ASTR367

Neutron Stars

Remarks on Super-Novae and Cosmic Rays

We have recently called attention to a remarkable type of giant novae.[1] As the subject of super-novae is probably very unfamiliar we give here a few more details which are not contained in our original articles.

1. Distribution of super-novae

In our calculations we made use of the assumption that on the average one super-nova appears in each galaxy every thousand years. This estimate is based on the occurrence of super-novae in the following galaxies,

Our own galaxy	in 1572
Andromeda	1885
Messier 101	1907

These three systems are located within a sphere of radius 12×10^5 light years.

In the Virgo cluster, which contains about 500 nebulae, six super-novae were found on plates taken during the last thirty years. As a curiosity we mention that in N.G.C. 4321, which is a member of Virgo, two super-novae have appeared in 1901 and 1914, respectively.

In the same interval of 30 years six additional super-

We wish to emphasize that all of these finds are chance finds since a systematic search for super-novae has been organized only recently.

From the estimate of one super-nova per galaxy per thousand years it follows that 10^7 super-novae appear per year in the 10^{10} nebulae which are contained in a sphere of 2×10^9 years radius (critical distance derived from the red shift of nebulae). If cosmic rays come from super-novae their intensity in points far away from any individual super-nova will be essentially independent of time.

2. *Comparison with the lifetime of stars*

The lifetime of stars is supposed to be of the order of at least 10^{12} years. A nebula contains about 10^9 stars. These estimates, combined with the frequency of occurrence of one super-nova per galaxy per 10^3 years suggest that the super-nova process might occur to every star once in its lifetime, marking perhaps the cessation of its existence as an ordinary star. We realize that this suggestion is highly speculative in view of the possibility that the frequency of occurrence of super-novae may depend on time and in view

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1 W. Baade and F. Zwicky, Proc. Nat. Acad. Sci. May,

of our complete ignorance with respect to the evolution of the universe.

3. *Ions in super-novae*

If super-novae are giant analogues to ordinary novae we may expect that ionized gas shells are expelled from them at great speeds. If this assumption is correct, part of the cosmic rays should consist of protons and heavier ions. Direct tests by cloud chamber experiments at high altitudes are desirable in order to test this conclusion. Also the problem suggests itself to investigate how much energy corpuscular particles lose on their long journey through space. On the picture of an expanding universe this loss has been computed by R. C. Tolman.

4. *Fluctuations of cosmic rays*

In our original papers we have calculated the change in intensity of cosmic rays caused by flare-ups of super-novae in nearby galaxies. The estimates given are perhaps too optimistic in view of the fact that the velocities of different particles are different. If various particles are ejected simultaneously at the time $t=0$ from a galaxy which is 10^6 L.Y. away the times t of arrival on the earth are

$t=10^6$ years for light if its velocity does not

$t_1=10^6$ years$+410$ seconds for 10^{11} volt electrons.

$t_2=$ " $+47.6$ days " 10^9 " "

$t_3=$ " $+44$ years " 10^{11} " protons.

These time lags t_i-t would tend to smear out the change of intensity caused by the flare-up of individual super-novae. Dr. R. M. Langer in one of our seminars was the first to call attention to the straggling of simultaneously ejected particles.

5. *The super-nova process*

We have tentatively suggested that the super-nova process represents the transition of an ordinary star into a neutron star. If neutrons are produced on the surface of an ordinary star they will "rain" down towards the center if we assume that the light pressure on neutrons is practically zero. This view explains the speed of the star's transformation into a neutron star. We are fully aware that our suggestion carries with it grave implications regarding the ordinary views about the constitution of stars and therefore will require further careful studies.

