Contribution ID: **140**

Type: **not specified**

Equations of state of nuclear matter tested by simulating the merger of two neutron stars

Thursday, 6 September 2018 16:13 (17 minutes)

Binaries Neutron Stars (NSs) mergers can provide many constraints about stellar composition because the evolution and features of these processes strongly depends on the Equation Of State (EOS) of NSs. Indeed, the time of the collapse after the merger, for given masses, is determined by the softness of the EOS. Moreover, the process results in the ejection of matter, both during the merger due to tidal torques and/or shocks and after the merger from the disk formed around the remnant. This suggests NSs mergers to host r-processes. The decay of the produced nuclei has been directly detected as an EM signal (AT2017gfo kilonova), after the merger event observed on the 17th August 2017. The luminosity, frequency, time evolution and angle of the signal has been directly related to the features of the ejecta. We have performed hydrodynamical simulations of the NS merger in the general relativistic framework of the Einstein Toolkit code. We have compared two EOSs for different total masses of symmetric binaries; the first is the SFHo EOS which contains just ordinary matter while the second is an EOS which is characterized by the appearence in the high density regime of hyperons and delta particles. This feature leads to a softening, preventing this EOS to reach the two solar mass limit (in this scenario the more massive compact stars would be quark stars). The features of the two EOSs translate into different outcomes of the simulations: we have calculated the treshold mass for the hyperonic EOS, meaning the maximum mass for which the remnant does not make a promtp collapse to black hole. While the remnant in the case of SFHo survives for dozens of ms for a 1.3-1.3 solar masses binary, we found that already the 1.23-1.23 solar masses binary collapses promptly. In this scenario the event of August 2017 is interpreted as the merger of a quark star with a NS. We have also calculated the amount, the mean velocity and the angular distribution of the dynamical ejecta for a NS-NS merger. We found that, if a prompt collapse does not take place, the amount of matter ejected is from 4 times to an order of magnitude larger for the hyperonic with respect to the SFHo EOS case. This can be explained in terms of a greater contribution of the shock component for softer EOS.

Selected session

Nuclear Astrophysics

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Session Classification: Nuclear Astrophysics