

Towards experimental study of compact binary ejecta opacity relevant for kilonova transient signals

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Joint observations of gravitational-wave (GW) event to compact binary objects mergers, and of their electromagnetic counterpart, known as kilonova (KN) lead to a new avenue in the multi-messenger astronomy era to constrain the astrophysical origin of the r-process elements and the equation of state of dense nuclear matter [1]. Coalescence of double neutron star releases n-rich ejecta which undergoes r-process nucleosynthesis, driving the quick evolution of the KN transient powered by freshly synthesized decaying radionuclides. KNe act as spectral probes to explore the merger environment, hence of fundamental relevance for future detection and for providing sounder nucleosynthetic yields occurring in these loci [2]. However, largely heterogeneous post-merging ejecta composition, of both light and heavy-r process nuclei, propagates strong effects on the KN light-curve prediction through the ejecta opacity, till today hard to be fully addressed by theoretical models. Here we will present some peculiar features of the KN studies, focusing on the opacity issue, from the atomic and plasma physics perspectives. We report on the paradigm of early-stage timescale KN emission at optical wavelengths from light r-process ejecta component, and we present the work carried out in the framework of the PANDORA collaboration [3] to support planned experimental measurements of plasma opacity with in-laboratory plasmas resembling these KN-stage conditions [4]. In this view, the results of recently performed experiments at the INFN-LNS on the Flexible Plasma Trap (FPT) to reproduce suitable early-stage ejecta conditions for the designed first-of-its-kind opacity measurements of under-dense and low-temperature plasmas are here reported. We will also discuss some of the experimental progresses on the problem, including instruments and methods opening to an interdisciplinary approach for tackling astrophysical problems in laboratory plasmas.

[1] Rosswog S. The multi-messenger picture of compact binary mergers. *International Journal of Modern Physics D* 24 (2015) 1530012.

[2] Kasen D., et al. Origin of the heavy elements in binary neutron-star mergers from a gravitational-wave event. *Nature* 551 (2017) 80–84.

[3] Mascali D., et al. A novel approach to beta-decay: PANDORA, a new experimental setup for future in-plasma measurements. *Universe* 8 (2022).

[4] Piatella A., et al. In-plasma study of opacity relevant for compact binary ejecta. *Il Nuovo Cimento C* 44 (2021) 4.

Primary author: PIDATELLA, Angelo (Istituto Nazionale di Fisica Nucleare - Laboratori Nazionali del Sud)

Presenter: PIDATELLA, Angelo (Istituto Nazionale di Fisica Nucleare - Laboratori Nazionali del Sud)

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