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Phase-resolved polarimetry constraints for the white dwarf pulsar AR Sco

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Marsh et al. (2016; M16) detected radio and optical pulsations from the binary system AR Scorpii (AR Sco). This system, with an orbital period of 3.55h, is composed of a cool, low-mass star and a white dwarf with a spin period of 1.95min. X-ray pulsations have also been detected from this source (Takata et al. 2018). Optical observations by Buckley et al. (2017) showed that optical pulsations from the white dwarf are strongly linearly polarised (up to 40%). These pulsations are thought to be powered by the spinning down of the highly magnetised (5×10^8G) white dwarf. We fitted a standard rotating vector model to the polarisation emission angle data, and found a magnetic inclination angle $\alpha \sim 90^\circ$ and the observer angle to $\sim 60^\circ$.Using zeta and the mass function from M16, we constrained the mass of the white dwarf to $M_{\rm WD} = 1.00^{+0.19}_{-0.13}$. From the timescales of different radiation processes and the observed spectral cutoffs in the spectral energy distribution from M16, we determine that synchrotron radiation dominates as long as the pitch angles of the particles can be maintained; otherwise curvature radiation would dominate. Lastly we applied our model to the orbitally phase-resolved polarisation position angle data from Potter and Buckley (2018b) and obtained a $\sim 10^\circ$ variation in α and $\sim 30^\circ$ variation in ζ over the orbital period. We speculate that the observer is detecting radiation from a non-uniform emission region that is a stable structure over several orbital periods.

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