NEUTRON STAR COOLING AND THE VELA PULSAR

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We have calculated cooling models of young neutron stars.[3] The theoretical cooling curves for several models are compared with the Einstein X-ray observations of young supernova remnants (Figure 1).

Our most interesting new finding may be that for the Vela pulsar the observed temperature upper limit is below the *standard* cooling curve. This may raise some interesting possibilities for the Vela pulsar, i.e., greatly enhanced cooling through the presence of *exotic* particles such as charged pion condensates and quarks. This may be possible if the Vela pulsar is slightly more massive than a neutron star in, e.g., RCW103. Note that the observed temperature upper limits for point sources RCW103, 3C 58, and the Crab are consistent with the *standard* cooling.

This outcome is interesting in view of the recent report[4] that the temperature of the internal crustal layers of the Crab and Vela pulsar independently estimated by the vortex creep theory is 3.8×10^8 K and 1.5×10^7 K, respectively. The corresponding temperatures of these pulsars obtained from the *standard* cooling model are $\sim (3 - 6) \times 10^8$ K and $(2 - 4) \times 10^8$ K, respectively. This leads to a potentially important implication that for the Crab the *standard* cooling model (i.e., no *exotic* particles included) is consistent with the vortex creep theory but it would not be so for the Vela pulsar.

[3]Nomoto K. and Tsuruta S. 1986, *Ap. J. (Lett)*, *305*, L19; 1987, *Ap. J.*, Jan. 15.
[4]Alpar M.A., Nandkumar R., and Pines D. 1985, *Ap. J.*, *288*, 191.

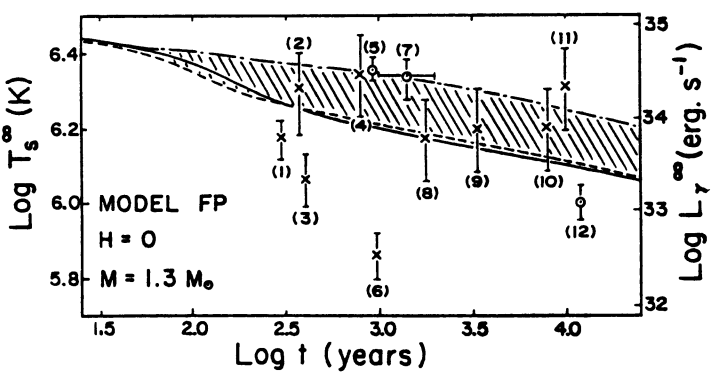

Figure 1:
The numbers refer to
(1) Cas A, (2) Kepler,
(3) Tycho, (4) 3C58,
(5) Crab, (6) SN1006,
(7) RCW103, (8) RCW86,
(9) W28, (10) G350.0-18,
(11) G227.7-0.2,
(12) Vela.

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