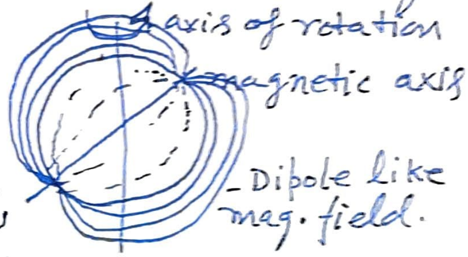
Pulsars

Pulsars are rotating neutron stars formed by the compression of the core of a massive star when it explodes as a supernova. Pulsars should not be confused with pulsating stars that are also known as intrinsically variable stars. The compression of the stellar core also give rise to high surface magnetic fields of about 10^{12} Gauss. If the magnetic axis is inclined to the axis of rotation, we would have a fast rotating oblique rotator.



Periods of pulsars are found to range from 1.5×10^{-3} to 3.75 seconds, with a majority of them being between 0.5 and 1.0 seconds.

The duration of the pulse is only 1 to 10% of the period, which shows that the source of radiation is restricted to a small region on or near the neutron star. During the pulse, the pulsar emits more than 10^{30} ergs of energy. As the life time of a pulsar is estimated to be 1 to 10 million years, the total energy emitted by the pulsar comes out to be 10^{44} ergs. In most of pulsars this energy is radiated in the radio region of the electro-magnetic spectrum. But some pulsars also show pulses in optical as well as in X-ray region.

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Observations show that all pulsars slow down over the long period of time. That means their period of revolution slowly increase during their life time. Every pulse is almost 100% polarized and principal plane of polarization rotates through a large angle (π to 2π) from one end of the pulse to the other.

The properties of pulsars can be explained on the basis of oblique rotator model. As the neutron star has a high surface magnetic field of 10^{12} Gauss, its fast rotation gives rise to strong electric fields. Consequently, charged particles like electrons are accelerated to high velocities in the direction of the lines of force and finally come out along the polar axis. Their combined coherent motion produces plasma oscillations and energy is radiated in the form of electromagnetic waves. In this mechanism the radiation is emitted at the cost of rotational energy of the neutron star. Hence, the rotation slows down, causing a continuous increase of period with time. It is inferred that the neutron star has six main parts:

Structure of a netron star:

1. The top 10 meters where density ρ is equal to 10^4 to 10^5 gm/cm^3 and temperature is in the range 10^5 to 10^6 K, form the magnetic suface, made up of iron peak elements. It behaves like a one dimensional metal in the direction of the magnetic field.

2. The region from 10 to 100 meters is called the outer crust. At its bottom ρ is nearly 4×10^{11} gm/cm^3. It contains normal solid metals predominantly with $Z = 40$ and $A = 127$, arranged in a cubic lattice (crystallized behaviour). It is 10^{17} times stiffer than steel and 10^{6} times more conducting than copper.

3. The next hundred meters reaching up to $\rho = 3 \times 10^{14}$ gm/cm form the inner crust, where neutron rich nuclii dominate and electrons are relativistically degenerate.

4. Super fluid neutron core forms the main bulk of neutron star. It contains 96% degenerate neutrons and 4% degenerate protons and electrons.

5. In deep interiors, where ρ becomes 1.5×10^{15} gm/cm^3, the neutron gas solidifies into crystals. This is crystalline outer core.

6. Finally, when ρ reaches a value much larger than 10^{15} gm/cm^3, we have innermost core, where neutrons condense into hyperons which form 65% of the matter.
