Physics Department Dissertation Defense

Alireza Rashti
Advisor: Dr. Wolfgang Tichy

Tuesday, June 21, 2022
10:00 AM in SE 319A

`Elliptica`*: a new pseudospectral code for the construction of initial data*

Unveiling the secrets of gravity necessitates numerical relativity simulations of gravitational systems, as observations made by gravitational wave detectors expect an interpretation. In the other hand, these numerical simulations require physical and constraint-satisfying initial data. Therefore, the accuracy of simulations go hand in hand with the accuracy of initial data. As such, constructing accurate initial data is an indispensable task and it is the very subject of this dissertation. In this dissertation, we present the newly developed pseudospectral code `Elliptica`, an infrastructure for construction of initial data for various binary and single gravitational systems of all kinds. The elliptic equations under consideration are solved on a single spatial hypersurface of the spacetime manifold. Using coordinate maps, the hypersurface is covered by patches whose boundaries can adapt to the surface of the compact objects. To solve elliptic equations with arbitrary boundary condition, `Elliptica` deploys a Schur complement domain decomposition method with a direct solver. In this version, we use cubed sphere coordinate maps and the fields are expanded using Chebyshev polynomials of the first kind. Here, we explain the building blocks of `Elliptica` and the initial data construction algorithm for black hole-neutron star binary systems. We perform convergence tests and evolve the data to validate our results. Within our framework, the neutron star can reach spin values close to breakup with arbitrary direction, while the black hole can have arbitrary spin with dimensionless spin magnitude ~ 0.8.