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On the theory of relativistic collapse and relativistic explosion. 3. The frozar and frozon crystallizations.

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Abstract

A free radial falling to a common centre of inertia of two and more identical gravitationally-frozen objects - frozars (stellar mass or supermassive) and frozons (particles of Planck energy, the fluctuations of which are frozen in the self-gravitational field) is studied. Two frozars cannot merge and freeze without touch of nearest points of their surfaces, and the distances between the system's centre of inertia and centers of frozars always exceed the system's gravitational radius. The gravitational radius of a system of three and more frozars always several times exceeds the gravitational radius of each of frozars. For this reason the freely falling frozars freeze by forming a frozar supercrystal, where mean distances between the surfaces of frozars several times exceed a radius each of them. Frozons also cannot merge and only form frozen complexes, mainly as pairs of particle-antiparticle, up to frozon microcrystals. Frozar and frozon crystallizations appear as two fundamental general relativistic phenomena determining the structure of most compact and most massive objects in particle physics, astrophysics and cosmology. In astrophysics supermassive collapsed objects at the centre of stellar clusters, galaxies and quasars most probably are supercrystals of frozars and ordinary matter. During cosmological expansion primordial frozon and frozar crystals were centers of inhomogeneities, and also appear as a dark matter. If there will be a contraction stage, the Universe as whole also will freeze in a state of global frozar crystal and the contraction will stop, so there the cosmological singularity will absent and entropy of the Universe will be conserved. In particle physics the vertexes of interaction with frozons do not exist and compact objects having energy exceeding the Planck energy are "atoms", "molecules" and microcrystals of frozons.

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Content

Introduction

In the first part of the paper [1] the collapse of a single compact object has been studied in the frameworks of standard general relativity (GR) and consequences of freezing of proper times in all parts of the object with respect to world time have been discussed. It has been shown that consecutive taking into account of the freezing as a fundamental physical phenomenon in the strong fields leads only to the formation of frozars - the frozen

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stars a surface of which is frozen beyond the gravitational radius and where world lines of particles in entire volume are practically parallel each other. Such freezing is invariant and the physical consequences do not depend on in what coordinates of frames of reference these physically distinguished two types of time will be expressed – the local proper time (rate of local processes) measured locally by standard clocks and the world time (a global simultaneity of events in a rest frame of object's centre) measured by globally synchronized coordinate clocks.

Radial falling of an ordinary matter on a formed frozar will lead only to the growing of its mass and the gravitational radius. At radial falling of two and more already frozen compact objects toward common centre of inertia there appears a new situation. In the Newtonian gravity compact objects can merge by forming larger compact object of almost the same structure as before. In GR at approaching of two and more frozars there appears in principle new structure – a frozar complex up to supercrystal. It is clear already on an example of three frozars which cannot merge since the gravitational radius of the system approximately three times exceeds a surface radius of each of them and they fully freeze at some distance from each other.

Particles of the Planck energy also turn to a frozon state - the particles, fluctuations of which are frozen in strong own gravitational field [1,2]. Therefore, there appear the questions – how to be created particles exceeding the Planck energy and what kind of structure they may have?

In the present part of the paper the collapse of a system of two and more identical frozars with formation of frozar supercrystals, and also a system of several frozons with formation of frozon microcrystals are considered. All analysis will be performed in the rest frame of system's centre of inertia where there are global hypersurfaces of simultaneity $t = const.$ of world time *t*.

In the first section crystallization in systems of frozars is considered. In the second section crystallization on the Planck distances in systems frozons and their possible contribution to a dark matter are considered. In the third section consequences frozar and frozon crystallizations as new general-relativistic structure formation mechanisms are considered.

1. Impossibility to be merging of two frozars and frozar crystallization

Let's consider two identical frozars of mass m and surface radius r_b very close to the gravitational radius $r_b > r_g = 2Gm$, and let they are freely falling to a common centre of inertia. Here r_g almost twice less than the gravitational radius of this two frozar system $\overline{r}_g = 2GM$.

