POLARIMETRIC OBSERVATIONS OF 20 WEAK PULSARS AT 1720 MHz

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Introduction

We present average polarization profiles for 20 pulsars at 1720 MHz made with the 100-m Effelsberg radio telescope. All four Stokes parameters were appropriately delayed in a linear dedisperser to correct the interstellar dispersion on-line. Our sample includes a number of complex profiles which were observed polarimetrically for the first time at a high frequency, with the aim of describing their frequency evolution. Classification of the corrected profiles is attempted according to the empirical pulsar model described earlier by Rankin(1990).

For a number of these objects the evolutionary scenario is in good agreement with that predicted by the model. Further more our results support the correlation between the profile types and the physical parameters B_{12}/P^2.

A calibration method is described which utilizes the unique polarization properties of radio pulsars (large linear polarization angle swing, significant amounts of linear and circular polarization) in order to evaluate the instrumental polarization performance of the receiving setup. The inverse of the Muller matrix derived with this method was then used to correct the systematic error introduced to the polarization profiles of 20 pulsars observed with this setup. The good agreement of the corrected profiles with well observed published profiles supports the reliability of the proposed method.

Observations and method of analysis

The observations were made with the 100-m Effelsberg radiotelescope between 17 and 19 December 1984 at 1720 MHz. The two circularly polarized outputs of the single-horn, prime-focus 18-cm receiver were combined in an adding polarimeter to produce the linear polarization channels. Then a four-port dedispersion device appropriately delayed all signals to account for the interstellar dispersion across the 40-MHz bandwidth. Two well studied pulsars PSR 1929+10 and PSR 0355+54 were used as calibrators and were observed frequently at various effective position angles (parallactic angles plus offset feed positions).

Stokes parameter profiles of our calibrators, extracted from the literature, were digitized and taken to represent the true polarization state. The profiles were interpolated to match the resolution of the observations and shifted to the maximum correlation position of the observed profiles. The linear Stokes parameters Q and U were rotated to the parallactic angle at which the observations were made to allow for the time dependent part of the polarimeter matrix.

Each longitude point of the profile was treated as an individual continuum source exhibiting its own polarization state. We fitted the observed Stokes polarization profiles to the theoretical profiles (templates) and in this way we evaluated the antenna response. The calculated matrix was applied to the theoretical values and in this way the estimation of the matrix elements was optimized by using the χ^2 criterion.

Individual pulsars

We continue by describing the polarization characteristics of the individual pulsars in an effort to establish their classification. Table I summarizes the physical parameters B_{12}/P^2 and $1/Q$, both of which are related to the acceleration potential available to the pulsar and their importance as indices of classification has been discussed by Rankin(1990). Also tabulated is the derived classification for each star. The polarization profiles are shown in figure 1. The circular polarization on the plots is always

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Table 1 Pulsar parameters and classification

Pulsar	B_{12}/P^2	$1/Q$	Class	Linear (%)	Circular (%)	Linear Traverse
0136+57	23.4	5.39	S_t	86	15	50°
0148−06	0.38	0.24	D	43	30	130°
0149−16	1.52	0.68	D	< 6	10	
0355+54	34	6.95	S_t	100	5	160°
0402+61	5.21	1.76	M/T	< 25	10 R−L	135°
0450+55	7.82	2.31	T	85	12	95°
0559−05	4.65	1.54	T	65	< 20	160°
0756−15	2.28	0.92	D	38	< 12	
0906−17	3.26	1.16	T	< 15	< 8	120°
1112+50	0.75	0.41	T	25	< 15	
1742−30	14.9	3.88	T?	55	15	
1745−12	4.5	1.503	M/T	30	< 30	
1804−08	2.5		M/T	30	10	75°
1831−04	2.85	1.02	M		2.3	
1834−10	9.4	2.52	T/S_t	40	10	75°
1851−14	1.68	1.52	S_t/T	< 20	20	
1905+39	0.53	0.31	M/T	< 60	< 10	
2003−08	0.46	0.25	T/M	< 60	< 25	135°
2310+42	1.67	0.67	T/M	40	< 20	60°
2351+61	4.44	1.62	T	24	9	85°

left-hand when positive and right-hand when negative.

Results

A sample, rich in multi-component pulsars, has been studied with the aim of investigating their polarization characteristics at high frequency. The main difficulty in this study is the intrinsic weakness of many pulsars above 1 GHz. For 17 of these stars, we give high frequency polarization information for the first time.

