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Book of Abstracts

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Innovative pulsar searching techniques, and the discovery of a relativistic binary pulsar

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Pulsars, rapidly-rotating and highly magnetised neutron stars, can be utilised as tools in the study of many fundamental physical questions, most notably in the application of binary pulsars to the study of gravitational theories such as General Relativity. The discovery of ever-more relativistic binary systems than those presently known will allow for such tests to probe even deeper into the nature of gravity. Here, I will present results from the processing of 44% of the the HTRU-South Low Latitude pulsar survey, the most sensitive blind survey of the southern Galactic plane taken to date. This includes the discovery and long-term timing of 40 new radio pulsars identified through the continued application of a novel "partially-coherent segmented acceleration search" technique, which was specifically designed to discover highly-relativistic binary systems. These pulsars display a range of scientifically-interesting behaviours including glitching, pulse-nulling and binary motion, and along with other discoveries from the HTRU-S Low Latitude survey appear to comprise a population of older, lower-luminosity pulsars as compared to the previously-known population. In addition, I will also present an in-depth study of PSR J1757-1854, the only relativistic binary pulsar to have been discovered in the HTRU-S Low Latitude survey. This extreme binary system promises to provide new insights into gravitational theories within the coming years.

Highlight talks / 5

THE SEARCH FOR PEVATRONS IN VHE GAMMA RAYS AND NEUTRINOS

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Since its discovery more than one hundred years ago, the origin of the cosmic-ray flux measured on Earth is still unknown: in order to explain the region under the knee, supernova remnants (SNRs) are usually addressed as PeV cosmic accelerators. In particular, young SNRs are potential candidates since they might act as PeVatrons at least during some initial stage of their evolution: among these, the brightest TeV SNR is RX J1713.7-3946. However, no clear indication of PeV energies has been observed so far in such a kind of sources. Recently, the Galactic Center region has been detected as a multi-TeV gamma-ray emitter. Two emission regions have been resolved by H.E.S.S.: a point source, spatially associated to the known radio source SgrA*, and a diffuse flux, characterised by a simple power law gamma-ray spectrum with no visible cut-off up to gamma-ray energies of about 50 TeV. Such a detection triggers the search for PeVatron at the center of our Galaxy. A clear evidence of the hadronic nature of the emission would be the detection of a neutrino counterpart. I will here review the potential of the under construction KM3NeT for the detection of these and other galactic sources, in view of the discovery power of the next generation ground-based instrument CTA.

Highlight talks / 13

Supernova remnants and pulsar wind nebulae at high and very-high energies

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Supernova remnants (SNRs) and pulsar wind nebulae (PWNe) have long been considered potential sources of Galactic cosmic rays. Radiating from the radio band to gamma rays, these objects are ideal to study the acceleration of cosmic rays. In particular, understanding the nature of the gamma-ray emission allows probing the population of high-energy particles (leptons or hadrons) and inferring the highest energy limits achieved via their acceleration process. At TeV energies, the H.E.S.S. Galactic Plane Survey (HGPS) has recently revealed several unidentified sources, often dark in other wavelengths, challenging our understanding on the origin of the emission. I will highlight our current knowledge on SNRs and PWNe and in particular stress what we may learn about them from an observational point of view. I will also present a method to constrain the nature of the unidentified TeV HGPS sources using a multi-wavelength approach, aiming to be applied on the next generation gamma-ray observatory (CTA, Cherenkov Telescope Array) which is expected to reveal several hundreds of TeV sources along the Galactic plane.

Highlight talks / 9

Measuring the polarization of the CMB with the QUIJOTE experiment

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In the last years we have obtained a very detailed picture of the early Universe, measuring the intensity and polarization of the Cosmic Microwave Background (CMB), the relic radiation from the Big Bang. The last two space missions WMAP and Planck, and also previous ground-based and balloon experiments, allowed us to consolidate the precision Cosmology era. Nowadays, ground-based experiments are measuring the sky looking for the detection of CMB B-modes at large angular scales, the tiny polarization signal relic from Inflation. This is one of the most challenging objectives of modern Cosmology, since many contaminants are strongly hiding it. For this purpose, we must achieve a very precise characterization of the Galactic emissions, and experiments as QUIJOTE have a very important role in this context. In this talk we will briefly introduce the origin of CMB radiation and the physics of the foreground emissions. Then we will describe the QUIJOTE experiment with its present scientific results and future plans. In particular, we will discuss the map-making process, that is the main topic of my PhD until now.

