

PASA Letters

Discovery of a 36-min long-period transient ASKAP J142431.2–612611

Joshua Pritchard¹, Tara Murphy^{2,3} , Dougal Dobie^{2,3}, Emil Lenc¹ , Akash Anumalapudi^{4,5},
Manisha Caleb^{2,3}, Sophia Grainger^{6,7,1}, Natasha Hurley-Walker⁸, David L. Kaplan⁵ , Samuel McSweeney⁸ ,
Jackson Mitchell-Bolton^{2,1} , Kovi Rose^{2,1}, Rahul Sengar^{9,10,5}, Ziteng Wang⁸ , Jayde Willingham^{6,7,1}  and Andrew Zic¹

¹CSIRO Space & Astronomy, Epping, NSW, Australia, ²Sydney Institute for Astronomy, School of Physics, The University of Sydney, NSW, Australia, ³ARC Centre of Excellence for Gravitational Wave Discovery (OzGrav), Australia, ⁴Department of Physics and Astronomy, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA, ⁵Department of Physics, University of Wisconsin-Milwaukee, Milwaukee, WI, USA, ⁶School of Mathematical and Physical Sciences, 12 Wally's Walk, Macquarie University, NSW, Australia, ⁷Macquarie University Astrophysics and Space Technologies Research Centre, Sydney, NSW, Australia, ⁸International Centre for Radio Astronomy Research, Curtin University, Bentley, WA, Australia, ⁹Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Hannover, Germany and ¹⁰Leibniz Universität Hannover, Hannover, Germany

Abstract

We report the discovery of a new long-period radio transient, ASKAP J142431.2–612611, with a 36 min period, identified in the Australian SKA Pathfinder Evolutionary Map of the Universe survey. We detected pulsed emission from ASKAP J142431.2–612611 over a period of eight days during follow-up observations with the Australia Telescope Compact Array, after which the source appears to have switched off. No optical or near-infrared counterpart is detected in archival surveys or in targeted Gemini South FLAMINGOS-2 observations. During its active state, the source exhibits a stable pulse profile with fractional polarisation consistent with 100%, evolving from elliptically to linearly polarised and tracing a well-defined great-circle trajectory on the Poincaré sphere. We show that this behaviour is consistent with fully linearly polarised intrinsic emission modified by propagation through a linearly polarised birefringent medium. This discovery expands the known population of long-period transients and highlights the intermittent nature of their activity. We discuss the implications for proposed models of long-period transients and outline future observations needed to constrain the origin of their intermittency and polarisation properties.

Keywords: radio astronomy; radio interferometry; radio transient; sources polarimetry; transient detection

(Received 28 January 2026 UTC; revised 4 March 2026 UTC; accepted 6 March 2026 UTC)

1. Introduction

Long-period radio transients (LPTs) are a recently discovered class of radio sources characterised by coherent pulsed emission with pulse durations of seconds to minutes, repeating periodically on timescales of tens of minutes to several hours (e.g. see Hurley-Walker et al. 2022; Hurley-Walker et al. 2023; Caleb et al. 2024; Dobie et al. 2024; Li et al. 2024; Wang et al. 2025; Anumalapudi et al. 2025; Bloot et al. 2025; de Ruiter et al. 2025; Dong et al. 2025; Lee et al. 2025; McSweeney et al. 2025). These timescales of periodicity are orders of magnitude longer than the millisecond to second timescales of typical pulsars, placing LPTs within or below the ‘death-valley’ of the period-period derivative diagram (Rea et al. 2024). In this regime, spin-down powered decay of the magnetic field cannot support the pair-production required to power pulsar emission. Hence LPTs can not be explained by conventional pulsar emission models, raising fundamental questions about how coherent radio emission can be sustained on such timescales.

The small number of LPTs that have been identified to date (~14 at the time of publication, depending on exactly how the class is defined; Rea et al. 2026) show a rich diversity of radio properties. Some have been routinely active over decades (e.g. Hurley-Walker et al. 2023) while others appear intermittent and only remain detectable for short windows before switching off (e.g. Hurley-Walker et al. 2022; Caleb et al. 2024; Dobie et al. 2024; McSweeney et al. 2025). The emission often shows high degrees of circular and linear polarisation; yet while some sources show evolution in the polarisation position angle (PA) reminiscent of pulsars (Dobie et al. 2024), others display flat or slowly varying PA profiles (Caleb et al. 2024). In some objects the pulse morphology and polarisation remain stable over an active window (Lee et al. 2025), while in others these properties change from pulse to pulse, showing a variety of behaviours such as emission mode changes (e.g. Caleb et al. 2024), narrowband structure (e.g. Anumalapudi et al. 2025), timing glitches (e.g. Dong et al. 2025), frequency-dependent polarisation conversion, and orthogonal mode jumps (e.g. Men et al. 2025).

Multi-wavelength detections are beginning to provide insight into the astrophysical classification of LPTs, and as a result at least two subclasses are emerging. Some LPTs have infrared, optical, or ultraviolet counterparts suggestive of a white dwarf (WD) main-sequence binary system (e.g. de Ruiter et al. 2025;

Corresponding author: Joshua Pritchard; Email: joshua.pritchard@csiro.au

Cite this article: Pritchard J, Murphy T, Dobie D, Lenc E, Anumalapudi A, Caleb M, Grainger S, Hurley-Walker N, Kaplan DL, McSweeney S, Mitchell-Bolton J, Rose K, Sengar R, Wang Z, Willingham J and Zic A. (2026) Discovery of a 36-min long-period transient ASKAP J142431.2–612611. *Publications of the Astronomical Society of Australia* 43, e083, 1–8. <https://doi.org/10.1017/pasa.2026.10177>

Hurley-Walker et al. 2024; Rodriguez 2025; Anumalapudi et al. 2025; Bloor et al. 2025). Others show behaviour more consistent with a neutron star progenitor: such as ASKAP J1832–0911 which produces periodically pulsed X-ray emission (Wang et al. 2025). However, the diverse radio phenomenology observed so far does not align neatly with these associations, and more research is required to understand and explain the phenomena.

