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PERIODIC VARIATIONS IN PULSAR RADIATION INTENSITY

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ABSTRACT

Power spectra of pulsar-intensity fluctuations at 318 MHz indicate that seven pulsars have line structure in their intensity spectra. Since two of these pulsars, AP 1237+25 and AP 2303+30 are newly discovered, their characteristic parameters are presented. The power spectra of CP 1919+21 and AP 2015+28 do not show features corresponding to the alias of the class 2 pulsation that is thought to cause subpulse structure.

Recent observations of AP 0823+26 and CP 0834+06 at low radio frequencies indicate that their pulse-to-pulse intensity fluctuations contain strong periodic components (Taylor, Jura, and Huguenin 1969). Several pulsars have been observed at Arecibo Observatory in order to detect a periodic modulation of their pulse intensities at 318 MHz. Pulse intensities were calculated from data simultaneously recorded with eight radiometers that had 10-msec time constants, 1-MHz bandwidths, and radio frequencies sequentially separated by 1 MHz in the range 314.5–321.5 MHz. Pulse intensities (ON intensities) were calculated by integrating the power within windows of data that were slightly wider than 1 pulse width and centered on each pulse. Intensities due to system noise (OFF intensities) were similarly calculated for windows placed midway between pulses. Power spectra of the fluctuations of the ON intensities about their mean value were then taken on arrays of 2048 points of intensity, using the Cooley-Tukey algorithm. The eight power spectra were then averaged, and the result was smoothed by taking a running mean over ten spectrum points. The resulting power spectra (Fig. 1) have a frequency resolution of 0.005 cycle per pulse period. Similar power spectra were taken on the OFF intensities and compared to those of Figure 1. Each arrowed feature in Figure 1 stands well above the noise spectra.

Two of the pulsars shown in Figure 1 have been recently discovered, and their parameters are therefore presented in Table 1. The pulsar AP 2303+30 is especially interesting, since it is coincident, within our pointing accuracy, with the continuum radio source B2 2303+30 (Gruppo Roub 1969).

The features shown in Figure 1 are generally narrower than the frequency resolution of the power spectra. The frequencies of these lines, f_L, are given in Table 2, together with the Nyquist frequency, $f_N = 0.5$ (pulse period)$^{-1}$. The errors in f_L are the estimated rms errors in the determination of the line frequency, and the f_N are accurate to $\pm 10^{-4}$ Hz. The values of f_L for AP 0823+26 and CP 0834+06 agree, within the rms errors, with the values measured by Taylor *et al.* (1969), whose spectra have a frequency resolution of 0.03 cycle per pulse period. This broad frequency resolution and the predominant scintillation component at the lower radio frequencies probably explain the failure of Taylor *et al.* to detect the CP 1133+16 and CP 1919+21 lines.

It is possible that the observed lines are caused by some radiation feature whose periodic appearance results in a modulation of the pulsar output energy at the frequencies given in Table 2. The observed lines, however, may be the result of a higher frequency, f_H, which has been aliased into the observed spectra and which follows the relationship $f_H = 2nf_N \pm f_L$, where n is an integer. One possible f_H would be the class 2 pulsation that Drake and Craft (1968) proposed to be the cause of pulsar subpulse structure. They measured $f_H = 64.479 \pm 0.001$ Hz and $f_H = 93.564 \pm 0.002$ Hz for CP 1919 and AP 2015, respectively. If we choose that n that allows f_L to be less than f_N, the respective f_L are 0.168 and 0.370 Hz. Because these features are not present in the power spectra shown in Figure 1, it is unlikely that the two phenomena are related unless the subpulse phenomenon is time-variable. The observed lines, however, may be aliases of the vibrational frequency, $f_V \approx 10^3$ Hz, of a pulsating neutron star. Vila (1969) has

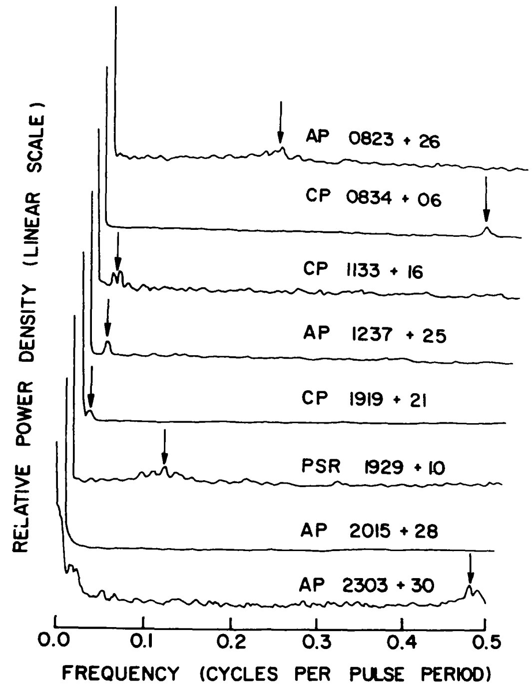

FIG. 1.—Power spectra of pulse intensities at 318 MHz. Frequency resolution is 0.005 cycle per pulse period, and origins of adjacent spectra are displaced by 0.075 cycle per pulse period. Each spectrum is normalized to be unity at the first data point, which is at 0.005 cycle per pulse period.

TABLE 1

CHARACTERISTIC PARAMETERS OF TWO PULSARS*

Parameter	AP 1237+25	AP 2303+30
α(1950.0).................	$12^h37^m17^s \pm 10^s$	$23^h03^m30^s \pm 10^s$
δ(1950.0).................	$25°10' \pm 4'$	$30°45' \pm 4'$
l^{II}.......................	250°	98°
b^{II}.......................	+86°	−27°
Heliocentric period.........	1.382449 sec	1.575869 sec
Pulse width at 318 MHz....	60 ± 5 msec	30 ± 5 msec
Dispersion measure........	9 ± 1 pc cm^{-3}	46 ± 1 pc cm^{-3}

* All errors rms errors, the periods are accurate to $\pm 10^{-6}$ sec, and the pulse widths are full widths at half-maximum.

proposed that an alternative explanation of the second periodic pulsation might be that a neutron-star precession is coupled to the star's rotation. Still another explanation might be that there are oscillations of a circumstellar plasma about its equilibrium position (Bertotti, Cavaliere, and Pacini 1969).

TABLE 2

LINE FREQUENCIES f_L, AND NYQUIST FREQUENCY f_N, FOR THE POWER SPECTRA OF 318-MHz PULSE INTENSITIES

Pulsar	f_L (Hz)	f_N (Hz)
AP 0823+26.........	0.377±0.040	0.9423
CP 0834+06.........	0.357±0.004	0.3926
CP 1133+16.........	0.021±0.008	0.4209
AP 1237+25.........	0.015±0.004	0.3617
CP 1919+21.........	0.007±0.004	0.3739
PSR 1929+10........	0.441±0.090	2.2075
AP 2015+28.........	...	0.8961
AP 2303+30.........	0.308±0.006	0.3173

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