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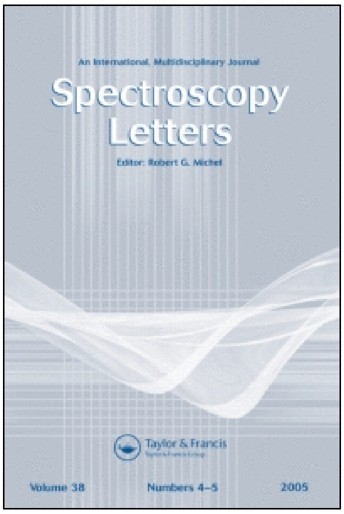


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# Pulsar NP-0532-A "Spectroscopic" Binary?

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# PULSAR NP-0532--A "SPECTROSCOPIC" BINARY?

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In November, 1967, the first pulsar was discovered by Antony Hewish of Cambridge University. Within a year a dozen more were discovered. They may be described as radio sources within the Milky Way Galaxy that emit pulsed radio signals. Very little else is known about them with certainty, although most astronomers believe they are probably neutron stars. The mechanism by which they emit radio signals is unknown.

Careful measurements of the pulse period, i.e., the time interval between consecutive pulses, has revealed that all of them, except NP-0532 which is the subject of this paper, have pulse periods which have remained absolutely constant since their discovery to within $1 \times 10^{-8}$ seconds, the limit of accuracy of measurement. These pulse periods range from a maximum of 1.9616633 seconds for the source known as PSR 2045 to a minimum of 0.03309014 seconds for the source known as NP-0532.(1)

The period of NP-0532 was first measured on October 20, 1968, at Arecibo, Puerto Rico, where it was picked up by the large radio telescope operated there by Cornell University. It differs from all other pulsars in that the pulse period is <u>not</u> constant. Seven measurements of the pulse period were made from 20 October, 1968 to December 1969, as follows: (2)

| | |
|---|---|
| 20 October | 0.03309014 seconds |
| 15 November | 0.03309112 seconds |
| 22 November | 0.03309139 seconds |
| 26 November | 0.03309154 seconds |
| 2 December | 0.03309175 seconds |
| 5 December | 0.03309185 seconds |
| 9 December | 0.03309199 seconds |

It should be carefully noted that the above measurements are corrected for the Doppler effect resulting from motion of the earth in its orbit around the sun. Likewise, the period measurements of all other pulsars are corrected for the earth's motion. After the correction is made, however, we find that all other pulsars have constant periods, while NP-0532 is increasing as indicated above.(3)

A plot of the pulse period against time shows that the increase is perfectly linear from 20 October to 26 November, with an increase in period of $3.78 \times 10^{-8}$ seconds per day for 37 days. Thereafter, however, the rate of increase declined as follows:

| | | |
|---|---|---|
| 26 Nov.) 2 Dec.) | 6 days | $3.50 \times 10^{-8}$ sec. per day |
| 2 Dec.) 5 Dec.) | 3 days | $3.33 \times 10^{-8}$ sec. per day |
| 5 Dec.) 9 Dec.) | 4 days | $3.25 \times 10^{-8}$ sec. per day |



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The writer believes this apparent curvature in the plot is quite real, although it could be due to error in measurement. Observations subsequent to 9 December, when published, will show the extent of the curvature, if any.

A second feature of NP-0532 which distinguishes it from all other pulsars is that an optical source, i.e., a visible star, has been discovered at the same position as the radio source. The light from this star also arrives in pulses having the same period as the radio pulses![4]

These two features (variable period and a visible star at the same position) distinguish NP-0532 from all other pulsars which have constant periods and are invisible. This has led the writer to conclude that NP-0532 is a member of a spectroscopic (sic) binary system, i.e., in orbit around the common center of gravity it shares with the visible star, with the plane of orbit nearly parallel to the line of sight, while all other pulsars are single sources.

The visible component is a bluish looking star, with a visual magnitude of about 16.2, located in the Crab Nebula. Its spectrum has no lines at all.[5] Since its light pulsates at the same frequency as the pulsar, it is reasonable to suppose that there is a cause and effect relationship between the invisible pulsar and its luminous mate. Rapid pulsation of the stellar surface at speeds approaching the speed of light would, of course, smear out the spectral lines. It is possible that when the visible star is at the apastron position, the pulsation effect will



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either diminish or disappear, at which time we may be able to detect lines in the spectrum.

If NP-0532 is in fact a "spectroscopic" binary, as the writer believes, the discovery of this source has the greatest significance. Most of man's knowledge of stellar masses and distances comes from spectroscopic binaries, eclipsing binaries, and pulsating stars of the Cepheid type. Continued measurement of the pulse period of NP-0532 will enable astronomers to determine with precision its orbital period, the eccentricity of its orbit, and the distance by which it is separated from its visible companion at various points on the orbit. This information, in turn, when coupled with information gained from observation of the visible companion, will surely lead to a better understanding of the mysterious pulsars and the mechanism by which they emit radio waves.

The discovery of this source has further significance in that it will permit measurement of the speed of the source to a much higher degree of accuracy than ever before possible. Heretofore the speeds of binary stars have been measured by the Doppler effect through the shifting of spectral lines. This method leaves much to be desired insofar as accuracy is concerned. Now, for the first time, the Doppler effect produced by rotation of a double star can be measured with an accuracy of one part in $10^8$. It follows that the radial velocity of the source can be determined with similar accuracy.

Since improved accuracy of measurement almost always leads to new discoveries, it is not unreasonable to expect big things in the future from the "spectroscopic" pulsar, NP-0532.

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