For simplicity, while we suppose that initially two frozars were rested not so far (few r_g) and that their masses are defined without gravitational mass defect. This mass defect due to the presence of the companion will lead to the decreasing both m and M, thus without loss of generality we may take:

$$M \sim 2m, \quad r_b > r_g \sim \overline{r}_g / 2 \qquad (1)$$

Notice also that the decreasing of the gravitational radius of the system $\overline{r}_g$ will be compensated by corresponding flattening of each of frozars along the direction to the centre of inertia of the system because of the additional radial contraction caused by the presence of the second frozar. Thus the spherical frozar transforms into an object with two gravitational radii - $r_{g(a)}, r_{g(b)}$ in longitudinal and transverse directions to the system's centre. Along the radial direction to the centre of the system the relation between "small" radii of surfaces of frozars and the gravitational radius of the system at approaching of the frozars will remain almost the same as at removal: $\overline{r}_g \sim 2r_{g(a)}$.

Thus, in process of their approaching a distance between the centre of inertia of the system and the most remote points of surfaces of the frozars, effectively playing a role of points of a "surface" of the system, will always remain larger than the gravitational radius of the system because of higher freezing of proper times. As a result, at freezing of the system as a whole there will be some distance between the nearest points of surfaces of the frozars and, consequently, even two frozars cannot merge and at sufficient closing in fast freeze without touch of their surfaces.

In cases of three and four (symmetrically placed) frozars, as triangle or tetrahedron, the system's gravitational radius will exceed the gravitational radius of each of frozars three or four times and there one cannot talk about closing enough - the system freezes in a state when distances between neighbors are equal several radiuses of each of frozars.

Interesting configurations can form a two frozar system with another frozar or a frozar cluster where two frozars have been joined and frozen before approaching of other neighbors. As a result at approaching two frozar system the remaining single frozar or the cluster freeze on rather large distance from it.

Thus, at approaching of frozars there will be formed frozen two- or many-frozar clusters – *supercrystals* - where separate frozars or two frozar clusters freeze at some distance, having be slightly flattened, and world lines of their centers and all remaining points will evolve be almost mutually parallel. Therefore, in astrophysics and cosmology, at modeling of the structure of the most compact gravitationally-frozen massive or supermassive clusters of frozars and ordinary matter, in addition to ordinary processes, it should be necessarily taken into account the formation of the frozar supercrystals too.

2. The frozon crystallization at the Planck distances

The fact of freezing of quantum fluctuations at the Planck scale region, where a particle of the Planck energy is localized, was considered already in 2006 in the first publication on the frozar treatment of collapse [1,2]. The particles of the Planck energy which are frozen in own strong gravitational field further we will name as *frozons*. Notice, that at emission of quanta of lower energy a frozon will be "refrozen", since its rest energy decreases and becomes as for ordinary particles, practically without gravitational freezing effects. Further we will consider only an idealized case when the existence of the Planck energy particles is supposed and where the effects of freezing dominate and they suppress the decay processes.

Transition into the frozon state of any kind of virtual particles of the Planck energy, created in loop diagrams of quantum field theory, is the fundamental general relativistic restriction for particle physics, independent on further possible graviton contributions. This fact excludes divergences from quantum field theory by introducing a natural and invariant cutting of energies and distances at the Planck scales. This fact explains high efficiency of the perturbation theory in quantum electrodynamics in which, at such gravitational cutting, one-loop contributions are few percent from the "tree" diagrams ones [1,2].

Here there appears a question: can two, three and more frozons merge by forming of particles having larger energy? Formally, the problem is reduced to the existence in quantum field theory, accounting the general-relativistic freezing effects, some "quasilocal" (in the sense of localization in the Planck volume) interaction vertexes for frozons. The answer appears unexpected - such vertexes do not exist and frozons cannot merge, moreover, the existing frozon cannot decay on two or more frozons. It is again is related by the freezing of a two-frozon system at approaching by each of frozons the gravitational radius of the system. Such closing up will lead only to formation of two- or many-frozon "*atoms*" in which all processes are strongly slowered and practically frozen. These frozon atoms, in next stage, can form frozon "*molecules*", up to formation of *frozon microcrystals*.

Observable consequences of such gravitational crystallization may be various, but simplest consequence is that frozars and frozar "atoms", if they exist, will be appeared as *a* "*dark matter"*. With ordinary matter and radiation they will interact mainly pure gravitationally and practically will not participate in other interactions. It is related by, at first, compensating by vacuum polarization effects almost all their quantum numbers, thus the many-frozar structures will be formed mainly across the condensation of particle-antiparticle pairs, and secondly, difference between their neighbor energy levels are of order of the Planck energy, and thirdly, if something will be happen, it will last in world time much more longer than other ordinary processes.

