EP 6: Astrophysics

Time: Wednesday 11:00–13:15 Location: EP-H1

Invited Talk EP 6.1 Wed 11:00 EP-H1
Three-dimensional topology-driven magnetic reconnection — •Raquel Mäusle[1], Jean-Mathieu Teissier[1], and Wolf-Christian Müller[1,2] — [1]Technische Universität Berlin, Berlin, Germany — [2]Max-Planck/Princeton Center for Plasma Physics, Princeton, NJ, USA

Magnetic reconnection is a dissipative process, by which the magnetic field structure within a plasma is changed. It is important in many astrophysical systems, such as the Sun's corona, where it is believed to be of importance for the generation of solar flares.

We study a three-dimensional model of magnetic reconnection driven by magnetic field topology. Magnetic field lines in three-dimensional systems have the tendency to become highly entangled, making them exponentially sensitive to very small non-ideal effects. Therefore, entanglement could be the dominant mechanism for fast reconnection in low-resistivity plasmas, requiring far smaller current densities than otherwise needed. We investigate this model numerically using a fourth-order finite-volume scheme to solve the magnetohydrodynamic (MHD) equations. We start from a system with an initially constant magnetic field and line-tied boundaries, and drive it into a chaotic state in which reconnection is occuring. We study the dynamics of this system, the correlation between the field line entanglement and the occurrence of reconnection events, as well as the dependence of the reconnection rate on the resistivity.

In this talk I will introduce the model and numerical method employed and present our preliminary results.

EP 6.2 Wed 11:30 EP-H1
Very high-order subsonic magnetohydrodynamics solvers — •Jean-Mathieu Teissier[1] and Wolf-Christian Müller[1,2] — [1]Technische Universität Berlin, Berlin, Germany — [2]Max-Planck/Princeton Center for Plasma Physics, Princeton, NJ, USA

Magnetohydrodynamics (MHD) solvers are very important tools to analyze the large-scale, long time behaviour of astrophysical plasmas. Direct numerical simulations are however linked with high computational costs, so that a trade-off between accuracy of the results and the available resources has to be made. Higher-order solvers, i.e. solvers with a discretization order strictly higher than two, can typically achieve higher accuracy at a lower resolution than second-order ones, leading to an overall gain in performance. However, with increasing discretization order, solvers based on 3D-reconstructions may become prohibitively expensive. We present a finite-volume dimension-by-dimension method which allows to solve for the MHD equations at arbitrarily high discretization orders (we show results up to order ten), while maintaining affordable numerical costs for 3D problems. The magnetic field solenoidality is preserved up to machine precision with the constrained-transport approach. The study is limited to subsonic systems since shocks are not handled properly by higher-order methods. For a discretization order of six and above, the numerical dissipation is too low to prevent a pile-up of energy at small scales in turbulent systems, so that explicit diffusive terms need to be added. We present a formulation to do so, respecting the finite-volume and the constrained-transport frameworks.

EP 6.3 Wed 11:45 EP-H1
ComPol - A Compton polarimeter in a Nanosat — •Matthias Meier for the ComPol-Collaboration — Excellence Cluster ORIGINS, Garching, Germany — Technical University of Munich (TUM), Munich, Germany — Max-Planck Institute for Physics (MPP), Munich, Germany

The possibilities to investigate astrophysical compact objects are strongly limited. Due to the small size of these objects it is hardly possible to resolve their geometry. The CubeSat mission ComPol will investigate the black hole binary system Cygnus X-1. The goal is to improve its physical model by measuring the polarization of the hard X-ray spectrum. The information about the polarization can be extracted from the kinematics of the Compton scattering. A Silicon drift detector (SDD) is used as a scatterer. The SDD is stacked onto a CeBr3 calorimeter to be able to measure the full kinematics.

The talk will give an overview of the scientific motivation, the underlying physics and the detector setup.

This research was supported by the Excellence Cluster ORIGINS which is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy - EXC-2094-390783311

EP 6.4 Wed 12:00 EP-H1
A background study via simulations for the ComPol CubeSat experiment — •Cynthia Glas for the ComPol-Collaboration — Max-Planck-Institut für Physik, München, Deutschland — Technische Universität München, Deutschland

The objective of the CubeSat mission ComPol is to investigate the black hole binary Cygnus X-1 and to improve its physical model by measuring spectrum and polarization in the hard X-ray range. The information about the polarization can be extracted from the kinematics of Compton scattering.

To ensure a correct measurement, all physical processes occurring in the detectors, as well as common background sources need to be understood in advance. Therefore, the response of the setup to cosmic radiation in low earth orbit, as well as the south Atlantic anomaly is simulated with the Monte Carlo toolkit Geant4. Special focus was set on the cosmogenic activation of the CubeSat material. In order to determine which orbits are suitable for the ComPol mission, the activation of each material and the influence of radioactive decays originating from this activation on the individual detectors are studied in detail. To optimize the shielding strategy, simulations with different shielding configurations were performed. The talk will give an overview of the performed simulations, present the conclusions drawn from them, as well as discuss different shielding configurations.