The discovery of LPTs has been enabled by widefield facilities, namely the Australian SKA Pathfinder (ASKAP; Johnston et al. 2008; Hotan et al. 2021), the Murchison Widefield Array (MWA; Bowman et al. 2013), the Low-Frequency ARray (LOFAR; van Haarlem et al. 2013), and the Canadian Hydrogen Intensity Mapping Experiment (CHIME; CHIME/FRB Collaboration et al. 2018). The large instantaneous fields of view of these instruments allows widefield radio surveys to prioritise long dwell times or repeat sampling of the sky with high cadence, probing regions of transient parameter space that have been previously inaccessible. Discoveries have also been aided by the development of novel search techniques such as fast-imaging (e.g. Caleb et al. 2024) and circular polarisation searches (e.g. Anumalapudi et al. 2025; Lee et al. 2025), allowing these new regions of parameter space to be explored.

In this paper we report the discovery of a new long-period transient, ASKAP J142431.2–612611 (hereafter ASKAP J1424), with a 36 min period, identified via a circular polarisation search. The source exhibited stable pulsed emission for eight days before becoming undetectable, limiting the available data but highlighting its intermittent nature. We present these observations to enable and encourage future monitoring and follow-up of this object. In Section 2, we describe the observations and data analysis, and in Section 3 we discuss the radio properties of the source in the context of the growing population of LPTs.

2. Observations and data analysis

2.1. Detection and radio follow-up

We discovered ASKAP J1424 in a circular polarisation search of a 10 h ASKAP observation, conducted on 2025-01-09 (scheduling block SB70271) as part of the Evolutionary Map of the Universe (EMU; Norris et al. 2011, 2021) survey. We identified ASKAP J1424 in the full-integration images with a flux density of 1.50 ± 0.01 mJy beam^{−1} in Stokes *I* (total intensity) and -0.12 ± 0.01 mJy beam^{−1} in Stokes *V*,^a giving a fractional circular polarisation of 8%.

Following the ASKAP discovery, we conducted a multi-facility radio follow-up campaign with the Australia Telescope Compact Array (ATCA; Wilson et al. 2011), MeerKAT (Jonas 2009), the Parkes 64 m radio telescope (Murriyang), and the Murchison Widefield Array (MWA; Tingay et al. 2013; Wayth et al. 2018). We detected ASKAP J1424 in both ATCA follow-up observations at 2100 MHz, but made no detections with any other facility. The details of all radio follow-up observations are described in Appendix A and summarised in Table 1. We also searched archival radio and multi-wavelength observations, including 60 observations as part of the Rapid ASKAP Continuum Survey (RACS; McConnell et al. 2020; Duchesne et al. 2023) and Variables And Slow Transients (VAST; Murphy et al. 2021) surveys with

Table 1. Summary of radio observations of ASKAP J1424 with ASKAP, ATCA, MWA, MeerKAT, and Murriyang. Columns are the observation start time, telescope, project code/SBID, frequency range ν_{obs} , and duration t_{obs} .

UT start time	Telescope	Project code	ν_{obs} (MHz)	t_{obs} (h)
2025-01-09 20:00	ASKAP	SB70271	800–1 088	10
2025-01-14 18:30	Murriyang	P1050	704–4 032	1
2025-01-15 18:30	MWA	G0115	185–215	3
2025-01-15 20:00	ATCA	C1726	1 100–3 100	1.5
2025-01-16 18:30	MWA	G0115	185–215	8
2025-01-17 21:08	ATCA	C3363	1 100–3 100	6.1
2025-01-28 18:30	Murriyang	P1050	704–4 032	2
2025-02-21 03:10	MeerKAT	20250224-0006	544–1 088	4
2025-02-26 02:11	MeerKAT	20250217-0010	544–1 088	4
2025-09-28 01:16	ASKAP	SB77270	800–1 088	10

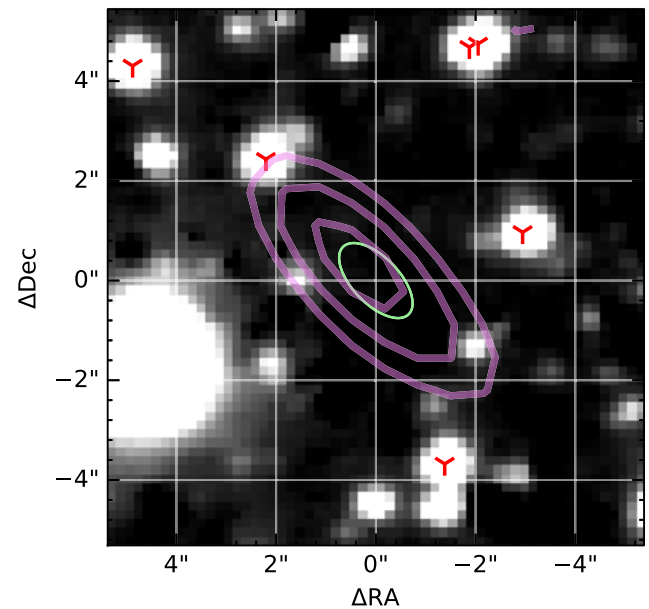


Figure 1. K_s -band Gemini observation with Stokes *I* radio contours from ATCA C3363 observation overlaid. The green ellipse indicates the 5σ astrometric uncertainty of $0''.9 - 1''.9$. The positions of catalogued VV sources are indicated with red markers.

ASKAP, but made no detections. Details and limits are provided in Appendix B.

2.2 Infrared photometric follow-up

We acquired near infrared observations in the *J* and K_s bands with the FLAMINGOS-2 instrument on Gemini South on 2025-01-21. We performed standard data reduction using the DRAGONS pipeline (Labrie et al. 2023), and astrometric calibration by extracting source positions with PHOTUTILS and registering against the proper-motion corrected positions of stars in Gaia DR3 (Gaia Collaboration et al. 2023). Photometric calibration was obtained by matching isolated and unsaturated field stars to the Variables in the Via Lactea survey (VVV; Minniti et al. 2010), yielding zero-point uncertainties of 0.1 and 0.15 mag in the *J* and K_s bands, respectively. In Figure 1, we show a cutout image of the K_s -band data with contours of our ATCA C3363

^aThroughout this paper we adopt the IAU/IEEE definition of Stokes *V* (Robishaw & Heiles 2021).

observation overlaid. We did not detect a source within the 5σ astrometric uncertainty of $0''.9 - 1''.9$ in either band, with 3σ limiting magnitudes^b of $J > 22.5$ and $K_S > 19.5$.

