PhD project : **Pulsars and their Wind Nebulae at High Energies**

Pulsars have been intriguing astrophysical sources ever since their discovery more than four decades ago. Only two years after their discovery (1967) in radio waves, gamma-rays and X-rays were detected from the Crab pulsar. Remarkably, the energy loss through the slowing-down of their rotation can provide the power necessary for the detected signals. We also know that these objects exhibit extremely high matter densities (which can oversize the nuclear density of few 10^17 kg/m^3), short rotation periods (sometimes of order of few milliseconds), and we infer, through simple models, that they possess immense magnetic (10^12 G) and electric fields (10^12-10^13 V/m) capable of accelerating particles to ultra-relativistic energies. Different zones of the pulsars magnetosphere, either close to the magnetic poles, or further along the region in between closed and open magnetic field lines, or even in the equatorial plane much further away, are considered to be prime candidates for acceleration of particles and emission of the radio and gamma-ray signals.

In addition to their pulsed emission, the nebular and steady optical, radio, X-ray and gamma-ray emission in the vicinity of many pulsars has been observed since decades (more than two century for the optical!). This phenomenon known as Pulsar Wind Nebula, or PWN, can be attributed to the cooling of the ultra-relativistic gas of particles injected by pulsars into their vicinity.

We are, however, far from a consistent model for the magnetosphere of the pulsars and for their wind nebula, not to mention the pulsar-wind system as a whole.

The present decade constitutes a rare opportunity in terms of wealth of available data in multiple wave-length domains for studying these fascinating objects. The radio catalog of pulsars encompasses more than 2000 objects. While in the mid-1990s, only 7 gamma-ray pulsars had been firmly identified in the GeV range, this number has grown by an order of magnitude since the launch of Fermi/LAT (Large Area Telescope) gamma-ray space telescope in 2008. At very high energies (VHE : >~100 GeV), the H.E.S.S. (High Energy Stereoscopic System), MAGIC and VERITAS ground-based Cherenkov telescopes have unveiled tens of galactic gamma-ray sources, of which the most prominent population is that of PWNe.

Mid-2011 saw the discovery of VHE pulsations from the Crab pulsar by ground-based gamma-ray Cherenkov telescopes, a discovery which was not expected given the very quickly falling spectra (exponential cut-off) measured by Fermi-LAT in the GeV domain for almost all objects.

The thesis work proposed here will cover both observational and phenomenological aspects in the study of pulsars and their wind nebula. The PhD candidate will participate to the development of analysis tools and will analyse data from the Fermi-LAT and from the phase II of the HESS gamma-ray observatory located in Namibia. The overlap in the energy-range of the two instruments should enable she/he to study the high energy behaviour of pulsar spectra, and investigate whether other pulsars than the Crab exhibit a pulsed VHE emission. In parallel she/he will acquire a deep understanding of different models of pulsar magnetospheres and wind nebulae in order to be able to constrain them using the gamma-ray and radio data. The latter could be obtained in collaboration with the Nançay radio-telescope in France. Alternatively a population study could be undertaken, linking the pulsar and its wind nebula properties in a comprehensive scheme.

A significant part of the thesis will be dedicated to the preparation of the next generation ground-based gamma-ray observatory : the CTA (Cherenkov Telescope Array). Putting in application the progress made during the first part of the thesis, and using numerical models of different array configurations, the PhD candidate will participate in the preparation of the Key Observation Program for the CTA consortium for compact objects, including pulsars and their environment.

Supervision of the PhD candidate :

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