HONEST 3 The high end of Pulsar spectra
HOT TOPICS IN HIGH ENERGY ASTROPHYSICS

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Pulsar wind nebulae meeting the circumstellar medium of their progenitors

A significative fraction of high-mass stars sail away through the interstellar medium of the galaxies. Once they evolved and died via a core-collapse supernova, a magnetized, rotating neutron star (a pulsar) is usually their leftover. The immediate surroundings of the pulsar is the pulsar wind, which forms a nebula whose morphology is shaped by the supernova ejecta, channeled into the circumstellar medium of the progenitor star in the pre-supernova time. Consequently, irregular pulsar wind nebulae display a large variety of radio appearances, screened by their interacting supernova blast wave and/or harboring asymmetric up–down emission. Here, we present a series of 2.5-dimensional (2 dimensions for the scalar quantities plus a toroidal component for the vectors) non-relativistic magneto-hydrodynamical simulations exploring the evolution of the pulsar wind nebulae (PWNe) generated by a red supergiant and a Wolf-Rayet massive supernova progenitors, moving with Mach number $M = 1$ and $M = 2$ into the warm phase of the galactic plane. In such a simplified approach, the progenitor's direction of motion, the local ambient medium magnetic field, the progenitor and pulsar axis of rotation, are all aligned, which restrict our study to peculiar pulsar wind nebula of high equatorial energy flux. We found that the reverberation of the termination shock of the pulsar wind nebulae, when sufficiently embedded into its dead stellar surroundings and interacting with the supernova ejecta, is asymmetric and differs greatly as a function of the past circumstellar evolution of its progenitor, which reflects into their projected radio synchrotron emission. This mechanism is particularly at work in the context of remnants involving slowly-moving and/or very massive stars. We find that the mixing of material in plerionic core-collapse supernova remnants is strongly affected by the asymmetric reverberation in their pulsar wind nebulae.

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