lower energies in the gamma-ray spectra of two SNRs, IC 443 and W44, with the Fermi-LAT provided a strong evidence that cosmic-ray protons are indeed accelerated in SNRs based on the interpretation of this cutoff as a characteristic pion-decay feature. However, it can be shown that certain spatial or temporal variability of the ambient medium can result in similar spectral features in the leptonic scenario adding another uncertainty to the determination of the emitting process. SNRs created in core-collapse explosions expand inside the stellar wind bubble blown up by a progenitor star. The magnetic field in the wind medium follows a 1/r profile with high values at the surface of the star, e.g. 1-10 G for red supergiants. This means that at the early stages of its evolution the remnant interacts with a very strong magnetic field, which results in a synchrotron cooling feature in the electron spectrum, which in turn shows up in the gamma-ray spectrum as a break at similar energies as a pion-decay signature. In this work, we study how the circumstellar magnetic field might modify the resulting spectrum of electrons and subsequent gamma-ray spectrum.

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MAGIC observations of extreme blazars

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The current generation of Cherenkov telescopes have identified a population of BL Lacertae objects characterized by a hard spectrum in the TeV band. The peak of their gamma-ray SED component is located beyond 100 GeV and up to several TeV, and their synchrotron peak is located beyond 1 keV and often in the hard-X-ray band. These peak frequencies are extreme within the blazar population, at the very end of the so-called blazar sequence, justifying the name extremely-high-frequency-peaked BL Lac objects (EHBLs) for this blazar subclass. The MAGIC array of Cherenkov telescopes started a long-term observing campaign on EHBLs, with the double goal of monitoring the gamma-ray emission from EHBLs, and extending the EHBL population. Interestingly, some standard HBLs have also been observed in a transient EHBL-like state during flaring activity. The results from MAGIC and multi-wavelength observations of EHBLs will be presented in this contribution.

Parallel / **117**

The Blazar Hadronic Code Comparison Project: First Results

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Blazar hadronic models have been developed in the past decades as an alternative to leptonic ones. In hadronic models the gamma-ray emission is associated with synchrotron emission by protons in the jet, and/or secondary leptons produced in proton-photon interactions. Together with photons, hadronic emission models predict the emission of neutrinos from blazars. Neutrinos are therefore the smoking gun for acceleration of relativistic hadrons in blazar jets. The recent advances in neutrino astronomy, with IceCube detection of the first neutrino blazar TXS0506+056, have revived the interest in these hadronic scenarios. The simulation of proton-photon interactions and all associated radiative processes is a complex numerical task, and different approaches to the problem have been adopted in the literature. So far, no systematic comparison between the different codes has been performed, preventing a clear understanding of the underlying uncertainties in the numerical simulations. To fill this gap, we have undertaken the first comprehensive comparison of blazar hadronic codes, and the first results from this effort will be presented in this contribution.

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The diffuse neutrino flux from jetted AGN due to interactions of relativistic protons with the CMB and the EBL

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The extragalactic neutrino background (ENB) has been measured from tens of TeV and constrained up to ultra-high energies. This work considers the unresolved source contribution to this neutrino flux produced in the jets of AGN through photomeson production considering as target the omnipresent cosmic microwave background (CMB) and extragalactic background light (EBL) radiation fields. This is relevant for cases where proton acceleration to relativistic energies occurs at locations within the jet devoid of strong radiation fields.

These external target photon fields appear as beamed anisotropic radiation fields in the co-moving frame of the jets. We use the gyro-phase averaged interaction rates for hadronic and electromagnetic proton-photon interactions in these anisotropic targets, and modify the corresponding Monte Carlo codes to calculate the yields of all secondaries. The total neutrino flux that results from the evolving gamma-ray loud AGN populations of various types is then compared to the ENB. We find that the contribution from misaligned AGN dominates the total neutrino flux, and that neutrinos produced due to interactions with the EBL make up the largest contribution for most parameter combinations. Constraints for the maximum possible baryon loading for such setups are derived.

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FACT - Results from Eight Years of Unbiased Monitoring at TeV Energies

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The First G-APD Cherenkov Telescope (FACT) has been monitoring blazars at TeV energies since October 2011. An unbiased observing strategy, robotic operation and the usage of solid state photosensors (SiPM, aka G-APDs) facilitated maximizing the instrument's duty cycle and minimizing observational gaps. This provides an unprecedented data sample of more than 14300 hours of physics data, of which more than 2500 hours were taken in the past 12 months.
An automatic quick-look analysis provides results with low latency on an open-access website. More than 100 alerts and 11 astronomer's telegrams have been issued in 5.5 years, triggering a variety of multi-wavelength observations. Target-of-opportunity programs with X-ray satellites are in place.
Analyzing combined gamma-ray observations (FACT, Fermi-LAT, HESS) from Mrk 501 in 2014, the underlying physics processes are constrained using the PSDs and PDFs on different time scales.
Based on a trigger for 1ES 2344+51.4 in 2016, an unprecedented study of the spectral energy distribution is carried out, revealing a very hard TeV spectrum and an extreme behaviour of the source during high state.
Studying 5.5 years of multi-wavelength data of Mrk 421, more than 30 flares are found. Based on correlation analyses, models are constrained.
In addition to multi-wavelength studies, the unprecedented, unbiased data sample at TeV energies provides a unique chance to study the duty cycle and variability behaviour of the sources. Based on this, a search for a periodic signal has been performed.
The presentation summarizes the results from eight years of monitoring.

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CosmoBit –Towards Simultaneous Global Fits of Cosmology and Particle Physics

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Upcoming data from experiments like the LSST, Euclid or the SKA will help to greatly advance the precision of cosmological parameter estimation in the next decade. However, the yet unknown nature of Dark Matter and Dark Energy hint for the need to extend the current standard model of cosmology and particle physics. Non-standard scenarios can leave imprints on cosmological, astrophysical as well as laboratory measurements, e.g. neutrino self-interactions or the presence of an

Axion-like particle (ALP) as a Dark Matter candidate. To maximise the knowledge one can obtain from present and upcoming data it is therefore important to simultaneously consider all measurements constraining a specific model at the same time. In this talk I will present a tool designed for this purpose: CosmoBit, a module of GAMBIT – the Global And Modular BSM Inference Tool. As an example I will present constraints on a keV scale ALP arising from complementary probes from BBN, the CMB, X-ray emission from the galactic centre and photon bursts from supernovae.

Parallel / **121**

A systematic approach to neutrino masses and their phenomenology

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The picture painted by the standard model is elegant, but incomplete: It predicts neutrinos to be massless. Although it is straightforward to introduce neutrino masses, there is a huge number of possibilities and we do not know which one is realized in nature. Thus it is important to build a framework to distinguish models. I will discuss a new way to systematically discuss phenomenology of neutrino masses.

Parallel / **122**

Prospective Science with the Cherenkov Telescope Array: Active Galactic Nuclei

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The Cherenkov Telescope Array (CTA) is the next-generation observatory for ground-based gamma-ray astronomy, providing unprecedented sensitivity and angular resolution in an energy range from 20 GeV to more than 300 TeV.
Active Galactic Nuclei (AGN) emit variable radiation across the entire electromagnetic spectrum up to multi-TeV energies. CTA's observations of AGNs will allow probing particle acceleration and emission mechanisms in AGN and reasons for temporal variabilities from time scales of a few minutes up to a few years. It will also allow performing population studies of AGN and a measurement of the extragalactic background light. To answer these questions, programmes for long-term monitoring of a few prominent AGNs are foreseen, as well as programmes for the search for, and following-up of AGN flares and obtaining high-quality AGN spectra.
This contribution will give an overview of the AGN Key Science Project within CTA and present its prospective science and observation strategy.

Parallel / **123**

Searching for Sterile Neutrino Dark matter with X-ray lines using NuSTAR

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X-ray line searches are sensitive probes for many dark matter models, such as sterile neutrino dark matter in the nuMSM. I will discuss the current status of the experimental efforts, including that of the tentative signal at 3.5 keV. Then I will discuss some recent progress with NuSTAR and its prospects in the near future. Finally, I will talk about the idea of dark matter velocity spectroscopy, a powerful diagnostic tool for tentative dark matter line signals, which is achievable with high-resolution spectrometers, such as XRISM and Athena.