2.3 Time-domain analysis

We processed all calibrated radio observations by forming a model of background sources of emission with WSCLEAN (Offringa et al. 2014), and extracting model-subtracted dynamic spectra in all Stokes parameters using DSTOOLS^c (Pritchard 2025). We then frequency-averaged the dynamic spectra to form visibility lightcurves.

We fit Gaussian profiles to each detected pulse and used the barycentric times of arrival to determine an ephemeris of the form $\phi(t) = \frac{t-t_0}{P} + \phi_0$, with a best fit period $P = 2147.27 \pm 0.01$ s. The reference time $t_0 = 2025-01-09\ 20:32:11.701$ corresponds to the barycentric time of arrival of the first fully sampled pulse in SB70271, with a reference pulse phase of $\phi_0 = 0.5$. The sequence of 17 consecutive pulses detected in this observation uniquely constrains the period and rules out alias periods. Owing to the small time range spanned by the 2025 detections, we are unable to meaningfully constrain the source's spin-up or spin-down and place an upper limit of order 10^{-8} s s⁻¹ on the period derivative.

We used this ephemeris to phase-fold all radio observations. Several archival observations obtained between 2021-02-01 and 2024-10-03 sample a significant fraction of the estimated pulse window yet show no emission, suggesting that ASKAP J1424 was not active for multiple years prior to the 2025-01-09 detection. However, it is possible that ASKAP J1424 has short windows of activity as observed in several other LPTs (e.g. Hurley-Walker et al. 2022; Caleb et al. 2024; Dobie et al. 2024; McSweeney et al. 2025), and that such intervals were not sampled by the available archival data. The phase-folded lightcurves for all $\sim$ GHz observations are presented in Appendix A.

Phase-folded dynamic spectra of the 17 pulses detected in SB70271 show frequency-dependent phase shifts across the folded pulse profile. Interpreting these shifts as purely dispersive implies a dispersion measure of $DM = 1\,400 \pm 100$ pc cm⁻³. However, intrinsic frequency-dependent pulse morphology can produce similar phase offsets. When we allow the pulse profile to vary with frequency while simultaneously fitting for dispersion, the inferred DM decreases to 200 ± 40 pc cm⁻³. As the phase shifts in these data are small compared to the pulse width, dispersion and profile evolution cannot be distinguished. We therefore treat $1\,400$ pc cm⁻³ as a conservative upper limit on the DM under the assumption that the observed phase shifts are entirely dispersive. Details of the dispersion modelling are provided in Appendix C.

We measured the spectral index α_ν of ASKAP J1424 in these observations by fitting a power law $S(\nu) \propto \nu^{\alpha_\nu}$ to the peak sample of the phase-folded lightcurves. All detections are well-described by a power law, though α_ν changes from -1.6 in the 800–1 088 MHz ASKAP band on 2025-01-09 to -1.2 in the 1 100–3 100 MHz ATCA band on 2025-01-15. These observations also show a significant decrease in band-averaged flux density from ~ 65 to 12 mJy, which cannot be explained solely by spectral shape. As our MWA observations were acquired quasi-contemporaneously with the ATCA observations, non-detection at 200 MHz suggests a limit on the 200–1 100 MHz spectral index $\alpha_\nu > -1$. It is therefore

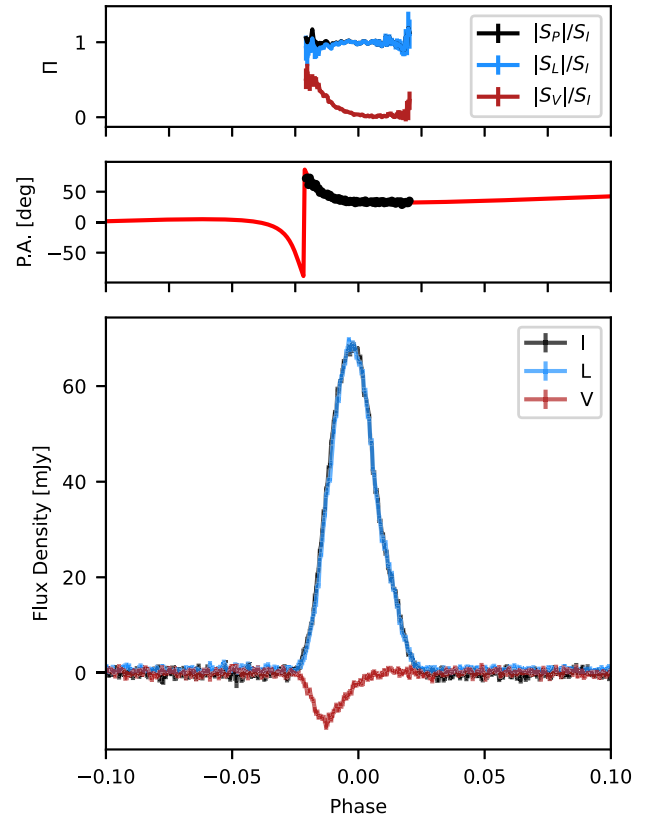


Figure 2. Folded pulse profile of 17 pulses detected in ASKAP observation SB70271. Lightcurves are formed from frequency-averaged dynamic spectra binned to 2 000 pulse phase bins, folded at a period of 2 147.27 s. From bottom to top, panels show full polarisation folded pulse profiles, polarisation position angle, and fractional polarisation. Points in the top two panels are masked below a signal-to-noise ratio (SNR) of $S_i/\sigma_{S_i} < 5$.

likely that ASKAP J1424 has a spectral turnover between 200–800 MHz, similar to ASKAP J1832–09 (Wang et al. 2025) and ASKAP J1839–07 (Lee et al. 2025).

2.4 Polarisation properties

We measured the Faraday rotation measure (RM) of all detected pulses using RM synthesis (Brentjens & de Bruyn 2005) with the RM-LITE^d implementation of RM-TOOLS (Purcell et al. 2020). All pulses show a simple Faraday dispersion function with a single unresolved peak at an RM of -222 rad m⁻² and no evidence for RM variations with pulse phase. In Figure 2 we show the phase-folded, RM-corrected pulse profile of 17 pulses from the ASKAP SB70271 observation. The fractional polarisation is consistent with 100% across the full pulse profile, transitioning from an elliptical state during the first half of the pulse to fully linearly polarised.

The PA begins at 70 deg and flattens out at 30 deg as the circular polarisation fraction decreases. The evolution in PA is reminiscent of the S-shaped swing in pulsar PA profiles and commonly explained by the rotating vector model (RVM; Radhakrishnan & Cooke 1969), in which the PA corresponds to the projection of the local magnetic field orientation at the emission site onto the plane of the sky. We used the Markov chain Monte Carlo

^b All magnitudes are in the AB system.

