Reconstruction of Light-curve Anomalies of Radio Pulsars

H. L. Hakobyan[1*], A. A. Philippov[1†], V. S. Beskin[2,3‡], A. K. Galishnikova[3], E. M. Novoselov[3], M. M. Rashkovetskyi[3]

[1]Princeton University, Princeton, New Jersey, USA

[2]Lebedev Physical Institute, Moscow, Russia

[3]Moscow Institute of Physics and Technology, Dolgoprudny, Russia

Five years ago the theoretical aspects of the polarization formation based on the Kravtsov & Orlov approach were studied, and the numerical simulation method was proposed [1]. It allowed us to describe the general properties of mean profiles such as the position angle of the linear polarization $p.a.$ and the circular polarization for the realistic structure of the magnetic field in a pulsar magnetosphere. We found the correlation of signs of the circular polarization, V, and the derivative of the position angle with respect to pulsar phase, $\mathrm{d}p.a./\mathrm{d}\phi$, for both emission modes. In most cases it gave us the possibility to recognize the orthogonal mode, ordinary or extraordinary, playing the main role in the formation of the mean profile.

On the other hand, there are some pulsars which observations disagreed with our predictions. For example, PSR J0452–1759 and J0738–4042 show transitions between the polarization modes which occur not at the transitions between subpulse components. Furthermore, PSR B0329+54 whose linear polarization demonstrates the presence of two orthogonal modes has the same sign of the circular polarization V within the entire pulse. And v.v., for some pulsars such as PSR J2048–1616 the position angle data correspond to one orthogonal mode while the Stokes parameter V changes sign through the mean profile.

To clarify these properties, we focus on a more detailed analysis of the wave propagation in the pulsar magnetosphere. It is shown that within our theory the circular polarization of a given mode can switch its sign, without the need to introduce a new radiation mode or other effects. The point is that the role of the electric drift motion of particles in the pulsar magnetosphere (affecting the dielectric tensor and, hence, the propagation properties) is different at small and large distances from the neutron star. As a result, the sign of the circular polarization can be different in different parts of the mean profile although they correspond to the same orthogonal mode. Moreover, generation of different emission modes on different altitudes can explain the deviation of some pulsars from the prediction of the O-X-O mode sequence for pulsars with triple mean profiles. This work was partially supported by the Russian Foundation for Basic Researches (grant N. 17-02-00788).

References

[1] Beskin, V. S., & Philippov, A. A. 2012, MNRAS, 425, 814

*E-mail: hakobyan@astro.princeton.edu