This research was supported by the Excellence Cluster ORIGINS, which is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany*s Excellence Strategy.

EP 6.5 Wed 12:15 EP-H1
ComPol's way to space - preparing a CubeSat Compton Telescope for its in orbit verification (IOV) at the ISS — •Katrin Geigenberger for the ComPol-Collaboration — Max-Planck Institute for Physics (MPP), Munich, Germany — Technical University of Munich (TUM), Munich, Germany

ComPol will be a 3U-CubeSat with a Compton polarimeter consisting of a Silicon Drift Detector and a CeBr3 calorimeter. It will perform a long-term measurement of Cygnus X-1 in the hard X-ray range. The goal is to determine the polarization between 20 and 300 keV - a region where the polarization of Cygnus X-1 was hardly observed before. This talk is about the steps towards the first big milestone: a scaled-down version of ComPol's future instrumentation will be operated along with essential parts of the CubeSat bus on an external platform aboard the International Space Station (ISS). This IOV-mission will be a first real life demonstration of the detector system in space environment (background radiation, thermal loads and vacuum). The goal is to receive and process coincident signals from both detectors and to determine the influence of solar, x-ray, and cosmic radiation backgrounds. An overview of the current status of both mechanical and electrical hardware for the very first ComPol prototype will be given with focus on the space-mission specific challenges: e.g. shortage of room, protection of the sensitive detectors from solar radiation, constraints due to vacuum, and the investigation of the behavior at launch loads. This research was supported by the Excellence Cluster ORIGINS which is funded by the Deutsche Forschungsgemeinschaft (DFG).

EP 6.6 Wed 12:30 EP-H1
Stochastic Fluctuations of Cosmic Rays: From Voyager Data to Ionization Rate in Molecular Clouds — •Vo Hong Minh Phan[1], Florian Schulze[1], Philipp Mertsch[1], Sarah Recchia[2], and Stefano Gabici[3] — [1]Institute for Theoretical Particle Physics and Cosmology (TTK), RWTH Aachen University, Aachen, Germany — [2]Dipartimento di Fisica, Universitá di Torino, Torino, Italy — [3]University of Paris, CNRS, Astroparticule et Cosmologie, Paris, France

Data from the Voyager probes have provided us with the first measurement of cosmic ray intensities at MeV energies, an energy range that had previously not been explored. Simple extrapolations of models that fit data at GeV energies, e.g., from AMS-02, however, fail to reproduce the Voyager data in that the predicted intensities are too high. Oftentimes, this discrepancy is addressed by adding a break to the source spectrum or the diffusion coefficient in an ad hoc fashion, with a convincing physical explanation yet to be provided. In this talk, we will show that the discrete nature of cosmic-ray sources, which is usually ignored, is instead a more likely explanation. We model the distribution of intensities expected from a statistical model of discrete sources and show that its expectation value is not representative but has a spectral shape different from that for a typical configuration of sources. The Voyager proton and electron data are however compatible with the median of the intensity distribution. We will also discuss some preliminary results concerning the ionization rate induced by low-energy cosmic rays in molecular clouds.

EP 6.7 Wed 12:45 EP-H1

Efficient numerical simulations of dynamical cosmic-ray transport — •Stefan Kis[1], Pranab Deka[2], Ralf Kissmann[1], and Lukas Einkemmer[2] — [1]Institut für Astro- und Teilchenphysik, Leopold-Franzens-Universität Innsbruck, A-6020 Innsbruck, Austria — [2]Institut für Mathematik, Leopold-Franzens-Universität Innsbruck, A-6020 Innsbruck, Austria

Understanding the transport of charged particles in the Galaxy requires numerically solving a parabolic linear partial differential equation known as the cosmic-ray transport equation. Various codes aim at doing so, however most rely on a single approach in solving the time dependent problem and some do not provide substantial testing grounds for their solvers. We present a study case for various numerical time integrator schemes employed in solving the dynamical cosmic-ray transport equation. We asses the stability of the time integrator schemes and compare the numerical output against an analytical solution to determine their accuracy as well as judge their efficiency in the context of cosmic-ray transport.

EP 6.8 Wed 13:00 EP-H1

Relativistic regularized kappa distributions — •Linh Han Thanh — Ruhr-Universität Bochum

Within the framework of relativistic kinetic theory, a special relativistic generalization of isotropic kappa distributions is proposed, based on the requirement that in the non-relativistic limit the original distributions are recovered. By studying the moments, it is found that the relativistic description of the standard kappa distribution leads to an even greater restriction on allowed kappa values than in the non-relativistic case, whereas the relativistic regularized kappa distribution is able to remove all divergences.