Particle accelerator in pulsar magnetospheres: A unification scheme of inner and outer gap models

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ABSTRACT: We investigate the self-consistent electrodynamic structure of a particle accelerator in the Crab pulsar magnetosphere on the two-dimensional poloidal plane, solving the Poisson equation for the electrostatic potential together with the Boltzmann equations for the electrons, positrons and gamma-rays. If the trans-field thickness of the gap is thin, the created current density becomes sub-Goldreich-Julian, giving the traditional outer-gap solution but with negligible gamma-ray luminosity. As the thickness increases, the created current increases to become super-Goldreich-Julian, giving a new gap solution with substantially screened acceleration electric field in the inner part. In this case, the gap extends towards the neutron star with a positive acceleration field, extracting ions from the stellar surface. The acceleration field is highly unscreened in the outer magnetosphere, resulting in a gamma-ray spectral shape which is consistent with the observations. Outside of the gap, pair creation cascade takes place nearly uniformly, supplying 8×10^{38} particles per second as the source of the pulsar wind.