

Measuring RM variations of pulsars with LOFAR: ISM vs ionosphere

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Pulsars are known to be a powerful probe of Galactic magnetic fields, which are a major agent in the dynamics and energy balance of the interstellar medium (ISM) and the general evolution of the Galaxy. Information about magnetic fields in the Milky Way is encapsulated in Faraday rotation measures (RMs) of highly linearly polarised pulsar signals. However, besides the effects of the magnetoionic ISM, polarised properties of pulsar radiation can be significantly altered by the highly variable terrestrial ionosphere, which can introduce excess noise in experiments aimed at investigating astrophysical plasma. Due to exacerbation of propagation effects at larger observational wavelengths, the impact of the ionosphere is especially relevant for data taken with facilities sensitive to low radio frequencies. One very promising approach of mitigating the ionospheric contribution consists in joint exploitation of semi-empirical geomagnetic field models and global ionospheric maps of electron column densities in the ionosphere, which are based on dual-frequency data from GPS stations spread all around Earth [1]. By using the thin layer ionosphere approximation, we have investigated the capacity of this approach and estimate the accuracy of various publicly available global ionospheric maps through the data of highly polarised pulsars observed individually with German LOw-Frequency ARray (LOFAR) stations. Additionally, we estimate parameters of the systematics and correlated noise generated by residual unmodeled ionospheric effects. For the best ionospheric maps, we have found that the rotation measure corrections on one-year timescales after subtraction of deterministic systematics have a precision of $0.06 - 0.07$ rad per m^2 . The results of this work are in detail described in [2].

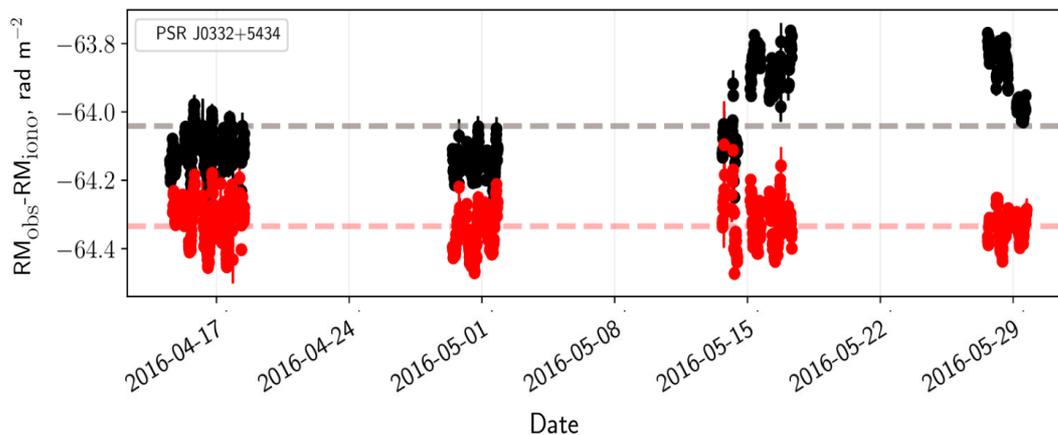


Figure 1. Residual RMs, while applying the CODG (black dots) and JPLG (red dots) ionospheric maps for PSR J0332+5434 observed with LOFAR German station in Norderstedt. The RMs corrected with CODG maps show the jump around 15th of May 2016.

References

- [1] C. Sotomayor-Beltran et al., “Calibrating high-precision Faraday rotation measurements for LOFAR and the next generation of low-frequency radio telescopes,” *Astronomy and Astrophysics*, **552**, April 2013, pp. A58, doi:10.1051/0004-6361/201220728.
- [2] N.K. Porayko et al., “Testing the accuracy of the ionospheric Faraday rotation corrections through LOFAR observations of bright northern pulsars,” *Monthly Notices of the Royal Astronomical Society*, **483**, 3, March 2019, pp. 4100-4113, doi: 10.1093/mnras/sty3324.