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Implementation of a general relativity module in the OSIRIS PIC code

The magnetospheres of compact objects are complex systems, that comprise kinetic-scale pair plasma physics, quantum electrodynamics (QED) processes, and general relativity (GR). To study such rich systems, advanced simulation techniques are required. Combining traditional particle-in-cell (PIC) codes with dedicated modules that capture these exotic processes allows for a global description of compact objects' magnetospheres. Furthermore, detailed simulations capable of coupling all these processes may be important to identify the key particle acceleration mechanisms and corresponding radiation signatures.

In this work, we will show the first results from the implementation of a GR module in the PIC code OSIRIS, with a focus on benchmarks of generalized Maxwell's equations solver and particle pushers. The GR generalized vacuum solution obtained numerically to the electromagnetic fields surrounding a neutron star will be presented and compared with an analytical solution. A new boundary condition for the fields that perfectly absorbs radial modes will be presented. Finally, we will also show trajectories of test particles obtained with GR generalized particle pushers in regions of combined strong spacetime curvature and electromagnetic fields. These particle pushers will be compared in their accuracy and numerical performances, in order to be used in future global simulations of compact objects' magnetospheres.

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