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Joint radio and X-ray modelling of PSR J1136+1551

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Multi-wavelength observations of pulsar emission properties are powerful means to constrain their magnetospheric activity and magnetic topology. Usually a star centred magnetic dipole model is invoked to explain the main characteristics of this radiation. However in some particular pulsars where observational constraints exist, such simplified models are unable to predict salient features of their multi-wavelength emission. This paper aims to carefully model the radio and X-ray emission of PSR J1136+1551 with an off-centred magnetic dipole to reconcile both wavelength measurements. We simultaneously fit the radio pulse profile with its polarization and the thermal X-ray emission from the polar cap hot spots of PSR J1136+1551. We are able to pin down the parameters of the non-dipolar geometry (which we have assumed to be an offset dipole) and the viewing angle, meanwhile accounting for the time lag between X-ray and radio emission. Our model fits the data if the off-centred magnetic dipole lies about 20% below the neutron star surface. We also expect very asymmetric polar cap shapes and sizes, implying non antipodal and non identical thermal emission from the hot spots. We conclude that a non-dipolar surface magnetic field is an essential feature to explain the multi-wavelength aspects of PSR J1136+1551 and other similar pulsars.

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