# X-ray properties of the mode-switching pulsar PSR B0943+10

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The prototypical mode-switching pulsar PSR B0943+10 has been extensively studied in the radio band since many years and more recently it has been found to vary also in X-rays. It alternates between two states: in B (radio-bright) mode, its radio emission displays a regular pattern of drifting subpulses, while during the Q (radio-quiescent) mode the radio pulses have a chaotic pattern and the X-ray flux is higher by a factor ∼2.4. Previous X-ray observations only partially constrained the spectrum of PSR B0943+10, especially during the X-ray-fainter B-mode, where pulsations could not be detected.

A new, longer campaign of observations was obtained with *XMM-Newton* and the LOFAR, LWA and Arecibo radio telescopes in November 2014. This allowed us to detect X-ray pulsations also during the B-mode and to better constrain the spectral and variability properties. We found that in Q-mode the pulsed emission has a thermal blackbody spectrum with temperature $\sim 3.4 \times 10^6$ K and the unpulsed emission is a power-law with photon index ∼2.5, while during B-mode both the pulsed and unpulsed emission can be fit by either a blackbody or a power law with similar values of temperature and photon index. These results support a scenario in which both unpulsed non-thermal emission, likely of magnetospheric origin, and pulsed thermal emission from a small polar cap (∼1500 m$^2$) with a strong non-dipolar magnetic field ($\sim 10^{14}$ G), are present during both radio modes and vary in intensity in a correlated way. This is broadly consistent with the predictions of the partially screened gap model and does not necessarily imply global magnetospheric rearrangements to explain the mode switching.

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