diabetes, phenylketonuria there will be genetic therapy. The appropriate DNA will be provided in the appropriate dose")[20] are justified. If, however, as I have tried to show, the specificity transmitted in inheritance is determined by a multimolecular system vastly more complex than a DNA molecule, any promise to control inheritance by chemical manipulation of DNA is likely to be illusory and, in certain social circumstances, harmful to the welfare of man.

Biologists have confronted successively—like a nest of Chinese boxes—levels of complexity ranging from the ecosystem to the internal chemistry of the cell. The last box has now been opened. According to the Watson–Crick theory, it should have contained the single source of all the inherited specificity of living organisms—DNA. It is my view that we now know that the last box is empty and that the inherited specificity of life is derived from nothing less than life itself.

This article reflects, in part, work supported by a grant from the US Public Health Service.

Received July 2; revised August 16, 1968.

[1] Crick, F. H. C., *Cold Spring Harbor Symp. Quant. Biol.*, **31**, 3 (1966).
[2] Commoner, B., *Nature*, **203**, 486 (1964).
[3] Commoner, B., *Amer. Sci.*, **52**, 365 (1964).
[4] Commoner, B., in *Horizons in Biochemistry* (Academic Press, New York, 1962).
[5] *Nature*, **218**, 317 (1968).
[6] Crick, F. H. C., *Symp. Exp. Biol.*, **12**, 138 (1958).
[7] Kornberg, A., *Enzymatic Synthesis of DNA* (Wiley, New York, 1961).
[8] Speyer, J. F., Karam, J. D., and Lenny, A. B., *Cold Spring Harbor Symp. Quant. Biol.*, **31**, 693 (1966).
[9] Freese, B., and Freese, E., *Proc. US Nat. Acad. Sci.*, **57**, 650 (1967).
[10] Marshall, R. E., Caskey, C. T., and Nirenberg, M., *Science*, **155**, 820 (1967).
[11] Parisi, B., Milanesi, G., Van Etten, J. L., Perani, A., and Ciferri, O., *J. Mol. Biol.*, **28**, 295 (1967).
[12] Gorini, L., Jacoby, G. A., and Breckenridge, L., *Cold Spring Harbor Symp. Quant. Biol.*, **31**, 687 (1966).
[13] Barnett, W. E., Brown, David H., and Epler, J. L., *Proc. US Nat. Acad. Sci.*, **57**, 1775 (1967).
[14] Barnett, W. E., and Epler, J. L., *Cold Spring Harbor Symp. Quant. Biol.*, **31**, 549 (1966).
[15] Arca, M., Frontali, L., Sapora, O., and Tecce, G., *Biochim. Biophys Acta*, **145**, 284 (1967).
[16] Commoner, B., *Nature*, **202**, 960 (1964).
[17] Bennett, J. M., thesis, Washington Univ. (1968).
[18] Britten, R. J., and Kohne, D. E., *Science*, **161**, 529 (1968).
[19] Alper, T., Cramp, W. A., Haig, D. A., and Clarke, M. C., *Nature*, **214**, 764 (1967).
[20] Sinsheimer, R., *Bull. Atomic Scientists*, **23** (No. 2), 9 (1967).

A Pulsar Supernova Association?

by
M. I. LARGE
A. E. VAUGHAN
B. Y. MILLS

Cornell-Sydney University Astronomy Centre,
School of Physics,
University of Sydney

A pulsar with a very short period (0·089 s) has been discovered at the position of a suspected supernova remnant, raising several interesting consequences.

In a search for southern pulsars at the Molonglo Radio Observatory, a very short period pulsar has been discovered at the position of a suspected supernova remnant. The estimates of distance are also compatible. The apparent coincidence of the pulsar and the supernova may be fortuitous, so it is premature to draw any far reaching conclusions. But it is interesting to explore the possibility of a physical association and to assume tentatively that the pulsar represents the final collapsed stage of a star which exploded. A number of deductions can then be made and some further observations suggested.