Parallel / **124**

Peculiar High-Energy Gamma Rays from the Sun

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The Sun has long been expected to be a steady gamma-ray and neutrino (>GeV) source due to constant bombardment by cosmic rays. I will discuss recent progress in studies of these solar atmospheric gamma rays with the Fermi Space Gamma-ray Telescope, and the prospects of the detecting the Sun with high-energy neutrinos. Surprisingly, the gamma-ray flux was found to be higher than the previous prediction by almost a factor of 10 and displays rich and surprising features such as large time variation, hard spectrum, strange spectral features, and morphological changes. Understandings of these gamma rays could lead to a new probe of the deep layers of the solar atmosphere and cosmic-ray propagation in the solar system. Near-future TeV gamma-ray (HAWC, LHAASO) and neutrino (IceCube, KM3NeT) observations could provide additional insights to the problem, and have interesting implications for dark matter searches with the Sun.

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Deep lensing: uniting gravity and neural networks

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Strong gravitational lensing is a unique probe of dark matter substructure, which in turn provides a window into the particle physics properties of dark matter. However, dark matter subhalos produce only percent-level distortions in lensed images, thus requiring a pipeline capable of detailed source modeling. In this talk, I discuss how to tackle this problem by seamlessly combining a generative neural network model for source galaxies with a physics-based lens model. Our approach leverages automatic differentiation, a core machine learning technology, making it simple to perform accurate optimization and posterior sampling even for nearly one hundred lens and source parameters. I will also demonstrate how this approach enables detecting multiple dark matter subhalos in mock images for upcoming survey telescopes.

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Status and prospects of KM3NeT, the next-generation neutrino telescope in the Mediterranean Sea

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Using novel technology, the KM3NeT Collaboration is building a very large neutrino telescope in the Mediterranean abyss. KM3NeT comprises two detectors, ARCA and ORCA. ARCA is under construction at 3,500 m depth, about 80 km offshore the coast of Porto Palo in Sicily (Italy). It is optimsed for high-energy measurements (Tev-PeV) to perform neutrino astronomy with unprecedented sensitivity. From its location in the Mediterranean Sea, ARCA will have an optimal view of the southern sky, including the Galactic Centre. ORCA is being built at 2,500 m depth, about 40 km offshore Toulon (France). With a detector configuration denser than ARCA, it is optimised for lower-energy measurements, down to few GeVs, to investigate neutrino oscillations. The science case of KM3NeT, the status, the results obtained with the first data and the construction plans will be illustrated in this talk.

Parallel / 127

Higgsstrahlung and You: What Future Colliders Can Tell Us About Neutrinos

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Though the exact nature of neutrino masses is presently a mystery, there exists a variety of experimental avenues for siphoning information about them. Of these, we are interested in what can be gleaned from precision measurements of the Higgsstrahlung ($e^+e^- \to Zh$) cross section, a route that will become available with the next generation of lepton colliders. Generically, $\sigma(e^+e^- \to Zh)$ is anticipated to function as a powerful probe of physics beyond the Standard Model, and in particular it is especially sensitive to the contents of the neutrino sector. In this talk I will discuss our work on quantitatively characterising the influence of Seesaw models (most notably, Type I Seesaw) on the Higgsstrahlung cross section.

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Lorentz Invariance Violation searches:\\combined likelihood study on data by H.E.S.S., MAGIC and VERITAS

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Some Quantum Gravity (QG) models developed to unify general relativity and quantum mechanics predict an energy-dependent speed of light in vacuum which breaks Lorentz Symmetry. Such effects are expected to contribute at a characteristic energy scale E_QG of the order of the Planck Energy. These models are tested by monitoring energy-dependent time-lags for photons emitted by distant, highly energetic and highly variable astrophysical sources - flaring Active Galactic Nuclei, Gamma-Ray Bursts and Pulsars - observed with Imaging Atmospheric Cherenkov Telescopes (IACT) or satellites. However, such studies are restricted by a limited pool of observational data sets. Three major IACT collaborations - H.E.S.S., MAGIC and VERITAS - address such a complication with an inter-experiment working group providing a joint analysis method combining for the first time all three types of available sources, enabling an improved sensitivity to energy-dependent time-lags and a sensitive search for Lorentz Invariance Violation (LIV) redshift dependencies.
This presentation reviews the new standard combination method, based on a maximum likelihood analysis, and assesses its performances using simulations of published source observations from H.E.S.S., MAGIC and VERITAS. It also presents the strategies used to deal with data from different sources and instruments as well as statistical and systematic uncertainties treatment. This new analysis will lead to new limits on E_QG together with results on redshift dependancies of LIV effects, and paves the way for future population studies with the Cherenkov Telescope Array (CTA).

Parallel / 129

Lorentz Invariance Violation searches: modeling intrinsic time-lags in flaring blazars

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Some Quantum Gravity (QG) theories, aiming at unifying general relativity and quantum mechanics, predict an energy-dependent modified dispersion relation for photons in vacuum leading to a Violation of Lorentz Invariance (LIV). QG effects are expected to become sensible at a characteristic energy scale E_{QG} of the order of the Planck Energy. One way of testing these theories is to monitor TeV photons time-of-flight emitted by distant, highly energetic and highly variable astrophysical sources such as flaring Active Galactic Nuclei. Only one time-lag detection was reported so far. We have recently shown however that significant intrinsic time-lags should arise from in situ blazar emission processes.
In this contribution we will present a time-dependent modeling of blazar emissions which is developped to trace back the origins of intrinsic delays and provides predictions on their contributions with different emission scenarii. Our final aim is to disentangle intrinsic effects from extrinsic ones in order to highlight LIV effects. This distinction is becoming increasingly crucial considering the upcoming light from the future Cherenkov Telescope Array (CTA) Observatory which will constitute a vast step-up in sensitivity needed for time-lag searches.

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Massive Argon Space Telescope (MAST): heavy time projection chamber as a next-generation space gamma-ray observatory

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We propose a new concept of gamma-ray telescope called MAST [1] (an abbreviation from "massive Argon space telescope") for the energy range of 100 MeV –1 TeV based on the liquid Argon time projection chamber (LAr TPC) technique. The LAr TPC technique has many important advantages, including simplicity, scalability and cost-effectiveness, at the same time allowing to obtain good spatial (and hence angular) resolution. Using last-generation rockets such as Falcon Heavy [2], it is possible to launch a payload with the mass up to 30–40 t to a medium (~500 km) circular Earth orbit, for the first time allowing to reveal the potential of the LAr TPC technique in gamma-ray astronomy. We estimate the basic parameters of the MAST telescope and show that the achievable angular resolution is 3-10 times better than the Fermi-LAT one [3] depending on the energy, and the differential sensitivity is about one order of magnitude better than the Fermi-LAT one. The energy resolution of the MAST telescope is comparable to the Fermi-LAT one (about 20 % at 100 MeV and between 6 % and 10 % for the 10 GeV –1 TeV energy range). Such an instrument with an effective energy threshold ˜100 MeV, very good sensitivity, and reasonable energy resolution would have a great potential in a wide range of astrophysical tasks, including observations of active galactic nuclei, the search for gamma-ray counterparts of IceCube astrophysical neutrinos, the studies of the extragalactic background light, extragalactic magnetic field and extragalactic gamma-ray background, and dark matter searches. The details of our calculations are available in [1]. This work was supported by the Russian Science Foundation (RSF) (project No 18-72-00083).

