Kinetic models in neutron star charge starved vacuum gaps

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Magnetic poles are considered as relevant candidates for producing the electron-positron plasma in the close environment of neutron stars [1]. Vacuum gaps appear there because of charge starvation of the magnetosphere and trigger pair discharge. More precisely, the strong rotationally induced electric field accelerates leptons to ultra-relativistic energies, allowing gamma-ray emission. Electron-positron pairs are then created by the quantum electrodynamics (QED) interaction of high-energy photons with the strong electromagnetic field. The cascade process goes on until the electric field is screened. A better understanding of the underlying physics of those discharges would permit to set up analogous laboratory experiments in the future.

In the last decades, several attempts have been made to model from first principles (and with QED effects) the gaps dynamics by the mean of 1D electrostatic particle-in-cell (PIC) codes [2] and 2D electromagnetic PIC codes [3, 4]. It is shown that after its first screening the electric field oscillates and triggers coherent plasma waves. However, there is no existing full kinetic model coupled to the QED processes that can predict the cascade's growth rate, the screening time or the period of the electric field oscillations. In this work, we show that those can be derived analytically in a simplified vacuum setup for a special range of the pulsar parameters. All the analytical results are compared with equivalent simulations using the PIC code OSIRIS-QED.

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