Astrophysics Seminars

Pulsar/Stellar wind collision in 3D and The origin of the X-ray-emitting object moving away from PSR B1259-63

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For the first time, we simulate in 3 dimensions the interaction of isotropic stellar and relativistic pulsar winds along one full orbit, on scales well beyond the binary size. We used the code PLUTO to carry out relativistic hydrodynamical simulations in 2 and 3 dimensions of the interaction between a slow dense wind and a mildly relativistic wind with Lorentz factor 2, along one full orbit in a region up to ~100 times the binary size. The simulations in 3 dimensions confirm previous results in 2 dimensions, showing: a strong shock induced by Coriolis forces that terminates the pulsar wind also in the opposite direction to the star; strong bending of the shocked-wind structure against the pulsar motion; and the generation of turbulence. The shocked flows are also subject to a faster development of instabilities in 3 dimensions, which enhances shocks, two-wind mixing, and large-scale disruption of the shocked structure. In addition to the Kelvin-Helmholtz instability, discussed in the past, we find that the Richtmyer-Meshkov and the Rayleigh-Taylor instabilities are very likely acting together in the shocked flow evolution.

A mysterious X-ray-emitting object has been detected moving away from the high-mass gamma-ray binary PSR B1259-63, which contains a non-accreting pulsar and a Be star whose winds collide forming a complex interaction structure. Given the strong eccentricity of this binary, the interaction structure should be strongly anisotropic, which together with the complex evolution of the shocked winds, could explain the origin of the observed moving X-ray feature. We propose here that a fast outflow made of a pulsar-stellar wind mixture is always present moving away from the binary in the apastron direction, with the injection of stellar wind occurring at orbital phases close to periastron passage. This outflow periodically loaded with stellar wind would move with a high speed, and likely host non-thermal activity due to shocks, on scales similar to those of the observed moving X-ray object. Such an outflow is thus a very good candidate to explain this X-ray feature. This, if confirmed, would imply pulsar-to-stellar wind thrust ratios of 0.1, and the presence of a jet-like structure on the larger scales, up to its termination in the interstellar medium.

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