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Polarization of high-energy emissions from the Crab pulsar

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We discuss polarization characteristics of high-energy photons from pulsar magnetospheres. For the Crab pulsar, the polarization in the optical band has been measured, and the next generation Compton telescope may be able to do that in soft γ -ray bands. Polarization measurements will play an important role to discriminate the various models that successfully explain observed spectra or light curves. As indicated by the outer gap model of Cheng et al. (2000), the Crab optical and soft γ -ray spectrum can be easily explained by the synchrotron radiation. We therefore study the polarization predicted by the **synchrotron emission** in the framework of the outer gap model and the two-pole caustic model (Dyks et al. 2004).

We assume that the emitted photons are linearly polarized at degree of $(p + 1)/(p + 7/3)$ in the direction of particle acceleration, which is perpendicular to the magnetic field line, for which the rotating dipole field is used. Emission direction and Stokes parameters Q and U are appropriately treated with the effects of particle's gyration and aberration. A radial-distance dependent emissivity (Cheng et al. 2000) is employed for the outer gap model and a constant one is assumed for the caustic model.

We find that the degree of polarization predicted by the synchrotron emission in general is more consistent with observation than that of curvature radiation. We find, however, that the minimum in the polarization degree is $< 10\%$ at bridge phase for both models, and the maximum is $\sim 60\%$ at outer wings of peaks for the outer gap model and $\sim 20\%$ at trailing of peaks for the caustic model. These patterns are not similar to the Crab optical data, in which the minimum is at both peaks and the maximum is at the bridge phase. The computed position angle swing does not match with the data either. As another empirical model, we assume an emissivity with a Gaussian profile in the longitudinal direction. In such a case, the model successfully predicts the observed polarization degree, but the position-angle swing is still not consistent.

The curvature radiation model predicts too high a degree of polarization (Dyks et al. 2004) and no successful spectra have been achieved up to date. On the other hand, although various models are examined with the synchrotron emission, which is favored for the Crab spectrum, none of the models is able to reproduce the Crab optical data. To understand the Crab polarization, we may need a more realistic structure of the pulsar magnetosphere.