Project: Merging Neutron Stars and Related Phenomena

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The discovery of the gravitational event GW170817 has focused our attention on merging of compact objects such as neutron stars.
Matteucci et al. (2014) had first envisaged the importance of computing the rate of merging neutron stars to test whether these systems could be the main responsible for the production of r-process elements, such as Europium, in the Milky Way. In fact, supernovae core collapse (CC-SNe) have some difficulty in producing the right amount of Eu to explain its abundance in the Solar System.
The conclusions of Matteucci et al. (2014) were that merging neutron stars can produce all the Eu in the Solar System and reproduce the [Eu/Fe] vs. [Fe/H] relation observed in the solar vicinity only if the delay time requested to merge is constant and very short (1 Myr). Then, the GW170817 event showed that the merging event had occurred in an early type galaxy where star formation stopped 10 Gyr ago. This creates a clear problem for the short time delay as well as for explaining the cosmic rate of short gamma ray bursts (SGRBs), as pointed out in Simonetti et al. (2019), who suggested that either the inclusion of CC-SNe as Eu producers and a distribution of delay times for merging, or a variable fraction of binary systems of neutron stars with time could reproduce at the same time the [Eu/Fe] in the Milky Way, the rate of SGRBs and the event GW170817. The contribution of CC-SNe and longer time delays were suggested also by Cescutti et al. (2015) to explain the [Eu/Fe] data in the Galactic halo by means of a stochastic model able to reproduce the observed spread of this ratio at low metallicities.
The scope of this project will be to compute the rates of merging neutron stars in galaxies of different morphological type, whose models are already available, by adopting a new delay time distribution function for merging thoretically derived (Greggio, Simonetti & Matteucci, 2020 in preparation), including several parameters mostly related to the distribution of separations of the binary systems when the secondary star explodes. This is a new formulation since generally the delay time distribution functions are obtained in the literature from numerical computations based on population synthesis models. Then, the computed rates will be compared with the cosmic rate of SGRBs, the local and cosmic rates of kilonovae, as well as the [Eu/Fe] vs. [Fe/H] plot in the Milky Way and other galaxies of the Local Group.

References

Cescutti et al. 2015, A&A, 577, 139
Matteucci et al. 2014, MNRAS, 438, 2177
Simonetti et al. 2019, MNRAS 486, 2896