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Exploring Multi-Messenger Evidences of a Magnetar Birth in Gamma-Ray Bursts

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Gamma-ray bursts (GRBs) are among the most explosive and brightest transient phenomena in the universe, occurring at cosmological distances. After decades of investigation, the origin of the jet composition, the radiation, and energy dissipation mechanisms of GRBs are among the most important open questions regarding the nature of the GRB central engine.
Here, we consider the evolution of a newly formed magnetized NS as a power source of GRBs through multi-Messenger Evidences. Both compressible and incompressible Maclaurin spheroid are adopted to model the time evolution of the magnetar and the resulting Electromagnetic (EM) and gravitational wave (GW) emissions. The properties of the EM and GW luminosities are significantly affected by NS parameters, including the magnetic field's strength and structure, ellipticity, and the fluid's equation of state (EOS).
We show that some of the observed characteristics of GRB light curve such as the appearance of X-ray flares can be captured by our model. Our findings indicate that the ongoing and upcoming joint multi-messenger observations of GRBs can be used to understand the nature of the central engine and to give hint about the possible formation of a highly magnetized NS at the early times of the burst formations.

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