Following the scheme of Turtle and Vaughan[1] the pulsar is designated *PSR* 0833–45. The measured parameters are given in Table 1. The position given in the table was measured with the east–west arm of the telescope. The full cross shows a "point" source at $\alpha(1950.0) = 08^h\ 33^m\ 39.0^s \pm 1^s$ and $\delta(1950.0) = -45°\ 00'\ 05'' \pm 15''$. This source is of the correct flux density and close enough in position to be identified with the pulsar. Because of the short period of the pulsar (the shortest yet found) and the comparative constancy of the pulse amplitudes, the pulsar would be expected to appear as an ordinary "point" radio source when recorded with the normal 3 s time constant of the full cross (see Turtle and Vaughan[2]). We have therefore adopted the much more precise declination of the point source as that of the pulsar.

The pulsar is situated in a region of complex emission which has recently been discussed by Milne[3]. It lies within the boundaries of the extended radio source Vela *X* (*MSH* 0833–45) which Milne has shown to be part of a supernova shell some 4 or 5 degrees in diameter. The shell includes also the sources Vela *Y* and Vela *Z* and the filamentary nebula Stromlo 16. Milne suggests that the shell is at a distance of 500 ± 100 pc, which is in good agreement with the distance of the pulsar based on the dispersion measurement. The approximate centre of the emission region (as defined by Milne's outer contour 5 at 635 MHz) is at $\alpha(1950{\cdot}0)$ $08^h\ 38^m$, $\delta(1950{\cdot}0)$ $-45°$. The shell shows evidence of distortion, presumably due to interaction with the interstellar gas, so that the original supernova might well be considerably displaced from the centre of the radio emission region. *PSR* 0833–45 is situated less than 1° (20 per cent of the shell diameter) from the radio centre. An identification of the pulsar with the stellar remnant of the supernova thus seems to be a reasonable working hypothesis. In the following discussion we examine some of the interesting consequences of such an identification.

Table 1. MEASURED PARAMETERS OF *PSR* 0833–45

$\alpha(1950{\cdot}0)$	$08^h\ 33^m\ 38{\cdot}9^s \pm 1^s$
$\delta(1950{\cdot}0)$	$-45{\cdot}4° \pm 0{\cdot}3°$
l^{II}	263·5°
b^{II}	−2·8°
P(s)	$0{\cdot}0892 \pm 0{\cdot}0002$
$-\frac{d\nu}{dt}$ (at 408 MHz) MHz s^{-1}	155 ± 15
Distance (assuming $\bar{n}_e = 0{\cdot}1$ cm^{-3}) pc	500
Mean flux density (at 408 MHz) 10^{-26} W m^{-2} Hz^{-1}	$1{\cdot}7 \pm 0{\cdot}4$
Pulse length ms	~10

By comparison of the Faraday rotation of the polarized radio emission from Vela *X* with the dispersion measurements on the pulsar it is possible to obtain directly the mean longitudinal component of the interstellar magnetic field. There is some uncertainty about the rotation measure because, according to Milne, a large part of the Faraday rotation occurs within the radio emitting regions.

In particular, he notes large differences of rotation measure for points only 0·25° apart near the peak of Vela *X*. If Milne's estimate of 46 rad m^{-2} for the component of rotation measure introduced between the source and the Sun is combined with the figure of 155 MHz s^{-1} for the dispersion of the pulsar at 408 MHz, we find that the mean longitudinal field is equal to 10^{-6} gauss. The mean absolute value for the field would obviously be greater. The mean electron density of 0·1 cm^{-3} initially assumed is also consistent with the astronomical distance to the supernova derived by Milne.

The short period of *PSR* 0833–45 and the low optical luminosity of other pulsars[1,2,4] makes it most unlikely that they can be associated with rotating or pulsating white dwarf stars. The most reasonable hypothesis is that they are neutron stars as originally suggested by Hewish *et al.*[5]. The radially pulsating model suggested by them would, however, be very difficult to reconcile with the long period of 1·96 s found for *PSR* 2045–16 (see Thorne and Ipser[6]). It is more plausible to invoke rotation as the basic modulation mechanism.