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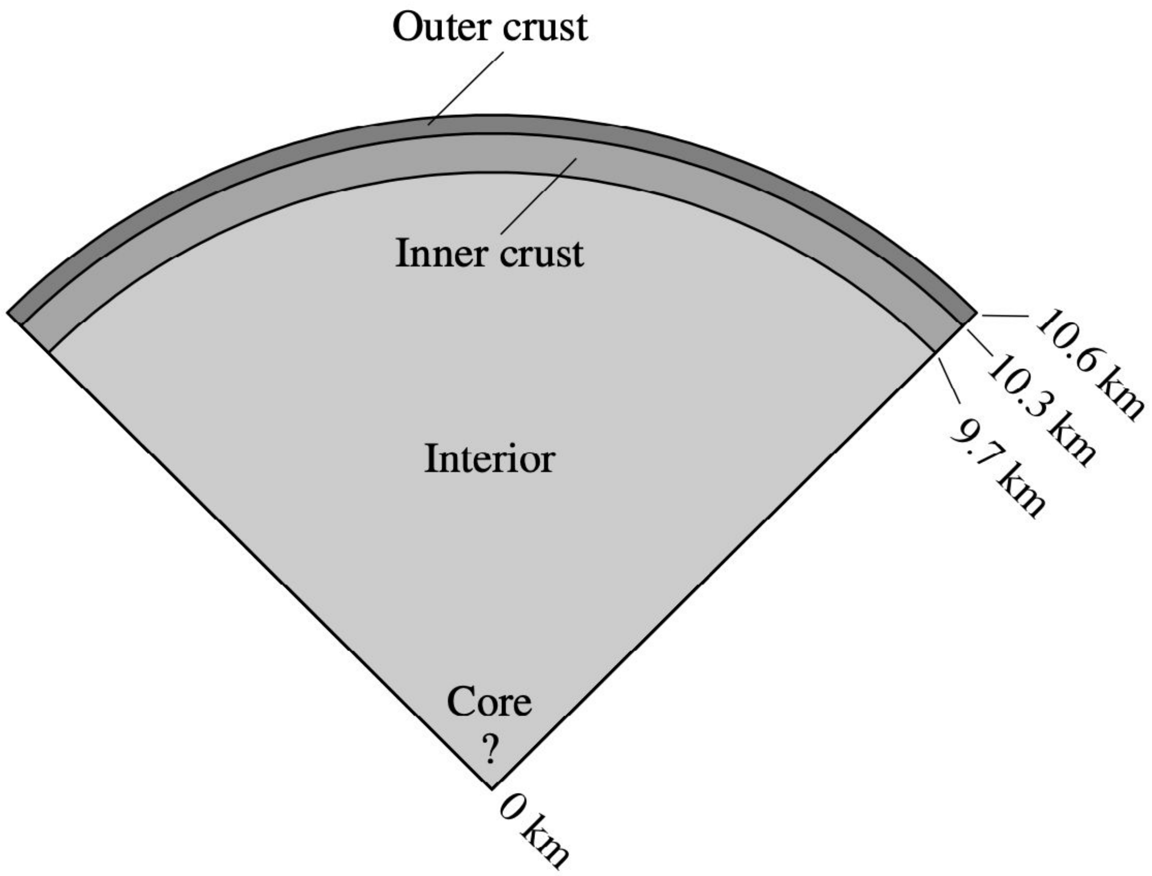
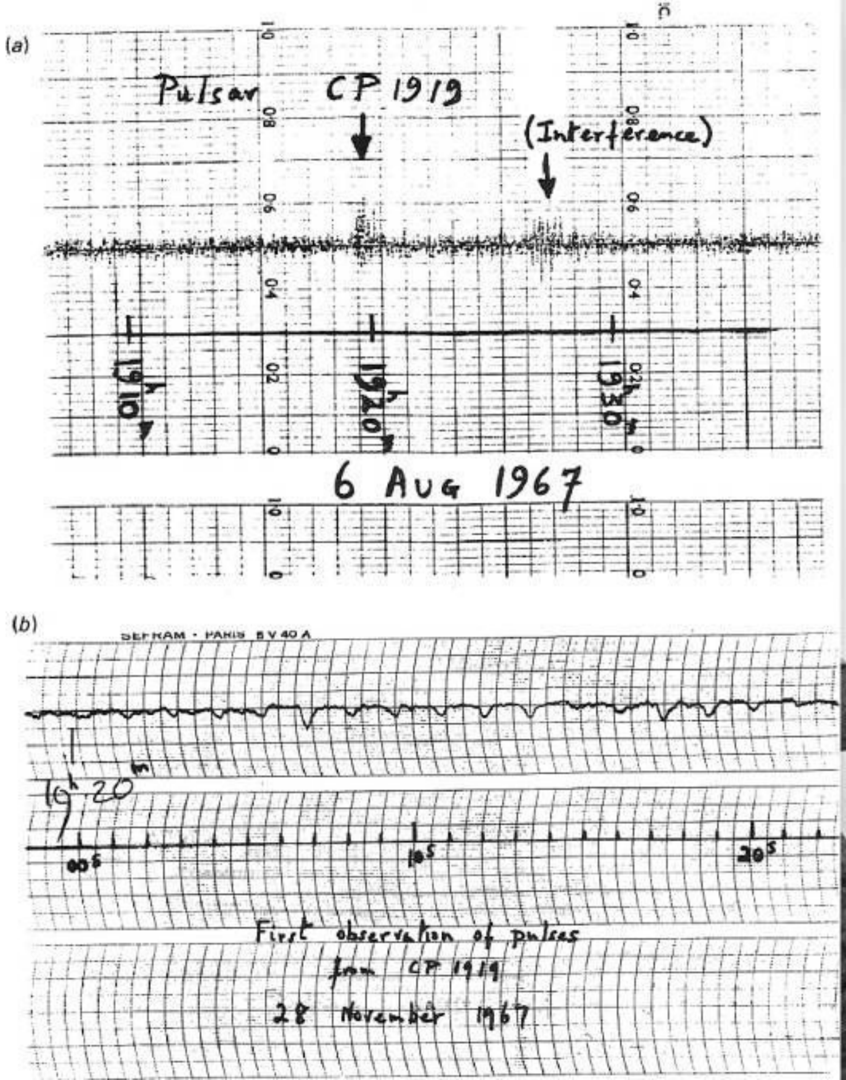
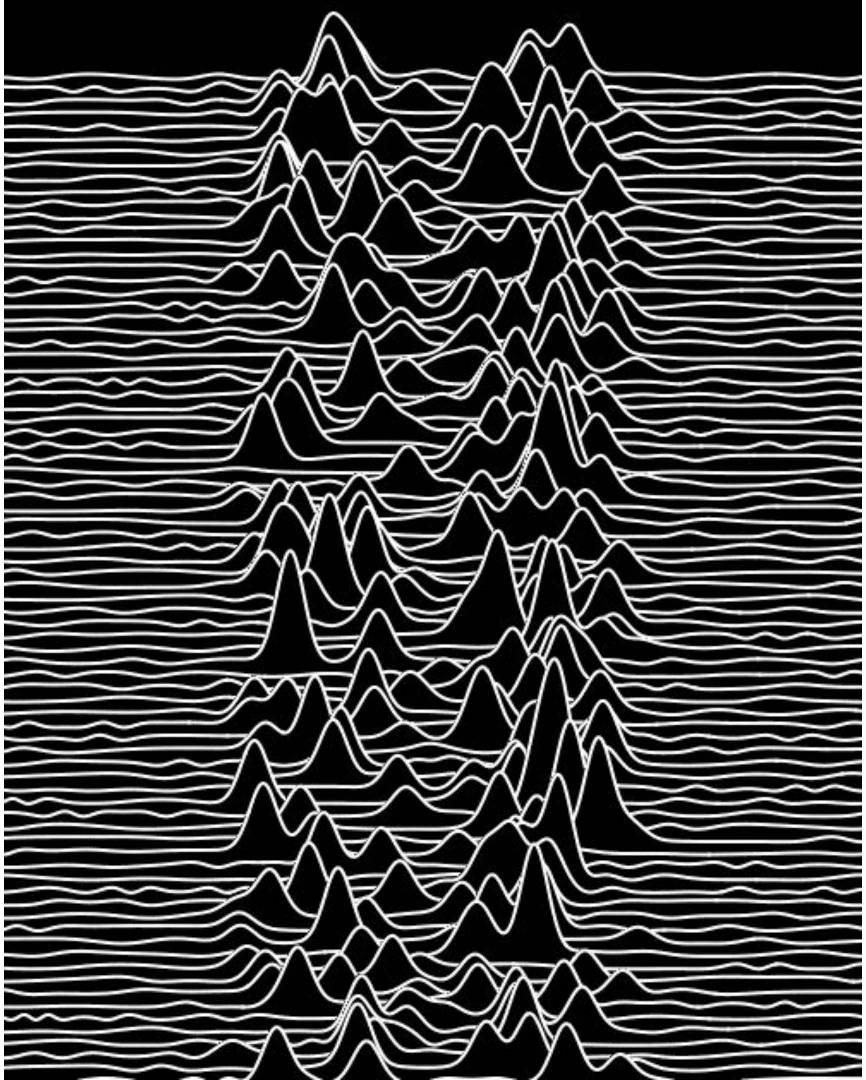
