АСТРОФИЗИКА

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ON THE INTERNAL STRUCTURE OF SUPERMASSIVE COMPACT CELESTIAL BODIES

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The conceptual part of the physics of baryonic protomatter and the alternative approach to understanding of the internal structure of highly compact stationary supermassive celestial bodies have been previously suggested in [1-5]. There are a number of advantages to this approach, which differs in principle from the standard black hole accretion models and is in good agreement with the observational data from active galactic nuclei. In order to be more consistent and convinced in the correctness of previously drawn statements, in our research it has been advantageous to verify them by expansion of the basic ideas with the appropriate and consistent theoretical constructions backed up by detailed numerical studies of the models, which are physically more realistic, with the spherical-symmetric distribution of matter in many-phase stratified states. Multiple integrations in the aftermath prove the validity of the previous physical scenario and correctness of drawn statements that *the process of inner distortion of the space-time continuum just serves as the eligible mechanism counteracting to collapse.*

1. *Background and Significance.* There is a sufficiently large number of observational data in astrophysics, which prove the presence in the Universe of highly compact supermassive formations existing in the stable stationary state for a long time compared to the age of the Universe. In spite of the considerable progress achieved over the last twenty years in astrophysics in regard to the extensive program of systematic surveys of those well-defined celestial sources of immense power of radiation, our understanding of their internal constitution and environment close to their cores still remains far from being complete. Moreover, we are only at the very beginning of a deeper understanding of the physical properties of supervenes matter, which are uncertain by now and there is still a long way to go.

The most important astrophysical phenomenon such as active galactic nuclei (AGN's) with super-Eddington luminosity has been in central part of those investigations, since they display most clearly the nonthermal behavior that is believed to exist

in their cores. Over the entire subsequent period the standard black hole accretion models have became a generally acceptable paradigm as the view on those objects. The fact that accretion processes really take place in AGN's seemed to be proven for certain by many observations. But with in respect to standard models, one should note that this approach to understanding of physics of superdense equilibrium configurations based on the main idea of black holes suffers from some grave shortcomings and it can no longer support itself against the inner inconsistency from the theoretical point of view as well as astrophysical observations. First among them: the fate of collapsing sphere, with respect to the proper coordinate system that is being used, remains indefinite. The theory breaks down inside the black hole, where static observers cannot exist, because they are inexorably drawn into the central singularity. Then, it is impossible to calculate corresponding integral characteristics of the supermassive objects. But the main deficiency is the fact that the observed time-scale for flux variations of some AGN's are inconsistent with contemporary black hole accretion models. That is, on the base of the diagram of the minimum variability time-scale against the bolometric luminosity of 60 sources (AGN's) it has been shown that a few BL Lac objects -B2 1308+72,3C 66A, OJ 287, AO 02335+16 and quasars - 3C 345, 3C 446, 3C454.3, LB 9743 remained in forbidden zone (particularly the initial three of them). Therefore, the creation of the new viable theoretical constructions to overcome all these shortcomings and for the explanation of an abundant spectra of observational data is the problem of paramount significance.

As a matter of fact during increasing the mass of configuration, it achieves (irrespective of the gravitational theory which is being used) the critical turning point beyond which the gravitational forces of compression become dominant (a stage of relativistic collapse). Moreover, it is enough to add from the outside a small amount of energy nearby the critical point in order to begin a process of irresistible infinite catastrophic compression of configuration under the pressure of grand forces. The big problem as it was seen at the outset was how to get a concrete mechanism for the supermassive objects, which could provide a proportional increase of internal pressure of degenerate Fermi gas with the sharp increase of the gravitational forces . Only due to the validity of hydrostatic equilibrium, the supermassive formation really could remain in the stable state for a long time, even up to the limit of masses much greater than solar mass.

