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Analysing pulsar timing noise with a Kalman filter to test the two-component pulsar model

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Pulsar timing noise is the stochastic deviation of the pulse arrival times of a pulsar away from their long term trend. In the standard two-component crust-superfluid neutron star model, timing noise can be explained as the perturbation of the two components by irregular torques. Interactions between the crust and superfluid cause these perturbations to decay exponentially with a characteristic relaxation timescale, similar to post-glitch relaxation. In this research we assume the two-component model, then use a Kalman filter to track the pulsar frequency over time and produce a Bayesian posterior for the two-component model parameters given the data. Our method is reliable on simulated data, which we show through individual and large-scale Monte Carlo tests. We also show a representative example with a real pulsar, in which physical properties of the star including the relaxation timescale are efficiently measured. Our measurements of neutron star properties may lead to information about their equation of state and the crust-superfluid interaction and also provide evidence for or against the two-component model.

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