MACHO HALO OBJECTS AS SOURCES OF GAMMA BURSTS

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Abstract

A new model of gamma bursts (GB) generated by MACHO’s in the form of non-compact dark matter halo objects (NO) is proposed. The model explain well the spherical symmetry, \( \log N - \log S \) curve of GB absolutely identically to the well-known giant dark matter halo (GDMH) model. The main difficulty of GDMH model – the lack of neutron stars in our galactic halo is eliminated because of the large number of NO (\( \sim 10^{13} \)) which is quite close to a total number of bursts during the life time of the Universe. The proposed mechanism of the burst is the instability and explosion of the baryonic core (BC) of NO. The structure of BC and possible mechanism of BC explosion are discussed.

The intensive infrared emission from BC of neutralino stars (NeS) at the wavelength (3–8)\( \mu \) is predicted. The possibility to discover NeS by observation of infrared emission from the recently distinguished point-like gamma sources is indicated.

1 Introduction

The origin of gamma bursts is one of the mostly intriguing problem in astrophysics during the last 20 years. Analysis of the observational data shows that today exist two main models of the origin of gamma bursts: cosmological and giant halo model [1].

Giant dark matter halo (GDMH) model was proposed in [2]. It considers relic neutron stars as the source of gamma bursts. These stars should have the same density distribution as distribution of cold dark matter in the Galactic halo, which has a size \( R_h \approx 200 \text{kpc} \) [2,3]. This proposition allowed to explain the main statistical properties of gamma bursts: their tightly spherical symmetry and a considerable condensation to the center, known as \( \log N - \log S \) curve [1]. Furthermore GDMH model fairly well describes weak asymmetries in the distribution of gamma-ray bursts, observed during first years of measurement by the BATSE device of COMPTON Observatory [4,5]. The characteristic energy \( E_\gamma \) released in gamma-rays in one burst as follows from this model is \( 10^{41} - 10^{42} \) erg.

The weak point of this model is the supposition that the source of gamma bursts is relic neutron stars (NS). The full number of these stars is not large enough \( N \leq 10^6 - 10^7 \), what means that every NS must repeat gamma burst many times: \( 10^6 - 10^7 \) , since the total number of bursts should be \( \sim 10^{13} \). The same difficulty has analogous model, which consider high velocity NS as a source of gamma bursts [6,7]. These stars have got high velocities during supernova explosion and are moving out of the Galaxy. The number of such NS is about \( 10^6 - 10^7 \). It is difficult to find the mechanism of repeating gamma bursts from NS and the source of energy needed for repeating \( 10^6 \) times bursts. It should be noted also that according to observations bursts never repeat (we do not speak here about special

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small group of the so-called "repeaters"). These difficulties for the NS models as the source of gamma bursts were emphasized in numerous papers [2-9].

Here we will propose a new mechanism of gamma burst connected with the instability and a possible explosion of the baryonic core of noncompact dark matter halo objects (NO). Microlensing established, that the large part of dark matter in Galaxy halo consist of MA-CHO's – unseen objects with masses $(0.05 - 0.8)M_⊙$ [10,11]. These objects are naturally considered to be White Dwarfs, Brown Dwarfs, Jupiters or some other stars or planets. To the contrary in [12,13] was supposed the existence of quite a new type of massive structures – gravitationally compressed objects from nonbaryonic cold dark matter (CDM). These objects are the results of a small scale hierarchical structuring developing in CDM [14,15]. They are noncompact, having some spectrum of characteristic dimensions and masses. After recombination a baryonic component falls down into the potential well formed by nonbaryonic matter. In this way the compact baryonic core is created. The nonbaryonic component forms a spread spherical halo, where the dominant mass of the object is concentrated. The main hypothesis of [12]-[15] is that these noncompact nonbaryonic objects (NO) determine significant part of microlensing events observed in [11].

NO were proposed in [12,13] to avoid the difficulties arising from microlensing observations. Here we consider them as the source of gamma bursts. Because of supposition that the main part of dark matter consist of NO this mechanism gives the same statistical results as GDMH model. It explains well the spherical symmetry, $\log N - \log S$ curve and small asymmetry absolutely identically to [2-5]. The new very essential point is connected with $N_{NO}$ – the number of NO in Galaxy halo. According to [12-15] $N_{NO} \sim 10^{13}$ what is quite close to the total number of bursts in our Galaxy during lifetime of the Universe. So no bursts repetition is needed for this model.