We have combined our measurements with the existing lower-frequency observations in an effort to study the frequency evolution of the profiles and establish a classification. We have identified two core-single ($\mathbf{S_t}$), 9 probable triple (**T**) and 6 five-component (**M**) pulsars as well as 2 apparent conal single ($\mathbf{S_d}$) and 1 double (**D**) pulsar.

Core-single ($\mathbf{S_t}$) and double (**D**) profiles usually conform closely to the empirical model described by Rankin (1983) and therefore their identification is not difficult. Triple (**T**) and five component pulsars (**M**) have a core component at lower frequencies which normally weakens in intensity at higher frequencies. In addition these pulsars generally exhibit a steep traverse of the polarization angle and often show profile mode changing. A significant difficulty in attempting to classify these pulsars is that their components are often closely spaced and merge into an overall "boxy" shaped profile. The B_{12}/P^2 values for the triple and multiple profiles in our sample all fall into the range suggested by Rankin (1990), with the **M** pulsars generally having values lower than about 2.5 and the triple pulsars having a somewhat broader range.

Comparing our data with lower frequency polarization measurements we note that the linear polarization decreases with frequency as expected, but the power of circular polarization remains effectively unchanged.

Certain pulsars merit further study in their own right. Pulsar 1742−30 exhibits a profile in which the core component possibly lies outside the conal outrider, a unique configuration. Pulsar 0756−15 has an extremely narrow profile. And, interestingly, pulsar 0450+55's profile has an intrinsic "decaying" feature on the trailing edge of its profile.

This paper has been published since the Colloquium in Poland. See Xilouris et al. 1991.

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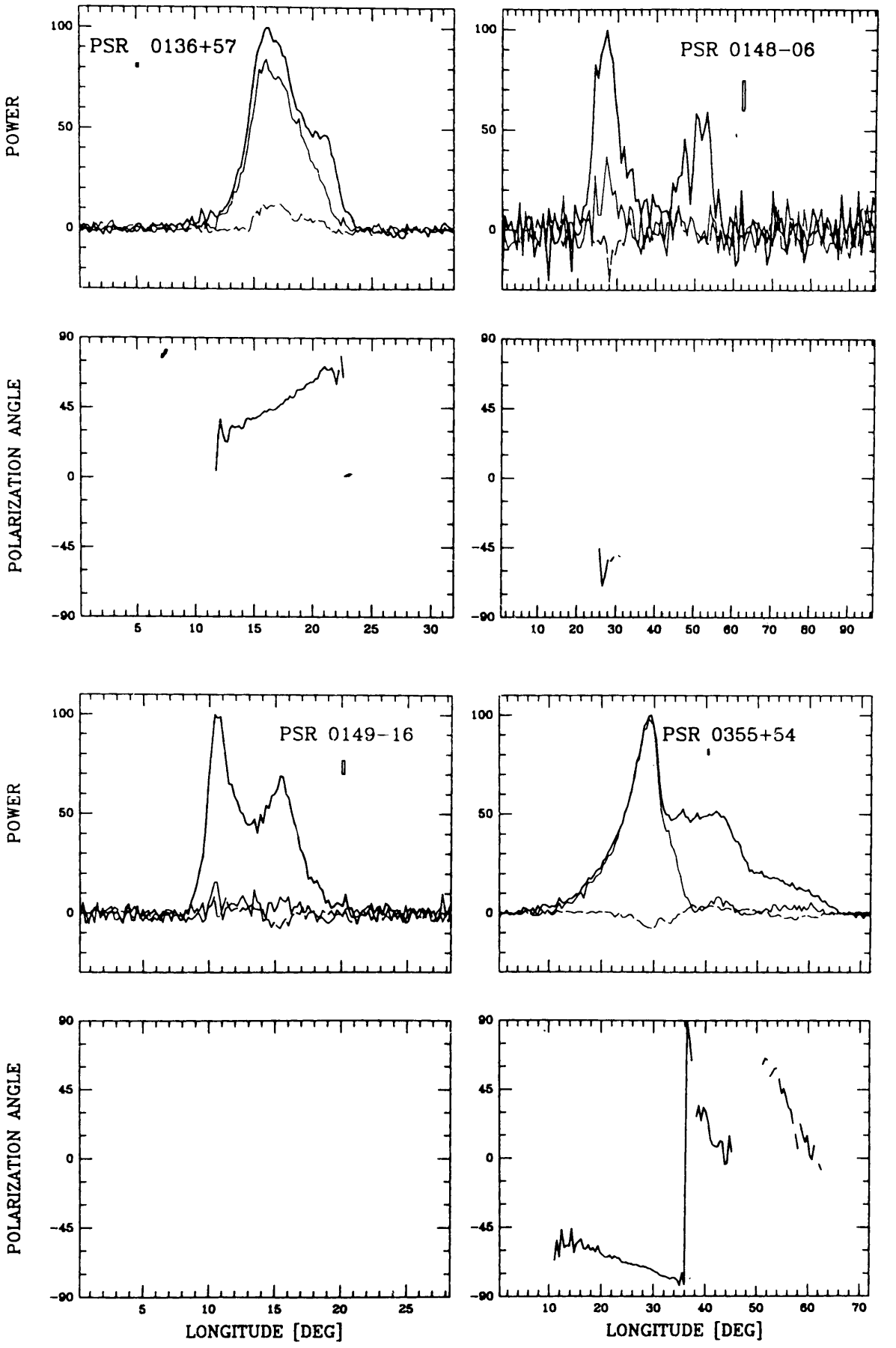

