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The Pulsar Sequence

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A decade of Fermi-LAT operations has provided a wealth of observational data that shifted the study of gamma-ray pulsars from discovery to astronomy. Moreover, recent observations from ground-based imaging atmospheric Cherenkov telescopes has revealed multi-TeV pulsed emission. The consensus from the latest theoretical modeling is that the high-energy pulsar emission is produced in the equatorial current sheet outside the light cylinder. I will discuss how the observational data along with theoretical considerations constrain the various emission processes (curvature, synchrotron, inverse Compton). I will show that the entire Fermi pulsar population (young and millisecond pulsars) lies on a Fundamental Plane that connects the total gamma-ray luminosity, the cut-off energy, the spin-down power, and the stellar surface magnetic field, which is consistent with curvature radiation emission. Nonetheless, synchrotron radiation can reproduce the lower energy (up to infrared) segment of the pulsar spectrum, while its photons can serve as the seeds that produce emission up to multi-TeV radiation in IC interactions with the high-energy curvature emitting electrons. Finally, I will present our innovative kinetic PIC models of global pulsar magnetospheres with magnetic-field-line dependent particle injection. I will show not only how our simulations validate the above description but also how the particle population, which is injected near the separatrix that separates the open from the closed field lines, regulates the Fermi-LAT gamma-ray emission. Our simulations, more accurately than ever before, reproduce the observed Fermi gamma-ray phenomenology of the millisecond and young pulsars for the entire range of spin-down powers.

Author: KALAPOTHARAKOS, Constantinos (NASA GSFC / UMCP)

Co-authors: Dr HARDING, Alice (NASA GSFC); Dr KAZANAS, Demosthenes (NASA GSFC); Dr WADIASINGH, Zorawar (NASA GSFC / USRA)

Presenter: KALAPOTHARAKOS, Constantinos (NASA GSFC / UMCP)

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