2 Dark matter in the baryonic core.

Non dissipative cold dark matter creates stationary spherically-symmetrical structures compressed by their own gravitational forces. For these objects the theory established a fundamental scaling low for density distribution [16]:

$$\rho \propto r^{-\alpha}, \quad \alpha \approx 1.8$$

which holds quite well for large scale structures in the Universe.

Noncompact dark matter objects (NO) are the small scale structures with the masses $M_x \sim (0.01 - 1)M_⊙$ and characteristic dimensions $R_x \sim 10^{14} - 10^{15}$ cm [13-15]. For small scale dark matter structures the distribution (1) holds on up to the dimensions $r_c$ an order magnitude less than $R_x$ [17]:

$$r_c \sim 0.1R_x.$$ (2)

The density distribution of CDM particles in NO could be presented in a form [17]:

$$\rho = \begin{cases} 
\rho_0 & 0 < r < r_c \\
\rho_0 \left( \frac{r}{r_c} \right)^{-\alpha} & r_c < r < R_x \\
0 & r > R_x 
\end{cases}$$

(3)
This distribution does not take into account the existence of baryonic core. The fundamental difference between nonbaryonic dark matter and baryonic is determined by dissipative processes. After recombination the baryonic matter under the action of radiative cooling loses its thermal energy and falls down into the potential wells formed by nonbaryonic matter. It leads to the creation of baryonic body (baryonic core) with mass \( M_b \sim 0.05M_x \) at the center of the dark matter object.

It is essential, that the process of the baryonic matter condensation change significantly the density and a full amount of the nonbaryonic matter trapped inside the baryonic core (BC). Let us consider this process in details. One can neglect the collisions between nonbaryonic particles, which are oscillating in the potential well created by their gravitational field. It is easy to estimate, that the typical oscillation time \( \sim 10 \) years is essentially less than the time of baryonic core formation. It means that the core formation is a slow process. Because of this reason we can describe the changing of distribution function of dark matter particles using the adiabatic approximation. Initial adiabatic invariant \( I_i \) is defined by the formulae:

\[
I_i = \int_{r_{\text{min}}}^{r_{\text{max}}} \sqrt{\hat{E} - p_0 r^2 - \frac{m^2}{2r^2}} \, dr
\]

Here \( E = \varepsilon/m_x, \varepsilon \)-is the energy of a particle moving in potential \( p_0 r^2, \psi_{00} \)- is the depth of the potential well, \( m \)- is the particle angular momentum and \( r_{\text{min}}, r_{\text{max}} \) are reflection points, determined as a roots of the expression under the integral. Since we are interested in changing of distribution function near BC, in (4) was chosen (in accordance with (3)) \( \psi = \psi_{00} + 2\pi G\rho_0/3r^2 \).

After the formation of BC the adiabatic invariant \( I_f \) of a particle near the center takes a form

\[
I_f = \int_{r_{\text{min}}}^{r_{\text{max}}} \sqrt{E + \frac{GM_b}{r} - \frac{m^2}{2r^2}} \, dr
\]

here \( GM_b/r \)-is a potential of a created baryonic body. In expression (5) we took into account only potential of baryonic body and neglected the potential of dark matter. As we will see below (12) the mass of CDM particles in BC and its neighborhood is essentially less than the mass of baryonic body.

In view of conservation of the adiabatic invariant, it follows that for any value of \( I \), we have for the distribution function \( f(I) \):

\[
f(I) = f_0(I_i)|_{I_i=I}.
\]

The density distribution \( \rho \) in variables \( E, m^2 \) can be written in a form [16]:

\[
\rho(r) = \frac{2\pi m_x}{r^2} \int_0^{\infty} dm^2 \int_{\psi + m^2/2r^2}^{\psi} \frac{f(E)}{\sqrt{E - \psi - m^2/2r^2}} \, dE
\]