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Parallel / **132**

H.E.S.S. observations of pulsars at very high energies

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More than 50 years after the discovery of pulsars by Jocelyn Bell-Burnell and Antony Hewish, their study remains a very active field of research.
Although great progress has been made in the last decade in interpreting the high energy emission of pulsars, thanks in particular to the wealth of data from the Fermi-
LAT satellite borne telescope, there are still many open questions, specially concerning the acceleration and radiative processes at play and the regions involved.
Very High Energy gamma-rays (VHE; >100 GeV) which are produced by the highest energy particles, are valuable probes for testing acceleration and emission processes in their extreme energy limit, but they are beyond the reach of satellites.
However, the expectation of the level of emission in this range – which has been lowered as a result of previous non-detections – is at the limit of sensitivity of current Imaging Atmospheric Cherenkov Telescopes (IACTs), and hence requires deep observations.

Since the discovery of VHE pulsations from the Crab in 2011, the number of pulsars detected from ground is increasing gradually. I will present the latest results from H.E.S.S. and discuss their implications on pulsar emission models.

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Searching for Fast Radio Burst Counterparts with VERITAS

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Imaging atmospheric Cherenkov telescopes are uniquely suited to searching for transient astrophysical sources of both gamma-ray and optical emission. One promising class of targets for such searches are fast radio bursts (FRBs) - bright flashes of radio emission lasting just a few milliseconds and originating from outside of the Milky Way. The origin of these mysterious outbursts is unknown, but their high luminosity, high dispersion measure and short duration requires an extreme, high-energy, astrophysical process. The discovery of repeating FRBs, coupled with the commissioning of new wide-field radio telescopes such as CHIME, dramatically improves the prospects for finding prompt counterparts to the radio emission at other wavelengths. We present the status of the VERITAS FRB observing program, both for repeating and non-repeating FRBs, and the results of these observations.

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A mixed origin of neutrinos from TXS 0506+056

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The blazar TXS 0506+056 was recently identified as a tentative source of very high energy neutrinos. In 2017, the IceCube Observatory recorded a track-like event initiated by a neutrino with the primary energy E between 200 TeV and 7.5 PeV (90 % CL) accompanied with a bright "flare"across the electromagnetic (EM) spectrum, in particular, in the high energy (HE, E>100 MeV) domain [1]. Additionally, in 2014-2015 the same instrument detected a "cluster"of track-like events from the same source; most of these are compatible with ~100 TeV neutrinos with a ~E^{-2} power-law spectrum [2]. The 2014-2015 neutrino events were not accompanied by a bright EM flare, but the HE gamma-ray spectrum during the "neutrino cluster"episode was probably harder than during the "gamma-ray flare"[3].
Given the different behaviours of neutrino and photon emissions recorded during the above-mentioned two episodes, it is natural and tempting to presume the different emission mechanisms during the "flare"and "cluster"episodes. In the present work, profiting by the recent re-classification of TXS 0506+056 as a flat-spectrum radio quasar (FSRQ) [4] (that probably has a broad line region (BLR), narrow line region (NLR), and a dusty torus), we propose a model where the "flare"is explained by the photohadronic (proton-gamma or nucleus-gamma) mechanism, while the "neutrino cluster"and the associated EM emission are due to hadronuclear (proton-proton or nucleus-nucleus) interactions with subsequent development of EM cascade in the dusty torus/NLR photon field.
We show that such a "mixed"model reasonably well describes the observations. This model predicts an "ankle"in the diffuse neutrino spectrum, where the low-energy neutrinos are predominantly due to the hadronuclear mechanism, while the high-energy neutrinos are mostly of the photohadronic origin. We discuss the signatures in the high energy and very high energy (E>100 GeV) gamma-ray ranges that could be used to test our model.

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Pulsar Wind Nebulae as seen in TeV gamma-rays and their Galactic environments

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Pulsar Wind Nebulae (PWNe) constitute the largest class of identified Galactic sources of TeV gamma-rays, as revealed by the Galactic Plane Survey with the HESS telescopes. This survey allowed a systematic study of a large number of PWNe in TeV gamma-rays, and revealed properties that could only be hinted at previously. In particular, there is a weak but significant trend for the gamma-ray luminosity to decrease with age, and seemingly to depend on Galactic location. Furthermore, older PWNe are often significantly offset from the associated pulsar, with separations considerably larger than may be explained solely by typical pulsar proper motions.

We first review the above properties of TeV-emitting PWNe, with emphasis on the observational evidence for large offsets and constraints on the associated pulsar's proper motion. We investigate possible explanations in terms of their respective Galactic environments. In particular, we consider recent models of the photon density in the Galaxy and its spiral arms, and study their possible influence, in a leptonic (inverse Compton) model, on the observed contrasts in luminosity. We also discuss an explanation of the offsets which relies, in addition to the pulsar proper motion, on density heterogeneity in the surrounding medium. We explore this scenario by means of relativistic magneto-hydrodynamic numerical simulations. Looking at individual examples, we examine publicly available multi-wavelength data to search for evidence of the required density variations.

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Suppressing astrophysical backgrounds for gamma->ALP searches in extreme blazar spectra

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Most of the existing works on extragalactic TeV gamma-ray propagation account for only adiabatic losses and primary gamma-ray absorption due to pair production on extragalactic background light (EBL) photons, i.e. assuming the "absorption-only model"(AOM). However, the observable spectra of some active galactic nuclei (AGN) reveal a tentative excess in photon counts with respect to the AOM in the optically thick region of the spectrum (where the optical depth of pair production on

EBL photons \tau>1) [1-3]. This apparent excess could be due to an exotic process, namely, oscillations of primary gamma-rays into axion-like particles (gamma→ALP) in magnetic fields and back into gamma-rays relatively near to the observer [4-5].
In the framework of the AOM, the shape of the intrinsic spectrum of an extragalactic gamma-ray source could be reconstructed by compensating for the attenuation and redshift. Some blazars, called "extreme TeV blazars"(ETBs), have such reconstructed intrinsic spectral energy distributions (SEDs) peaking at an energy E>1 TeV. ETBs are very promising sources for the gamma→ALP oscillation search. However, compared to "classical"blazars such as Mkn 501 and Mkn 421, ETBs, as a rule, reveal weak and slow variability in the high energy (HE, E >100 MeV) range. Therefore, it is possible that a part of observable emission of these sources was produced not inside the source, but as a result of electromagnetic (EM) cascade development in the intergalactic medium. This intergalactic cascade process could, in principle, create a dangerous source of background for gamma→ALP oscillation search, especially if these cascades were initiated by ultra high energy cosmic rays (UHE CR). A part of interactions of these primary CR occurs relatively near to the observer, and thus cascade gamma-rays experience a lesser degree of absorption on EBL photons than the primary gamma-rays from the same source.
In the present work we demonstrate that the background from CR-initiated intergalactic EM cascades could be greatly suppressed as follows. During their propagation from the source to the observer, primary CR are deflected to appreciable angles (˜0.1-1 degree) in filaments of the large scale structure. This effect broadens the observable angular distribution significantly and leads to an effective cutoff in the observable point-like spectrum (i.e. the spectrum collected inside the point spread function of the observing instrument). We have performed detailed simulations of integralactic UHECR propagation using the publicly-available code CRPropa3 [6] and, profiting by a hybrid approach developed by us in [7], calculated the observable spectrum and the angular distribution of gamma-rays. We show that the observable spectrum is similar to the so-called universal spectrum of the intergalactic EM cascade model. This study could significantly facilitate future gamma→ALP oscillation searches in the optically thick region of blazar spectra with existing and future gamma-ray instruments such as Fermi-LAT, H.E.S.S., MAGIC, VERITAS, CTA, HAWC, and LHAASO.
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Towards a Cherenkov Telescope Ring

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The extreme and often varying nature of Active Galactic Nuclei can be investigated by observations of very-high-energy gamma rays. Studying their long-term behaviour and their flaring episodes requires long-term and continuous observations, respectively. Very-high-energy gamma-ray observations can be obtained with imaging air Cherenkov telescopes. They have the benefit of high sensitivities in the GeV to TeV energy regime, but the observation time is limited to night hours.

The Cherenkov Telescope Ring is thus a project to establish a worldwide network of these telescopes for long-term continuous observation and 24-hour follow-up availability in case of transient events. Establishing a site in Australia will be crucial to obtain full sky coverage.

