PhD Project in Astrophysics

Title: A new vision of particle acceleration in the intracluster medium

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Summary:

The existence of large-scale diffuse radio emissions from galaxy clusters and filaments volume filling magnetic fields and of stochastic processes which channel a fraction of the gas kinetic energy into the acceleration of relativistic particles (Brunetti+Jones 2014 for review). The most recent discoveries allowed by low frequency radio observations, especially with LOFAR, have further opened a window into these mechanisms operating in novel regimes, never explored so far.

High resolution numerical simulations represent an ideal tool to couple the state-of-the-art in the theoretical modelling of such processes with the complex evolution of the cosmic structures in which major mergers or the continuous accretion of matter onto clusters of galaxies frequently generate shocks and stir turbulent motions on scales of Megaparsec.

However, in order to match the quality of the data provided by current and upcoming radio surveys, cosmological simulations software has to be extended and improved, introducing innovative algorithms and numerical approaches to describe cosmic ray astrophysics and to exploit the most powerful HPC systems.

In this project, the PhD candidate will work at the design and implementation of new algorithms describing relativistic processes (like injection of relativistic electrons from shocks, radio jets and galactic activity), capable to run on cutting-edge supercomputers, effectively exploiting GPUs and efficiently scaling on thousands of computing nodes in order to study the observable properties of state-of-the-art models of the relativistic particle content of our Universe.

Throughout the PhD programme, the candidate will have the chance to work extensively on cutting-edge supercomputing systems at INAF and CINECA. The candidate will also design, test, and run new large cosmological simulations exploiting the developed algorithms and will have the chance to explore uncharted theoretical territory, by testing the outcome of numerical predictions of particle acceleration scenarios against the latest observational results produced by the new generation of radio surveys.