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Transport, Turbulence and Instabilities in Cosmic Magnetic Fields

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ABSTRACT

THIS DECADE HAS SEEN a large number of space missions, which, alongside ground-based radio, optical and γ-ray telescopes, have enabled a deep insight into the non-thermal astrophysical environments. Interstellar Medium (ISM), Supernovae Remnants (SNRS) and Black-Hole (BH) accretion discs (ADS) are only a few examples of *natural habitat* of interaction of relativistic particles and magnetic fields, largely mediated by the action of the turbulence. In spite of many efforts, and the recent progress in this field, we are still missing a fully comprehension of the nature of the problem.

Throughout the THESIS, the key science driver concept is the transport in magnetic turbulent fields. The aims of the work here presented are meant to be a step in that direction. They can be precisely grouped into two main themes: (i) understanding the transport of Cosmic Rays (CRS), and their dynamical role in the *Milky Way*; (ii) understanding the physics of ADS, with special attention on the magnetic, turbulent environment around compact objects responsible of driving inflow material through the discs. In this regard, I will firstly give a review intended to cover the main theoretical aspects involved in the astrophysics of CRS. A section will be dedicated to the presentation of preliminary results accomplished in the context of the magneto-hydrodynamics (MHD) shearing box numerical simulations of turbulence in ADS.

I will move on by introducing the main achievements of my scientific activity, as reported in the following THESIS. A detailed cosmic ray transport description in the Galaxy has been implemented in the DRAGON code, a numerical tool used to simulate the local interstellar spectra (LIS) of CRS. There is by now compelling evidence of an *anomalous* rise with energy of the cosmic ray positron fraction. Conversely to the *standard picture* of a pure secondary positron production, the data strengthen the evidence for the presence of two distinct electron and positron spectral components. Given the cosmic ray transport model, I will show that nearby pulsars are viable source candidates of the required $e^{\pm}$ extra-component.

In a multichannel analysis of cosmic ray electron and positron spectra, I will present the results of our recent study on the diffuse synchrotron emission of the Galaxy. At low energies - roughly below 4 GeV - we find that the electron primary spectrum is significantly suppressed so that the low-energy total spectrum will turn out to be dominated by secondary particles. Comparing the computed synchrotron emission intensity with the radio data, we placed a constraint on the diffusive magnetic halo scale height, of relevant importance especially for indirect Dark Matter searches.

Fairly poor knowledge is still present about the cosmic ray spectra at low energies, due to the distortion produced by the solar wind on the particle fluxes. Going beyond the standard force-field solar modulation, I will show the results of a self-consistent galactic-plus-solar transport model, where charge-sign dependent motion effects are taken in account.

Lately, I will discuss the impact of a realistic spiral arm distribution of CRS source in the Galaxy, modelling the $e^{\pm}$ spectra measured by PAMELA and AMS-02 by running DRAGON in a full three-dimensional version.

Keywords: Cosmic Rays, ISM, Galactic Magnetic Fields, MHD turbulence, ADS.

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