In this contribution, the concept and science cases of a Cherenkov Telescope Ring will be introduced, and preliminary simulation comparisons will be presented. Moreover, an evaluation of possible

Australian sites will be given.

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Lepton polarization asymmetry in excited b-meson

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Recently, some unexpected phenomena in various B meson decays are being observed in several experiments. Few of the observables are branching ratio of $B_s \to ^{+-}$ decay, angular observable P_5ˆ' in $B \to K^{*+-}$ decay, lepton flavour non-universality parameters $R_{K^{(*)}}$,$R_{D^{(*)}}$ etc. The fact that these observables show significant deviation around 3σ from their standard model (SM) values declares them as anomalies in recent time. To find the possible solutions scientists extend their ideas beyond the SM which points towards the presence of new physics (NP). There are various NP models like leptoquark, 2HDM, non-universal Z', fermion fourth generation etc which are being examined to see whether they could explain the recent anomalies. Here, we are interested to study the heavy-light systems like the $(b\bar{q})$ mesons which have a rich spectrum of excited states. We are mainly concerned about the decay $B^*_{(s,d)} \to l^+ l^- (l = e, ,)$ which includes $b \to sll$ flavor-changing neutral-current (FCNC) transition. The excited mesons $B^*_{(s,d)}$ are unstable under electromagnetic and strong interactions and possess narrow width with corresponding lifetime of the order of 10^{-17} s. The $B^*_{(s,d)} \to l^+ l^-$ decays are sensitive to short-distance structure of $B = 1$ transitions. Some theoretical studies are being done in ref. [1, 2]. The authors of ref. [1] have proposed a novel method to study FCNCs in the $B^*_{(s,d)} \to e^+ e^-$ transition and predicted the branching ratio [1] $BR(B^*_{(s,d)} \to e^+ e^-) = 0.98 \times 10^{-11}$. In ref. [2] $B^*_{(s.d)} \to l^+ l^-$ decay modes have been studied in the SM and the branching ratio has been predicted as $BR^{SM}(B_{(s,d)})^* \to l^+ l^-) = (0.7 - 2.2) \times 10^{-11}$ for decay width $= 0.10(5)$ keV, irrespective of the lepton flavor. We have recently studied [3] $B^*_{(s,d)} \to l^+ l^- (l = , e)$ decay in Z' model and predicted the branching ratio as $BR(B^*_s \to l^+ l^-) = (1.5 - 2.2) \times 10^{-11}$ and $BR(B^*_d \to l^+ l^-) = (1.7 - 2.2) \times 10^{-13}$.
Theoretical investigation of longitudinal lepton polarization asymmetry (A_{P_L}) is found to be more clean compared to the branching ratio of this decay channel as the observable A_{P_L} is independent of the total width of B^* meson which is not confirmed theoretically or experimentally. In this work, we first calculate the SM prediction of A_{P_L} and then analyse its sensitivity to the non-universal Z' model [4] which is an extension of SM with an extra U(1)' symmetry. The main attraction of this NP model is that FCNC transitions could occur at tree level due to the off-diagonal couplings of non-universal Z' with fermions, which is not allowed under SM consideration. The relation between the electroweak interaction eigenstates and mass eigenstates induces GIM mechanism within SM due to which flavor changing neutral interaction (FCNI) becomes forbidden at tree level. However, the relation between the interaction eigenstates of NP and the mass eigenstates is not same as of the SM. In such a situation, Z' model could allow the tree level FCNC $b \to sll$ transitions. As, $B^*_{(s,d)} \to l^+ l^-$ decay modes are not observed experimentally till now, so these decays are expected to be used to test the flavour sector of the SM and search for NP.

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White dwarf constraints on CHAMPs

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White dwarfs (WD) effectively act as high-gain amplifiers for relatively small energy deposits within their volume via their instability to thermal runaway that culminates in a supernova. I will detail how a contamination of WD by $\mathcal{O}(1)$-charged massive particles (CHAMPs) could trigger the instability, leading to the destruction of old WD. Such a CHAMP contamination can either be present already in the WD-progenitor, or be accumulated onto the WD over its lifetime. The dense core structure formed at the centre of the WD when the heavy CHAMPs sink can either cause density-enhanced (pycnonuclear) fusion of carbon nuclei dragged into the core by the CHAMPs, or can lead to the formation of a mini black hole (BH) inside the WD. In the latter scenario, Hawking radiation from the BH can heat material and ignite the star if the BH forms with a sufficiently small mass; on the other hand, if the BH forms at large enough mass, acceleration of carbon nuclei that accrete onto the BH as it grows in size may be able to achieve the same outcome (with the conservative alternative being simply that the WD is devoured by the BH). These mechanisms collectively guarantee the destruction of old WD if a sufficient galactic CHAMP abundance is present. Using the known existence of a number of old, massive WD, I will present stringent galactic CHAMP abundance constraints that are up to many orders of magnitude stronger than existing limits in the regime of large CHAMP mass, $m_X \sim 10^{11} - 10^{17}$GeV. I will additionally offer some speculations that, in certain regions of parameter space, this setup might be able to provide a mechanism to explain the calcium-rich gap transients, a class of anomalous, sub-luminous Type Ia-like supernova events that are observed to occur far outside of a host galaxy.

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Particle Acceleration in Young Supernova Remnants with Non-thermal X-ray and TeV Gamma-ray Observations

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Nonthermal (synchrotron) X-ray spectrum is the most powerful tool to study the nature of particle (electron) acceleration in shock wave of supernova remnant (SNR). For eleven young SNRs, we measure cutoff energy parameter (ε_0) in the synchrotron X-ray spectrum and Bohm factor (η) by the theoretically predicted relation of $\varepsilon_0 \propto v_{\rm sh}^2 \eta^{-1}$, where $v_{\rm sh}$ is shock velocity and η is defined as mean free path of electron over its gyro radius, i.e., indicative of acceleration efficiency. The obtained ε_0-$v_{\rm sh}$ plots show variations, depending on SNRs and even on regions inside each SNR. For example, we found ones well-reproduced by the theoretical prediction with constant η (Kepler's SNR and Tycho's SNR) or ones effected by the surroundings, in particular magnetic field orientation (SN 1006) and number density (Cassiopeia A). Putting all the eleven SNRs together, the η parameter tends to be smaller as the SNR evolves and becomes older, which implies a connection with turbulent production. We will discuss a possibility of acceleration up to PeV range (PeVatron) taking the time dependence on η into consideration. We also apply the inverse Compton scattering model to TeV gamma-ray observations of five SNRs. The gamma-ray spectrum is also utilized for estimation of η in the leptonic scenario, although the obtained η is larger than that with the X-ray observations.

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Effects of dark matter from Big Bang Nucleosynthesis to atomic clocks

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I will present a review of experiment and theory in these areas based on our 30 Phys. Rev. Lett., Phys. Rev. D, A and Nature-Physics papers published in 2018-2019.
A. Zhitnitsy et al developed Axion Quark Nuggets (AQN) model which can explain both bariogenesis and dark matter within the Standard Model plus axion. We have suggested methods to detect axions produced by AQN passing through Earth and demonstrated that AQN model may also solve primordial Lithium deficit puzzle.
Axion and dilaton dark matter produces apparent variation of fundamental constants and violation of the fundamental symmetries including oscillating electric dipole moments (EDM). In our work with nEDM collaboration first measurements of this effect improved limits on the interaction of low mass axion with gluons and nucleons up to 3 orders of magnitude.
According to the Schiff theorem, nuclear EDM is completely screened by electrons in atoms and molecules, i.e. non-observable. We derived the dynamical screening theorem including cases of the oscillating electric field and oscillating EDM and demonstrated that the screening is incomplete in these cases. Moreover, nuclear EDM may be enhanced by many orders of magnitude in the case of the resonance. This gives us an efficient method to search for the axion dark matter (which produces the oscillating nuclear EDM).
Interference with atomic photon transition makes effect of axions and dark photon to appear in the first order in the extremely small interaction constants (instead of the first order in the traditional detection scheme). Coherent axion production in atomic transitions is possible. Information about CP-violating axion interaction has been extracted from the measurements of atomic and molecular. [1]V.V.Flambaum,A.R.Zhitnitsky,Phys. Rev. D 99, 023517 (2019). arxiv:1909.09475[2]G. Abel et al. Phys. Rev. X, 7, 041034 (2017).[3]V.V. Flambaum, H.B. Tran Tan, Phys. Rev. A98, 043408 (2018),arXiv:1904.07609[4]V.V. Flambaum, I.B. Samsonov, H.B. Tran Tan, Phys. Rev. D 99, 115019 (2019).[5]V.V.Flambaum, I.B.Samsonov,H.B.Tran Tan, D.Budker,Phys.Rev.D 98, 095028, (2018).[6]Y.V. Stadnik, V. A. Dzuba, V. V. Flambaum, Phys. Rev. Lett. 120, 0132024 (2018).

