MODELING PHYSICAL PROCESSES IN MAGNETAR MAGNETOSPHERES

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Neutron stars – with sizes only ~ 3 times larger than the Schwarzschield radius (the radius of a black hole of the same mass) and densities comparable to the density of atomic nuclei – are, as far as we know, the most extreme stable objects in the Universe. The extreme physical conditions inside and in the near vicinity of neutron stars could never be reproduced in Earth-based laboratories, and so neutron stars offer a unique opportunity to test fundamental physical theories in the most extreme regimes. Among the various types of neutron stars, the most extreme ones are magnetars – isolated neutron stars with extremely strong magnetic fields. Their magnetic fields exceed the critical quantum field strengths of $\sim 4.4 \times 10^{13}$ Gauss. At these field strengths, particle interaction with the magnetic field proceeds in the quantum regime, and the vacuum can become unstable to the creation of electron-positron pairs. The magnetic field in magnetars is believed to be twisted/tangled. The evolution of the magnetar magnetic field towards configurations with smaller twists powers its activity. Magnetars are powered by the decay of their magnetic fields. Magnetar magnetospheres are filled with dense plasma consisting of electrons and positrons, which plays an important role in the production of magnetar emission.

In the frame of this project, we will model the global structure of twisted magnetar magnetosphere using a high-resolution numerical code for modeling the magnetospheres of neutron stars. We will study in detail how electromagnetic electron-positron cascades operate in different regions of magnetar magnetosphere, filling it with dense electron-positron plasma. Using a hybrid Particle-In-Cell/Monte-Carlo (PIC/MC) numerical code, we will perform a truly self-consistent simulation of particle acceleration, photon emission, and electron-positron pair creation in the magnetar magnetosphere with realistic physical parameters. We will also work on models for Fast Radio Bursts and Long-Period Radio Transients - recently discovered sources of bright radio emission, some of which are suspected to be the observational manifestations of magnetars.