Fast Neutrino Oscillations and Supernova

A theoretical study of the Tata Institute of Fundamental Research(TIFR) finds that the fast neutrino oscillations could be the driving force behind supernova explosions.

- **Neutrino:** are the subatomic particles that are very similar to an electron, but has no electrical charge and very small mass, which might even be zero.
    - Neutrinos are one of the most abundant particles in the universe. Because they have very little interaction with matter, they are difficult to detect.
    - Nuclear forces treat electrons and neutrinos identically; neither participate in the strong nuclear force, but both participate equally in the weak nuclear force. Particles with this property are termed **leptons**.
    - **Natural sources of neutrinos:** include the radioactive decay of primordial elements within the earth, radioactivity in sun, cosmic interactions in atmosphere and others.
    - **Neutrinos come in three flavours: electron neutrino, muon neutrino** and **tau neutrino,** so named because of the corresponding **leptons** they are associated with (electron, muon and tau).
- **Fast Neutrino Oscillations:** Same neutrinos are in the presence of many other neutrinos and when the different flavours are emitted slightly differently in various directions **(anisotropy)** the oscillations from one flavour to another happen at a higher frequency.
    - It is proportional to the density of neutrinos in the medium, and not the masses of the neutrinos.
- **Supernova:** a star that collapses under its own gravity after having run out of its fusion fuel is called a supernova. Usually stars more massive than eight times the Sun’s mass enter this phase of explosive death.
- Fast neutrino oscillations have not been observed because it requires a large neutrino density and **anisotropy,** conditions that can be met only in the hearts of massive stars, neutron star collisions etc.
- **The outcome of the study:**
    - The key advance is to treat neutrino collisions and oscillations self-consistently in a single calculation.
    - Earlier, it was assumed that under high density and anisotropy conditions the neutrinos travel in straight lines without colliding.
    - But this study concludes that collisions lead to high anisotropy conditions. It shows how in the presence of collisions the fast oscillations take place.

Anisotropy is the property of substances to exhibit variations in physical properties along different molecular axes. It is seen in crystals, liquid crystals and, less commonly, in liquids.