7th Heidelberg International Symposium on High-Energy Gamma-Ray Astronomy

Contribution ID: **263** Type: **Contributed talk**

Particle acceleration at pulsar wind termination shocks revisited: shear, reconnection and giant plasmoids

Thursday, 7 July 2022 15:00 (15 minutes)

Particle acceleration in relativistic shocks is quenched in the presence of a transverse magnetic field, even for a moderately low upstream magnetization. Pulsar wind nebulae form downstream of an ultra-relativistic magnetized shock; yet these objects are one of the most efficient particle accelerators known in the Galaxy. We propose that the key to this striking discrepancy lies in the anisotropic nature of the magnetic field profile in the pulsar wind. Using particle-in-cell simulations, we show that it has a dramatic impact on the structure and evolution of the shock. The formation of a current sheet in the equatorial plane, combined with a large-scale velocity shear flow lead to strong plasma turbulence and efficient non-thermal particle acceleration near the Bohm limit. The interplay between these processes may power the bright synchrotron nebula surrounding pulsars and possibly the puzzling Crab gamma-ray flares. Another important feature of the predicted shock structure is the presence of hot macroscopic filaments whose formation is driven by reconnection along the equatorial plane. We argue that these compact plasma structures (giant plasmoids) may explain the mysterious knots contained within the Crab Nebula inner ring.

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Session Classification: Contributed Talks