^c <https://github.com/askap-vast/dstools>.

^d <https://github.com/AlecThomson/rm-lite>.

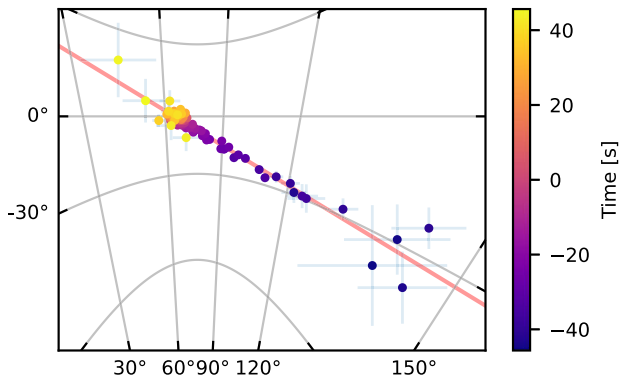


Figure 3. Time evolution of polarisation state in the ASKAP SB70271 folded pulse profile. Points show a Gnomonic projection of the Poincaré sphere normalised by total polarisation $P = \sqrt{Q^2 + U^2 + V^2}$. The red line shows the best linear fit to the projected data, corresponding to a great circle of inclination 31.5 ± 0.6 deg crossing the equator at 64.0 ± 0.4 deg longitude.

sampler EMCEE (Foreman-Mackey *et al.* 2013) to fit an RVM profile to the phase-folded ASKAP SB70271 lightcurve with a best fit of $\alpha = 170 \pm 4$ deg, $\beta = -0.3 \pm 0.1$ deg, $\phi_0 = -8.37 \pm 0.04$ deg, and $\psi_0 = -72.6 \pm 0.3$ deg. Here $\psi(\phi)$ is the PA as a function of pulse phase ϕ , α is the angle between rotation and magnetic axes, β is the angle between the magnetic axis and line of sight, and ψ_0 and ϕ_0 are the PA and phase around which the PA swing is centred.

While the RVM provides a good empirical description of the observed PA evolution, it is not clear that the emission mechanism powering ASKAP J1424 produces radiation polarised in the sense of the local magnetic field, as is typically assumed for pulsar emission, nor that the fitted RVM parameters map directly onto a rotational geometry. The fitted offset ϕ_0 between steepest PA gradient and the total intensity peak is also atypical of most pulsars, for which ϕ_0 is generally positive and attributed to aberration and retardation effects associated with finite emission heights (Blaskiewicz *et al.* 1991).

The RVM also only accounts for the linearly polarised component of the emission and does not describe the presence or evolution of circular polarisation. To characterise the full polarisation behaviour we therefore analysed the evolution of the normalised Stokes parameters (Q/P , U/P , V/P) on the Poincaré sphere, where $P = \sqrt{Q^2 + U^2 + V^2}$. Full details of the Poincaré sphere analysis are provided in Appendix D.

In Figure 3 we show the polarisation state of the folded ASKAP SB70271 pulse profile in a Gnomonic projection of the Poincaré sphere, in which great circles are mapped to straight lines. The data are well fit by a great circle with inclination angle of $\delta = 31.5 \pm 0.6$ deg and intersecting the equator of the sphere at a longitude of $2\psi_{\text{eq}} = 64.0 \pm 0.4$ deg, corresponding to a PA of $\psi_{\text{eq}} = 32.0 \pm 0.2$ deg. The great circle trajectory shows only marginal evidence for weak frequency dependence, with inclination angle varying with wavelength as $\delta \propto \lambda^p$ with $p = 0.5 \pm 0.2$ when keeping $2\psi_{\text{eq}}$ fixed to 32.0 deg and $p = 0.21 \pm 0.06$ when allowing it to vary freely. A full description of this model is provided in Appendix D.2.

3. Discussion and conclusions

We have presented the discovery of a long-period transient, ASKAP J1424, with a 36 min period that exhibits an extremely stable pulse profile over an 8 d activity window, as observed with

ASKAP and ATCA across 800–3 100 MHz. The emission is consistent with being 100% polarised across the full pulse profile and evolves along a great circle trajectory on the Poincaré sphere as a function of pulse phase transitioning from an elliptical to fully linearly polarised state.

Evolution of the polarisation state along a great circle may be explained by a fully linearly polarised intrinsic polarisation state which then passes through a linear birefringent medium (LBM) in which the natural modes are linearly polarised (Lyutikov 2022; Bera *et al.* 2025). In the Poincaré sphere picture, such a medium applies a fixed rotation to the intrinsic polarisation state about an axis aligned with the LBM natural modes, transforming an intrinsic equatorial great circle trajectory into an inclined great circle. Evolution of the pulse phase-resolved polarisation state along a great circle has been previously observed from the LPT ASKAP J1755-2527 (Dobie *et al.* 2024), though with lower fractional polarisation and possibly being driven by partially coherent mixing of orthogonal modes (Oswald *et al.* 2023). Similar behaviour has also been observed in fast radio bursts (Bera *et al.* 2025).

We have not identified an optical or infrared counterpart to ASKAP J1424 in either archival data or targeted follow-up observations. As is the case for the majority of LPTs, ASKAP J1424 is located at low Galactic latitude ($b \sim -0.5^\circ$) where significant extinction is expected, limiting the constraining power of our optical and infrared limits on the nature of the progenitor. Horváth *et al.* (2026) demonstrate that GPM J1839–10 is likely a WD binary system, with pulse activity driven by magnetic interaction when the WD magnetic axis intersects the companion’s magnetised wind, and recurring at the beat between WD rotation and orbital periods. Considering similar modulation of the activity of ASKAP J1424, we constrain the activity window of this system to be between 8–141 d based on the ASKAP and ATCA detections and nearest-in-time non-detections. Under the Horváth *et al.* (2026) model this would imply a beat period of at least several weeks, possibly months. The lack of detections across two years of the VAST Galactic survey may be difficult to reconcile with quasi-periodic activity windows on timescales of weeks. However this is not a strong constraint, as each VAST observation only samples a third of the period and the observing cadence is longer than the nominal activity window.