It seems most likely that the Vela supernova was of type II, resulting from an explosion of a massive star. Milne's data are compatible with either a type I or a type II, but Kesteven[7] has shown that the strong non-thermal galactic radio sources are typically associated with type II supernovae. If neutron stars are formed at every type II supernova explosion, and these have been continuing at their present rate of the order of one per 100 yr over the whole age of the galaxy, then there will be about 10^8 neutron stars in the galaxy, with a space density of the order of 10^{-3} pc^{-3}. While the statistics of pulsars is not yet well established, their space density must be of the order of 10^{-6} pc^{-3}. Thus on the hypothesis that all pulsars are neutron stars, the probability of a neutron star exhibiting pulsar characteristics is of the order of 10^{-3}, with an uncertainty of about two orders of magnitude. One possibility is that all neutron stars pass through a pulsar stage lasting for a time of the order of 10^7 yr (shortly after their formation if the suggested identification is correct). Alternatively, a fraction of neutron stars may be pulsars of longer lifetime. The limiting case is when one neutron star in 10^3 is a pulsar with an active lifetime at least as long as the age of the galaxy. A pulsar phase of long duration seems possible in view of the necessarily slow evolution of neutron stars, although the chance then of detecting the ephemeral gaseous remnant would be rather small. Pulsars probably exist with periods appreciably shorter than those already detected. It is not impossible that some pulsars are included as point sources in radio catalogues.

It is obviously necessary to examine all known and suspected supernova remnants with the greatest possible sensitivity. A preliminary search at the Molonglo Radio Observatory of fifteen possible remnants listed by Kesteven[7] has yielded no further pulsars. This is not surprising because most of the objects are more than 1 kpc distant and the resulting low flux densities and large dispersions would hinder discovery. Although the sensitivity of the east–west arm of the Molonglo Cross is high, the time of observation at each transit is limited to about 10 s. It would be more promising to track these and similar objects with a large steerable reflector with a fairly wide beam and to examine the output for periodicities, using averaging techniques extended over several hours. A range of frequencies and bandwidths should be used because the optimum receiver characteristics depend on the spectrum, rate of frequency drift, inherent pulse length and pulsar period. Frequencies of a few hundred megahertz with bandwidths in the range 0·1 MHz to 1 MHz seem promising on the present evidence.

If the age of most pulsars is very great an appreciable slowing down of the rotation rate might be expected due to the transfer of angular momentum to the interstellar medium. One might expect the older and more numerous pulsars to have significantly longer average periods than the newer and rarer pulsars. Such an effect would appear as a negative correlation between pulsar period and distance. For the eleven pulsars known at present, the correlation coefficient between these parameters is 0·53, a value which is statistically significant at the 10 per cent level. Several times the present number of pulsars is required to establish any such correlation. Indeed, systematic surveys to detect more pulsars are one of the most pressing requirements at present.

To conclude, the possible association between *PSR* 0833–45 and the Vela supernova remnant opens several interesting lines of enquiry. The hypothesis that pulsars are rotating neutron stars formed in the explosion of massive supernovae receives considerable support. If the identification is correct, however, it seems clear that it was made possible by fortunate astronomical circumstances. Verification of the idea that supernovae and pulsars are associated may require a great deal of further radio and optical observations. Details of the instrumentation used in the pulsar search and more accurate parameters of this and other pulsars already detected in the programme will be given in a later publication.

We thank Dr R. Wielebinski for his help in providing recording facilities used during the observations. This research was supported by grants from the Australian Research Grants Committee and the US National Science Foundation.

Received October 17, 1968.

[1] Turtle, A. J., and Vaughan, A. E., *Nature*, **219**, 689 (1968).
[2] Turtle, A. J., and Vaughan, A. E., *Nature*, **219**, 845 (1968).
[3] Milne, D. K., *Austral. J. Phys.*, **21**, 201 (1968).
[4] Bailey, J. A., and Mackay, C. D., *Nature*, **218**, 129 (1968).
[5] Hewish, A., Bell, S. J., Pilkington, J. D. H., Scott, P. F., and Collins, R. A., *Nature*, **217**, 709 (1968).
[6] Thorne, K. S., and Ipser, J. R., *Astrophys. J. Lett.*, **152**, L71 (1968).
[7] Kesteven, M. J. L., *Austral. J. Phys.*, **21**, 369 (1968).

East Pacific Rise and Westward Drift of North America

by
HAROLD PALMER
Dames and Moore,
Los Angeles, California

There is some evidence for an ancestral East Pacific Rise which was overridden by North America in Mesozoic time.

THE conformity of the Mid-Atlantic Ridge system to a position midway between North America and Europe, and South America and Africa, and its magnetic, thermal and seismic characteristics lend credence to the seafloor spreading hypothesis. Hurley's recent review[1] of matching structural, lithologic and radiometric data which cross