Progress in pulsar wind nebulae models

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I will review the magnetohydrodynamic and particle transport modeling of PWN, highlighting recent advances with 3D global models of the Crab nebula [1, 2]. Earlier 2D MHD models were very successful in reproducing features of the inner Crab nebula such as the jet, concentric wisps and variable knots. However, these models are limited to a purely toroidal field geometry which leads to a strong polar jet accompanied by an exaggerated axial compression of the termination shock - in contrast to the observations. In three dimensions, the toroidal field structure is susceptible to current driven instabilities which imprints on the dynamics of the nebula and is able to resolve long standing problems in the modeling of PWN.

High velocity fluctuations in the turbulent nebula (downstream of the termination shock) give rise to efficient diffusive transport of particles, with average Péclet number close to unity, indicating that both advection and diffusion play an important role in particle transport. A simple model that relates the diffusive transport coefficient to the size of the termination shock yields good fits to the spectral index in selected young PWN[3]. The ensuing turbulent magnetic dissipation is now increasingly becoming the focus of current research. [4, 5, 6] I will conclude with a discussion of solved and unsolved problems posed by PWN.

References