Further monitoring (e.g. as part of the planned second phase of the VAST Galactic survey) will allow us to determine whether the observed emission follows an intermittent activity pattern, or was powered by a one-off or stochastic event such as accretion of plasma from a companion. Continued characterisation of the polarisation dynamics of ASKAP J1424 in these observations will also provide insight into the viability of an LBM model in explaining the great circle trajectory of the polarisation state, providing important insights into further understanding the emission mechanism and constraining the plasma properties of the near-source medium.

The second phase of the VAST Galactic survey will begin in early 2026 with a revised observing strategy consisting of several high-cadence observing blocks per year. The VAST Galactic fields will be looped over ~ 10 times in the space of a few days, supplementing the fortnightly cadence executed in the first phase of the survey. This strategy will provide stronger constraints on orbital modulation in tight binary orbits and will allow characterisation of pulse evolution over timescales of days, such as the fading observed in ASKAP J1424 and mode switching observed in ASKAP J1935 (Caleb *et al.* 2024).

Acknowledgements. Parts of this research were supported by the Australian Research Council Centre of Excellence for Gravitational Wave Discovery (OzGrav), project number CE230100016. DK was supported by NSF grant AST-2511757.

This scientific work uses data obtained from Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory. We acknowledge the Wajarri Yamaji People as the Traditional Owners and native title holders of the Observatory site. CSIRO's ASKAP radio telescope is part of the ATNF Australia Telescope National Facility. Operation of ASKAP is funded by the Australian Government with support from the National Collaborative Research Infrastructure Strategy. ASKAP uses the resources of the Pawsey Supercomputing Research Centre. Establishment of ASKAP, Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory and the Pawsey Supercomputing Research Centre are initiatives of the Australian Government, with support from the Government of Western Australia and the Science and Industry Endowment Fund.

The Australia Telescope Compact Array is part of the Australia Telescope National Facility (ATNF, Australia Telescope National Facility) which is funded by the Australian Government for operation as a National Facility managed by CSIRO. We acknowledge the Gomeroi people as the Traditional Owners of the Observatory site.

Support for the operation of the MWA is provided by the Australian Government (NCRIS), under a contract to Curtin University administered by Astronomy Australia Limited. ASVO has received funding from the Australian Commonwealth Government through the National eResearch Collaboration Tools and Resources (NeCTAR) Project, the Australian National Data Service (ANDS), and the National Collaborative Research Infrastructure Strategy.

The MeerKAT telescope is operated by the South African Radio Astronomy Observatory, which is a facility of the National Research Foundation, an agency of the Department of Science and Innovation.

Based on observations obtained at the international Gemini Observatory, a programme of NSF NOIRLab, which is managed by the Association of Universities for Research in Astronomy (AURA) under a cooperative agreement with the US National Science Foundation on behalf of the Gemini Observatory partnership: the US National Science Foundation (United States), National Research Council (Canada), Agencia Nacional de Investigación y Desarrollo (Chile), Ministerio de Ciencia, Tecnología e Innovación (Argentina), Ministério da Ciência, Tecnologia, Inovações e Comunicações (Brazil), and Korea Astronomy and Space Science Institute (Republic of Korea).

Data availability statement. The ASKAP data used in this paper can be accessed through the CSIRO ASKAP Science Data Archive (CASDA^e) under project codes AS106 and AS107. The MWA data used in this paper can be accessed through the All-Sky Virtual Observatory (ASVO^f) under project codes G0080 and G0115.

References

- Anumalapudi, A., et al. 2025, *MNRAS*, **542**, 1208
- Bera, A., et al. 2025, *ApJ*, **982**, 119
- Blaskiewicz, M., Cordes, J. M., & Wasserman, I. 1991, *ApJ*, **370**, 643
- Bloot, S., et al. 2025, *A&A*, **699**, A341
- Bowman, J. D., et al. 2013, *PASA*, **30**, e031
- Brentjens, M. A., & de Bruyn, A. G. 2005, *A&A*, **441**, 1217
- Caleb, M., et al. 2024, *NatAs*, **8**, 1159
- CHIME/FRB Collaboration, et al. 2018, *ApJ*, **863**, 48
- de Ruiter, I., et al. 2025, *NatAs*, **9**, 672
- Dobie, D., et al. 2024, *MNRAS*, **535**, 909
- Dong, F. A., et al. 2025, *ApJ*, **990**, L49
- Duchesne, S. W., et al. 2023, *PASA*, **40**, e034
- Foreman-Mackey, D., Hogg, D. W., Lang, D., & Goodman, J. 2013, *PASP*, **125**, 306
- Gaia Collaboration, et al. 2023, *A&A*, **674**, A1
- Gehrels, N., et al. 2004, *ApJ*, **611**, 1005
- Hobbs, G. B., Edwards, R. T., & Manchester, R. N. 2006, *MNRAS*, **369**, 655
- Hobbs, G., et al. 2020, *PASA*, **37**, e012
- Horváth, C., et al. 2026, *NatAs*, **10**, 522–530
- Hotan, A. W., van Straten, W., & Manchester, R. N. 2004, *PASA*, **21**, 302
- Hotan, A. W., et al. 2021, *PASA*, **38**, e009
- Hurley-Walker, N., et al. 2022, *Nature*, **601**, 526
- Hurley-Walker, N., et al. 2023, *Nature*, **619**, 487
- Hurley-Walker, N., et al. 2024, *ApJ*, **976**, L21
- Jansen, F., et al. 2001, *A&A*, **365**, L1
- Johnston, S., et al. 2008, *ExA*, **22**, 151
- Jonas, J. L. 2009, *IEEE Proc.*, **97**, 1522
- Labrie, K., et al. 2023, *RNAAS*, **7**, 214
- Lee, Y. W. J., et al. 2025, *NatAs*, **9**, 393
- Li, D., et al. 2024, arXiv e-prints, p. arXiv:2411.15739
- Lyutikov, M. 2022, *ApJ*, **933**, L6
- McConnell, D., et al. 2020, *PASA*, **37**, e048
- McSweeney, S. J., et al. 2025, *MNRAS*, **10.1093/mnras/staf1203**, 542, 203
- Men, Y., McSweeney, S., Hurley-Walker, N., Barr, E., & Stappers, B. 2025, *SciAd*, **11**, eadp6351
- Minniti, D., et al. 2010, *NewA*, **15**, 433
- Murphy, T., et al. 2021, *PASA*, **38**, e054
- Norris, R. P., et al. 2011, *PASA*, **28**, 215
- Norris, R. P., et al. 2021, *PASA*, **38**, e046
- Offringa, A. R., et al. 2014, *MNRAS*, **444**, 606
- Oswald, L. S., Karastergiou, A., & Johnston, S. 2023, *MNRAS*, **525**, 840
- Pacholczyk, A. G., & Swihart, T. L. 1970, *ApJ*, **161**, 415
- Pennucci, T. T. 2019, *ApJ*, **871**, 34
- Perley, R. A., Greisen, E., & Hugo, B. 2022, Technical report, Enabling MeerKAT Polarimetric Imaging in AIPS. EVLA Memo 219, National Radio Astronomy Observatory
- Pritchard, J. 2025, askap-vast/dstools: v2.0.0, <https://doi.org/10.5281/zenodo.15232974>
- Purcell, C. R., Van Eck, C. L., West, J., Sun, X. H., & Gaensler, B. M. 2020, RM-Tools: Rotation measure (RM) synthesis and Stokes QU-fitting, Astrophysics Source Code Library, record ascl:2005.003 (ascl:2005.003)
- Radhakrishnan, V., & Cooke, D. J. 1969, *ApL*, **3**, 225
- Rea, N., et al. 2024, *ApJ*, **961**, 214
- Rea, N., Hurley-Walker, N., & Caleb, M. 2026, *JHEAp*, p. arXiv: <https://ui.adsabs.harvard.edu/abs/2026JHEAp..5200566R/abstract>
- Robishaw, T., & Heiles, C. 2021, in The WSPC Handbook of Astronomical Instrumentation, Volume 1: Radio Astronomical Instrumentation, ed. A. Wolszczan (World Scientific), 127, 10.1142/9789811203770_0006
- Rodriguez, A. C. 2025, *A&A*, **695**, L8
- Saydjari, A. K., et al. 2023, *ApJS*, **264**, 28
- Tingay, S. J., et al. 2013, *PASA*, **30**, e007
- van Haarlem, M. P., et al. 2013, *A&A*, **556**, A2
- Wang, Z., et al. 2025, *Natur*, **642**, 583
- Wayth, R. B., et al. 2018, *PASA*, **35**, e033
- Wilson, W. E., et al. 2011, *MNRAS*, **416**, 832

