EP 10: Astrophysics: Cosmic Rays and Galaxies I

Time: Thursday 11:00–13:00 Location: ZEU/0160

Invited Talk EP 10.1 Thu 11:00 ZEU/0160

Arne-Richter Lecture: From nonthermal plasmaastrophysics to modeling of pandemic outbreaks — •Reinhard Schlickeiser — Institut für Theoretische Physik, Lehrstuhl IV: Weltraum- und Astrophysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany — Institut für Theoretische Physik und Astrophysik, Christian-Albrechts-Universität zu Kiel, Leibnizstr. 15, D-24118 Kiel, Germany

During the last 45 years of my career I almost exclusively did research on topics of nonthermal astrophysics including gamma-ray astronomy, radio astronomy, cosmic ray transport and acceleration in partially turbulent electromagnetic fields, astroparticle physics, kinetic theory of fluctuations in collision-poor plasmas and cosmological magnetogenesis. I had the privilege to meet and interact with a number of splendid and marvelous scientists including Arne Richter. In the talk I will cover important milestones of my career and summarize my positive experiences with fellow scientists.

EP 10.2 Thu 11:45 ZEU/0160

Modelling magnetic turbulence with log-normal intermittency by continuous cascades* — •Jeremiah Lübke[1], Frederic Effenberger[2], Horst Fichtner[2], and Rainer Grauer[1] — [1]Institute for Theoretical Physics I, Ruhr-University Bochum, Universitätsstr. 150, 44801 Bochum — [2]Institute for Theoretical Physics IV, Ruhr-University Bochum, Universitätsstr. 150, 44801 Bochum

The transport of cosmic rays in turbulent magnetic fields is commonly investigated by solving the Newton-Lorentz equation of test particles in synthetic turbulence fields. These fields are typically generated from superpositions of Fourier modes with prescribed power spectrum and uncorrelated random phases, bringing the advantage of covering a wide range of turbulence scales at managable computational effort. However, almost all of these models to date only account for second-order Gaussian statistics and thus fail to include intermittent features. Recent observations of the solar wind suggest that astrophysical magnetic fields are strongly non-Gaussian, and the question of how such higher-order statistics impact cosmic ray transport has only received limited attention. To address this, we present an algorithm for generating synthetic turbulence based on Kolmogorov's log-normal model of intermittency. It generates a divergence-free magnetic field by computing the curl of a vector potential, which in turn is obtained from an inverse wavelet transform of a continuous log-normal cascade process. We investigate the statistics of the generated fields, show that anomalous scaling properties are accurately reproduced and discuss implications on cosmic ray transport. *Supported by DFG (SFB 1491)

EP 10.3 Thu 12:00 ZEU/0160

From test particle simulations to cosmic-ray transport — Marco Kuhlen, •Vo Hong Minh Phan, and Philipp Mertsch — TTK, RWTH Aachen University, Aachen, Germany

The transport of high-energy particles in the presence of small-scale, turbulent magnetic fields is a long-standing issue in astrophysics. Analytical theories disagree with numerical simulations at rigidities where the particles' gyroradii are slightly smaller than the correlation length of turbulence. At the same time, extending the numerical simulations to lower rigidities has proven computationally prohibitive. In this talk, we will discuss a solution to the problem of perpendicular transport in isotropic turbulence at both, high and low rigidities. Our study has important implications for the transport of Galactic cosmic rays, acceleration at perpendicular shocks and for high-energy particles in the heliosphere.

EP 10.4 Thu 12:15 ZEU/0160

Particle acceleration capability of a black hole at the Galactic centre — •Arman Tursunov — Institute of Physics, Silesian University in Opava, Czech Republic — Max Planck Institute for Radio Astronomy, Bonn, Germany

A compact supermassive source Sagittarius A* located at the centre of our Galaxy has been observed at different wavelengths across the electromagnetic spectrum. It is the closest and largest in projection supermassive black hole candidate. At the same time, its particle acceleration capability related to the cosmic ray and neutrino messengers were not yet experimentally probed despite indirect indications of the existence of a PeVatron at the Galactic centre. In this talk, I will present a novel scenario of particle acceleration at the Galactic centre involving electromagnetic extraction of rotational energy from the central black hole. I will show that the maximum energy of accelerated protons may reach a few PeV at the source, contributing thus to the knee of the observed cosmic ray spectrum.

EP 10.5 Thu 12:30 ZEU/0160

Multi-wavelength modelling of FR0 galaxies — •Therese Paulsen[1] and Foteini Oikonomou[2] — [1]Bergische Universität Wuppertal, Gaußstraße 20, 42119 Wuppertal, Germany — [2]Norwegian University of Science and Technology, Høgskoleringen 5, NO-7491 Trondheim, Norway

In the last decade, high-sensitivity radio and optical surveys have unveiled a new class of radio galaxies, called the Fanaroff-Riley type 0 (FR0). Due to their abundance in the local universe, this source class is of particular interest in the context of multi-messenger analyses as a possible neutrino emitter. The properties of FR0s at γ-ray energies are still largely unexplored due to the lack of observational data. However, observations have been made for the galaxies LEDA 55267, LEDA 57137, and LEDA 58287.

The multi-wavelength emission of these galaxies was modeled to determine the physical conditions under which the observed radiation is generated. The synchrotron, synchrotron self-Compton and the external Compton processes were considered. As a first result, we find that all the sources are consistent with being powered by the synchrotron self-Compton mechanism.

EP 10.6 Thu 12:45 ZEU/0160

Bayesian Inference of the 3D Galactic HI-Gas Density — •Laurin Söding, Philipp Mertsch, and Vo Hong Minh Phan — Institute for Theoretical Particle Physics and Cosmology, RWTH Aachen University, Aachen, Germany

While other galaxies can be observed with various techniques in great detail and precision, the structure of our own galaxy is mostly obscured from view due to our vantage point. Creating a 3D map of e.g. HI gas density or magnetic fields is therefore a challenging task. We have used the 21-cm emission line from atomic hydrogen - together with a velocity model - to reconstrcut a 3D-map of the galactic distribution of HI gas using new Bayesian inference techniques. While the first results look very promising, we have characterised systematic uncertainties of the method due to, e.g. the choice of velocity model. In the future, we will strive to determine velocity fields and gas densities in a common inference machinery to obtain the best maps of the Galaxy yet.