The impact of rotation and dynamos on the multi-messenger emission of core-collapse supernovae

Matteo Bugli, Jérôme Guilet, Thierry Foglizzo, Martin Obergaulinger,
Meriem Bendahman, Sonia El Hedri, Isabel Goos

Abstract

The gravitational collapse of a massive star leads to the strong emission of gravitational waves and neutrinos during the first few seconds of the supernova event. Multi-messenger observations offer, thus, a unique window over the dynamics that regulate the explosion mechanism and the physical properties of the still-forming central proto-neutron star (PNS). In recent years, numerical models of core-collapse supernovae (CCSN) have started to produce quantitative predictions of both gravitational waves and neutrino emissions which provide the key ingredients necessary to constraint the physics of the explosion engine from actual observational data. Despite the fundamental role that strong magnetic fields play in the case of exceptionally energetic stellar explosions (e.g. long GRBs, hypernovae, superluminous supernovae. . .), their impact on the multi-messenger emission from CCSN remains still largely unknown.

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. However, this can also lead to a broadening of the spectral shape of the GW signal due to the magnetic field's impact on rotation and possibly the onset of the kink instability within the PNS. I will finally show how current and upcoming neutrino detectors (e.g. KM3Net, DUNE, DarkSide) will be sensitive to the effects of rotation and strong magnetic fields predicted by our numerical models.