Figure 1a 1720 MHz polarization profiles of 12 pulsars. Four vertical curves are plotted: the total intensity (Stokes parameter I) is the bold outside curve, whose maximum is scaled to 100. The total linear polarization [Stokes parameter $L = (Q^2 + U^2)^{1/2}$] is the interior, positive going curve, and the circular polarization (Stokes parameter $V \equiv LH - RH$) the dashed curve. The linear polarization angle [$\Phi = 1/2 \tan^{-1}(U/Q)$] is plotted on a lower scale in degrees, and measured counterclockwise from north on the plane of the sky. All four curves are plotted against the pulsar longitude in degrees.

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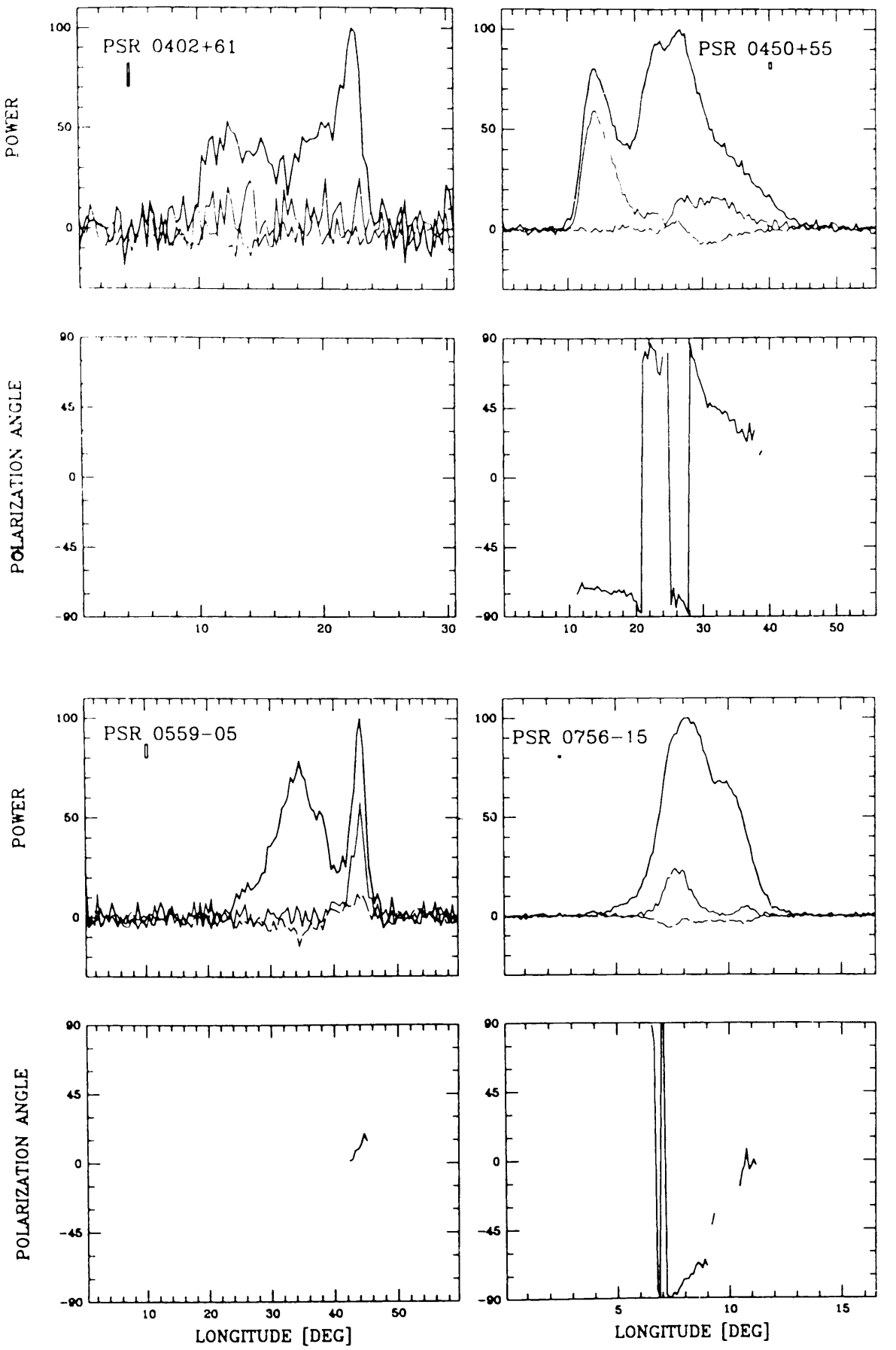

