Editorial

Editorial to the Special Issue “Selected Papers from the 17th Russian Gravitational Conference—International Conference on Gravitation, Cosmology and Astrophysics (RUSGRAV-17)”

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This Special Issue consists of selected papers reflecting the plenary and sectional talks presented at the 17th Russian Gravitational Conference—International Conference on Gravitation, Cosmology and Astrophysics (RUSGRAV-17). The aim of this Conference and Special Issue is to present important new results regarding classical and quantum gravity, cosmology, relativistic astrophysics, physics of black holes, neutron stars, dark matter and dark energy, and possible unification schemes of particle and gravitational theories. Although the listed topics are rather diverse, all of them are concentrated around the greatest problem of modern physics, namely, what is the origin, structure, and evolution of our Universe. During the last decades, great progress has been made in the resolution of this fundamental problem, but many important questions remain unanswered. We still do not have a clear understanding of the very early stages of the Universe evolution, nor do we know what is the nature of dark matter and dark energy, which contribute the major part of the Universe energy. Moreover, the mechanisms of huge outputs of energy from remote astrophysical objects remain unknown. These global problems, whose resolution might demand some changes in our fundamental concepts, are supplemented by a great number of questions regarding the models of inflation, physical effects in black holes and different predictions of gravitational theories alternative to Einstein’s general relativity theory.

In accordance to the main subjects discussed at RUSGRAV-17, selected papers included in the Special Issue can be conditionally attributed to classical gravity, physics of black holes and wormholes, cosmology, alternative gravity theories, quantum gravity, and to relativistic astrophysics.

Several articles of this Special Issue are devoted to different problems of classical gravity. An impact of extra symmetries on the exact solutions of general relativity is discussed in [1]. Article [2] considers the problem of universal constants and natural systems of units in the spacetime with an arbitrary number of dimensions. The concept of energy-momentum pseudotensor in generally covariant theories of gravity and the possibility of negative energy in generalized Vaidya spacetime are analyzed in [3,4]. We emphasize that the talk of Dr. Vertogradov reflected in the article [4] was awarded by the Organizing Committee of the Conference as the best talk presented by young scientist. Articles [5–7] are devoted to a comparison of gravitational and light frequency shifts, gravitational interaction in a null string gas, and to spinors in the cylindrically symmetric spacetime, respectively.

During the last years, much attention was devoted to investigation of black holes and wormholes. It should be noted that black holes, which were first predicted theoretically in

the framework of Einstein's general relativity theory as some hypothetical objects, are now observed in the Universe and actively investigated by astrophysicists. It is well known that the spherically symmetric solutions of Einstein equations describing black holes are singular. The possibilities to find regular static solutions to Einstein equations for a spherically symmetric distribution of matter with no restriction on a total mass is discussed in [8,9]. In articles [10,11] the collapsing wormholes sustained by dustlike matter and a discrete version of the Schwarzschild solution are considered, respectively. Null and timelike geodesics near the throats of phantom scalar field wormholes are investigated in [12]. Some other problems in the physics of black holes, such as matter accretion versus semiclassical bounce in the Schwarzschild interior [13], a description of black holes in terms of the axiomatic set theory [14], and an analysis of black hole formation in $(2 + 1)$ -dimensional spacetime with the negative cosmological constant due to the collapse of a dust shell [15] are also discussed.

The largest scale application of gravitational theory is in cosmology which investigates the origin, structure, and evolution of the Universe. Modern cosmology is based on the solutions to Einstein equations found by Alexander Friedmann in 1922 which describe the expanding Universe. Some issues on the foundations of modern cosmology, gravitation and quantum physics are considered in review [16]. As was already mentioned above, the major part of the Universe energy avoids immediate observation through strong, electromagnetic and weak interactions and is seen through gravity only. According to one of the proposed approaches, dark matter may consist of light pseudoscalar particles called axions. In this connection, article [17] discusses a question: Is the axionic dark matter an equilibrium system? Several articles investigate gravitational radiation as the bremsstrahlung of superheavy particles in the early Universe [18], energy conservation law in the closed Universe in connection with a concept of the proper time [19], and the possibility of applying the Copenhagen interpretation to quantum cosmology [20]. The cosmological constant problem in the super-early Universe and the collision of relativistic shock waves and its impact on the large scale structure of the Universe are considered in [21,22], respectively. Articles [23,24] are devoted to exact and slow-roll solutions for exponential power-law inflation and to a qualitative analysis of the dynamics of two-component chiral cosmological model. Article [25] discusses a relationship between the 5D theory and cosmology.

