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Exploring the Progenitor of the Crab Nebula and Crab Pulsar: Insights from Binary-Driven Hypernovae

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We propose that the progenitor of the Crab Nebula and the Crab pulsar shares similarities with binary-driven hypernovae. The understanding of binary-driven hypernovae has revealed the crucial role played by the explosion of the supernova, as well as the hypercritical accretion of the supernova ejecta onto the binary companion neutron star (NS) and the newborn NS (νNS) in determining the dynamics of gamma-ray bursts (GRBs). The synchrotron emission resulting from the νNS-pulsar emission and the accreted supernova ejecta onto the νNS gives rise to X-ray afterglows. Notably, we find evidence that the X-ray afterglow luminosity of GRB 190114C, selected as a prototype binary-driven hypernova, when extrapolated to 1000 years, coincides with the presently observed emission of the Crab Nebula. To model the νNS, we employ the equilibrium sequence of Maclaurin spheroids. By ensuring that the νNS period extrapolated to 1000 years matches that of PSR B0531+21 (the Crab pulsar), we determine the initial spin of the νNS to be 0.9 ms. Subsequently, we track the evolution of the eccentricity, which manifests itself through the release of rotational and gravitational energy of the νNS-pulsar.

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