Figure 1b (See caption for figure 1a)

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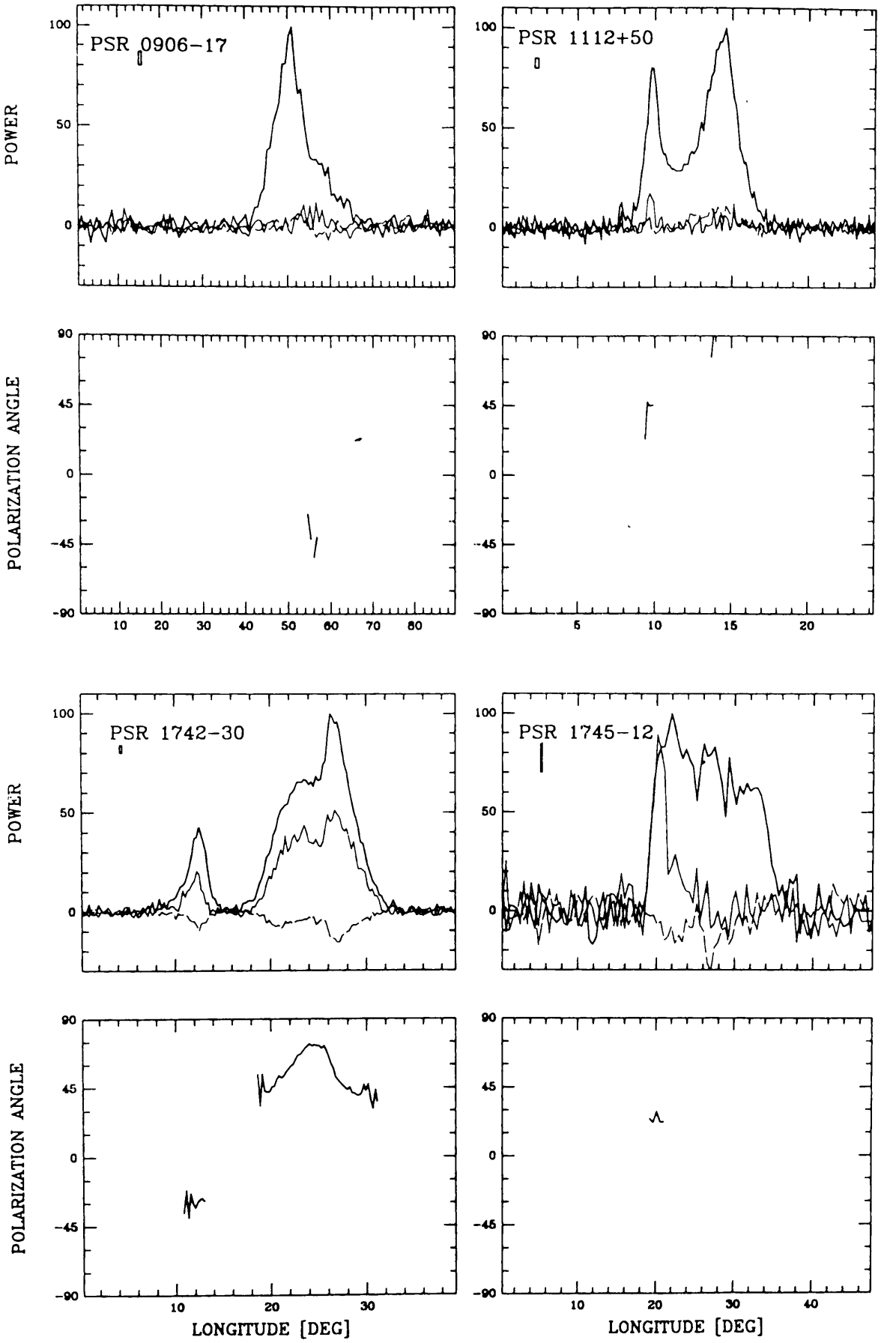