2. *Preliminary Studies.* The novel viewpoint came up recently to overcome the above-mentioned difficulties of the contemporary theory [1-5], where outlined the main principles of an alternative approach to understanding of internal structure of stationary supermassive cosmic objects. A simple way of effecting a reconciliation is

to assume that the considerable changes of the properties of the space-time continuum take place in the density range above nucleus, that is at short distances below some length scale is about 0.4fm. This hypothesis, which actually needs in further confirmation, seemed could lead to substantial impact on progress in considered field. This idea comes from the theory of distortion of space-time continuum [5-7], in which a perception of space and time has been suggested by means of new concepts. While the problems and dynamics of the processes, which are of the interest of Special and General Relativity, Quantum Field Theory have been studied from a specific novel point of view. The spatial-time concepts have been properly substituted by the appropriate new ones. The general theory of distortion of the space-time continuum has been suggested, which predicts the new important phenomena existing below the threshold length scale. Two regimes are distinguished: First one is the curvature of the space-time continuum, which is considered as the familiar regime of distortion and leads to the new gravitational theory. The latter is in good agreement with the general relativity up to the limit of neutron stars. But this theory should begin to manifest its virtues around the threshold length, where the second regime should be switched on. Second regime is a quite new one, which is called *the inner distortion of the space-time continuum* (IDST). At the short distances equal or less than 0.4fm, along with many other processes, in particular, the considerable changes of the space-time continuum take place, the metric undergoes the phase transition of second kind, and as a direct consequence of it the matter, which is found in this continuum also undergoes the phase transition of second kind. Each particle goes off from the mass shell. The shift of mass at rest, the energy-momentum spectra of the particles upwards along the energy scale took place. *The new phase state of matter, which is found in the inner distorted space-time continuum, we called a protomatter.* The study of these processes and the laws of phase transitions is the main subject of suggested theory, which is of decisive importance for more deeper understanding of the physics of superdense matter. Latter will have to be considered anew and will have to be adjusted to fit this novel viewpoint. To facilitate our altered approach it seems well to present below some formal matters which one will have to know in order to understand the structure of theory. So far as displayed at short distances new phenomena relate directly to IDST, they hold irrespective to concrete model of configuration. This allows oneself to carry out -the numerical calculations in the most simple case of equilibrium one-component configurations of degenerate ideal neutron gas in presence of one-dimensional space-like inner distortion of space-time continuum. It has been shown, that *due too IDST in the central region of superdense core of neutron protomatter, the internal pressure rises proportional with sharp increase of gravitational forces of compression in near*

about 18-20 order of magnitude with respect to the central pressure of neutron star. This counteracts the catastrophic compression of central region. Hence, the stable equilibrium remains valid in outward layers too, even up to the limit of masses much greater than solar mass. As the models of AGN's one has considered the configurations consisting of such cores surrounded by accretion disks. The principle difference from standard models is the fact that central cores are in stable equilibrium state with the certain radial distribution of density and pressure of matter, and a number of integral characteristics. The important effect of metric singularity cut-off has been established, due to which the metric singularity ceased to be significant no longer. The rigorous restriction on the upper limit of possible values of the total masses of equilibrium configurations is obtained ($M \leq 3.5 \times 10^8 M$), which is in good agreement with the observational data from AGN's. It seems that a decisive significance has the metric singularity cut-off effect for the BL Lac objects OJ 287, 3C 66A and B2 1308+32, hence their observed sizes are less than the sizes of corresponding spheres of even horizon. This may serve as a strong indication that suggested approach is preferable to the standard models.

