JET OUTFLOWS BY COLLAPSE OF MAGNETIZED GAS CLOUDS AND STARS.

V. Kryvdyk, *National Taras Shevchenko University of Kyiv, (kryvdyk@univ.kiev.ua).*

1 Introduction

In the previous author papers [3-4]have been investigated particles dynamics and their non-thermal emission from the collapsing magnetized stars with dipole magnetic fields and the homogeneous particles distribution in magnetosphere. It is showed that the collapsing stars can be the powerful sources of the non-thermal radiation, which can be observed by means of the modern telescopes. In this poster we consider the formation of relativistic jets by gravitational collapse of the magnetized star or clouds . The stellar magnetosphere compress during the collapse and its magnetic field increases considerably. A cyclic electric field is produced and the charged particles will accelerate, and the relativistic jets will formed in polar caps of stellar magnetosphere.

2 Particle dynamics by collapse

The external stellar electromagnetic fields will change as [1-2]

$$B(r,\theta,R) = (1/2)F_o R r^{-3}(1+3\cos^2\theta)^{1/2}, \quad (1)$$

$$E(r,\theta,R) = (1/2)(F_0/cr^2)\sin\theta\frac{\partial R}{\partial t}. \quad (2)$$

Here $F_o = B_o R_o^2$ is the initial magnetic flux of star with the radius R having the initial radius R_o and the initial magnetic field B_o.

The field structure and particle dynamics in the magnetosphere are influenced by three factors: particles pressure, collisions, and star rotation. As follow with the detail analysis [2], these effects can be neglected during the collapse.

The particles energy will change as results of the two mechanisms. First is betatron acceleration in the variable magnetic field, second is bremsstrahlung energy losses in this field. For the resulting rate of particle energy change in the magnetosphere [2]

$$\frac{dE}{dR} = a_1(\frac{2GM}{R_*})^{\frac{1}{2}}(\frac{R_*-1}{R^3})^{\frac{1}{2}}E - a_2F_0^2R^2E^2r^{-6}, \quad (3)$$

Here $a_1 = (5k_1/3)(3\cos^4\theta + 1.2\cos^2\theta - 1)(1+3\cos^2\theta)^{-2}$; $a_2 = (e^4/6m^4c^7)(1+3\cos^2\theta)\sin^2\theta$; k_1=2 and k_1 =1 for relativistic and non-relativistic particles respectively; $R_* = R_o/R$; G is gravitational constant, M is the mass of collapsing star.

For heterogeneous distribution particle dynamics can be investigated using the equation of transitions particle in the regular magnetic fields [8]

$$\frac{\partial N}{\partial t} + \frac{\partial}{\partial E}(N\frac{dE}{dt}) + \frac{\partial}{\partial r}(N\frac{dr}{dt}) = 0. \quad (4)$$

For the initial power-series ($N_P(E,r) = r^{-3}K_P E^{-\gamma}$), relativistic Maxwell ($N_M(E,r) = r^{-3}K_M E^2\exp(-E/kT)$) and Boltzmann distributions ($N_B(E,r) = r^{-3}K_B\exp(-E/kT)$) the solution Eq. (5) are

$$\begin{aligned} N_P^i(E,R) &= (r_*)^3K_pE_*^{-\gamma}R_{*,}^{-\beta_P} & (5)\\ N_M^{'}(E,R) &= (r_*)^3K_ME_*^2R_*^{-\beta_M}\exp(-E/kT), & (6)\\ N_B^{'}(E,R) &= (r_*)^3K_BR_*^{-\beta_B}\exp(-E/kT), & (7)\end{aligned}$$

$$\begin{aligned} N_P^{ii}(E,R) &= (r_*)^3K_p\exp(-\gamma(1-\gamma_1)), & (8)\\ N_M^{ii}(E,R) &= (r_*)^3K_ME_*^2\exp(-(1-\gamma_1)E/kT), & (9)\\ N_B^{ii}(E,R) &= (r_*)^3K_B\exp(-(1-\gamma_1)E/kT), & (10)\end{aligned}$$

Here K_C, K_M, K_B are the spectral coefficients, k is the Boltzmann constant and T is the temperature, $E_* = E/E_0$; $r_* = r_0/r$; $\beta_P = a_1(\gamma-1)$; $\beta_M = a_1(E/kT\ln E_* - 3)$; $\beta_B = a_1(E/kT\ln E_* - 1)$; $\gamma_1 = a_2(\theta)F(R,R_*)r^{-6}E_*$.