Figure 1c (See caption for figure 1a)

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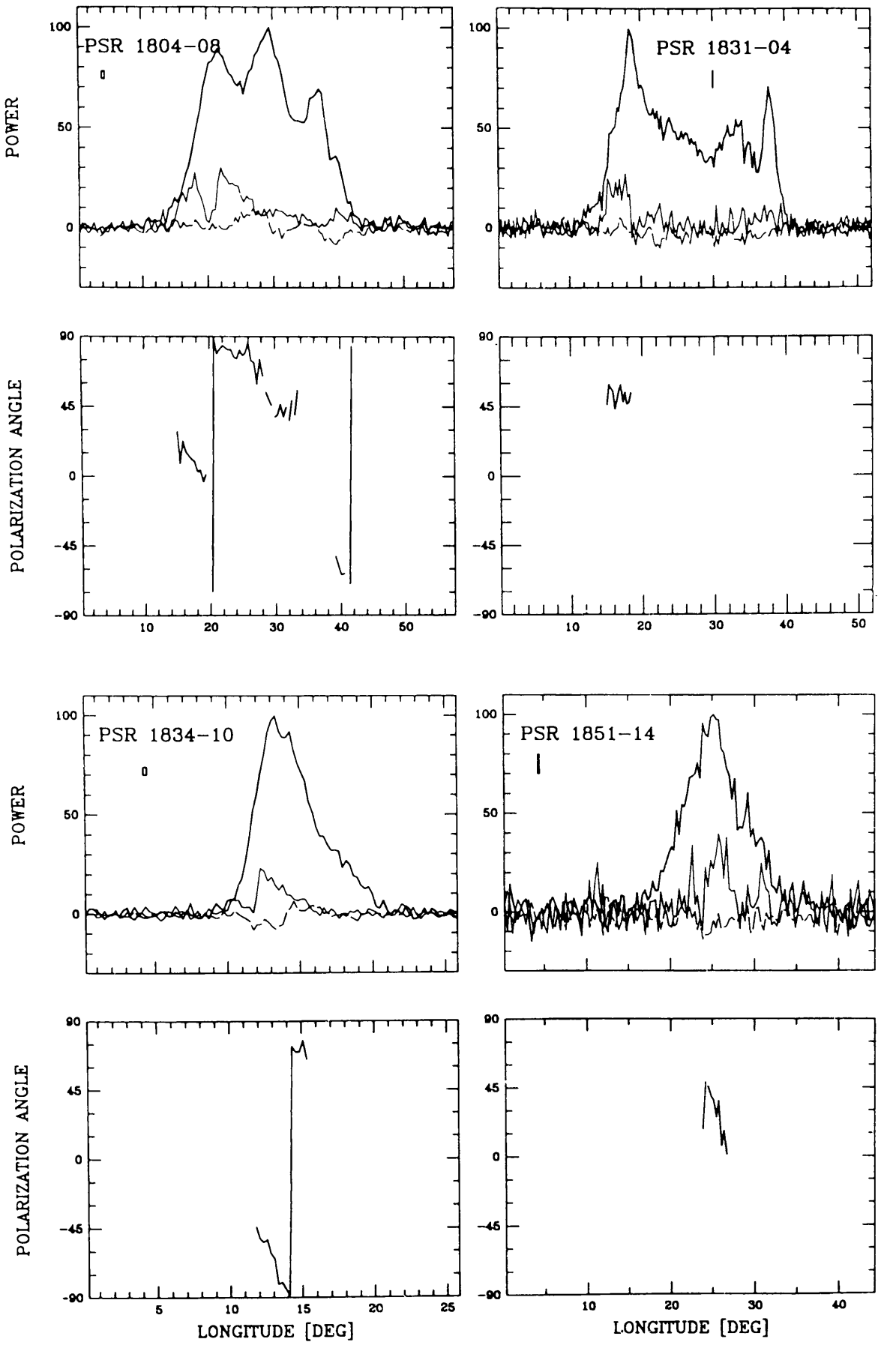