The alternative gravity theories have a long history. The first of them have been developed very soon after the creation of Einstein's general relativity theory. Nowadays the work in the field of alternative gravity theories is motivated by existing problems which remain unresolved in the framework of general relativity theory for a long time. Among them one could mention the problems of dark matter and dark energy, as well as a failure of all attempts to create consistent quantum theory of gravity based on general relativity theory. Scale-dependent gravity in the superfluid vacuum theory is considered in [26] as a possible alternative to dark matter and dark energy. Three articles are devoted to quark stars in massive Brans-Dicke gravity with Tolman-Kuchowicz spacetime [27], non-relativistic limit of embedding gravity as general relativity with dark matter [28], and to the formation and clustering of primordial black holes in Brans-Dicke theory [29]. The hybrid metric-Palatini gravity in the case of regular stringlike configurations and gravity with higher derivatives in D -dimensions are discussed in [30,31], respectively. Finally, the gravitational interaction in the unified scalar field theory is considered in [32].

As mentioned above, we are still lacking fully consistent theory of quantized gravitational field. However, during the last decades an important progress has been made in quantum field theory in curved spacetime. It is some kind of tradition that both these scientific directions are often referred to as quantum gravity. In this Special Issue, the vacuum quantum effects in braneworlds on anti-de Sitter bulk are considered in [33]. Article [34] is devoted to a consideration of inherent relation between the Higgs mechanism and spacetime symmetry. The state of the art in constraining axion-to-nucleon coupling and non-Newtonian gravity from laboratory experiments is reviewed in [35].

The radiation from an inertial mirror horizon and the gravitational interaction of cosmic string with spinless particle are analyzed in [36,37], respectively. The other problems of quantum gravity, such as quantization of gravitationally bound systems [38], a comparison between Einstein's geometrical and Feynman's quantum-field-theoretical approaches to gravitational physics [39], and a crucial role of gravity in the formation of elementary particles [40], are also investigated.

With creation of powerful instruments and space programs, astrophysics has now become an important branch of both fundamental and applied science based on the solid foundation of gravitational and particle physics. Modern astrophysics investigates not only stars and planets, but also an interstellar medium, including dark matter and dark energy, the microwave background radiation, gravitational waves, galaxies, and the large-scale structure of the Universe. Some of these subjects were touched upon at the RUSGRAV-17 Conference and are reflected in this Special Issue. Thus, the density operator approach to turbulent flows in plasma and atmospheric fluids [41] and the line-of-sight analysis of spatial distribution of galaxies in the COSMOS2015 catalogue [42] are considered. Articles [43,44] discuss a question of whether the object OJ 287 is a single supermassive black hole and the resonant effect for a Breit-Wheeler process in the field of a X-ray pulsar, respectively. Some other articles included in this Special Issue are devoted to relativistic effects in the orbital motion of S-stars at the galactic center [45], the resonant production of an ultrarelativistic electron-positron pair at the gamma quantum scattering [46], visible shapes of the black holes M87* and SgrA* [47], and the resonant effects in a photoproduction of ultrarelativistic electron-positron pairs on a nucleus [48]. Possible wormhole candidates in active galactic nuclei [49] and resonant effect of an annihilation channel in the interaction between an ultrarelativistic electron and a positron [50] are also discussed. Finally, article [51] considers the intensity and polarization of radiation emerging from a rotating accretion disc with increasing height and article [52]—the resonant ultrarelativistic electron-positron pair production by high-energy electrons in the field of a X-ray pulsar.

The above articles reflect the present state of the art in the already resolved and still unresolved problems in the field of gravitation, cosmology and astrophysics. The Guest Editors of this Special Issue hope that it will be useful for further progress and stimulate new important research directions.

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