Numerical modeling of dynamos in compact objects: the impact of magnetic field amplification and dissipation

Matteo Bugli, Jérôme Guilet, Thierry Foglizzo, Martin Obergaulinger, Andrea Mignone, Vittoria Berta, Giancarlo Mattia, Luca Del Zanna

Abstract

The amplification of magnetic fields via dynamo mechanisms is a fundamental process that not only shapes the dynamics of stars, but also deeply affects the evolution of compact objects from their formation throughout their activity. Understanding how magnetic fields are dissipated and amplified in the environment surrounding neutron stars and black holes can thus disclose the connection between the properties of the central object and the multi-messenger emission related to the accretion process.

In this talk I will present results from recent studies aimed at quantifying the impact of dynamo-generated magnetic fields on the neutrino and gravitational waves emitted at the formation of a stellar compact object. I will clarify how magnetic fields, by modifying the rotational profile of the proto-neutron star, weaken the development of large-scale instabilities connected to strong multi-messenger signals. I will also show how mean-field dynamos can modify the dynamics of accreting black holes, as weak magnetic seeds are amplified to strong large-scale fields that can reshape the properties of the accretion flow and launch polar outflows. Finally, I will present some recently developed high-order numerical schemes for (relativistic) magnetohydrodynamics whose high-accuracy can significantly reduce the numerical dissipation of magnetic fields observed in simulations and enhance the robustness of their predictions.