ON THE GAMMA-ACTIVITY OF STELLAR FLARES

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ABSTRACT. The principal possibility of γ-ray manifestation of stellar flares in the framework of pinch-model is shown. Validity of assumption that γ-bursts are connected with magnetically active dwarfs (MAD) is discussed.

1. INTRODUCTION.

Present-day models of γ-bursts postulate that for interpretation of the emission and absorbtion features of their energetic spectra it is necessary to invoke the neutron stars of various forms. However, all suggested models encounter with difficulties within the used mechanism. In [1] the pinch-model of stellar flares was suggested which predicts that γ-bursts must follow the powerful optical flares. In present paper an analysis of observatinal data on flares and cosmic γ-bursts in the light of pinch-model is given.

2. CONDITIONS FOR THE THERMONUCLEAR BURNING OF DEUTERIUM

The general picture of flare evolution within the pinch-model was discribed in [1,2].The model supposes a generation of the closed magnetic configuration (magnetic thor) with low plasma β in upper layers of stars which is unstable to system compression relative to the symmetry axis. The numerical modeling shows that configuration compression with plasma within the thor take place. It leads to warm moderate density pinch-column and dense high temperature stretching unstability formation. The plasma column (with parameters $n \propto 10^{15}-10^{16} cm^{-3}$, $T \propto 10^{4} K$) is responsible for optical flare and the stretchings ($n \propto 10^{17}-10^{18} cm^{-3}$, $T \propto 10^{7} K$) are able to give X-ray radiation.

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However, a further compression of stretchings is also possible if the magnetic energy density exceeds the density of plasma thermal energy on this stage.Then if this condition is available magnetic compression must be continued up to balance realisation. And when the plasma temperature reachs the value $\propto$ 1 kev and deuterium concetration n_d as well as its life-time τ satisfy the Lawson criterion $n_d\ \tau^d > 10^{14}\ cm^{-3}s$, a thermonuclear wave of deuterium burning owing to $d(d,n)^3He$, $T(p,n)^3He$, $n(p,\gamma)d$ reactions can be generated.

The possibility of plasma compression in stretchings up to these conditions depends on plasma energy losses due to heat conductivity,thermal bremsstrahlung and plasma radiation in lines of heavy elements. The characteristic time of bremsstrahlung looses can be estimated by means of $\tau \propto nkT/\varepsilon$ (where ε is thermal bremsstrahlung emission coefficient) and τ happens to be less than the stretching hydrodinamic time or, so called, "flight time". The energetic losses by other ways also occur for a less time. So, the losses of energy lead to plasma cooling and, therefore, the balance between plasma and magnetic pressures will be disturbed. It holds a particular promise for the further compression of stretching plasma (radiational collapce). Just on this stage can be switched the thermonuclear channel of energy release. Every stretching then must show short γ-pulses.

Energy production by the thermonuclear channel is proportional to I^4 where I is the equivalent current intensity according to simple plasma focus model. Depending on the initial density of magnetic field the producted energy in γ-rays can reach values up to 10^{35}-10^{37}ergs. It is easy to obtain the condition for thermonuclear burning initiation in pinch

$$B \geq 5\mathrm{x}10^5/\sqrt{\tau_o}$$

where B is the initial magnetic field strength, τ_o is the burst duration time. One can easily find from the mentioned expressions 100 kGs for the magnetic energy strength. It corresponds to magnetic energy of the order of 10^{34}erg (under column volume $V \propto 10^{25}\ cm^3$). In this case the energy of optical flare is proposed 10^{34} ergs and the γ-burst energy is 10^{36}ergs. Thus the luminosity ratio gamma/optics can have values more than 100. And because of stretchings formation after the column stage a delay of X- and γ-flares to optical flares must take place.

It must be mentioned also that the pinch column stretchings have a fluctuative nature and, therefore, it assums an uncorrelated γ-burst generation.

3. COSMIC γ-BURSTS AND MAD

Let us consider now basic observation data on γ-bursts in detail. Those are the very short duration times (0.01-10 s), fine structure of light curves, irregularities in time, thermal energetic spectrum of $10^{6}-10^{10}$ K temperature plasma with emission (440 kev) and absorption (30-70 kev) features, existence of γ-"precursors" and etc [3].Thermonuclear models of γ-burst radiation meet with insuperable difficulties under "precursors" and time scale interpretation. Moreover, explanation of emission and absorption features requires the existence of strong magnetic ($\propto 10^{12}$ Gs) and gravitational ($\propto$ 0.1-0.3 c^2) fields. However, it was shown in [4] that these features can be explaned without above mentioned requirements. Emission feature around 400 kev, for example, can be caused not only by red shifted e^+e^- annihilation but also due to $^4He(\alpha,n)^7Be$ reaction.

The theoretical preconditions allow us to interprete the γ-bursts in the pinch-model framework, namely, that MAD with deep covective zones and low absolute magnitudes can be considered as effective γ-sources. First of all, both MAD and γ-bursts optical identification show that stellar magnitudes are limited by $M_v > 14^m$. Secondly, MAD stars and γ-ray bursts are distributed isotropically in the sky. In third place, there exist sufficiently serious indications to optical identification of 34 objects, being flare stars of solar vicinity, RS CVn stars, cataclysmic variables with γ-sources. Moreover,the temporal and positional corellations between X-ray flares from AR Mon and UX Ari and γ-burts are found [4]. It must be noted also that there are preliminary evidences for identification of T Tau stars in ρ Oph cloud with γ-sources [5]. It means, that all magnetically active dwarfs can be treated as γ-sources. Such a treatment seems to be plausible, because all of the mentioned objects possess of deep convective zones, spot structure, noticeable magnetic fields of local structure and,as a consequence, flare activity. In forth place, taking into account, that the distance of MAD are of order 10-30 ps on one hand and stellar pinch-model predicts $10^{35}-10^{37}$ ergs for γ-bursts energy on other hand, we can obtain γ-fluxes in solar vicinity, which compose $10^{-7}-10^{-5}$ erg/cm^2 and show a good agreement with observation data [3]. And finally, from our point of view, it is important, that "precursors" are observed for both powerful optical flares and γ-bursts. This is an indirect evidence of analogy of these two phenomena.

Thus, the results of pinch-model and recent observational data analysis speak in favour of flare nature of cosmic γ-bursts. And so, the further cooperative optical and gamma observations, for example, of stellar associations seem to be necessary.

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