Cosmic gamma-ray bursts and a simple model of type II supernova

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Gamma-Ray Bursts (GRBs) were detected at about the same time as pulsars and also accidentally. It turned out that some GRBs of duration more than 2 s are reliably identified with extragalactic supernovae (SNe). To adjust the average rate of GRB detections and SN explosions two variants are possible: either GRBs are related to a very rare type of SNe called hypernovae, or the gamma-ray radiation of GRBs is strongly collimated ($10^{-6} - 10^{-5}$ of the celestial sphere area, so that we can register only a small fraction of GRBs and associated SNe).

A SN explosion is the endpoint of the evolution of stars with the initial mass from $8\,M_\odot$ to $150\,M_\odot$. The SN energy balance is formed by the release and loss of energy. The further fate of a star depends on its mass at the moment of collapse and on its axial angular momentum. The following scenarios are possible:

1) The mass is large, the angular momentum small. The released fireball and thermonuclear energies are insufficient for the total destruction of the star or for a partial release of this energy through a kind of valve. In that case neither the SN phenomenon itself, nor GRB phenomena are created. Only the star radius and luminosity increase over those in usual supergiants in the Hertzsprung-Russel diagram.

2) The mass and angular momentum are large. The energy is insufficient to destroy the star but sufficient to break a channel along the spin axis. In that case some fraction ($\sim\,10^{-6} - 10^{-5}$) of the stellar mass gets out to the stellar surface (as at volcanic eruptions on planets) from the deepest and hot inner layers, the hottest layers being outside. The free-free and recombination radiation of this hot whirling plasma with an inverse temperature distribution is observed in different spectral ranges as an afterglow in the GRB location. The GRB itself is a remnant of fireball radiation which broke out of the channel punched along the spin axis as from a volcanic orifice. That is why it is so collimated and observed only in the case if we look directly at this orifice. In that case we will not observe a SN, but only a GRB.

3) The mass and angular momentum are small. The energy is sufficient to destroy the star; the channel along the axis is not formed. A SN without any GRB is observed.

4) The mass is small, the angular momentum large. Both SN and GRB are observed.

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