EP 1: Astrophysics I

Time: Monday 14:45–15:45 Location: KH 01.019

Invited Talk EP 1.1 Mon 14:45 KH 01.019

Nuclear Astrophysics and Gamma Rays: From Space to Earth — •Thomas Siegert — JMU Würzburg

Gamma rays provide a unique window on nuclear processes occurring throughout the Universe, directly tracing radioactive isotopes and matter antimatter annihilation. In this talk, I will review key results from gamma-ray line spectroscopy in space, focusing on observations from 22 years of the now completed ESA satellite mission INTEGRAL. Measurements of radioactive isotopes, such as 26Al and 60Fe, reveal ongoing nucleosynthesis in the Galaxy and connect stellar explosions to traces found on Earth, including signatures preserved in ocean crust sediments. In this context, the long-standing puzzle of the Galactic 511 keV positron annihilation emission is also discussed. NASA's Compton Spectrometer and Imager (COSI) mission, scheduled for launch in 2027, is expected to significantly advance MeV measurements thanks to its increased sensitivity and imaging capabilities. I will introduce the Compton telescope concept and highlight open questions addressed by COSI, such as the role of massive stars and supernovae in Galactic feedback. Finally, I will show how analysis and imaging techniques developed for space-based gamma-ray astronomy are now being applied on Earth, enabling isotopic imaging of radioactive residues in nuclear facilities and related environments.

EP 1.2 Mon 15:15 KH 01.019

Contribution of Stellar flares to the 511keV galactic positron budget — •Saurabh Mittal and Thomas Siegert — Julius-Maximilian-Universität, Würzburg

The origin of the Galactic 511 keV positron annihilation line has been a mystery for five decades. One proposed explanation is positron production in stellar flares, motivated by the detection of the 511 keV line in solar flares and by the association of this emission with old stellar populations. In this work, we explore this scenario using two complementary approaches. First, we build a theoretical model to estimate the quasi-persistent 511 keV emission from flaring stars. Starting from solar flare observations, we construct empirical scaling relations between flare energy and 511 keV luminosity and extend them to Galactic stellar populations using flare-frequency-energy distributions for different spectral types. In parallel, we analyze INTEGRAL/SPI data in the 511 keV band using combinations of known point sources and simple spatial templates, such as disk and bulge components modeled as two-dimensional Gaussians. We also test alternative descriptions in which no bulge template is assumed and the emission is instead described by a disk component together with a population of globular clusters, scaled by their masses and distances. This ongoing work aims to assess whether stellar flares can plausibly account for the observed Galactic 511 keV emission.

EP 1.3 Mon 15:30 KH 01.019

On the cosmic-ray diffusion tensor in dynamical galactic halos — Jens Kleimann[1], •Horst Fichtner[1], Michael Stein[2], Ralf-Juergen Dettmar[2], Dominik Bomans[2], and Sean Oughton[3] — [1]Theoretische Physik IV, Ruhr-Universität Bochum, Germany — [2]Astronomisches Institut, Ruhr-Universität Bochum, Germany — [3]Department of Mathematics, University of Waikato, New Zealand

Galactic halos separate the interstellar from the intergalactic medium. One question related to their physics is: How are cosmic rays transported within these dynamic regions of low density plasma permeated by a turbulent magnetic field? An understanding of cosmic-ray transport in galactic halos is of significance for explaining, e.g., the radio continuum measurements of synchrotron radiation from energetic electrons. Of central importance for the transport is the spatial diffusion tensor of cosmic rays, which can be computed in an ab-initio manner if the turbulence in the background medium is known. After a 'hydrodynamic validation', which revealed a persistent instability of the near-axis flow and could be traced to the galaxy mass, we present numerical solutions of the Reynolds-averaged single-fluid MHD equations. This way we obtained the physical properties of both large-scale MHD and small-scale turbulent quantities and, by employing a state-of-the-art nonlinear theory, the coefficients of parallel and perpendicular diffusion. The simulation results reveal variations in turbulence quantities in a dynamical halo that translate in a significant variation of the corresponding diffusion tensor of cosmic rays.