Pulsar Magnetospheres

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The modeling of pulsar radio and gamma-ray emission suggests that in order to interpret the observations one needs to understand the field geometry and the plasma state in the emission region. In recent years, significant progress has been achieved in understanding the magnetospheric structure in the limit of abundant plasma supply. However, the very presence of dense plasma everywhere in the magnetosphere is not obvious. Even the region where the observed emission is produced is subject to debate. To address this from first principles, we constructed global kinetic simulations of pulsar magnetospheres using relativistic Particle-in-Cell codes, which capture the physics of plasma production and particle acceleration. In this talk I will describe how plasma is produced in magnetospheres of pulsars and show that effects of general relativity are crucial for the activity of pulsars with low inclination angles. I will present modeling of high-energy lightcurves, calculated self-consistently from particle motion in the pulsar magnetosphere. I will also show evidence that observed radio emission is powered by non-stationary discharge at the polar cap. Finally, I will argue that giant radio pulses in the Crab are produced by coherent plasma currents, which appear at the interfaces of merging plasmoids in the current sheet beyond the light cylinder.

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