Appendix A. Radio follow-up observations

ATCA observations were acquired on 2025-01-17 (project code C1726) and 2025-01-22 (project code C3363) in the 6C configuration using the 16 cm (L-band) receiver with a 2 048 MHz band centred on 2 100 MHz. We calibrated the bandpass response, flux scale, and polarisation leakage with observations of PKS B1934–638 (PKS J1939–6342) and solved for time-varying antenna gains with interleaved 90 s scans of ATCA calibrator 1352-63 (PMN J1355–6326). We flagged and calibrated the data using standard continuum data processing routines in MIRIAD. We detected ASKAP J1424 in both observations with an image-plane flux density of $330 \pm 30 \mu\text{Jy beam}^{-1}$ and a best fit position of $14^{\text{h}}24^{\text{m}}31.40^{\text{s}} \pm 0^{\text{''}}4 - 61^{\text{d}}26^{\text{m}}10.8^{\text{s}} \pm 0^{\text{''}}2$.

^e<https://data.csiro.au/domain/casdaObservation>.

^f<https://asvo.mwatelescope.org/>.

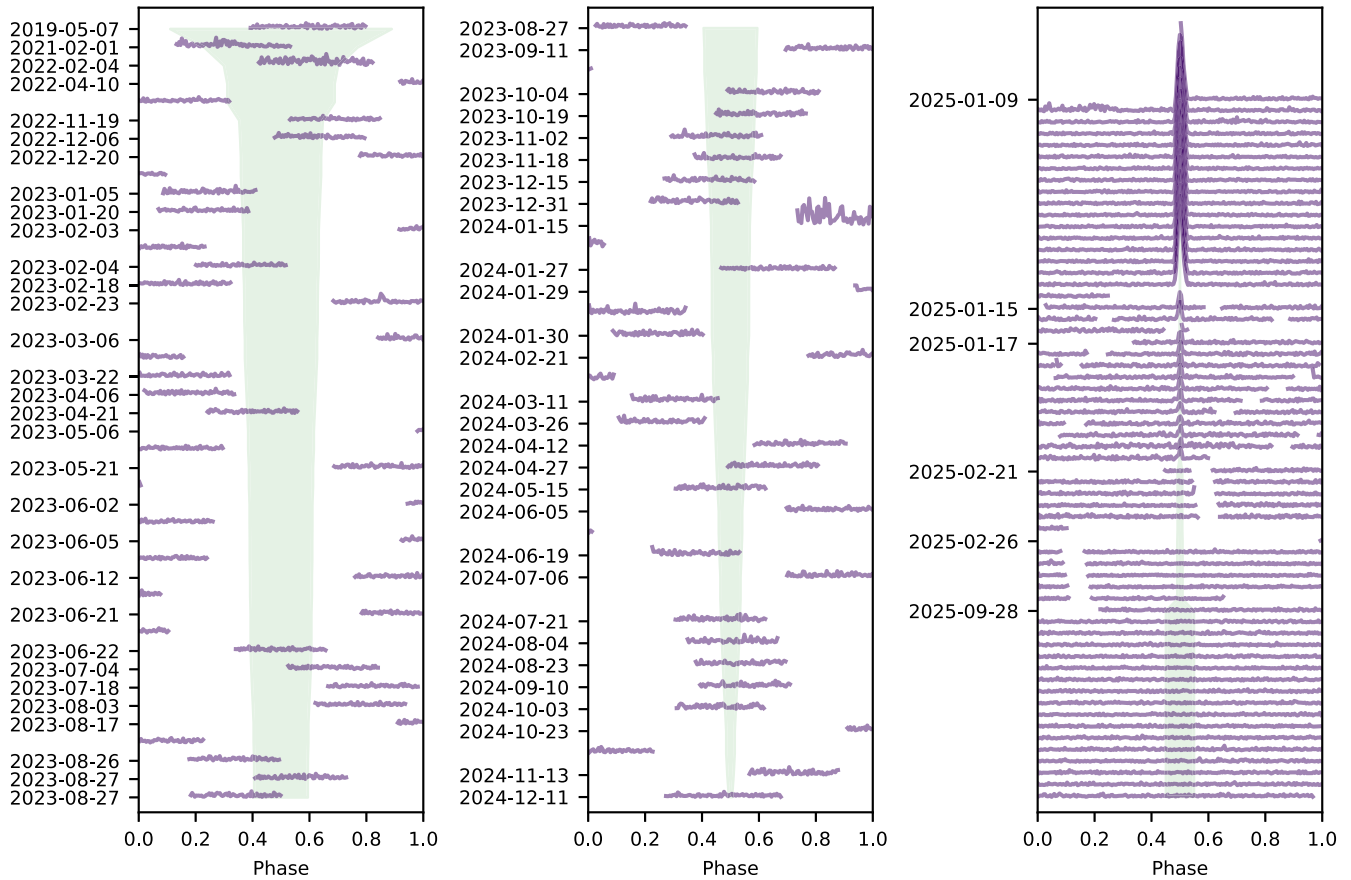


Figure A1. Lightcurves from all ASKAP, ATCA, and MeerKAT radio observations phase-folded to the radio period of 2 147.27 s. Green shading indicates the range of uncertainty in predicted pulse time around the expected pulse phase of 0.5. Pulses are only detected in the ASKAP and ATCA observations between 2025-01-09 and 2025-01-17.

We obtained two MeerKAT observations for 4 h each on 2025-02-21 and 2025-02-26 (project ID SCI-20241101-TM01) using the UHF band receiver, with a 544 MHz band centred on 816 MHz. We used the SARAO Science Data Processor (SDP) pipeline to flag and calibrate the data, using PKS J1939–6342 to solve for the bandpass response, flux scale, and polarisation leakage, J1446–4701 to solve for time-varying gains, and 3C 286 to calibrate the absolute polarisation PA. We further corrected the visibilities for mislabelling of the X and Y feeds (Perley *et al.* 2022) and parallactic angle rotation. We did not detect ASKAP J1424 in either observation, with 3σ Stokes *I* sensitivity limits of $\sim 100 \mu\text{Jy beam}^{-1}$ in the full-integration images and $\sim 1 \text{ mJy}$ in 2 min cadence lightcurves.

We acquired *Murriyang* observations on 2025-01-14 and 2025-01-28 for durations of 1 and 2 h, respectively. We used the ultra-wide-bandwidth low-frequency receiver (UWL; Hobbs *et al.* 2020) which provides continuous frequency coverage from 704 to 4 032 MHz, and recorded data with a sampling rate of 64 μs with 6 656 500 kHz-wide channels across the 3 328 MHz bandwidth. We conducted standard pulsar searches on the data from both epochs.⁸ In addition, we also conducted sub-banded searches, splitting the data into different sub-bands and performing pulsar searches in each sub-band. No pulsations were found in either epoch. We also examined the raw voltage data around the predicted time of arrival

of the pulse on 2025-01-14, but detected no significant excess corresponding to the 2 min pulse, even after cleaning the data for strong radio frequency interference.