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The emerging class of gamma-ray emitting colliding-wind binary systems

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Despite anticipation since the COS-B era, gamma-ray detections of particle-accelerating colliding-wind binary (CWB) systems are still not at all numerous even after a decade of Fermi-LAT observations. With η Carinae unambiguously established, the report of a weak detection of γ2 Velorum (WR 11) as well as the low upper limits obtained for WR 140 and other CWBs contrast previous class assessments remarkably. In order to investigate the structure and conditions of the wind-collision region in these three systems we use three-dimensional magneto-hydrodynamic modeling, including the important effect of radiative braking in the stellar winds. A transport equation is then solved throughout the computational domain to study the propagation of relativistic electrons and protons. The resulting particle distributions are subsequently used to compute nonthermal photon emission components. We obtained results that can account for the weak detection of γ2 Velorum, the strong detection of η Carinae, and the non-detection of WR 140 in identical computational setups, and expanded our modeling for WR 147 and HD 93129A.

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Overview of the status and plan of the PandaX experiment

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The PandaX experiment uses liquid xenon as the target material to perform the dark matter direct detection at China Jinping Underground Laboratory. Recently, the PandaX-II experiment with 580 kg liquid xenon in the sensitive volume just finished the data-taking and the total exposure is around 140 ton-day. Meanwhile, the PandaX collaboration is planing for the next generation multi-ton liquid xenon experiment. The immediate next step is a 4-ton scale liquid xenon experiment, PandaX-4T, with which we expect to extend the sensitivity to WIMP search by one order of magnitude as compared to the PandaX-II experiment. In this talk, I will discuss the latest results from the PandaX-II experiment and the progress of the PandaX-4T experiment.

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Inverse Compton emission revealed by observations up to TeV energies of GRB 190114C

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The hunt for Gamma-Ray-Bursts (GRBs) at very high energy (VHE) started more than 20 years ago. A hint of emission was already claimed by Milagrito from the observations of GRB 970417.
On 19 of January the Major Atmospheric Gamma Imaging Cherenkov (MAGIC) clearly detected GRB 190114C above 0.2 TeV. This is the first highly significant detection (over 50sigma reached in the first few tens of minutes after the burst) of a GRB at VHE. GRB190114C was also detected by several other instruments providing a wealth of multi-wavelength data across 17 orders of magnitude in energy. The detection of GRB190114C by MAGIC reveals a spectral component at the highest energies incompatible with being originated by synchrotron emission processes. In this talk we will present the detection of GRB 190114C and the interpretation of its emission resulting from a complete multi-wavelength study.

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Constraints on primordial gravitational waves from POLARBEAR data and the cross-correlation of gravitational lensing with optical survey by the Subaru HSC

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POLARBEAR is a ground-based experiment which is designed to measure the Cosmic Microwave Background (CMB) polarization at the James Ax Observatory at an elevation of 5,190 m in the Atacama Desert in Chile. Our science goals are for searching for the B-mode signal created by primordial gravitational waves (PGWs), as well as for characterizing the B-mode signal from gravitational lensing. POLARBEAR started observations in early 2012 at 150 GHz and has published a series of results

from its first and second seasons, including the first measurement of a non-zero B-mode auto-power spectrum at sub-degree scales where the dominant signal is gravitational lensing of the CMB. In 2014, we installed a continuously rotating half wave plate (HWP) at the focus of the primary mirror to search PWGs and demonstrate control of low frequency noise. In this talk, I present the result of an upper limit of large angular scale B-mode signal induced by PGWs with the HWP. I also present our result of cross-correlation of gravitational lensing between our CMB data and optical survey by the Subaru HSC. Finally I show the status of Simons Array, which consists of three new receivers that will have about 20 times better sensitivity than POLARBEAR and observe at 90, 150, 220, and 270 GHz.

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Strong first-order phase transitions in the Next-to-MInimal Supersymmetric Standard Model

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We perform a comprehensive survey of the phase structure of the Next-to-Minimal Supersymmetric Standard Model (NMSSM), focusing on the first order phase transitions. Strong first order phase transitions are required for successful electroweak baryogenesis explanations of the observed baryon asymmetry of the universe and can lead to gravitational wave signals. The NMSSM is one of the most plausible models that has a viable electroweak baryogenesis mechanism. We identify the regions of parameters space where strong first order phase transitions can be achieved and reveal very rich patterns of phase transitions that lead to the observed electroweak symmetry breaking vacuum. We classify the different types of patterns we find, showing what first order phase transitions may occur in each case. We present benchmark points for each scenario and discuss the implications for electroweak baryogenesis and observable gravitational wave signals.

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Searching for axions and axionic Dark Matter with interference and axion-induced nuclear moments.

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Detection schemes for the QCD axions and other axion-like particles (including axionic Dark Matter) in light-shining-through-a-wall (LSW) experiments are based on the conversion of these particles into photons in a magnetic field. An alternative scheme may involve the detection via a resonant

atomic or molecular transition induced by resonant axion absorption. The signal obtained in this process is second order in the axion-electron interaction constant but may become first order if we allow interference between the axion-induced transition amplitude and the transition amplitude induced by the electromagnetic radiation that produces the axions.

The interaction of Standard Model's particles with the axionic Dark Matter field may generate oscillating nuclear electric dipole moments (EDMs), oscillating nuclear Schiff moments and oscillating nuclear magnetic quadrupole moments (MQMs) with a frequency corresponding to the axion's Compton frequency. Within an atom or a molecule an oscillating EDM, Schiff moment or MQM can drive transitions between atomic or molecular states. The excitation events can be detected, for example, via subsequent fluorescence or photo-ionization. If the nucleus has octupole deformation or quadrupole deformation or both then the transition rate due to Schiff moment and MQM can be up to 10^{-18} transition per molecule per year. In addition to causing transitions, an oscillating nuclear EDM can also induced an atomic or molecular EDM, which can be directly measured in an external electric field. This results overcomes the famous Schiff theorem which states that a static nuclear EDM is completely screened from any static external electric field.

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BubbleProfiler: A new code to calculate the bounce action in cosmological phase transitions

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Calculating the field profile and bounce action for bubbles nucleating in cosmological phase transitions is a key step in understanding the baryogenesis and stochastic gravitational wave properties of Standard Model extensions with multiple scalar fields. These quantities are determined by the bounce equation, a nonlinear system that has several properties which make numerical solutions difficult to obtain. We present BubbleProfiler, a new C++ code which finds these solutions by solving a series of linear shooting problems to perturbatively correct an initial ansatz. In this talk, I will outline the design philosophy of BubbleProfiler, explain the core algorithms, and present examples of how the bounce calculation is used in phenomenological studies of models with multiple scalar fields. I will also discuss the ongoing development of BubbleProfiler and improvements that are expected to be realised in the near future.

