Fully general-relativistic simulations of binary neutron-star mergers

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I will present our results on **three-dimensional general-relativistic simulations of binary neutron-star coalescence and merger**, and of the subsequent formation and evolution of the merged object (black-hole) surrounded by a possibly massive self-gravitating disc, which may be the **engine of short gamma-ray bursts** (GRBs). I will focus also on the numerically extracted **gravitational radiation** and on the comparison with the results of independent codes and analytic approximations.

Neutron stars (NSs) are very compact objects formed in the gravitational collapse of massive stars. NSs are at the center of many fascinating phenomena in the Universe, including gamma-ray bursts, supernova explosions, pulsars, and gravitational waves. A large fraction of the current astrophysical research topics in the world focuses on one of the above phenomena.

Binary neutron star systems (BNSs) are especially interesting for two main reasons:

1) BNSs are very strong sources of gravitational waves. By measuring the gravitational signal from BNSs we can – among many other things – get information about the structure and equation of state of NSs; this is actually a prime possibility to investigate the properties of ultra-high density matter, because NS-like densities are not reproducible in laboratory experiments.
2) BNSs are thought to be the engine powering one type of GRBs.

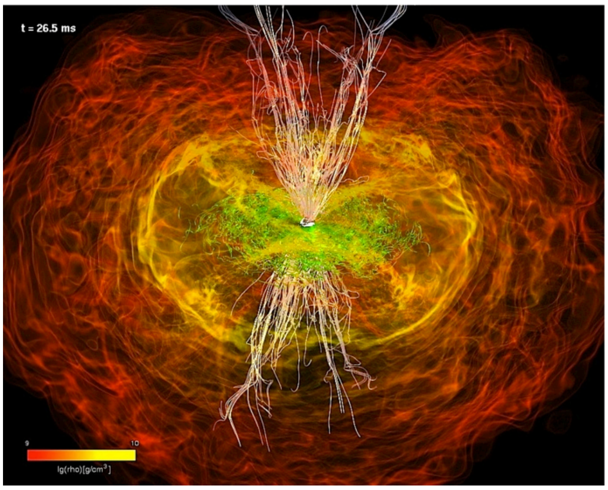

Figure. A snapshot of the formation of a large-scale ordered magnetic field after the merger and collapse of a BNS. Its structure includes a funnel, in which a GRB jet may be launched. Shown with a color-code map is the rest-mass density, over which the magnetic-field lines are superposed. Green lines sample the magnetic field in the disc and on the equatorial plane, while white lines show the magnetic field outside the disc and near the BH spin axis.

A subclass of "short hard" GRBs (lasting less than 2s and with a hard spectrum) are thought to originate from the merger of BNSs. The typical scenario is based on the assumption that a system composed of a rotating black hole (BH) and a surrounding massive torus is formed after the merger of NS-NS or NS-BH binaries. If the disc has a mass greater than 0.1 solar masses, it could supply the large amount of energy involved in GRBs by magnetic-field and neutrino processes.

Furthermore, we report on our study on the tidal effects due to the finite size of neutron stars and on how they can produce a detectable signature in gravitational signals that are likely to be observed by ground-based gravitational wave detectors such as Advanced LIGO. The observation of these tidal effects presents the possibility of measuring neutron star properties which in turn will constrain models for the neutron-star EOS.