It is natural to choose the initial distribution function \( f_0 \) as a maxwellian one

\[
f_0 = \frac{n_0}{(2\pi T)^{3/2}} e^{-E/T}, \quad T \approx \frac{GM_x}{R_x}, \quad n_0 = \frac{\rho_0}{m_x}
\]
After integration of (6),(7), one can find

\[ I_i = \frac{\pi}{2^{3/2}} \left( \sqrt{\frac{2}{p_0}} E - m \right), \quad I_f = \frac{\pi}{2} \left( \frac{2GM_b}{(-E)^{1/2}} - 2^{1/2}m \right) \]  

(8)

Substituting (8) into (6) we obtain:

\[ \rho(r) = \frac{2\pi m_x}{r^2} \int_{0}^{\infty} dm \int_{-GM_b - \frac{m^2}{2r^2}}^{0} n_0 e^{-\frac{\psi_0}{T}} \frac{\sqrt{E - \psi - m^2}}{2^{1/2}T} \exp \left\{ \frac{-2^{1/2}GM_b}{T(-E)^{1/2}} + \frac{m^{1/2}p_0}{2^{1/2}T} \right\} dE \]  

(9)

Let us find the asymptotic of solution (9) in the limit \( r \to 0 \). In this case \( E \to -\infty \), and taking into account, that \( m^2 \leq 2GM_br \), we find:

\[ \rho(r) = \frac{8}{3\sqrt{2}\pi} n_0 e^{-\frac{\psi_0}{T}} m_x \left( \frac{GM_b}{Tr} \right)^{3/2} \]  

(10)

It is easy to see that the law for density distribution (10) does not depend on the shape of distribution function (7), but it depends on its behavior at \( E \to 0 \). The law (10) has a singularity at \( r \to 0 \). The behavior of density is defined by this singularity of potential, but in reality the singular law (10) is cut on the scale of baryonic core \( r_b \). Borrowing in mind (in accordance with (3)) that

\[ \frac{4}{3} \pi n_0 m_x r_c^3 \approx 0.1 M_x, \]  

(11)

and choosing \( T \approx \psi_0 \) one can find from (10),(11):

\[ \rho(r_b) = 33 \times n_0 m_x \left( \frac{M_b r_c}{M_x r_b} \right)^{3/2} \]

So we see, that the adiabatic capture of dark matter particles lead to the increase of the dark matter density inside the baryonic core in \( 10^3 - 10^4 \) times. Because of this the full amount of the mass of a dark matter trapped inside the BC \( M_{xb} \) could reach a significant part:

\[ \frac{M_{xb}}{M_x} \sim 10^{-6} - 10^{-7} \]  

(12)

It means for \( M_x = 0.5 M_\odot \), that \( M_{xb} \sim 10^{25} - 10^{26} \) g.

3 The structure of baryonic core with CDM component.

Let us consider now the structure of baryonic core. The stationary state of this core is described by equations:

\[ \nabla P = -\nabla \psi \]

\[ \nabla (\kappa \nabla T) = -\sigma T_s^4 S + Q_n + Q_{th} \]

\[ \Delta \psi = 4\pi G (\rho_b + \rho_n) \]  

(13)
Here $P = P_b + P_n$ is the total pressure of baryons and nonbaryons, $T(r)$ is the temperature of baryonic particles, $\psi$ - potential of gravitational field, $\kappa$ - heat conductivity, $\rho_b$ and $\rho_n$ are densities of baryons and nonbaryons. $Q_n$ and $Q_{th}$ are the sources of the heating of BC by DM particles. These sources are significant for the DM particles of a special type and would be considered in the next section. $T_s$ is the temperature of a core surface $S$, $\sigma$ - Stephan-Boltzman constant.

The distribution of CDM particles inside the baryonic core is determined by their collisions with baryons, it means that in stationary conditions they have Boltzman distribution:

$$\rho_n = \rho_{n0} \exp \left\{ -\frac{\psi(r) m_x}{T^*} \right\} \quad (14)$$

where $\psi(r)$ is gravitational potential and $T^*$ is the effective temperature of CDM particles.

$$T^* = \frac{3m_x}{R_x^3} \int_0^{R_x} r^2 \begin{cases} \int_{\psi + m^2/2r^2}^{\psi + m^2/2r^2} E f(E) dE & \int_{\psi + m^2/2r^2}^{\psi + m^2/2r^2} f(E) dE \end{cases} \frac{E f(E) dE}{\sqrt{E - \psi - m^2/2r^2}} \frac{\sqrt{E - \psi - m^2/2r^2}}{r^2} \right\} \quad (15)$$

