Modelling the central engine of Gamma-ray Bursts

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The detection of the first gravitational wave signal GW170817 associated with a binary neutron star merger and its electromagnetic counterpart, the Gamma-ray Burst GRB 170817A, marked the dawn of multi-messenger astronomy. In addition, extreme core-collapse supernovae (type Ic-BL), known as "hypernovae", associated with long GRBs, would also emit gravitational waves and neutrinos. The production of a relativistic jet in these events may explain the electromagnetic emission of GRBs. The launch mechanism of these jets is intricately connected to the formation and the dynamics of the central engine, which corresponds to a fast-rotating compact object, either a black hole or a neutron star, surrounded by accreting matter. Understanding the jet launching conditions and the physical processes happening in these systems is therefore crucial for multi-messenger predictions.

I will give an overview of recent numerical models describing the evolution of extreme astrophysical events such as the collapse of massive rotating stars and the merger of neutron star binaries, which can both lead to the formation of relativistic jets. In particular, I will focus on the key physical ingredients, fast rotation and strong large-scale magnetic fields, that drive the jet launch mechanism and their impact on the resulting multi-wavelength, multi-messenger emissions.