Thus, the gravitational crystallization without merging is the basic process which will dominate in the systems of several approaching frozons and the formed frozon microcrystals, together with single frozons, can be a part of "the dark matter".

3. Cosmological consequences of the frozar and frozon crystallizations

Primordial frozons and their microcrystals, formed at early periods after the Big Bang, practically will not be "refrozen" during expansion and further they will reveal as a dark matter. This dark matter formation mechanism, which will appear in many structures, does not need in introduction of new types of fields and particles since it is enough to consider transition to the frozon state of the quanta of known fields in extreme conditions at early stages of the cosmological expansion.

In the closed models of the Universe in the contraction era there will dominate such structures as supergalaxies with bright nucleus and large number of compact objects, especially, frozars and frozar supercrystals. Since most of matter will concentrate in compact objects, such as white dwarfs and neutron stars, merging of them form at first stage single frozars, and after approaching of latters there will form many-frozar supercrystals. Similar process with participation of nuclei of galaxies and quasars will lead to the formation of the semi-frozen supermassive supercrystals.

Thus, the contraction era will differ sufficiently from the expansion era by that main part of matter will freeze in the form of frozar supercrystals with more and more growing effective gravitational radii. Eventually these supercrystals will prevent the further contraction of the Universe as a whole and contracting to a very small volume will not happen.

At formation of frozar supercrystals and their merging finally into a total supercrystal in scales of the Universe, the Great Collapse stops with transition into the Great Freezing.

However, if before some processes lead to stopping of contraction and to further expansion, a new cycle will begin. But, this cycle will not be similar any more to previous one since the most of matter will remain in the form of frozar supercrystals which do not depend in any way on the cosmological expansion and this frozen matter will reveal as supermassive nuclei of galaxies and quasars.

One of commonly accepted beliefs assigned to the standard GR is the statement about formation of initial or final cosmological singularity in the contracted state.

Ordinarily it is believed that the problem arises when process is described by a comoving observer in terms of own proper time. But in this case also the consecutive application of GR allows one to remove this problem.

In fact an origin of the problem is that till now it is supposed that the Universe was expanded from and can contract up to the Planck volume V_{pl}. However each of separate "point" particles is "an external observer" concerning another particle and at approaching together up to l_{pl} their proper times appear as slowed down with respect to world time of a centre of inertia of this two particle system.

Therefore, in fact in GR it is necessary to take into account, that *each* of N_0 present particles and additionally creating ΔN quanta contract up to own Planck volume V_{pl}, and then wavelength of these particles never decreases. As a result, at the contraction of the Universe, smallest really achievable volume $V_{\min}$ is sum of these elementary volumes V_{pl} of each of particles and in units of the Planck volume it always will exceed the present number of particles in the Universe:

$$V_{\min} > N_0 V_{pl} \sim 10^{88} V_{pl}. \tag{2}$$

At reaching of this minimal volume $V_{\min}$ the particles will be frozen because of self gravitational fields and the cosmological contraction will stop in terms of cosmological proper time τ too.

In cosmology there is also the problem of large value of entropy since it has been supposed that the Universe expands from and may contracts up to V_{pl}. But if one takes into account that in the closed Universe contracting is prolonged only up to $V_{\min}$ from (2) with number of particles not less the present one, in GR the problem with large value of entropy disappears.

Large number of elementary volumes at the smallest contracting and corresponding "number of sells" just characterize entropy of the Universe which is further conserved also, as well as there conserves the residual mean total number of particles in later periods of expansion.

Conclusion

Unlike the Newtonian picture of merging of collapsed objects, in GR the merging of the gravitationally frozen objects does not occur. Instead they form gravitational atoms, molecules and supercrystals where collapsed objects are frozen at sufficient distances from each other.

As a result, such gravitational crystallization forms a new state of matter which probably appear as a dark matter, and also forms the centers of most of massive galaxies.

References

1. Zakir Z. (2006) *Theor. Phys., Astrophys. and Cosmol*., **1**, 3, 51; (2007) **2**, 1, 1; arXiv:0507.2585
2. Zakir Z. (2012) *Theor. Phys., Astrophys. and Cosmol*., 7, 1, 1.