Here $\rho_{n0}$ is CDM density in the center of the core:

$$\rho_{n0} = \frac{M_n}{4\pi} \left\{ \int_0^\infty \exp \left( -\frac{\psi(r) m_x}{T^*} \right) r^2 dr \right\}^{-1}$$

Equations (13) take into account that the crosssection of CDM particles with baryons is small enough. It means that these particles oscillate many times inside the core between collisions with baryons. Using (15) we obtain CDM term in equations (13)

$$\frac{dP_n}{dr} = \frac{T^*}{\rho_n} \frac{d\rho_n}{dr}$$

Equations (13) have two different solutions describing two different stationary states of the baryonic core containing nonbaryonic component. The first one is usual, determined by baryons in the whole range of $r$: $0 \leq r \leq r_b$. It has value of baryons density in the center $\rho_b |_{r=0} = \rho_{b0}$ and distribution $\rho_b(r)$ gradually falling down to the edge of the body $\rho \to 1$, $r \to r_b$. For the planet of Jupiter type $\rho_{b0} \approx 30 g/cm^3$, but the temperature inside Jupiter is essentially less than in the center of BC. In our case the mass of baryonic body $M_b \sim 0.05 M_x$ could be higher, than Jupiter mass, but taking into account temperature, one can expect, that central baryonic density by the order of magnitude is

$$\rho_{b0} \sim 10 \frac{g}{cm^3} \quad (16)$$

If the density of nonbaryonic component $\rho_n(r)$ is everywhere less, than $\rho_b(r)$

$$\rho_n(r) << \rho_b(r) \quad (17)$$
the existence of CDM particles, trapped inside BC will lead to the small corrections to the usual baryonic stationary state.

But according to the Boltzmann distribution (14)

\[ \rho_n = \rho_{n0} \exp \left\{ - \left( \frac{r}{r_{n0}} \right)^2 \right\} \] (18)

Here \( r_{n0} \) gives the characteristic scale of the heated region

\[ r_{n0} = \sqrt{\frac{3T^*}{2\pi G \rho_{b0} m_x}} \] (19)

In (18),(19) we supposed a constant baryonic density \( \rho_b = \rho_{b0} \). Density of CDM particles in the centrum of the core \( \rho_{n0} \) is connected with full mass \( M_{xb} = M_n \) by relation:

\[ \rho_{n0} = \frac{M_n}{\pi^{3/2} r_{n0}^{3/2}} \] (20)

Condition (17) is fulfilled only if

\[ \frac{M_n}{\pi^{3/2} r_{n0}^{3/2}} < \rho_{b0} \]

Taking into account (19) we see, that for low temperatures \( T^* \) or for the high mass of CDM particles if:

\[ M_n \rho_{b0}^{1/2} \left( \frac{2G m_x}{3T^*} \right)^{3/2} > 1 \] (21)

condition (17) is not fulfilled. In this case \( \rho_{n0} > \rho_{b0} \) and CDM particles could significantly affect the density distribution being trapped by their own gravitational field in the central part of BC. General stationary solution of equation (13) is shown in the Fig.1. One can see from the figure that two different stationary modes for potential \( \psi \) exist. One is the mode determined mostly by baryons, this mode we have discussed earlier. Another is the CDM particles selftrapped mode. In the vicinity of the centrum \( r \to 0 \) the last mode is asymptotically described by:

\[ \psi = \frac{2T^*}{m_x} \ln \left( \frac{r}{R_c} \right) + \ldots \] (22)

\[ \rho = \frac{T^*}{2\pi m_x G r^2} + \ldots \]

Here \( R_c \) determines the dimension of the region of selftrapped CDM bulk

\[ R_c = \frac{G M_c m_x}{2\pi T^*} \] (23)

\( M_c \) is the full mass of selftrapped neutralino. The main term in (22) coincides with well-known Boltzman distribution of noninteracting gravitationally selftrapped matter [18].

