Multi-wavelength light-curve fitting of young and millisecond pulsars

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Since the launch of the Fermi gamma-ray telescope, several hundred radio-loud gamma-ray pulsars have been detected, some belonging to the millisecond pulsars and some part of the young pulsar population (with spin periods longer than 30 ms). Observing simultaneously pulsed radio and gamma-ray emission from these stars helps to constrain the geometry and radiation mechanisms within their magnetosphere and to localize the photon production sites. In this presentation we show how time-aligned gamma-ray light curve fitting of young and millisecond pulsars constrain their magnetospheric configuration, namely the magnetic axis and line-of-sight inclination angles. To this end, we assume a dipole force-free magnetosphere where radio photons emanate from high altitudes above the polar caps and gamma-rays originate from the pulsar striped wind. Further constraints were obtained from radio polarization measurements, if available, following the rotating vector model, including aberration and retardation effects.

We find good agreement between our emission model and the time-aligned single- or double-peaked gamma-ray pulsar observations. We deduce the magnetic inclination angle and the observer line-of-sight with respect to the rotation axis within a small error bar. The distinction between radio-loud or radio-quiet gamma-ray pulsars or only radio pulsars is entirely related to the geometry of the associated emitting regions. We are currently extending our analysis to thermal and non-thermal X-ray emission using observations from several X-ray telescopes. Preliminary results applied to a bright pulsar show that the non-thermal X-rays are produced between 20% and 40% of the light cylinder radius.

The high-altitude polar cap model combined with the striped wind represents a minimalistic approach able to reproduce a wealth of gamma-ray pulse profiles for the whole population of pulsars. Based on self-consistent force-free simulations, it gives a full geometrical picture of the emission properties without resorting to detailed knowledge of the individual particle dynamics and energetics. For the first time it becomes possible to localize with high confidence the non-thermal X-ray emission sites within the magnetosphere.