LETTERS TO THE EDITOR

PHYSICAL SCIENCES

Optical Candidate for Pulsar *PSR* 0833–45

Two of the most singular characteristics of the pulsar *NP* 0532 are its short period (33 ms) and its association with a supernova remnant. This suggests that the next most promising candidate for detection of optical radiation from a pulsar is *PSR* 0833–45 (ref. 1), associated with the supernova remnant in Vela, which has a period of 89 ms.

The colour measurements of *NP* 0532 (refs. 2–4) all show a strong ultraviolet excess. Because the radio dispersion of *PSR* 0833–45 is comparable with *NP* 0532 it is likely that the interstellar reddening is also comparable. This suggests that direct plates taken with U and B filters may be sufficient to identify stellar candidates. Accordingly, B. J. Bok took long exposure plates (103aO, UG2, 120 min; 103aO, GG13, 60 min; Eastman–Kodak Red Special, *RG*2, 90 min) with the Curtis–Michigan 24/36 inch f/3·8 Schmidt telescope at Cerro Tololo InterAmerican Observatory in Chile.

The U and B plates were compared by blinking. Only one star (see Fig. 1) was found within the error rectangle of the radio position the U image of which was as strong as or stronger than the B image. Positions on the plate are shown in Table 1.

Table 1

	α(1950.0)	δ(1950.0)
Radio position of pulsar	08 h 33 m 38·9 s ± 1 s	− 45° 00′ 05″ ± 15″
Measured position of candidate	08 h 33 m 38·8 s	− 45° 00′ 02″

No other candidate with such a strong ultraviolet excess was found within 70 arc s of the radio position.

Because there were no photoelectric standard stars present on the plates for calibration, it was not possible to measure accurately the magnitude of the candidate. But, by comparison with similar calibrated plates taken with the same telescope, the B magnitude was crudely estimated at +19. Comparison of all three plates shows a flat spectrum similar to that found for *NP* 0532.

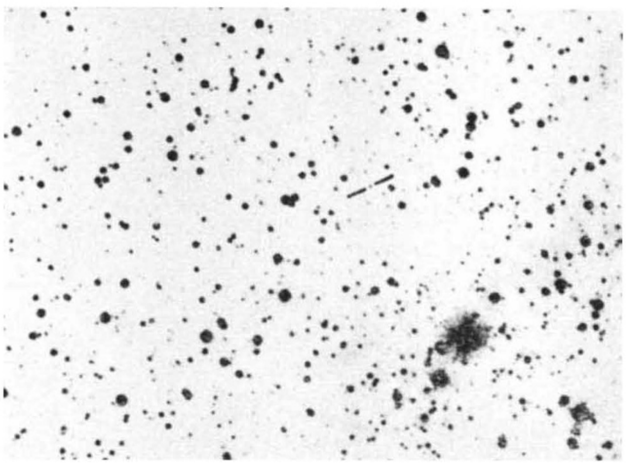

Fig. 1. Finder chart (GG 13 filter) for the pulsar candidate, which is located between the two ink lines. The brightest star on the chart is Smithsonian Catalogue No. 220143 ($m_V = 9·3$, α(1950) = 8 h 33 m 26·104 s, δ(1950) = −45° 3′ 20·45″), and is approximately 4 arc min south-west of the candidate.

The images on the U and B plates show a suggestion of faint nebular wisps emanating from the star. These wisps are so faint, however, that we are not certain of their nature or actual association with the star.

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Pulsars and Neutron Star Formation

THE current popularity of the rotating neutron star hypothesis as an explanation of pulsars suggests that a re-examination of the problem of the formation of neutron stars is appropriate. In particular it is of interest to know the predictions of the theory of stellar evolution concerning the formation of neutron stars and the type of object from which they are formed. I present here a few plausible assumptions that lead to some surprisingly general predictions. It will be suggested that pulsars are formed from massive O stars; observational tests of this hypothesis are possible and will be discussed.

Hoyle *et al.*[1] discussed the formation of neutron stars by the fragmentation of a rotating star undergoing gravitational collapse. Most investigations have taken a different approach, considering the neutron star as a remnant core of a spherically symmetric stellar explosion. Chiu[2] found that neutrino emission was adequate to cause collapse in evolved stars the mass of which was above the Chandrasekhar limit $(M/M_\odot) > 1·45(2/\mu_e)^2$. Fowler and Hoyle[3] have stressed that energy generation by thermonuclear burning will always dominate energy loss by neutrino emission as long as nuclear fuel is available. Exploratory computations[4] of the evolution of stellar cores through carbon, oxygen and silicon burning support this conclusion. The hydrodynamic collapse of a stellar core composed of iron (products of complete nuclear burning) was investigated first by Colgate and White (ref. 5 and see ref. 6).

None of these analyses, however, allows estimation of which main sequence stars will form neutron stars at the end of their lives (except that the total stellar mass of such stars must exceed the Chandrasekhar limit, otherwise only a white dwarf would result).

Recent work[7] suggests that if a direct electron–neutrino coupling in the weak interaction does exist, then stars the cores of which are less massive than about 1 $M_\odot$ at the end of helium burning will not ignite the $^{12}C + ^{12}C$ reaction immediately, but will develop highly degenerate cores. Investigation of the further evolution of such stars[8] suggests that ignition and detonation of the ^{12}C fuel will eventually result, causing a complete dispersal of the star into space, or that a white dwarf will result after non-catastrophic mass loss.

I considered the evolution of a helium-burning shell which surrounds a degenerate core of the carbon and oxygen which are formed in helium burning. As the shell burns its way toward the stellar surface it adds its reaction products to the degenerate core. This increases the mass