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Exploring the properties of pulsars and their nebulae through observations and modelling

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Crab-like and Vela-like pulsars are young, rapidly rotating neutron stars with strong magnetic fields. They are noted for their strong pulsed radio and gamma-ray emission and association with pulsar wind nebulae (PWNe). While Crab-like pulsars are generally younger and exhibit bright, compact nebulae, Vela-like pulsars are slightly older and often linked to more diffuse PWNe with complex emission characteristics. We identify sources that exhibit characteristic features such as phase-aligned radio and gamma-ray light curves (in the Crab-like case) and non-phase-aligned radio and gamma-ray light curves (in the Vela-like case), along with sharp gamma-ray peaks and highly polarised radio emission: imprints that are typical of these pulsar classes. We then apply the Rotating Vector Model (RVM) to their radio polarisation data to extract key geometric parameters, such as magnetic inclination and viewing angle, which shape the observed polarisation profiles. Following the RVM analysis, we model the gamma-ray light curves using high-energy emission models, which offer complementary constraints on the pulsar geometry and help identify the likely regions of particle acceleration within the magnetosphere. Our initial results show a good agreement between the models and observations, highlighting the importance of viewing geometry in pulsar emission. Further spectral and spatial modelling of their associated nebulae will enhance our understanding of energy transfer and the structure of pulsar-PWN systems.

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