The existence of a second stationary state means that if in the process of the slow cooling of the core conditions (21) could be reached then the transformation to the second stationary state will begin. This reconstruction will lead to the loss of the hydrodynamic stability of the system resulting in the release of a significant amount of energy \( E \sim 10^{43} - 10^{44} \) erg (see (35),(36)). This energy will be emitted into a wide spectrum of electromagnetic waves, including gamma rays, X-rays, optic emission and radio waves.
4 Explosion of baryonic core in neutralino star

The particles of which CDM is composed are not known now, though there exist some hypothetical candidates: neutralino, heavy neutrino, axions, strings. Neutralino and heavy neutrino like the Majorana particles can annihilate in mutual collisions. Noncompact objects which consist of such particles are partially disappearing because of annihilation processes. These specific objects we call "neutralino stars" (NeS) [12] and for nonbaryonic particles from which they consist of we will use as a general name "neutralino" [13].

Annihilation of neutralino leads to effective radiation of gamma photons and heating of baryonic core. Under definite conditions the core can explode. It should be emphasized, that the energy released in all these processes was input into CDM during the period of its freezing out. The possibility to detect CDM particles through their annihilation was discussed in a number of papers (see [19,20]). In these papers always was supposed a smooth distribution of CDM in the Galaxy. The existence of NeS leads to a new situation, connected with compression of CDM in NeS, which results in strong amplification of neutralino annihilation processes and gives significant constrain on possible type of neutralino particles [13,17,21]. From the other side it opens the possibility of existence of quite observable fluxes of gamma radiation by NeS. In particular, in [17] a NeS model of diffusive gamma emission and recently discovered nonidentified point like gamma sources [22] is developed. Here we will discuss a model of gamma bursts, which is connected with the possibility of blowing up of the baryonic core of NeS.

As was shown in section 2, the amount of the trapped in BC neutralino particles is high enough $M_{xb} \sim (10^{-7} - 10^{-6}) M_*$. Because of this reason the energy released in neutralino annihilation could effectively heat the baryonic core. On the other hand, the neutralino density $\rho_n$ could be small in comparison with the density of baryons $\rho_b$.

The heating term $Q_n$ in equation (13) could be written in a form

$$Q_n = 2 \rho_n c^2 \frac{\tau_n}{\tau_n}$$

where $\rho_n(r)$- is the neutralino density (18)-(20), and $\tau_n$ is the lifetime of neutralino in baryonic core. Taking into account that neutralino annihilation is a rare event in comparison with neutralino collisions with baryons, we obtain the following expression for $\tau_n$

$$\tau_n = \frac{m_x}{\rho_n \sigma v}$$

Here $< \sigma v >$ is a characteristic crossection of neutralino annihilation multiplied on typical velocity. Note that $\tau_n$ does not depend on $r$. So, the heating efficiency $Q_n$ is directly proportional to $\rho_n(r)$.

The distribution of $\rho_n(r)$ is given by equation (18). It follows from (24), that if conditions (21) are fulfilled the heating is going mostly in the central region of the core.

Let us estimate now the main parameters of the core. From (19) it follows that:

$$r_{n0} = 2.4 \times 10^9 \left( \frac{T^*}{10^6 K} \right)^{1/2} \left( \frac{10 Gev}{m_x} \right)^{1/2} \left( \frac{10 g cm^{-3}}{\rho_{b0}} \right)^{-1/2} cm$$

(26)
One can see that the dimension of heated region could be not too small in comparison with the radius of baryonic core:

\[ R_b = \left( \frac{3 M_b}{4 \pi \rho_b} \right)^{1/3} \approx 2 \times 10^{10} \text{cm} \]  \hspace{1cm} (27)

Here and below we take:

\[ M_b = 0.05 M_\odot = 5 \times 10^{31} \text{g}, \quad M_x = 5 \times 10^{33} \text{g}, \quad \rho_b =< \rho_b = = \frac{1}{g} \text{cm}^3 \]

Density of neutralinos in the center of BC, as follows from (20) is:

\[ \rho_{n0} = 1.3 \times 10^{-4} \left( \frac{M_n}{10^{25} g} \right) \left( \frac{10^6 K^\circ}{T^*} \right)^{3/2} \left( \frac{m_x}{10 \text{ GeV}} \right)^{3/2} \left( \frac{\rho_{\odot}}{10 \text{ g/cm}^3} \right)^{3/2} \text{g/cm}^3 \]  \hspace{1cm} (28)

and their number density:

\[ n_0 = 7.6 \times 10^{18} \left( \frac{M_n}{10^{25} g} \right) \left( \frac{10^6 K^\circ}{T^*} \right)^{3/2} \left( \frac{m_x}{10 \text{ GeV}} \right)^{1/2} \left( \frac{\rho_{\odot}}{10 \text{ g/cm}^3} \right)^{3/2} \text{cm}^{-3} \]  \hspace{1cm} (29)

We see that conditions (17), is usually fulfilled.