Figure 1d (See caption for figure 1a)

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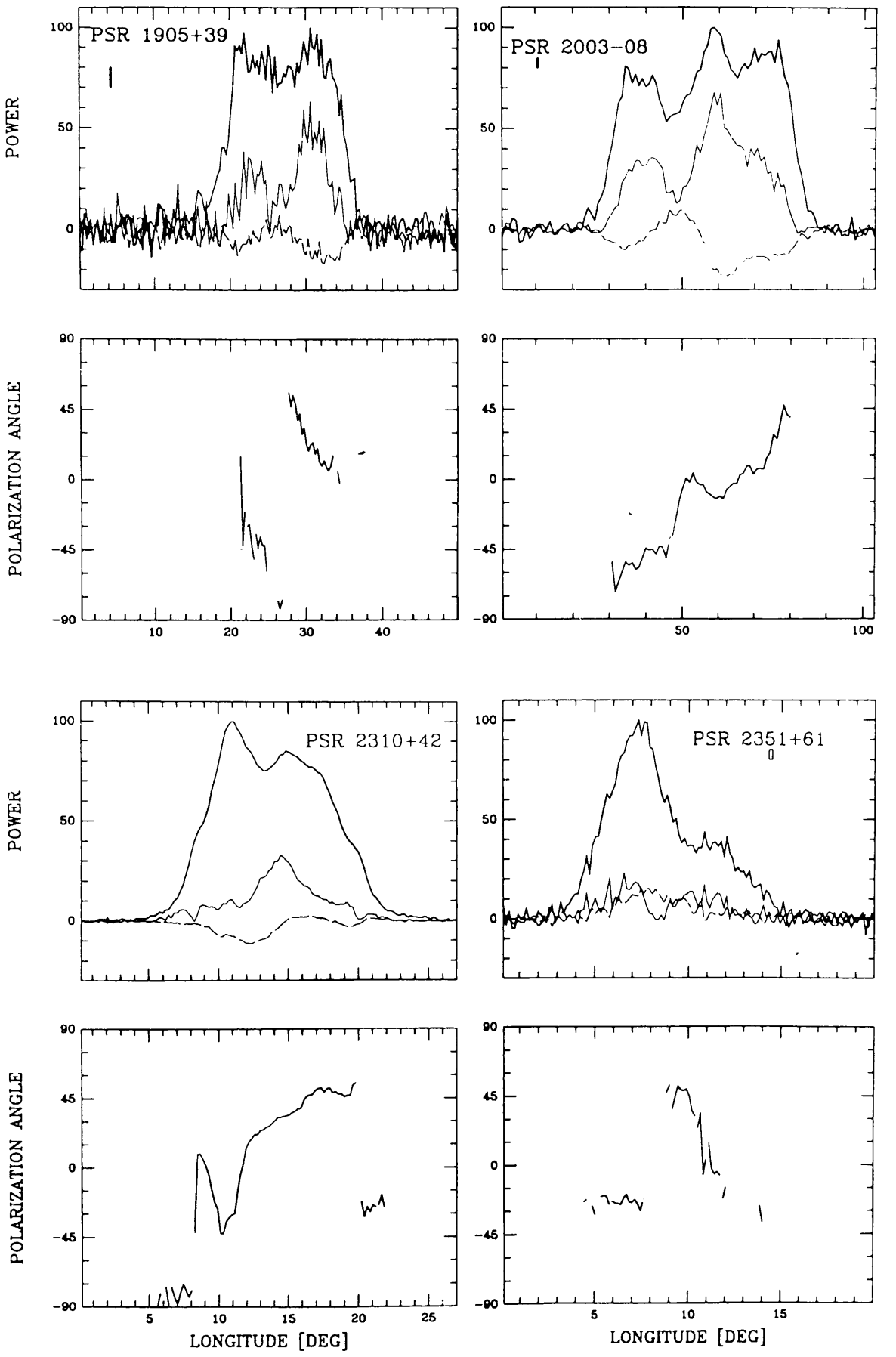

Figure 1e (See caption for figure 1a)

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