Inductive particle acceleration in pulsar winds

J.G. Kirk, G. Giacinti
Max Planck Institute for Nuclear Physics, Heidelberg, Germany

The magnetized neutron star at the heart of a pulsar loses its rotational energy by driving a wind. Close to the star, electron-positron pairs provide a plasma that is dense enough to justify an MHD description of the wind, leading to the well-known striped structure, provided an oblique dipole or split monopole configuration is assumed in the near zone. The MHD description implies that a such a cold, radial wind, with a strong, frozen-in wave pattern propagates at constant velocity. But, in spherical geometry, there exists a critical radius at which “charge-starvation” sets in and beyond which the current, caused by induction associated with the wave pattern, causes the wind to accelerate.

In many pulsars, this radius lies well beyond the point at which the ram pressure of the wind falls to that of the ambient medium. However, the effect is relevant for isolated pulsars, in particular, if the supply of charges from the star is, for some reason, disrupted. We show that the disruption of the charge-supply to the wind of the Crab pulsar can lead to a tightly collimated, radial beam of almost mono-energetic electrons and positrons with energy up to 10 PeV. When these penetrate into the surrounding Crab Nebula, they produce a burst of synchrotron radiation in the hard gamma-ray range (hundreds of MeV) [1]. The spectra, timescale of variation and overall luminosity of such bursts is strikingly similar to those of the gamma-ray flares observed by the AGILE and Fermi satellites. This talk will discuss the prospects for observing a similar acceleration process in other astrophysical objects and in the laboratory.

[1] Kirk, J.G., Giacinti, G., Physical Review Letters 119.211101 (2017)