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Ultralight dark photon can resolve the Hubble tension problem

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We consider a massive vector field as a model for early Universe dark matter. Assuming that the massive vector field interacts with the Standard Model matter very weakly and is produced non-thermally, we study the evolution of this field in early Universe during the radiation dominated epoch. We show that this

field may be naturally created with the equation of state of radiation (w=1/3), but at some time a transition happens and the field behaves as cold dark matter (w=0). If a small fraction of dark matter is described by such massive vector fields, the expansion rate of the Universe is slightly enhanced at early time and, thus, the value of the sound horizon of baryon acoustic oscillations (standard ruler) is reduced. As a result, in this model the value of the Hubble constant appears to be larger than that in the standard LambdaCDM model. We show that for certain values of the parameters of mass and density of the massive vector field the Hubble tension problem may be naturally revolved.

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High-energy neutrino and gamma-ray emission from the AGN-driven wind in NGC 1068

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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. Such winds can harbor collisionless shocks at different locations that may induce acceleration of protons and electrons and consequent nonthermal emission. We focus on the innermost regions of the winds, where photohadronic interactions between accelerated protons and the nuclear radiation field can cause emission of high-energy neutrinos and gamma-rays. In particular, we address the case of NGC 1068, a nearby Seyfert galaxy bearing a powerful wind, which is a known source of GeV gamma rays as well as a tentative source of sub-PeV neutrinos. Tests and further implications of this scenario are discussed.

Parallel / 158

Study of the Cosmic Rays and Interstellar Medium in local HI Clouds using Fermi-LAT Gamma-Ray Observations

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An accurate estimate of the interstellar gas density distribution is crucial to understanding the interstellar medium (ISM) and Galactic cosmic rays (CRs). However, a significant amount of gas not traced properly by standard radio line surveys ("dark gas") has been preventing accurate measurement of the total neutral gas column density and CR intensity. To overcome this difficulty, we performed a detailed study of the ISM and CRs in the mid-latitude region of the third quadrant. We used the *Fermi*-LAT data in the 0.1-25.6 GeV range and other interstellar gas tracers such as the HI4PI survey and the *Planck* dust model. Even though this region was analyzed in an early publication of the *Fermi*-LAT collaboration using six months of data, the analysis was significantly improved using eight years of *Fermi*-LAT data with the aid of newly available gas tracers and with the northern and southern regions treated separately. We used γ-rays as a robust tracer

of the ISM gas and obtained the integrated γ-ray emissivities above 100 MeV as $(1.58 \pm 0.04) \times 10^{-26}$ photons s^{-1} sr^{-1} $\mathrm{H\text{-}atom}^{-1}$ and $(1.59 \pm 0.02) \times 10^{-26}$ photons s^{-1} sr^{-1} $\mathrm{H\text{-}atom}^{-1}$ in the northern and southern regions, respectively, supporting the existence of a uniform CR intensity in the vicinity of the solar system. Our emissivity agrees with the calculation using the model based on the directly measured CR proton spectrum. However, we caution that the uncertainty of the γ-ray emissivity model is still at the 20% level. In this contribution, we will present the details of the data analysis, results, and implications of CRs and ISM in the local environment.

Parallel / 159

Stability of Axion Dark Matter-Photon Conversion

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A coherently oscillating axion field is one of the dark matter candidate. It is known that the propagation of photons in the presence of axion dark matter is governed by the Mathieu equation. It is also known that axion and photon can mix with each other in the presence of magnetic fields.

Thus, we investigated what happens to the system where the axion dark matter and magnetic fields coexist. This system can be regarded as a coupled system of the axion and the photon whose equations contain the Mathieu type terms. We found that the instability condition is changed in contrast to the conventional Mathieu equation.

In my talk, I will explain the stability of axion dark matter-photon system in terms of both numerical and analytical methods. I also touch on what type of physical system needs to be arranged to give rise to instability condition we found.

Parallel / 160

Phenomenology and cosmology of electroweak monopoles

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In this talk, I show the existence of topologically stable, finite mass monopoles within Born-Infeld extension of the standard model and discuss their phenomenological and comsological implications.

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A Novel Scheme for Dark Matter Annihilation Feedback in Cosmological Simulations

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We present a new self-consistent method for incorporating dark matter annihilation feedback (DMAF) in cosmological N-body simulations. The power generated by DMAF is evaluated at each dark matter (DM) particle which allows for flexible energy injection into the surrounding gas based on the specific DM annihilation model under consideration. Adaptive, individual time steps for gas and DM particles are supported and a new time-step limiter, derived from the propagation of a Sedov–Taylor blast wave, is introduced. We compare this donor-based approach with a receiver-based approach used in recent studies and illustrate the differences by means of a toy example. Furthermore, we consider an isolated halo and a cosmological simulation and show that for these realistic cases, both methods agree well with each other. The extension of our implementation to scenarios such as non-local energy injection, velocity-dependent annihilation cross-sections, and DM decay is straightforward.

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Recent results from MAGIC observations of extragalactic sources

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The MAGIC telescope array observes the very-high-energy gamma-ray (VHE; E > 100 GeV) sky since 2009. The system is composed of two 17-m diameter Cherenkov telescopes, sensitive to energies above 50 GeV, installed on the Canary island of La Palma. The study of gamma-ray extragalactic sources is one of the pillars of the MAGIC scientific activities. The extragalactic VHE gamma-ray sky is populated mainly by blazars, active galactic nuclei whose relativistic jet points in the direction of the observer. The low-energy threshold of the MAGIC telescope array is particularly suited for the study of high-redshift sources, and low-synchrotron-peaked blazars. In this contribution we present a review of the VHE gamma-ray extragalactic sky seen by MAGIC, with a focus on recent highlights and discoveries.

Parallel / 163

Recent Results of the LUX Dark Matter Experiment

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LUX (Large Underground Xenon) was a dark matter direct detection experiment which used a two-phase xenon Time Projection Chamber and operated at the Sanford Underground Research Facility (SURF) in South Dakota from 2012 to late 2016. It previously set world-leading limits on spin-independent cross-section for Weakly Interacting Massive Particle (WIMP) dark matter. Recent LUX analyses are probing different dark matter models and other rare-event phenomena. Advanced analysis techniques extend the LUX sensitivity to lower dark matter masses and recoil energies. LUX is also being used to understand the potential detector performance of future dual-phase detectors, and to demonstrate new analysis methods and calibration techniques that can be used to improve our discrimination of backgrounds within next-generation experiments.

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LZ experiment for dark matter search

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The LUX-ZEPLIN (LZ) experiment is a direct dark matter search experiment that is under construction at the Sanford Underground Research Facility (SURF) in South Dakota (USA). It is based on dual-phase xenon technology and contains 7 tonnes of active liquid xenon in the time projection chamber (TPC). The active xenon volume is surrounded by the instrumented xenon skin, a liquid organic scintillator and water that will help in reducing backgrounds from environment and detector components. LZ is expected to start taking data in 2020 and achieve a sensitivity of about 1.6*10^(-48) cm^2 at 40 GeV/c^2 WIMP mass after 1000 days of live time. This talk will review the status of the LZ project and expected sensitivity.

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Probing the independence within the dark sector in the fluid approximation

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The standard model of cosmology is based on two unknown dark components that are generally assumed to be non-interacting. Relaxing this assumption opens a class of interacting models that have recently seen renewed interest in light of cosmological tensions. In this talk, we discuss some of these models and present an analysis of recent datasets investigating whether there is evidence for an interaction between these components of cold dark matter and dark energy. In particular, this analysis leaves the interaction mechanism generic and reconstructs in a model-independent way the interaction history at low-redshifts using a variation of the principal component analysis commonly used. We further discuss what constraints on interaction might be achieved from upcoming LSST and DESI surveys.

Parallel / 167

TeV gamma-ray sources in the Galaxy

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The current generation of imaging atmospheric Cherenkov telescopes, complemented by ground-based particle detector arrays, have demonstrated that our Galaxy plays host to a wide variety of particle accelerators. These include supernova remnants, compact object binary systems and star forming regions, as well as pulsars and their extended nebulae and haloes. Bright TeV gamma-ray emission from the central region of the Galaxy is also observed, both spatially coincident with the supermassive black hole and along an extended ridge structure. Observations of these objects in the

TeV band reveal a range of spatial, temporal and spectral features through which to understand the underlying acceleration and emission processes. We will provide a brief overview of these results, and focus upon recent observations of some of the more interesting individual sources.

