LETTERS TO NATURE

Second Decrease in the Period of the Vela Pulsar

THE first discontinuity in period of the Vela Pulsar (PSR 0833-45) occurred between February 24 and March 3, 1969 (refs. 1 and 2). The period decreased by 208 ns and the rate of change of period increased by 1×10^{-15} s s^{-1}. A similar discontinuity occurred between August 21 and September 4, 1971. A preliminary analysis of the data shows that the period decreased by 179 ns and that the rate of change of period increased. A definitive analysis of the discontinuity will have to await more data because of the normally irregular behaviour of the period[3].

The antenna and receiver used and the techniques of data taking and reduction have been described previously[1,4]. The position of the pulsar used in the analysis of the data was $\alpha(1950.0) = 08$ h 33 m 39.09 s and $\delta(1950.0) = -45°\ 00'\ 05.3''$. Instrumental errors and data reduction techniques were eliminated as the cause of the discontinuity by comparing the data with those from other pulsars. Nineteen other pulsars were under observation both before and after the discontinuity. The same observational and data reduction techniques were used on these nineteen pulsars and their periods remained stable.

The data were separated into two blocks in order to measure the magnitude of the decrease. The first block extended from July 24 to August 21, 1971, and the second from September 4 to October 9, 1971. Using a model of the pulse period based on previous data[3], the relative phase drift between the model and the observed pulse train was compared. The mean drift over an interval of 30 min (the time span of a typical observation) was measured for both blocks. The data in the 30 min intervals were corrected for the motions of the antenna about the geocentre and of the geocentre about the solar system barycentre. The two measured drifts were then converted into errors in the model period and the two errors were differenced to obtain the change in period.

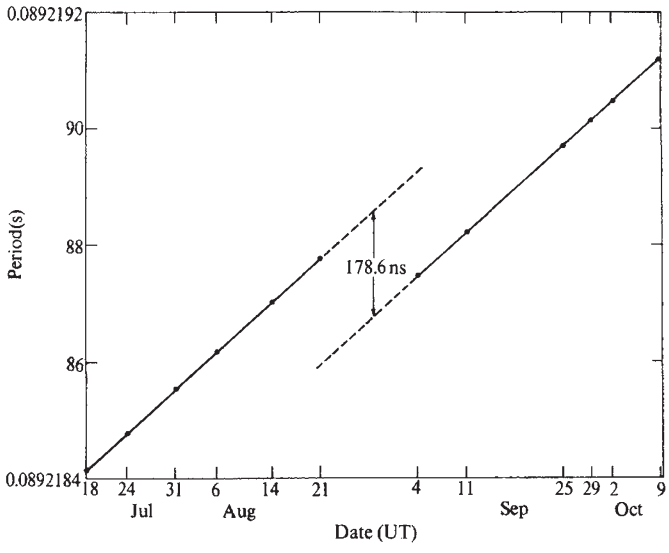

Fig. 1 The barycentric period (UTC) of the Vela Pulsar as observed from July 24 to October 9, 1971.

The model period was in error by -19.7 ± 0.4 ns for the first block and $+158.9 \pm 0.3$ ns for the second block. This yielded a decrease in period between the two blocks of 178.6 ± 0.5 ns. This decrease is shown in Fig. 1. The errors quoted above are formal one-standard-deviation errors. The computed period was 0.0892187771 s UTC at 1830 UT, August 21, 1971, and 0.0892187479 s UTC at 1730 UT, September 4, 1971. These periods are accurate to a few parts in the last decimal place.

Because of the method used to compute the decrease in period, a measurement could not be made of any change in the rate of change of period. Preliminary indications are that the rate of change of period increased, just as it did during the discontinuity of 1969. A measurement of any persistent changes in the time derivatives of the period will require a complete least squares analysis of data over a longer period of time. This analysis is necessary because the period contains short term fluctuations[3] not accurately described by a simple polynomial over a long period of time. These fluctuations are not of sufficient magnitude to effect the measured decrease of the period but would effect any measurement made now of changes in the time derivatives.

The fractional change in period is -2×10^{-6}, slightly less than the magnitude of the previous change. The time span between the discontinuities is 2.50 ± 0.03 yr; the uncertainty is determined by the time span between observations. Estimates of the age of the pulsar will have to take such period changes into account if the changes are accompanied by fractional changes in the rate of change of period of $\sim 10^{-2}$. One age estimate[5] is given by the ratio of the period to twice the rate of change of the period. This estimate yields 11,400 yr (ref. 4) for the Vela Pulsar. This age estimate increases considerably when allowances are made for discontinuities. The Vela Pulsar could very well be as old as the supernova remnant Vela X (ref. 6), which apparently surrounds the pulsar[7]. The age estimate could be correct if the observed changes in period are apparent. One cause of an apparent change could be a planetary companion to the pulsar[8,9]. The inclusion of more data and a least squares analysis will help to settle this problem.

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