We performed MWA follow-up observations under project code G0115, continuously tracking ASKAP J1424 for 3 h and 8 h on the nights of 2025-01-15 and 2025-01-16, respectively. We examined 5 min integration images, as well as 4 s resolution dynamic spectra, towards the location of ASKAP J1424. No detections were made, with 3σ sensitivity limits of $\sim 150 \text{ mJy beam}^{-1}$ in the 5 min integrations, and $\sim 1.5 \text{ Jy beam}^{-1}$ in the 4 s cadence light curves.

In Figure A1, we show the phase folded lightcurves of all $\sim \text{GHz}$ radio observations.

Appendix B. Archival multi-wavelength data

ASKAP J1424 was covered by a second EMU observation (SB77270) on 2025-09-28 but no pulses were detected. Phase one of the VAST Galactic survey ran for approximately two years from November 2022. Observations were carried out on an approximately fortnightly basis, with each observation lasting 12 min. ASKAP J1424 is within the survey footprint and was observed 53 times across the survey. The position of ASKAP J1424 was also observed seven times across the multiple epochs of RACS in the Low, Mid, and High band. ASKAP J1424 was not detected in any VAST or RACS archival observations.

We searched the Galactic Plane Monitoring programme undertaken with the MWA, described in the Methods of Hurley-Walker

⁸Due to heavy winds, observations during the first epoch were taken in a non-contiguous manner.

et al. (2023); 585 observations sensitive to ASKAP J1424 were taken under project code G0080 over 2022 and 2024 Jun–Oct. These covered 185–215 MHz over $|b| < 15$ deg and $285 \text{ deg} < l < 65$ deg, for 30–45 min integration on a bi-weekly cadence (Hurley-Walker et al. in preparation will describe the survey in full). No detections were made, with 3σ sensitivity limits of $\sim 60 \text{ mJy beam}^{-1}$ in the 5 min integrations, and $\sim 600 \text{ mJy beam}^{-1}$ in the 4 s light curves.

ASKAP J1424 has not been detected in any archival infrared (IR), optical, ultraviolet (UV), or X-ray data. The strongest archival limits in each band are $g > 23.5$, $r > 22.6$, $i > 22.1$, $z > 21.6$, and $Y > 20.8$ from the DECam Plane Survey (DECAPS; Saydjari et al. 2023); $J > 19.9$, $H > 18.1$, and $K_s > 16.9$ from the VISTA Variables in the Via Lactea (VVV; Minniti et al. 2010) survey; $UVM2 > 21.67$ from a 0.46 ks observation with *Neil Gehrels Swift Observatory* (Swift; Gehrels et al. 2004) (ID 00040976009). We also find no detection in *XMM-Newton* X-ray telescope (Jansen et al. 2001) observations in the 0.2–12 keV band above a 3σ flux limit of $F_X < 1.9 \times 10^{-12} \text{ erg s}^{-1} \text{ cm}^2$.

Appendix C. Dispersion modelling

We estimated the dispersion measure (DM) from the phase-folded SB70271 dynamic spectrum by measuring frequency-resolved times of arrival across the 744–1 032 MHz band. We fit a Gaussian of varying amplitude and central phase to the folded profiles in 4 MHz subbands, keeping the width fixed to that of the broadband pulse profile. We adopted the centre of the Gaussian model as the time of arrival for each subband, and fit the frequency-dependent phase offsets with the standard cold-plasma dispersion law to obtain $\text{DM} = 1\,400 \pm 100 \text{ pc cm}^{-3}$.

