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POSSIBLE CONVERSION OF ROTATIONAL ENERGY OF THE NEUTRON STAR IN THE CRAB NEBULA INTO ENERGY OF RELATIVISTIC ELECTRONS

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ABSTRACT

The observation that the period of the pulsating radio source in the Crab Nebula is increasing at a rate of 1 part in 2×10^3 per year suggests that a neutron star is releasing rotational energy at a rate of about 10^{38} ergs sec^{-1}, which is approximately the rate of energy release needed to account for the observed production of relativistic electrons at the center of the nebula.

The pulsating radio source NP 0532, recently discovered in the Crab Nebula, is the only such source known that is located in the position of a historically recorded supernova. NP 0532 has the shortest known period, 0.03309 sec, and this period has been observed to increase with time at a rate of approximately 1 part in 2×10^3 per year (Craft *et al.* 1968).

The second-shortest period, 0.0892 sec, belongs to PSR 0833 in the supernova remnant Vela X; this is the only other pulsating radio source located in the position of an observable supernova remnant.

One can then argue that the eighteen other known pulsating radio sources must have resulted from more ancient supernovae, whose radio remnants are no longer observable. The fact that the periods of such sources seem to increase steadily with time indicates that the time-keeping device is stellar rotation rather than stellar pulsation. The very short period of 0.03309 sec indicates further that the rotating star can only be a neutron star (Gold 1968).

If a neutron star is rotating with a period of 0.03309 sec and this period is increasing at a rate of 1 part in 2×10^3 per year, a large amount of rotational energy is being released. For instance, for the theoretical neutron stars considered by Tsuruta and Cameron (1966), the moments of inertia are between about 1.5×10^{44} g cm^2 and 1.5×10^{45} g cm^2; the release of rotational energy would be between 7×10^{37} ergs sec^{-1} and 7×10^{38} ergs sec^{-1}.

The indication that rotational energy is released by a neutron star in the Crab Nebula at a rate between 7×10^{37} ergs sec^{-1} and 7×10^{38} ergs sec^{-1} is a most exciting one, since at the center of the nebula about 10^{38} ergs sec^{-1} are observed to go into the acceleration of relativistic electrons and possibly into the creation of nebular magnetic fields (Shklovskii 1966; Haymes *et al.* 1968); mechanisms suggested to explain this energy output have all run into difficulties.

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