Characteristic annihilation time for neutralinos in the core could be of the same order as the lifetime of the Universe:

\[ \tau_n = 3.2 \times 10^{15} \left( 3 \times 10^{-27} \right) \left( \frac{10^6 K^\circ}{T^*} \right)^{-1/2} \left( \frac{10^{25} g}{M_n} \right) \left( \frac{\rho_{\odot}}{10 \text{ g/cm}^3} \right)^{-3/2} \left( \frac{10 \text{ GeV}}{m_x} \right)^{-1/2} \text{s} \]  \hspace{1cm} (30)

Here we took into account that according to [13], the dominant annihilation process of neutralinos is \( p \)-wave with crosssection:

\[ < \sigma v > = < \sigma v >_0 \frac{3 T^*}{2 m_x c^2}, \quad < \sigma v >_0 = \left( 10^{-26} - 10^{-27} \right) \left( \frac{m_x}{10 \text{ GeV}} \right)^2 \text{cm}^3 \text{s}^{-1} \]  \hspace{1cm} (31)

The annihilation time of neutralino should be greater than life-time of the Universe \( t_0 \). It depends very strongly (according to (30)) on the parameters of the NeS. If it is not so, the mass of neutralino \( M_n \) will decrease due to annihilation until \( \tau_n \approx t_0 \). It means that energy release due to annihilation which heats central region of the core in present time is (24):

\[ Q_{n0} = 6.8 \times 10^{-2} \frac{\text{erg}}{\text{cm}^3 \text{s}} \]  \hspace{1cm} (32)

Consequently the full energy dissipated by neutralino in BC is:

\[ Q = Q_{n0} r_{n0}^3 \pi^{3/2} = 1.4 \times 10^{29} \frac{\text{erg}}{\text{s}} \]  \hspace{1cm} (33)

This energy being transported to the surface of the core is emitted due to usual blackbody radiation.

\[ Q = Q_s = \sigma T_s^4 S = 1.4 \times 10^{29} \left( \frac{T_s}{800^\circ K} \right)^4 \left( \frac{R_b}{2 \times 10^{10} \text{cm}} \right)^2 \frac{\text{erg}}{\text{s}} \]  \hspace{1cm} (34)
Relation (33) determines the surface temperature $T_s$ as a function of parameters. For the stationary state formulas (25)-(33) describe some average situation, the exact distribution of temperature would be established in accordance with equation (13). To fulfill the stationary conditions a convective heat transport near the boundary region has to be selforganized.

Let us estimate the hydrodynamic stability (13) comparing the full pressure of baryonic gas $P$ with the gravitational energy $E$. Taking $\rho_b$ constant we have:

$$E = \frac{3 G M_b^2}{10 R_b}$$  \hspace{1cm} (35)

were $M_b$ is the full mass of the baryonic core. Total particle energy

$$P = N \bar{T}$$

where $\bar{T}$ is the average temperature and $N$ - number of baryonic particles. Here we took into account that the temperature is high enough to keep the object in gaseous state. Taking $\bar{T} \approx 0.6 T^* = 6 \times 10^5 K^o$, one can obtain

$$P \approx E = 2.5 \times 10^{45} \left( \frac{M_b}{5 \times 10^{32} g} \right)^2 \text{erg}$$  \hspace{1cm} (36)

We see that the particle energy is quite close to the gravitational one, it means that the main integral relation for equation (13) is well fulfilled.

So the structure of baryonic core of NeS because of neutralino heating is more alike to the star than to the planet. In the stationary conditions it has the temperature in the central part of the core an order of $10^6 K^o$. But the surface temperature is not very high.