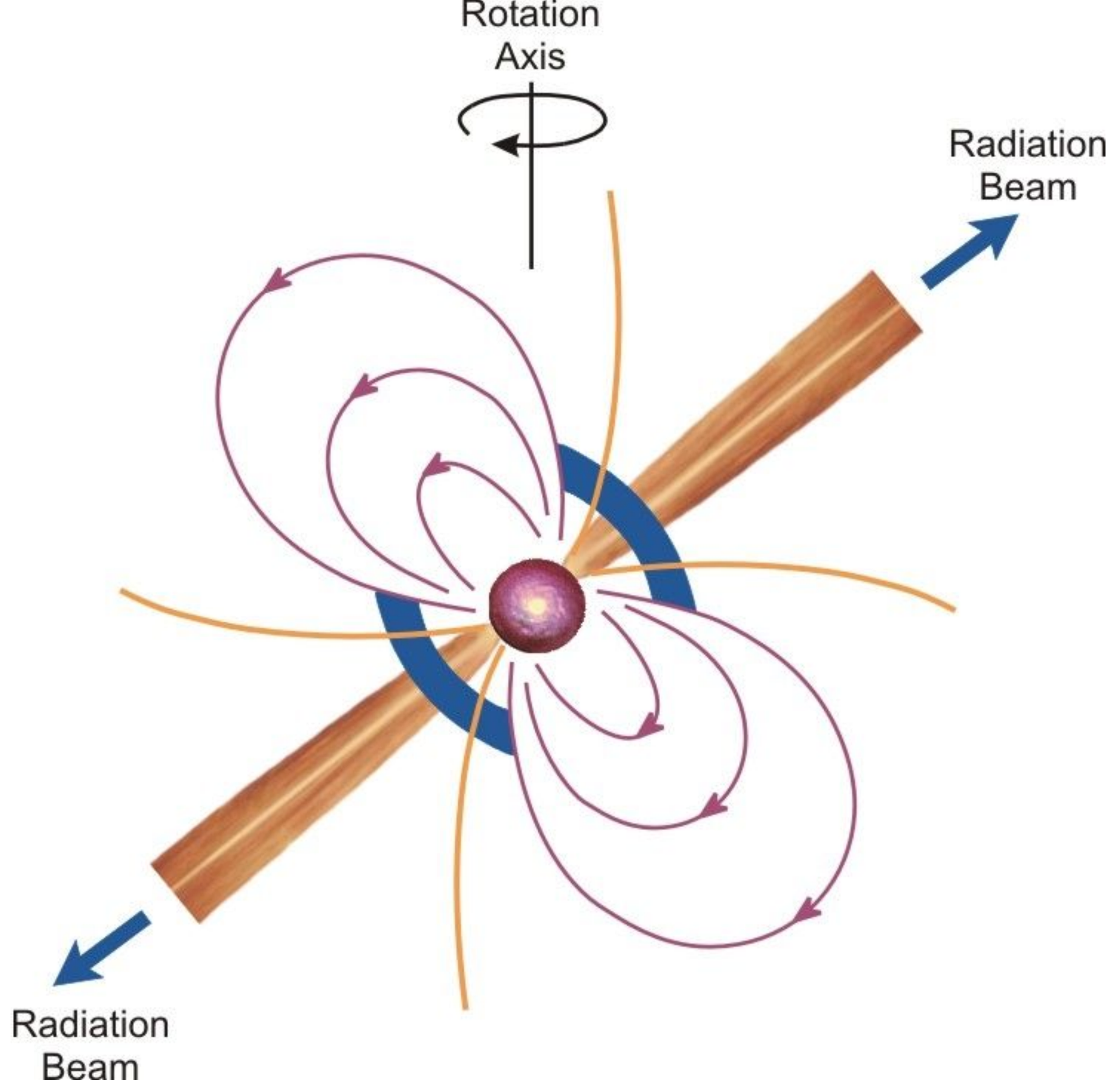


FIGURE 11 A 1.4 $M_\odot$ neutron star model.


(a)
Pulsar CP 1919
(Interference)
6 AUG 1967
(b)
SEFRAM · PARIS 5 V 40 A
First observation of pulses
from CP 1919
28 November 1967




Rotation
Axis
Radiation
Beam
Radiation
Beam

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