FREQUENCY STRUCTURE OF RADIO SCINTILLATIONS FOR SEVERAL PULSARS

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Abstract. Scintillation times and decorrelation bandwidths for the pulsars B0329+54, B1641–45, B1508+55 and B1919+21 are determined. The results are based on observations made with different instruments and at different radio frequencies. All objects but the pulsar B1508+55 were detected to have more than one frequency scale. The obtained values of scattering parameters are not contrary in general to the Kkolmogorov form of density fluctuation spectrum.

1. Data Processing

The purpose of the present work is to determine pulsar scattering parameters. We have different sets of observational data (see Table I) for the pulsars B0329+54, B1641–45, B1508+55 and B1919+21. In all observations undetected signal have been registered with further shifting to zero frequencies and converting to the digital code. Then correction for bandpass amplitude irregularities and dispersion smearing were performed by method of predetection dispersion removal suggested by Hankins in 1971.

To realize these and subsequent operations some computer software was created which is analogous to the spectrometer with high resolution that allows us to measure very narrow decorrelation bands at low radio frequencies. To analyze the frequency scintillation pattern of investigated pulsars we have calculated cross-correlation functions (CCFs) between power spectra of the pulses close in time in accordance with the method described in the paper of Popov & Soglasnov in 1984.

2. Main Results

- Scattering parameters for four pulsars were measured (see Table I).
- In general, the parameters obtained are close to the Kholmogorov form of the density fluctuation spectrum.

Astrophysics and Space Science **278:** 43–46, 2001.

TABLE I

Pulsar scintillation parameters with their dependences from frequency

Pulsar	DM (pc cm^{-3})	ν (MHz)	B (MHz)	$\Delta\nu_s$ (kHz)	t_s (sec)	Least Squares Fit to $\log\phi = x \log\nu_{[\mathrm{MHz}]} + y$				Obs. Site	Epoch
						$\phi = \Delta\nu_{s[\mathrm{Hz}]}$		$\phi = t_{s[\mathrm{sec}]}$			
						x	r	x	r		
B0329+54	26.8	111	2.5	0.007*	< 2	4.44 ± 0.16	0.994	1.14 ± 0.28	0.85	BSA, Puschino	1999.92
				0.243	> 11						
				0.567							
		406.6	2	1.5	1.5					NCRT, Medicina	1997.46
				43.5	36						
				180	236						
B1641–45	480.0	1650	2×16	0.187	1.1	4.9	1	–	–	DSN43, Tidbinbilla, Australia	1997.70
				1560*							
B1508+55	19.6	102.5	0.1	0.087	12.6	4.31 ± 0.77	0.93	1.07 ± 0.46	0.8	BSA, Puschino	1978.46
B1919+21	12.4	102.5	0.1	8.6	79.3	4.12 ± 0.29	0.97	0.68 ± 0.21	0.85	BSA, Puschino	1980.14
				30							
				51*							
				3.8	31						1980.15
				25							

Notes: ν – observation frequency, B – receiver bandwidth, $\Delta\nu_s$ – decorrelation bandwidth, t_s – scintillation time, x and r – slope of the line and correlation coefficient in the least squares fit to the decorrelation bandwidth and the scintillation time.

Underlined values are those which were used in the least squares fit to the decorrelation bandwidth or scintillation time together with data of other authors from the literature (see Figure 1).

* We are not quite confident of these scales.

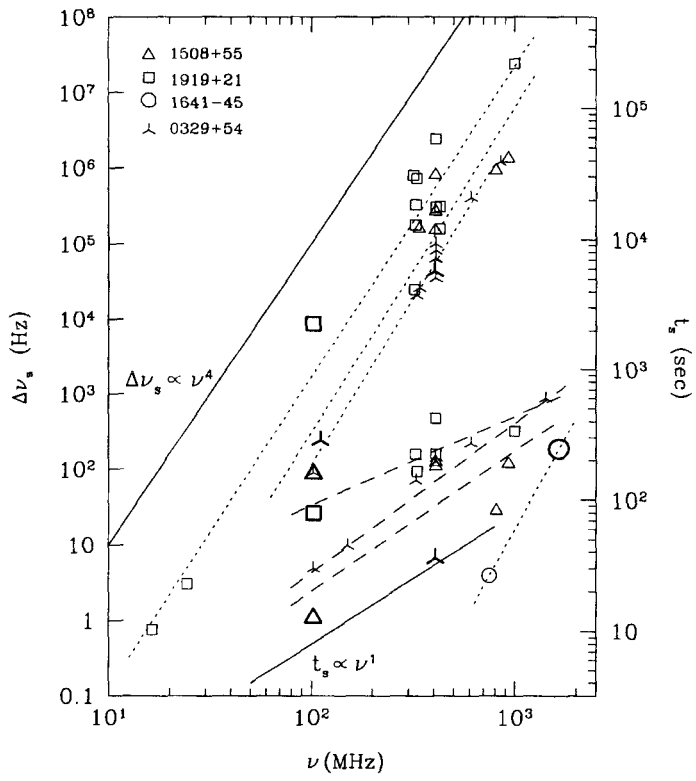

Figure 1. Decorrelation bandwidth $\Delta\nu_s$ and scintillation time t_s versus frequency ν for four pulsars. The data are from the present work (listed in Table I) marked by large bold symbols, and from works of other authors. The dot and long dashed lines are the least squares fits to the decorrelation bandwidth and scintillation time, respectively. The slope of solid lines corresponds to the case of the Gaussian form of the density fluctuation spectrum.

- Large errors in determination of the density fluctuation spectrum form, that corresponds to the large scatter of points in Figure 1, can be due to different frequency scales being measured by different researchers at different radio frequencies.
- Pulsars B0329+54, B1919+21 and maybe B1641–45 have ***more than one*** characteristic frequency scale.

Making some assumptions we could determine the smallest frequency scale for the pulsar B0329+54 to be 7 Hz, but this value is much smaller than our spectral resolution ($\sim$ 70 Hz), so we are not quite confident of this value although the expected value of this scale at 406.6 MHz coincides with the measured value at this frequency. The largest frequency scale of the pulsar B1919+21 of 51 kHz seems to be fictitious because there are two scintillation fringes on the dynamic spectrum, which are shifted from each other by just this value. So far as the second scale of the pulsar B1641–45 is concerned, there are some depressions in the average

https://doi.org/10.1017/S025292110000066X Published online by Cambridge University Press

power spectrum which give rise to the second scale in the CCFs. The connection of these depressions with scattering by interstellar plasma is a question because there are many recombination lines of H, He, O, C at the 158α, 345α, 369α and 389α transitions in the frequency range of the observations, which are slightly shifted in frequency, that together with the differential Galaxy rotation could give rise to the line broadening. But it should be noticed that this suggestion needs further analysis.

Acknowledgements

We are very grateful to Nichi D'Amico (Medicina, Italy), David Del Rizzo (Penticton, Canada), Valery Altunin (Pasadena, USA), Alexander Novikov (Toronto, Canada), Alexey Skulachev (Moscow, Russia), Konstantin Lapaev, Valentina Ivanova, Vladimir Kostromin (Puschino, Russia) and others who have helped us to conduct the observations and to perform the subsequent analysis.

References

Hankins, T.H.: 1971, Microsecond Intensity Variations in the Radio Emissions from CP 0950, *Astrophys. J.* **158**, 487–494.

Popov, M.V. and Soglasnov, V.A.: 1984, Observations of Interstellar Scattering of Radio Emission of Pulsar PSR 0329+54 at 102.5 MHz, *Soviet Astron.* **28**, 424–427.