Highlight talks / 4

On the accuracy of reflection-based supermassive black hole spin measurements in AGN

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It is genreally accepted that active galactic nuclei (AGN) are powered by accretion onto supermassive black holes (SMBHs) of masses $M \sim 10^{6-9}\,\mathrm{M}_{\odot}$. The matter is thought to accrete in a disc that is geometrically thin and optically thick, emitting the bulk of its light in the optical/ultraviolet range. Moreover, AGN are strong X-ray emitters. These X-rays are thought to be triggered by Compton up-scattering of the disc photons off hot ($kT \sim 10^9$ K) transrelativistic electrons, usually referred to as the X-ray corona. Several observational evidences suggest that the corona is located in the close vicinity of the SMBH (below ~10 gravitational radii). Hence, X-rays from AGN can be used in order to probe these regions, which can be considered as unique laboratories to directly test the effects of general relativity. In particular, the detection of a strong relativistic "reflection component", in X-ray spectra, is potentially the most powerful method to measure the spin, one of the fundamental observable properties of BHs. The spin measurement, particularly in AGN, is of great interest for understanding the physical processes on scales ranging from the circumnuclear region out to the host galaxy. It would be then timely to test how reliable the reflection-based BH spin measurements that can be currently achieved are. I will present in my talk an attempt to answer this question through blind-fitting a set of simulated high-quality *XMM-Newton* and *NuSTAR* spectra, considering the most generic configuration of AGN. Each member of our group (composed of three persons) simulated ten spectra with multiple components that are typically seen in AGN. The resulting spectra were blindly analysed by the other two members. Our main results show that at the high signal-to-noise ratio assumed in our simulations, neither the complexity of the spectra, nor the input value of the spin are the major drivers of our results. The height of the X-ray source instead plays a crucial role in recovering the spin. In particular, a high success rate in recovering the spin values is found among the accurate fits for a dimensionless spin parameter larger than 0.8 and a lamp-post height lower than five gravitational radii. I will then discuss the implications of our results and how some of the limitations faced in spin determination can be overcome.

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Cosmic-ray ionization in diffuse clouds

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Cosmic rays are believed to play an essential role in determining the chemistry and the evolution of molecular clouds. This is because they are usually considered to be the main ionization agent of these star-forming regions. In this talk, we will examine such hypothesis from a theoretical point of view for the case of diffuse clouds. This will be achieved by studying the cosmic-ray spectra in the cloud's interior using the one-dimensional cosmic-ray transport equation. Interestingly, it is found that energy losses effectively reduce the cosmic ray flux in the cloud interior for low energy cosmic rays in such a way that the predicted ionization rate is more than 10 times smaller than the one inferred from the observational data. A brief discussion on the implication of this finding in terms of spatial fluctuation of the Galactic cosmic ray spectra and possible additional sources of low energy cosmic rays will be given in the end.

Highlight talks / 6

Molecules in Space

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In the last 50 years, almost 200 molecules have been detected in space. Some of them, such as carbon monoxide (CO), water (H_2O) and ammonia (NH_3) are very simple, but others are formed by more than 10 atoms. The astrochemistry field in astrophysics aims to investigate the chemistry of space by means of observations, laboratory experiments as well as theoretical studies. In particular, molecules represent a promising way to follow the cycle of the interstellar medium (ISM) from the diffuse gas to the dense and cold clouds to the protostellar phases, with the ambitious goal to understand how and where molecules of biological interest are formed. In my talk, I will try to show the diagnostic power of molecular emissions at centimeter and millimeter wavelengths and to illustrate how to derive important information about the dynamic state of the ISM. My recent work is in particular focused on the analysis of the kinematics of a protostellar clump, Barnard 59, located in the Pipe nebula.

Contributed talks / 8

Multiple stellar populations in Magellanic Cloud clusters: disentangling between age spread and rotation

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The discovery of multiple stellar populations in young and intermediate-age clusters has been one of the major findings in the field of stellar populations of the last decade. Their origin is one of the most-intriguing open issues of stellar astrophysics and provides new constraints on the assembly of galaxies and on star formation and evolution.
I will present new results for a large dataset of young clusters (GO-14710, PI. Milone) observed with the Hubble Space Telescope.
Our results allow us to understand the physical mechanism that is responsible for the multiple populations in young clusters and disentangle the effects of age variation and rotation.
The study of this young objects open new perspective in the understanding of multiple stellar populations that formed at high redshift a few hundreds million years after the Big Bang.

Contributed talks / 11

Signatures of an eruptive phase before the explosion of SN 2013gc

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SN 2013gc is the first case of a type IId supernova with detections of outburst episodes before the explosion. During these outbursts the progenitor star expelled a circumstellar shell, which later interacted with the SN ejecta. The spectra show multiple components in emission, with a narrow P Cygni profile. The spectra and the light curve were compared with those of similar objects. The talk will be a description of the study done on this interesting object.

Contributed talks / 16

Cosmological Perturbation Theory beyond shell-crossing: Schrödinger equation approach

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In this dissertation, in order to study the growth of the density fluctuations of the Cold Dark Matter, the standard perturbation techniques, such as Eulerian perturbation theory and Zel'dovich approximation, have been reviewed. In the second part of this work, we introduce a novel approach to the study of large–scale structure formation in which the Cold Dark Matter is modelled by a complex scalar field whose dynamics are ruled by cou- pled Schrödinger and Poisson equations. In the last part, we show that the lowest order cumulants of Eulerian perturbation theory for the Cold Dark Matter are perfectly recovered.

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Aperitif, Award, and Concluding Remarks