We emphasize that the time needed to reach stationary temperature distribution in BC is compatible with the age of Universe. Because of this reason nonstationary processes could be significant. As the heating is going in the central part the temperature in this part $T^*$ at some conditions could be much higher than the stationary one. Nonstationarity of $T^*$ depends on the thermal conductivity and grows especially strongly with the full mass of neutralinos $M_n$ trapped in the core. The strong growth of $T^*$ follows from the relation (24) for neutralino dissipation rate and if $M_n \geq 10^{26} g$ it could increase on two orders of magnitude or even higher. This process can lead to the effective heating of the small central part of the core. The temperature in the center of BC could then increase in nonstationary process up to

$$T_m \approx 10^7 K^o.$$  \hspace{1cm} (37)

So we see that the baryonic core of NeS because of the heating by neutralinos is quite peculiar astrophysical object which could be constructed either like a planet or like a star depending on the efficiency of heating. The core can lose its hydrodynamical stability and explode, releasing the energy of the order of (35)

$$E \sim (0.1 - 0.01) P \sim 2 \times \left( 10^{43} - 10^{44} \right) \text{erg}$$

This energy is enough for creation of gamma burst ($E_{\gamma} \sim 10^{41} - 10^{42}$ erg), just what is needed for GDMH model of gamma bursts. We will consider now three main destabilization factors which can lead to explosion of BC.
1. Overheating of the central part of BC by neutralino.

A very strong heating of BC is connected with the high value of bulk of trapped neutralinos \( M_n \geq 10^{26} \) g. The heating would be more concentrated in the centrum of BC for the high values of neutralino mass \( m_x \). As the surface temperature of BC is of the order \( 500^\circ - 1000^\circ \) (what follows from the conservation of thermal flux) it is only weakly ionized which leads to the strong depression of thermal conductivity. Convective transport would be the main process of the heat transport in this region. Overheating in the central region could lead to the loss of hydrodynamical stability and explosion of BC.

2. Thermonuclear heating.

Neutralino annihilation inside the star leads to generation of highly energetic protons and gamma photons. These energetic particles produce ions of \( D_2^+ \) and some other light elements by interaction with the bulk protons of the core. Because of this process the number of \( D_2 \) and other particles is constantly growing in time in the central part of BC. Following (24), one can estimate the number density of deuterium produced for the lifetime of the Universe:

\[
N_{D_2} = \gamma_{D_2} \frac{Q_{n0}}{m_x c^2} t_0 \tag{38}
\]

\[
N_{D_2} = 2 \times 10^{21} \gamma_{D_2} \left( \frac{M_n}{10^{25} \text{g}} \right)^2 \left( \frac{10^6 K^\circ}{T^\star} \right)^{1/2} \left( \frac{m_x}{10 \text{ GeV}} \right)^{5/2} \left( \frac{\rho_0}{100 \text{ g cm}^{-3}} \right)^{3/2} \left( \frac{< \sigma v >_0}{3 \times 10^{-27} \text{ cm}^{-3}} \right)
\]

\( \gamma_{D_2} \) is the transformation coefficient for Gev-energy protons into \( D_2 \) ions due to collisions with the bulk protons. The number density (37) is big enough for initiation \( D_2 \rightarrow He_3 \rightarrow He_4 \) thermonuclear reaction. It means that if the temperature could reach high values (36) the effective nuclear process will begin. This process determine the heating term \( Q_{th} \) in equation (13) Thermonuclear process leads to a very effective heating \( Q_{th} \) (13) of the central part of BC and could become explosive, depending on initial state. It is necessary to mention that in (37) the total mass of trapped neutralino should be take into account, because even if according to (30) neutralino annihilate, the process of production of \( D_2 \) will take place.

3. Selftrapping of neutralino.

This process has been already considered in the previous section. As was mentioned above the dimension \( R_c \) could be small, it is diminishing with the growth of the mass of neutralino particles \( m_x \). On the other hand to reach the conditions (21), which determine the possibility of formation of selftrapped neutralino bulk (SNB) easier for low temperatures. So, it could be that SNB is formed during nonstationary process, when temperature in BC reach its minimum.

