Seventeenth Marcel Grossmann Meeting

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On the gravitational collapse and the formation of compact-object binaries from binary-driven hypernovae

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The binary-driven hypernova (BdHN) model proposes long gamma-ray bursts (GRBs) originate in binaries composed of a carbon-oxygen (CO) star and a neutron star (NS) companion. The CO collapse triggers the GRB. It generates a newborn NS (νNS) and a supernova (SN) that accretes onto the NS and the νNS. This accretion process, which is highly super-Eddington, rapidly transfers mass and angular momentum to the stars.

In this work, we investigate the binary parameters that determine whether the νNS or the NS companion undergoes gravitational collapse into a BH during the accretion process, weather quark deconfinement can occur and whether the system remains gravitationally bound forming NS-NS or NS-BH binaries.To this end, we use smooth hydrodynamic simulations to model the expansion of the SN material in the gravitational field of the NS and the νNS. We employ up-to-date nuclear equations of state (EOS) to describe the NS interior and calculate the structural evolution in full general relativity using an adapted version of the RNS code.

The existence of bound systems predicts an evolutionary connection between the long and short GRB populations. BdHNe I, the most compact (about five minutes orbital period) and energetic, show prompt BH formation. These systems form NS-BH binaries with merger timescales on the order of tens of kiloyears due to gravitational-wave emission. BdHNe II form NS-NS binaries with a wider range of merger timescales. In summary, our findings uncover the physical mechanisms responsible for BdHN and offer insight into the potential results of such catastrophic events in binary systems.

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