Eqs. (5) - (7) determine the particle spectrum in the magnetosphere and its evolution during collapse for the first case when the energy losses can be neglected. This case is typical for the initial stage of the collapse. Eqs. (8) - (10) determine the particle spectrum in the magnetosphere and its evolution for the final stage of the collapse, when the magnetic field grow to the extreme value and the energy losses influence on the particle spectrum considerably.

We can see from the Figures 1-2, that the polar jets formed in magnetosphere of collapsing stars on the initial stage of collapse. These polar jets will emite the non-thermal radiation and can be observed by means of the modern telescopes.

3 Non-thermal radiation from collapsing stars

The ratio between the radiation flux from collapsing stars on the any stage of collapse (when the stellar radius decrease to the value $R = R(t)$) and its initial radiation flux (when the radius is R_0), respectively for the power-law, relativistic Maxwell, and Boltzmann distributions are

$$\begin{aligned} \frac{I_{\nu P}}{I_{\nu P0}} &= (r_*)^3(\nu_*)^{(1-\gamma)/2}R_*^{\gamma-2}\int_0^\infty\int_0^{\pi/2}(R_*)^{-a_1(\gamma-2)}\sin\theta dEd\theta, & (11)\\ \frac{I_{\nu M}}{I_{\nu M0}} &= (r_*)^3R_*^{-3}\nu_*(\frac{1}{kT})\int_0^\infty\int_0^{\pi/2}R_*^{-\beta_M}e^{-\frac{E}{kT}}\sin\theta dEd\theta, & (12)\\ \frac{I_{\nu B}}{I_{\nu B0}} &= (r_*)^3R_*^{-3}\nu_*(kT)\int_0^\infty\int_0^{\pi/2}R_*^{-\beta_B}E_*^2e^{-\frac{E}{kT}}\sin\theta dEd\theta. & (13)\end{aligned}$$

Using equations (12)-(14) the radiation flux from the collapsing stars can be calculated. The ratio between the radiation flux from collapsing stars and its initial flux by $\nu_* = \nu/\nu_0 = 1$ are in the ranges:

$1 \leq I_{\nu P}/I_{\nu P0} \leq 1.34 \times 10^{10}$ for $2.4 \leq \gamma \leq 3.4$, $10 \leq R_* \leq 1000$;

$1 \leq J_{\nu M}/J_{\nu M0} \leq 4.86 \times 10^5$ for $1\, eV \leq kT \leq 9\, eV$, $145 \leq R_* \leq 850$;

$1 \leq J_{\nu B}/J_{\nu B0} \leq 2.23 \times 10^{11}$ for $1\, eV \leq kT \leq 9\, eV$, $145 \leq R_* \leq 850$;

These values obtained by the numerical integration of the equations for the ratio between the radiation flux in the range $2\, eV \leq E \leq 10^9\, eV$, $0 \leq \theta \leq \pi/2$ for the different radius R_* , temperature kT and index γ.

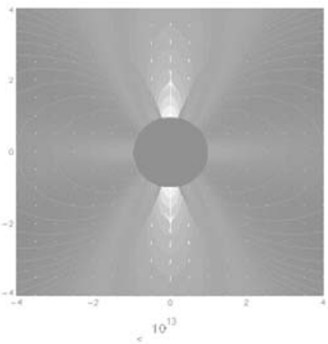

Figure 1: Jets form collapsing stars.

4 Conclusions

We can make next conclusions. By stellar collapse the charged particles will be accelerate. In polar caps of magnetosphere formed the relativistic jets. These jets emit the non-thermal electromagnetic radiation in the all frequency band. This radiation can be observed as bursts in the all-frequency band, from radio to gamma ray. The radiation flux on the final stage of collapse exceeds the initial flux in a millions time. Thus collapsing stars can be the powerful sources the non-thermal radiation which can be observed near Earth.

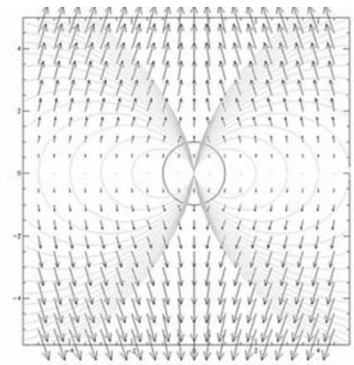

Figure 2: Particles velocity field in magnetosphere of collapsing star.

References

[1] V.L. Ginzburg, L.M. Ozernoj, *Journ. Exper. and Teor. Fiz.*, **47**, 1030 (1964)

[2] V. Kryvdyk, *Mon. Not. RAS*, **309**, 593 (1999)

[3] V. Kryvdyk, *Adv.Space Res.*, **28**, 463 (2001)

[4] V. Kryvdyk, A. Agapitov, *ASP Conf. Ser.*,**330,** 415 (2005)