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Cygnus: feasibility of a large-scale directional detector for dark matter and neutrinos

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Now that WIMP dark matter searches are rapidly approaching the neutrino floor, there has been a resurgence in interest towards detectors with directional sensitivity. A large enough detector with such a capability introduces the possibility of identifying a clear signature of dark matter particles with signals weaker than the neutrino background, all the while fulfilling a dual purpose in measuring these neutrinos from the Sun and other sources through the novel channel of coherent neutrino-nucleus scattering. I will present results from a detailed analysis of the potential for observing a directional nuclear recoil signal using low-pressure gas time projection chamber (TPC) technology at recoil energies below 10 keV. Such a detector will be able to achieve excellent background discrimination, probe dark matter cross sections below the neutrino floor, make novel contributions to both dark matter and neutrino particle physics and measure astrophysical characteristics of the local dark matter velocity distribution.

Parallel / 170

Paleo-Detectors for Galactic Supernova Neutrinos

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Paleo-detectors are a proposed experimental technique in which one would search for traces of recoiling nuclei in ancient minerals. Natural minerals on Earth are as old as 1 Gyr and, in
many minerals, the damage tracks left by recoiling nuclei are also preserved for time scales long compared to 1Gyr once created. Thus, even reading out relatively small target samples of order 100g, paleo-detectors would allow one to search for very rare events
thanks to the large exposure, 100gGyr=105tyr. Here, we explore the potential of paleo-detectors to measure nuclear recoils induced by neutrinos from galactic core collapse supernovae. We find that they would not only allow for a direct measurement of the average core collapse supernova rate in the Milky Way, but would also contain information about the time-dependence of the local supernova rate over the past 1 Gyr. Since the supernova rate is thought to be directly proportional to the star formation rate, such a measurement would provide a determination of the local star formation history. We investigate the sensitivity of paleo-detectors to both a smooth time evolution and an enhancement of the core collapse supernova rate on relatively short time scales, as would be expected
for a starburst period in the local group.

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Prospect of Cosmic Ray Energy Spectrum and Composition Measured by LHAASO Experiment

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One of main scientific goals of Large High Altitude Air Shower Observatory (LHAASO) is to measure individual cosmic ray spectra from 30 TeV to several EeV. A quarter array of LHAASO experiment, 6 Cherenkov telescopes, one 150 m × 150 m water Cherenkov pool, about 300 muon detectors and 1300 scintillator detectors, has been completed, and they started operation in October. The combined detection of showers can improve the energy reconstruction, the measurement of the direction and the core position of showers, and the composition identification. Thus, accurate cosmic ray energy spectrum and composition measurement can be obtained. A preliminary analysis result of the data and prospect of cosmic ray energy spectrum measured by a quarter array of LHAASO experiment will be presented in this talk

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Studying Cosmic Rays with the IceTop and IceCube Detectors

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The IceTop detector is the surface component of the IceCube Observatory. Its 81 stations of frozen water tanks are sensitive to multiple particle components of cosmic ray air showers, and can be used in coincidence with the deeply-buried in-ice component of IceCube for additional sensitivity to high-energy penetrating muons from air showers. This work focuses on measurements of cosmic rays between the knee and the ankle: the all-particle spectrum using IceTop alone, individual spectra for four different nuclear groups (protons, helium, oxygen, and iron) using IceTop and IceCube in coincidence, and the density of muons measured in IceTop tanks far from the shower's core.

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The eight-year high energy sterile neutrino result from IceCube

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Recent global fit results to the 3+1 sterile neutrino model indicate a preference for an eV-scale sterile state. The IceCube Neutrino Observatory is uniquely positioned to search for the signature of this state using matter enhanced oscillations of atmospheric muon neutrinos passing through the core of the Earth. We present the results from two such searches using eight years of IceCube data. The first result is from a sensitive search for a matter enhanced resonance at TeV neutrino energies. The second seeks to explore a higher mass sterile hypothesis, where the oscillations are averaged out.

Plenary / 174

Probing dark matter with galaxies

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Plenary talk

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Radio Follow-up of Gravitational Wave Events

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Plenary talk

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ETHOS: Structure formation with non-gravitational dark matter interactions

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Probing Extreme Gravity through Gravitational-wave Observations

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Plenary talk

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The Cherenkov Telescope Array: a new eye on the TeV sky

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

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Phenomenological and theoretical perspectives in neutrino physics

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Plenary talk

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Gravitational Wave Discoveries and Science from the First, Second and Third Observing Runs of Advanced LIGO and Advanced Virgo

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Plenary talk

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Pulsar origins of the Galactic Centre Excess

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The center of the Milky Way galaxy provides a promising target to search for signatures of dark matter self-annihilation or decay into Standard Model particles. However, competing high-energy astrophysical processes are complex and must be modeled with care. I will review on-going studies of the so-called "Galactic Center Excess" discovered in Fermi-LAT data. I will discuss recent developments that yield new insights on astrophysical emissions from the galactic bulge, in particular those arising from pulsars. I will discuss their impacts for understanding the origins of the Galactic Center Excess and future ways to test them.

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Neutrino cosmology

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Plenary talk

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Cosmology after Planck

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Plenary talk

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Recent results on ultra-high energy cosmic rays from the Pierre Auger Observatory

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Updates on the GAPS experiment - a search for light cosmic ray antinuclei

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Currently finalizing its design and beginning its construction, the General Anti Particle Spectrometer (GAPS) is a planned balloon-borne cosmic-ray experiment scheduled for a long duration balloon flight from McMurdo Station in the Antarctic. Its primary science goal is the search for light antinuclei in cosmic rays at energies in the region below 0.25 GeV/n. This energy region is especially of interest and still mostly uncharted.
Searches for light antimatter nucleons with energies below ˜0.25 GeV/n promise a novel approach for the search of dark matter. The large fraction of dark matter models proposes annihilation or decay of the unknown dark matter particle with matter/antimatter pairs in its final state. Positron/electron, as well as antiproton/proton searches, have been conducted. However, due to large uncertainties in the astrophysical backgrounds up to this date the interpetation of the data is still debated. GAPS promises to yield unprecedented sensitivity for the search of antiprotons and especially antideuterons.
To reach the required sensitivity, the GAPS detector incorporates a new approach for antimatter detection, utilizing a time-of-flight system together with a tracker with custom-designed, lithium-drifted silicon wafers. The detector is capable of measuring the beta and dE/dx profiles of particle tracks along with the X-ray cascade expected from antimatter capture in the detector material. The observation of the X-ray cascade from exotic atoms has a large potential for the identification of a golden channel of antideuteron candidates.
Major challenges in detector design and construction, as well as the development of reconstruction algorithms and simulation tools have been mastered by the GAPS collaboration in the last year. This talk will review the current status and the path forward to the first flight from Antarctica in December 2021.

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DarkSide-20k and the Direct Dark Matter Search with Liquid Argon

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Dual phase noble liquid Time Projection Chambers (TPCs) offer a competitive and scalable way to search for dark matter directly via elastically scattering off of detector target nuclei and electrons. The Global Argon Dark Matter Collaboration (GADMC) is undertaking an ambitious global program from the extraction and purification of Underground Argon (UAr), depleted in 39Ar which reduces the internal background, to the development of 25cm2 Silicon Photo Multiplier (SiPM) modules capable of resolving single photoelectrons. DarkSide-20k is the next stage of this program and will be the next generation dual phase Argon TPC. DarkSide-20k will be housed in the Gran Sasso underground laboratory (LNGS) and has an exposure goal of ˜100 tonne-years with zero instrumental background in expectation of a WIMP-nucleon cross section of 10-47 cm2 for a WIMP mass of 1TeV/c2 during a 5-year run. An overview of the DarkSide experimental program will be presented with a focus on the upcoming DarkSide-20k detector and the new technologies involved.

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Ultra High Energy Cosmic Rays from Dark Matter

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Plenary talk

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Supernova Remnants in the Galaxy - too many, too few and so diverse?

