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New Dynamics of Pulsar Wind Nebulae: Effects of Mass Loading

Pulsar wind nebulae (PWNe) are one of the most representative examples of galactic gamma-ray emitters and are thought to be the origin of cosmic ray (CR) positrons and knee CRs. The free energy of these non-thermal particles is the rotational energy of the central pulsar, but we have not understood how the rotational energy is converted into the pulsar wind, how the pulsar wind is dissipated, and how the non-thermal particles are accelerated in the PWN. Optical observations and hydrodynamical simulations showed that supernova ejecta mix with the PWN due to the Rayleigh-Taylor instability. However, no one investigates effects of the mass loading on the PWN structure (e.g. Kennel and Coroniti 1984). In this work, we solve the spherically-symmetric steady-state relativistic magnetohydrodynamical wind structure in the downstream region of the termination shock by considering the mass loading from the supernova ejecta. We found a surprising solution that the shocked wind accelerates due to the mass loading. Further more, this wind solution does not connect to infinite distances even though ten percent of the original electron-positrons is injected.There is no steady-state solution at some distance from the termination shock, which means the shocked pulsar wind is dynamic and turbulent. In this talk, we will provide the new solutions and the physical mechanism of the wind acceleration, and discuss effects of the mass loading on the above open questions and the so-called sigma problem.

Collaboration(s)

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