3. *Research Design and Methods.* The foregoing theory involves a drastic revision of our ideas of space and time and structure of superdense cores of suppermassive celestial bodies. In order to be more consistent and convinced in the correctness of previously drawn statements, in our research it would be advantageous to verify them by appropriate expansion of the basic ideas to models, which are physically more realistic, with the spherical-symmetric distribution of matter in many-phase stratified states. The layering of considered configurations is a consequence of the onset of different regimes in the equation of state. We consider the most general configurations of two classes. They including the same shells, which are made of cold catalyzed matter formed after nuclear burning in the density range below neutron drip $\rho_{dr}=4.3\times10^{11}$ gcm^{-3}. The latter is consisted of surface ($\rho \leq 10^6$ gcm^{-3}), of outer crust (10^6 gcm$^{-3} \leq \beta < \rho_{dr}$) and inner crust . This is made of separated nuclei in β equilibrium with the electron gas. The pressure is dominated by degenerate electrons that become fully relativistic above b. A considerable amount of those nuclear composition is changing along the radial direction step-by-step away from the state of lowest energy up to more neutron-rich larger nuclei depending of the pressure of relativistic electrons, which combine with bound nuclear protons to form neutrons (inverse β - decay). Increasing the density above ρ_{dr} leads more free neutrons emerge in a medium, until nuclei dissolve by merging together. It is well known that the nuclear matter at high density range above nucleus still remained not so well understood. A large number of representative models for the nuclear equation of state are available in literature, but they

all are subject to many uncertainties, including such exotic processes as a neutron and proton superfluidity, a pion condensation, a phase transition to quark matter and so on. For the simplicity, above the density $4.54\times10^{12}gcm^{-3}$ the first class configurations are now thought to be composed of two phases of ideal cold n-p-e gas. The latter is a mixture of neutrons, protons and electrons in complete inverse β – decay equilibrium. The first phase state covers the intermediate density domain $4.54\times10^{12}gcm^{-3} \le \rho<\rho_d=2.617\times10^{16}gcm^{-3}$, which is the regular n-p-e gas in absence of IDST. The second phase state is the n-p-e protomatter above the density $\rho\ge\rho_d$ with short distances between the nucleons $r_{NN}\le0.4fm$ *in* the presence of IDST. This regime needs in a special theoretical study. For the second class configurations we consider an onset of melting down of hadrons at the density about $\rho_{fl}=4.09\times10^{14}gcm^{-3}$. to which the nucleon-nucleon distances $r_{NN}\le1.6fm$ are corresponded, and nuclear matter consequently turns to quark matter. In the domain of $\rho_{fl}\le\rho<\rho_{qq}=m_n(0.25fm)^3=1.072\times1017gcm^{-3}$ where m_n neutron mass at rest, 0.25fm is the string thickness, we should consider two phase states of string flip-flop regimes:

1) the regular string flip-flop at the densities $\rho_g\le\rho<\rho_d$ (to which the distances $0.46fm<r_{NN}\le1.6fm$ are corresponded) and the IDST is absent. There is a kind of tunneling effect in which the strings stretch themselves violating energy conservation, and after touching each other they switch to the other configuration.;

2) the string flip-flop regime in presence of IDST at the densities $r_{fl}\le r<r_{qq}$ or distances $0.25fm<r_{NN}\le0.4fm$. That is, the system is made of the quark protomatter in complete b - equilibrium with rearrangement of string connections joining them. Here we concerned with the individual particle approximation (Hartree approximation). The Hartree potential is almost linearly proportional to the string length. The Y shape string is the most convenient for the calculation, just because the center of it almost coincides with the gravity center. The medium is made of the fully relativistic quarks of *u, d, s* flavors, in complete b - equilibrium. Finally, at the densities above the r^3r_{qq} the system is made of the quarks in one bag, in complete b - equilibrium under the weak interactions, and gluons including the effects of Quantum Chromodynamics (QCD) perturbative interactions in the presence of IDST. The QCD vacuum is generally believed to have a complicated structure is intimately connected to the glue-glue interaction. The confinement of quarks is a natural feature of the exercising a pressure on the surface of the local region of the perturbative vacuum to which quarks are confined. This is just the main idea of bag model: the quarks are assumed to be confined in a bag and the stability of the hadron is ensured by the vacuum pressure and the surface tension. Due to the screening of strong forces, the quark field is considered to be free inside the bag and to interact strongly only in the surface region.

The surface energy is estimated to be proportional to quark density. The medium is made of quark protomatter in overall color singlet ground state, which can be considered as the non-interacting relativistic Fermi gas found in the inner distorted space-time continuum. The last two domains need in special theoretical treatment. In achievement of the major specific goal of our approach, with the appropriate and consistent theoretical constructions backed up by detailed numerical studies, we have justified the previously drawn statements in the case of considered above modified realistic models of superdense configurations.

