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PhD Thesis Abstract

## Multiscale modelling of pulsar magnetospheres

Pulsar magnetospheres are one of the most extreme and exotic environments in the Universe. A global model of these high energy density systems involves following the self-consistent collective dynamics of the electron-positron plasma surrounding them, including its ab initio generation, acceleration and the associated radiation processes. Realistic electric and magnetic field geometries, as well as the relevant general relativity space-time metrics that strongly influence and warp their structure around the compact object must be considered. Only such a complete description will be able to determine the key signatures in the electromagnetic (incoherent and coherent, from the radio to the gamma ray region of the spectrum) and particle spectra and make the connection with astronomical observations.

Theoretical and numerical research of pulsar magnetospheres has focused independently on the development of the electron-positron plasma close to the star surface via quantum electrodynamical (QED) processes and in empirical models for plasma injection and dynamics in the outer magnetosphere. Even though these phenomena happen at extremely different (from the microscopic to the macroscopic) scales, they are intimately connected. However, an accurate combination of them requires advanced simulation techniques and has not yet been explored.

With this research, we propose to bridge the microscopic physical processes of electron-positron pair generation due to QED cascades and their self-consistent acceleration and radiative losses to the macroscopic plasma dynamics of pulsar magnetospheres. Resorting to multidimensional massively parallel particle-in-cell simulations and recently developed modules dedicated to first principles studies of QED and radiation processes in extreme plasma conditions, we aim to develop a novel multiscale model of pulsar magnetospheres with potential to make a strong impact in the field.