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A Spectral Cosmic Ray Model for Cosmological Simulations

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Cosmic Rays are the most likely source of non-thermal emission in galaxy clusters. These emissions are found at merger shocks where they can be observed as highly polarized radio relics, in jets of AGNs and sometimes as a diffuse radio halo across the entire galaxy cluster. Self-consistent simulations of these observations have been a challenge over the last decades, as they require models for (re-)acceleration of CRs at shocks, by AGN, or turbulence as well as accurate treatment of energy losses of CRs and their spacial diffusion. Since most of these effects depend on the distribution function of the CR population a simple two-fluid approach of CRs and gas is often not sufficient to self-consistently reproduce observations. We present a spectral cosmic ray model implemented in the cosmological MHD code OpenGadget3 that shows excellent scaling and can be used for the next generation of galaxy and galaxy cluster simulations that include the effects of both, magnetic fields and cosmic ray electrons and protons. After a detailed description of the model and its coupling to our large-scale simulation code, we will discuss the use case of a galaxy cluster merger simulation that includes magnetic fields and cosmic rays with a spectrum represented by up to 96 momentum bins. This simulation allows us to self-consistently investigate the emission from CR electrons while also constraining the kinematic impact of CR protons.

Keywords

Structure Formation; MHD Simulations; Fokker-Planck-Solver; Spectral Cosmic Ray Model;

Collaboration

other Collaboration

Subcategory

Theoretical Methods

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