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Time-Dependent Models for Cosmic Rays and Diffuse Emissions from the Galaxy

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Cosmic ray data collected by experiments like Pamela, AMS-02, CALET, and DAMPE show many spectral features that are not described by simple power laws. These features may be giving information on the time-dependent activity of individual cosmic ray sources, but the interpretation is unclear. Because the same cosmic rays are interacting also in the interstellar medium, these data are also intrinsically linked to the diffuse emissions from the Galaxy. Recent work has shown that the past activity of cosmic ray sources is indeed apparent in the high-energy diffuse emissions, with features appearing over a wide range of angular scales. I will talk about these time-dependent cosmic ray source models and propagation calculations, which may be providing novel explanations for features seen in high-energy gamma rays, such as the so-called 'Fermi Bubbles'.

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Constraining properties of neutron star merger outflows with radio observations

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The detection of the first neutron star merger, GW170817, heralded the dawn of a new era in multi-messenger astronomy. Observations of radio emission from the resulting afterglow helped constrain merger parameters including the jet opening angle, the energetics of the merger and the circum-merger density. However, these observations alone were insufficient to distinguish between two competing models for the merger geometry - where a relativistic jet launched along the merger axis either successfully breaks out of the dense surrounding medium, or dissipates within it (”choked” jet or cocoon). The tension between these models was not resolved until observations using Very Long Baseline Interferometry (VLBI) detected superluminal motion, suggesting that the late-time emission was jet- dominated.

In this talk I will discuss prospects for the detecting future compact object mergers and the versatility of radio observations in localising mergers and constraining their properties. I show that while the late-time outflow structure of nearby events can be constrained using VLBI observations to either directly image the outflow or detect centroid motion produced by the presence of a jet, these observations cannot be used to understand early-time behaviour. Instead we can place meaningful constraints on the early-time source size via the detection of interstellar scintillation from high-cadence multi-frequency observations. This technique also has a further effective range than VLBI follow-up, and will enable study of the geometry of events out to (and beyond) the horizon of third-generation gravitational wave detectors.

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Gamma-ray Binary Systems

Author: Dmitry Khangulyan[1]

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Gamma-ray binary systems are nowadays a complex class of compact binary systems displaying variable gamma-ray emission. This class includes different types of objects, which may host two stars or a star and a compact object. Depending on the specific realization, the physical scenario for production of gamma rays may differ considerably between some gamma-ray binary systems. In this talk, I will briefly introduce the knows types of sources with focus on the most interesting cases, their phenomenology, and underlying physics.

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Shining a light on the dark side of cosmology

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Testing the WIMP paradigm (an many others) with ultra-low background massive xenon detectors

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Plenary talk

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TeV emission - GRB's Rosetta Stone

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X-ray and Gamma-ray View of Particle Acceleration in Galactic Sources

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Plenary talk

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Exploring the Universe with High Energy Neutrinos

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The age of high energy neutrino astronomy has arrived, and the Universe has begun to reveal its secrets. IceCube has detected and characterised the astrophysical neutrino flux, and revealed evidence of the first source –the blazar TXS 0506+056 –which appears to be a cosmic particle accelerator.

Upgraded and new detectors (IceCube Upgrade, KM3NET, IceCube-Gen2) are in various stages of planning and construction, and will further improve the sensitivity to steady point sources and transient emissions. Present and future detectors are also excellent laboratories for tests of fundamental physics using the high fluxes of atmospheric neutrinos that form the backgrounds to the astrophysical observations.

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CR Acceleration Mechanisms: New Challenges From High-Fidelity Observations

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The Status and First Results of LHAASO Experiment

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Cosmic ray feedback in star-formation and implications for gamma-ray emission from starbursts

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The latest results of the Dark Matter Particle Explorer (DAMPE)

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Neutrino masses and Gravitational waves

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We present a set of minimal Dirac neutrino mass models and discuss their cosmological consequences. Specifically, such models generate a neutrino mass at tree level and can have a multiple gravitational wave signature through primordial phase transition(s), can explain the asymmetry between matter and antimatter via neutrinogenesis and accommodate a dark matter candidate in dark glueballs or dark baryons. We discuss situations where the effects on the parameter space from different cosmological considerations overlap and are complimentary to collider probes.

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Latest Results from the Alpha Magnetic Spectrometer

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The Alpha Magnetic Spectrometer (AMS) was installed aboard the International Space Station on May 19, 2011. In eight years AMS has collected over 145 billion cosmic rays. AMS conducts searches for the origin of antimatter, dark matter, and new phenomena through the precision measurement of cosmic rays. The latest AMS results on cosmic ray positrons, electrons, antiprotons, protons, nuclei, and the time variation of cosmic ray fluxes will be presented. The impact of these measurements on our understanding of the physics of cosmic rays will also be discussed.

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Multimessenger probes of the Fermi GeV excess nature

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Plenary talk

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Long-lived particles at current and future collider experiments

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Plenary talk

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Dark matter bound states: overhauling our understanding of thermal decoupling at the TeV scale

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Plenary talk

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The 21cm probe of cosmology

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Plenary talk

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Capture of Dark Matter in Neutron Stars

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Plenary talk

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Concluding remarks

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TBA

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Plenary talk

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Fast radio bursts - Past, present and future

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Fast Radio Bursts (FRBs) which are exotic millisecond duration radio bursts, are currently the hot topic in the field of transient astronomy. The discovery of FRBs has stimulated a range of theoretical investigations to understand their origin and physics as well as observational efforts around the world to search for more such bursts. In the recent decade or so, we have learned a lot about them with the discovery of repeating FRBs and localisation of FRBs to their host galaxies, which are providing essential clues to the puzzle of "what produces an FRB". In this talk, I will give a brief overview of our current understanding of these enigmatic bursts and talk about recent results from the Australian Square Kilometre Array Pathfinder (ASKAP). There is no more exciting time to be involved in the field!

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Discovering Galactic Supernova Remnants

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Supernova Remnants (SNRs) display a wealth of characteristics across the entire electromagnetic spectrum. These multiwavelength observations together with cosmic ray (CR) measurements make SNRs some of the first objects studied with multiple messengers. Answering some of the most compelling questions about Supernova Remnants requires not only multimessenger studies, but also sufficient populations of SNRs displaying each of their characteristics. For instance, to understand SNRs' evolution, we must observe them at all ages and in all the environments in which they evolve,

and which they in turn sculpt. The high energy domain is a key component to disentangling these questions. For example, measuring nuclear decay line emission such as from Ti44 with COSI-SMEX will reveal a new, younger population of Galactic SNRs, as the gamma-ray emission cuts through their typically dusty surroundings. COSI-SMEX's wide field of view 0.2-5 MeV Compton telescope on a satellite platform allows a uniform survey of the entire sky with the required high resolution spectroscopy. By finding and studying sufficient populations of SNRs using analysis techniques that account for remaining bias(es), we will gain insight into how these sources shape and are shaped by the environments and galaxies in which they live and their role in accelerating the most energetic particles in our Galaxy.

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WIMP dark matter searches with NaI: Status of the SABRE experiment and SUPL laboratory

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For almost 20 years, the DAMA experiment has observed annual modulations in the signal from heavily-shielded, ultra-pure NaI scintillator crystals housed in the Gran Sasso underground laboratory. This modulation is consistent with expectations for the motion of the earth through a galactic dark matter halo, but is in conflict with results from other dark matter direct detection experiments. Recent efforts with NaI-based detectors that aim to test the DAMA result will be reviewed, with a focus on the new SABRE experiment under construction that will be the first based in both the North and South Hemispheres and hence able to separate a potential dark-matter-induced modulation signal from any seasonal-induced background. The SABRE South experiment will be housed in the Stawell Underground Physics Laboratory (SUPL) in Australia; this will be the first deep-underground, low-background laboratory in the Southern Hemisphere and its progress will also be be presented.

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The detection of VHE emission in the deep afterglow of GRB 180720B

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Inverse Compton emission revealed by observations up to TeV energies of GRB190114C

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