

VLA proper motion constraints on the origin, age, and potential magnetar future of PSR J1734-3333

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Abstract

Context. The characteristic age of PSR J1734-3333 estimated from its current spin down rate implies that it is a young pulsar ($\tau_c = 8.1$ kyr). However, the time derivative of its spin-down rate differs markedly from that assumed for normal radio pulsars, meaning its actual age is uncertain. G354.8-0.8 is a supernova remnant (SNR) whose centre is located 21° away from the pulsar, and which has a morphology that suggests an association with the pulsar. **Aims.** We aim to assess the likelihood of the association between PSR J1734-3333 and G354.8-0.8 or other nearby SNRs quantitatively, with the objective of shedding light on the real age of this pulsar. **Methods.** Observations with the Karl G. Jansky Very Large Array were carried out in 2015 and 2019 that allow precise astrometric measurements and consequently a proper motion estimate for the pulsar. **Results.** The proper motion was found to be $\mu_\alpha = 10 \pm 10$ mas yr⁻¹ and $\mu_\delta = -29 \pm 11$ mas yr⁻¹ (error bars are 1- σ). Though marginal, this detection rules out the association with G354.8-0.8 because it means the pulsar is not moving away from the centre of the SNR. No SNR consistent with the measured proper motion and an age τ_c could be found. We also present the first measurement of the spectral index for this pulsar, $\alpha = -1.1 \pm 0.3$, measured between 1.5 and 3.0 GHz. **Conclusions.** The SNR produced by the birth supernova of PSR J1734-3333 could have already faded to undetectable brightness, estimates of which suggest timescales of 10-100 kyr. This and other considerations lead us to conclude that the pulsar is possibly older than 45-100 kyr. PSR J1734-3333 is a pulsar with rotational properties that place it between standard radio pulsars and magnetars, and we interpret our result in the context of a possible future life as a magnetar for this pulsar. © ESO 2022.

Author keywords

ISM: Supernova remnants; Proper motions; Pulsars: General; Pulsars: Individual: PSR J1734-3333; Stars: Neutron