Each configuration is defined by two parameters of central values of concentration of particles and the inner distortion field. Hence the central value of gravitational potential is being found by means of multiple integrations through with the subsidiary sewing condition of smoothness of matching of internal and external geometries.

Multiple integrations in the sequel prove the validity of the previous physical scenario, and convince us in the correctness of drawn statements. The all obtained previously results concerning to the integral characteristics of AGN's really have high enough accuracy. That is the modification of the models in the sense of form of state equation actually could not lead to the perceptible corrections in the domain of AGN's. Meanwhile we proved the validity of already cleared up physical scenario, according to which the process of IDST just serves as the eligible mechanism counteracting to collapse.

4. Beyond Geometry and Particles. One final observation is worth recording. All research works presented above, in fact, are only some part of more extensive program, the major goal of which is to achieve at last the consistent high energy physics. Certainly, the principle problems of the physics of superdense matter could not be solved separately, without consistent high energy physics. In view of all this, as the first stage, the fundamental question that guides our discussion in the theory of goyaks (goyak in Armenian means an existence ; an existing structure. This term has been firstly used in [6]) [8,9] is how did the geometry and particles come into being? To explore this query the theory of goyaks reveals primordial deeper structures underlying fundamental concepts of contemporary physics. It address itself to the prime-cause of origin of geometry and basic concepts of particle physics, such as the fundamental fields with the spins and various quantum numbers, internal symmetries and so forth; also basic principles of Relativity, Quantum, Gauge and Color Confinement, which, as it was proven, all are derivative and come into being simultaneously. The substance out of which the geometry and particles are made is the set of new physical structures-the goyaks, which are involved into reciprocal linkage establishing processes. It is appropriate to turn to them as the primordial deeper structures.

The most promising aspect of our approach so far is the fact that many of the important anticipated properties, fundamental concepts and principles of particle physics are appeared quite naturally in the framework of suggested theory. In pursuing the original problem further we have elaborated a new mathematical framework, which is, in fact, a still wider generalization of familiar methods of secondary quantization with appropriate expansion over the geometric objects.

One interesting offshoot of this generalization directly leads to the formalism of operator manifold, which, consequently yields the quantization of geometry. This approach differs in principle from all earlier studies. The theory of goyaks predicts a class of possible models of internal symmetries, which utilize the idea of gauge symmetry and reproduce the known phenomenology of electromagnetic, weak and strong interactions. In order to save writing in [8,9] we guess it worthwhile to leave the other concepts such as the flavors and so forth with associated aspects of particle physics for the further publications. Surely this is an important subject for separate research. Here we focused our attention mainly on developing the mathematical foundations for our viewpoint. Hence our discussion has been rather general and abstract. Of course, much remains to be done for a larger contribution into the particle physics. However, we believe that the more realistic final theory of particles and interactions can be found within the context of the theory of goyaks. We hope that all these seminal works would entail support of the large number of researchers from all over the world.

ВНУТРЕННЕЕ СТРОЕНИЕ СВЕРХМАССИВНЫХ КОМПАКТНЫХ НЕБЕСНЫХ ТЕЛ

Г.ТЕР-КАЗАРЯН, К.ЕРКНАПЕТЯН

Концептуальная часть физики барионного протовещества и новый подход к пониманию внутреннего строения сверхплотных, сверхмассивных стабильных небесных тел, первоначально были предложены в [1-5]. Этот подход принципиально отличается от стандартных моделей черных дыр и хорошо согласуется с результатами наблюдений Активных Галактических Ядер. Для последовательности и проверки первоначальных выводов исследованы физически более реалистические модели устойчивых сверхмассивных конфигураций теоретическими и численными методами. Результаты подтверждают, что процесс внутреннего искажения прост-

ранства-времени действительно является приемлемым механизмом, противодействующим коллапсу.

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