

Enigmatic results from an X-ray/radio campaign on the radio-mode-switching pulsar PSR B1822-09

W. Hermsen^{1,2*}, L. Kuiper¹, J. W. T. Hessels^{2,3}, D. Mitra^{4,5,8}, J. M. Rankin^{2,5}, B. W. Stappers⁶, G. A. E. Wright^{6,7}, R. Basu^{4,8}, A. Szary^{3,8}, J. van Leeuwen^{2,3}

¹SRON Netherlands Institute for Space Research, Utrecht, The Netherlands

²Anton Pannekoek Institute for Astronomy, University of Amsterdam, The Netherlands

³ASTRON, the Netherlands Institute for Radio Astronomy, Dwingeloo, The Netherlands

⁴National Centre for Radio Astrophysics, (NCFRA-TIFR), Pune University, India

⁵Physics Department, University of Vermont, Burlington, VT 05405, USA

⁶Jodrell Bank Centre for Astrophysics, University of Manchester, UK

⁷Astronomy Centre, University of Sussex, Falmer, Brighton BN1 9QJ, UK

⁸Janusz Gil Institute of Astronomy, University of Zielona Góra, Poland

We report on an X-ray and radio campaign of the radio-mode-switching pulsar PSR B1822-09 [1]. This pulsar switches between a radio-bright (B) and radio-quiet (Q) mode. Its radio Q mode exhibits an interpulse (IP) located at about half a rotation period from the main pulse (MP), which switches simultaneously but in anti-correlation with the MP. We now discovered in addition a relationship between the durations of its modes and known underlying radio-modulation time-scales within the modes. The fact that both, mode change and the modulations, occur simultaneously at both poles suggests that both reflect magnetospheric effects, rather than local polar cap physics.

Furthermore, we discovered X-ray pulsations with a single broad sinusoidal pulse, slightly lagging the radio main pulse in phase, with an energy-dependent pulsed fraction reaching a value of ~ 0.6 at 1 keV. The total X-ray spectrum appears to consist of a pulsed hot component and cool unpulsed emission. The high pulsed fraction seems to require rather enigmatic explanations like magnetic anisotropic beaming effects in its strong magnetic field.

The original aim of the simultaneous X-ray and radio observations was to reveal simultaneous X-ray and radio moding like we discovered earlier for the nearly aligned pulsar PSR B0943+10 [2]. However, we found no evidence for X-ray mode switching of PSR B1822-09. It appears that the thermal X-ray emission, of local origin, has no relation with the magnetospheric effects that explain the radio properties.

The characteristics of PSR B1822-09 will be discussed in the light of the synchronous mode switching in the radio and X-ray emission properties of PSR B0943+10 [2, 3].

References

- [1] W. Hermsen, L. Kuiper, J. W. T. Hessels, D. Mitra, et al., *MNRAS* 446, 1688 (2017)
- [2] W. Hermsen, J. W. T. Hessels, L. Kuiper, et al., *Science* 339, 346 (2013)
- [3] S. Mereghetti, L. Kuiper, A. Tiengo, J. Hessels, W. Hermsen, et al. *ApJ*, 831, 21 (2016)

*E-mail: W.Hermsen@sron.nl