The fundamental feature of SNB is that the gravitational selfcompression is growing up with the growth of temperature \( T^\star \): its dimension became smaller (23) and neutralino density becomes higher (22). Such process leads to an explosive heating of the central region of BC. As follows from (22),(23),(24),(31) the energy, dissipated in SNB in 1 cm \(^3 \) per second is:

\[
Q_{n1} = 3.2 \times 10^{32} \left( \frac{T^\star}{10^9 K^\circ} \right)^7 \left( \frac{10 \text{ GeV}}{m_x} \right)^8 \left( \frac{10^{25} \text{g}}{M_n} \right)^4 \left( \frac{< \sigma v >_0}{3 \times 10^{-27} \text{ cm}^{-3}} \right) \left( \frac{R_c}{r} \right)^4 \text{ erg cm}^{-3} \text{ s} \tag{39}
\]
And the full dissipated power is:

\[ Q = 2.5 \times 10^{44} \left( \frac{R_c}{r_{\text{min}}} - 1 \right) \left( \frac{T^*}{10^6 K} \right)^4 \left( \frac{10 \text{ GeV}}{m_x} \right)^5 \left( \frac{10^{25} g}{M_n} \right) \left( \frac{< \sigma v >_0}{3 \times 10^{-27} \text{ cm}^3 / \text{s}} \right) \text{ erg/s} \]  

(40)

Were \( r_{\text{min}} \) is a minimal dimensions for the bulk. We see, that the energy dissipation in SNB is explosive, lasting only a few seconds.

It is evident, that to reach in reality such a stationary state is impossible, but non-stationary transition to this state is also a fast process, which can explode the BC. Let us determine the characteristic time scale \( \tau_n \) of this process. Neutralinos crossection for elastic collisions is usually lower than for annihilation. So, they can establish Boltzman distribution only through collisions with baryons. Characteristic crossection for neutralino-proton collision according to [23] is:

\[ < \sigma_n p v > \approx 10^{-29} \left( \frac{\rho_b}{1 g/cm^3} \right) \text{ cm}^3 / \text{s} \]

Supposing the density of protons (16) \( \rho_b \approx 10 g/cm^3 \) we obtain

\[ \tau_n \sim 10^7 \text{s} \]

This time is much smaller than the characteristic time of establishing of thermal equilibrium by the heat transport. So we conclude, that it is possible to have an overheating and blowing up of BC due to selftrapping, heating and fast compression of neutralino bulk in the centrum.

5 Conclusions

1. We have shown here that MACHO’s in the form of noncompact CDM halo objects could serve as the source of gamma bursts. This model could be proved if in experiments the significant local asymmetry of gamma bursts distribution, connected with the existence of a Giant Halo of the Andromeda (M31) would be established by observations. To do that a device with the sensitivity an order of magnitude higher than BATSE is needed. These experiments were already proposed earlier in connection with GDMH model [5].

2. The explosion of barionic core of NO proposed here as a source of gamma bursts will lead also to the emission of X-rays, optic infrared and radio waves. So a wide spectrum of electromagnetic emission follows the gamma burst.

3. Let us discuss now the interesting new opportunities for observations which follow from our model. The intensive infrared emission from BC of neutralino star (NeS) is predicted in present work according to formulae (34). The wave length of this emission \( \lambda \sim (3 - 8) \mu \), its full power \( Q \sim 10^{28} - 10^{29} \text{ erg/s} \). Emission should have blackbody spectrum with effective temperatures \( T_s \sim (500 - 1000) K \). The intensity of this emission at the Earth from the nearest sources should be of the order \( S \sim (10^{-10} - 10^{-11}) \text{ erg/s cm}^2 \).

We emphasize, that the theory predicts gamma emission from the same NeS also. In [17] are distinguished nonidentified point-like gamma sources from EGRET data [22]. It is shown
that these sources could be considered as the emission generated by NeS. A more detailed analysis [15], demonstrated the existence of two types of the NeS gamma sources. Galactic type has the emission intensity an order of magnitude higher, than halo type, considered in [17], what is in full agreement with the intensity of point-like gamma sources observed by EGRET [22]. In [15] demonstrated also an especially good agreement of a new EGRET observations with the predictions of a space distribution of sources made in [17], basing on NeS model of gamma sources. So of a great interest is to observe the infrared emission from the same sources. If this observations would be successful it would mean that we see the neutralino stars: neutralino halo of such a star radiates in gamma and its baryonic core in infrared rays.

We conclude, that infrared observations of nonidentified point-like gamma sources [17] are of fundamental significance as they could lead to the discovery of NeS.

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Fig.1

Two solutions of equation (13). First one correspond to neutralino selftrapping regime (curve 1) at the center of barionic core, and the second one is regular solution defined basically by barions density (curve 2).