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Spectral evolution of CR electrons and their synchrotron emission in live MHD models of spiral galaxies

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Recent theoretical and numerical studies incorporating cosmic rays (CRs) into global modelling of magnetized interstellar medium demonstrate that CRs can play an important role in the generation of large-scale galactic magnetic fields and, at the same time, in driving galactic winds. Cosmic-Ray-driven dynamos produce magnetic arms in galactic disks and large-scale helical magnetic fields in galactic halos.

A new element of our present model is the population of CR electrons injected in SN remnants together with CR protons. We use the recently developed Cosmic Ray Energy Spectrum - CRESP module of PIERNIK MHD code (Ogrodnik et al 2021) to study the propagation of spectrally resolved CR electrons, coupled with the MHD evolution of modelled galaxies. The CRESP module is designed for modelling energy-dependent transport, of Cosmic Ray (CR) electrons in galactic magnetic fields. The module solves the Fokker-Planck equation for CR electrons characterized by the piece-wise power-law distribution function, with synchrotron, inverse Compton and adiabatic cooling effects are taken into account together with diffusive and advective propagation of CR electrons on an Eulerian grid.

We use the dynamical models of spectral evolution of synchrotron emitting electrons to generate synchrotron emission maps at different radio frequencies together with maps of spectral index and Faraday rotation. We demonstrate that the inclusion of the spectral evolution of CR electron population, combined with MHD modelling of galaxies, opens new opportunities for observational diagnostics of ISM dynamics, CR propagation parameters and for verification of galactic magnetic field structures and amplification models.

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