MAGNETIC RECONNECTION AT THE TERMINATION SHOCK IN A STRIPED PULSAR WIND

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Most of the rotational luminosity of a pulsar is carried away by a relativistic magnetised wind in which the matter energy flux is negligible compared to the Poynting flux. However, observations of the Crab nebula for instance clearly indicate that most of the Poynting flux is eventually converted into ultra-relativistic particles. The mechanism responsible for transformation of the electro-magnetic energy into the particle energy remains poorly understood. An important point is that most of the energy is transported in the equatorial belt of the wind and as the pulsar rotates obliquely, the magnetic field in this zone reverses polarity each pulsar period forming stripes with oppositely directed field lines. Dissipation of alternating fields in such a striped wind is the main mechanism of the energy release in pulsar winds. I show that alternating magnetic fields annihilate easily at the shock front arising when the wind interacts with the surroundings. A very simple criterion for dissipation of alternating fields at the shock front is found. The model depends on a free parameter $\xi > 1$, which is the ratio of the current sheet width to the particle Larmor radius. 1D relativistic PIC simulations confirm this criterion and enable us to fix the free parameter ξ in the analytical model.

I discuss implication of this result for pulsar wind nebulae and double pulsar systems. In pulsar wind nebulae, the condition for full magnetic dissipation is satisfied at the termination shock so that the Poynting flux may be converted into ultra-relativistic particles not in the pulsar wind but just at the termination shock. The constraints are more severe for the intra-binary shocks in double pulsar systems. Available models explaining observations require low magnetisation in the downstream flow. The condition that the magnetic field dissipates at the intra-binary shock implies an upper limit on the pair multiplicity in the pulsar wind, $\kappa <$ few $\times 10^4$. In the double pulsar PSR 0737-3039, the radio emission from the pulsar B is modulated with the period of the pulsar A, which implies that the striped structure is not erased completely; this gives a lower limit for $\kappa > 300$.