This approach assumes that the pulse shape does not vary with frequency. When the dispersive delay across the band is comparable to or smaller than the pulse width, intrinsic profile evolution becomes degenerate with dispersion and can bias the inferred DM. To assess the impact of profile evolution, we used PULSEPORTRAITURE (Pennucci 2019) to construct a frequency-dependent pulse model from the phase-folded SB70271 data, using three eigen-components to describe the frequency-dependent morphology. We used *pat* from PSRCHIVE (Hotan et al. 2004) to measure times of arrival for each channel of the profile across frequency using this frequency-evolving model, and fit the DM using TEMPO2 (Hobbs et al. 2006). This joint modelling of profile variation and dispersion results in a DM of $210 \pm 40 \text{ pc cm}^{-3}$.

The substantial difference between these estimates highlights the challenge of disentangling DM from profile frequency evolution. Given this degeneracy, we adopt $1\,400 \text{ pc cm}^{-3}$ as a conservative upper limit on the DM under the assumption the frequency-dependent phase offsets are purely dispersive. A robust measurement will require observations with higher time resolution capable of resolving pulse sub-structure, together with broader simultaneous frequency coverage.

Appendix D. Polarisation modelling on the Poincaré sphere

Appendix D.1. Poincaré sphere representation

In the Poincaré sphere formalism the polarisation vector

$$\mathbf{P} = \frac{1}{P} \begin{bmatrix} Q \\ U \\ V \end{bmatrix} = \begin{bmatrix} \cos 2\chi \cos 2\psi \\ \cos 2\chi \sin 2\psi \\ \sin 2\chi \end{bmatrix} \quad (\text{D1})$$

fully describes the polarisation state as a location on the surface of a sphere, where the longitudinal coordinate $2\psi \in [-\pi, \pi]$ describes the PA and latitudinal coordinate $2\chi \in [-\pi/2, \pi/2]$ describes the ellipticity angle (EA) of the polarisation.^h Orthogonal polarisation states are represented as antipodal points on the sphere.

Propagation effects such as Faraday rotation (FR) and generalised Faraday rotation (GFR) are represented as rotations of the polarisation vector on the Poincaré sphere, with trajectories tracing circles of constant colatitude with respect to the ‘modal axis’ defining the polarisation state of the two orthogonal, natural wave modes of the medium through which the wave is propagating (Pacholczyk & Swihart 1970). In both FR and GFR the evolution occurs as a function of frequency rather than pulse phase, and evolution along a great circle requires an intrinsic polarisation state with a colatitude of 90 deg with respect to the natural modes.

Appendix D.2. Propagation through a linear birefringent medium

A ‘linear birefringent medium’ (LBM) is a plasma medium with two linearly polarised natural wave modes with different phase velocities. The natural modes can be described as a ‘fast axis’ oriented at angle ζ_1 and orthogonal ‘slow axis’ $\zeta_2 = \zeta_1 + 90$ deg, with modal axis oriented towards longitudes of $2\zeta_1$ and $2\zeta_2$ on the equator of the Poincaré sphere. Propagation through an LBM introduces a relative phase delay between these two modes, characterised by a retardance δ , which depends on the plasma properties and thickness of the birefringent medium (e.g. Lyutikov 2022). On the Poincaré sphere, this corresponds to a rotation of the polarisation vector by an angle δ about the modal axis.

For an initially linearly polarised wave with intrinsic PA ψ_{in} , the polarisation state lies on the equator of the Poincaré sphere. If ψ_{in} coincides with one of the natural modes ($\psi_{\text{in}} = \zeta_1$ or ζ_2), the wave propagates in a single mode and no relative phase accumulation occurs, leaving the polarisation state unchanged. For other intrinsic angles $\zeta_1 < \psi_{\text{in}} < \zeta_2$, the wave propagates through the LBM in a mix of the natural modes and accumulates a relative phase, producing a rotation away from the equator by an angle δ converting linear to elliptical polarisation.

If the intrinsic state varies as a function of pulse phase, either due to emission geometry as with the RVM or through another mechanism, the intrinsic polarisation vector traces an arc of a great circle along the equator of the Poincaré sphere. Evolution along an arbitrary great circle as a function of pulse phase can then be explained as a rotation of the entire linearly polarised intrinsic pulse profile about the modal axis. The observed great circle track then has an inclination angle of δ , and equatorial crossing points occurring at longitudes corresponding to the LBM natural modes of $2\zeta_1$ and $2\zeta_2$.

Appendix D.3. Great circle fitting

We fit a great circle model to the phase-folded SB70271 pulse profile trajectory on the Poincaré sphere using the parameterisation

$$\tan(2\chi) = -\tan(2\chi_{\text{max}}) \sin(2\psi - 2\psi_{\text{eq}}), \quad (\text{D2})$$

^h Poincaré sphere coordinates are a factor of two greater than the electric vector angles they represent. In this paper we write the factor of two explicitly so that all angles unambiguously refer to electric vector angles.

where $2\chi_{\max}$ is the maximum latitude reached along the trajectory and $2\psi_{\text{eq}}$ defines the modal axis and longitude at which the great circle intersects the equator. We used EMCEE (Foreman-Mackey *et al.* 2013) to fit this model, with best-fit posterior parameters of $\chi_{\max} = 15.8 \pm 0.3$ deg corresponding to an inclination $\delta = 2\chi_{\max} = 31.5 \pm 0.6$ deg, and $\psi_{\text{eq}} = 32.0 \pm 0.2$ deg.

Birefringence in a magnetised plasma is typically dispersive and wavelength-dependent, with the accumulated phase difference between the natural modes following a power law $\delta \propto \lambda^p$. Great circles following this model are therefore expected to show a frequency-dependent inclination angle, though ψ_{eq} is

expected to be frequency-independent and determined purely from the modal axis of the LBM. We split the folded pulse profile into four 72 MHz-wide subbands and fit independent great circles to each band. The inclination angle shows only weak evidence for power law frequency dependence over the four subbands, with $p_{\psi_{\text{eq}}, \text{fixed}} = 0.5 \pm 0.2$ when fixing $2\psi_{\text{eq}} = 64.0$ deg and $p_{\psi_{\text{eq}}, \text{free}} = 0.21 \pm 0.06$ when allowing it to vary freely. In both cases frequency dependence of the great circle trajectory is poorly constrained by our data, and the index implies only mild frequency dependence for the phase delay induced by the LBM.