Editorial

Classical and Quantum Gravity and Its Applications

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After discovery of accelerated expansion of the universe in 1998, understanding its theoretical reasons presents one of the fundamental open questions in physics. This is the so-called Dark Energy issue. Another important issue is the so-called Dark Matter problem, which started in the 30s of the last century. If we observe the Doppler shift of stars moving near the plane of our galaxy and calculate the velocities, we find a large amount of matter inside the galaxy which prevents the stars from escaping. That matter, which is supposed and unknown, generates a very large gravitational force that the luminous mass in the galaxy cannot explain. On one hand, if one wants to explain that large discrepancy, the sum of all the luminous components of the galaxy must be two or three times more massive. On the other hand, if one calculates the tangential velocity of stars in orbits around the galactic center like a function of distance from the center, one sees that stars which are far away from the galactic center move with the same velocity independent of their distance from the center. These strange issues generate a portion of the Dark Matter problem. In fact, either the luminous matter is not able to correctly describe the radial profile of our galaxy or the Newtonian theory of gravitation cannot describe dynamics far from the galactic center. Other issues of the general Dark Matter problem arise from the dynamical description of various self-gravitating astrophysical systems. Examples are stellar clusters, external galaxies, and clusters and groups of galaxies. In those cases, the problem is analogous. There is indeed more matter arising from dynamical analysis with respect to the total luminous matter. Identifying the cause of the Dark Matter and Dark Energy problems is a challenging problem in cosmology. Physicists are interested in considering Dark Matter and Dark Energy in a gravitational background and they proposed some candidates to explain them. Modifying general relativity opens a way to a large class of alternative theories of gravity ranging from higher dimensional physics to non-minimally coupled (scalar) fields. On the other hand, one of the interesting dreams of physicists is finding a consistent quantum theory of gravity. Although there are a lot of attempts to join gravity and quantum theories together, there is no complete description of the quantum gravity. The main idea of promoting general relativity to a quantum level scenario is one of the big challenges of our century. The fact that gravitational collapse is the dominant mechanism in formation of massive objects motivates one to study its various properties. It has been predicted that gravitational collapse of massive objects may lead to the formation of singularities. The recent observational evidences of Laser Interferometer Gravitational-Wave Observatory (LIGO) confirm not only the existence of gravitational waves but also the life of black holes. From the other side, an interesting topic in multidisciplinary branches of theoretical physics is to study relation between certain types of gravity models and quantum systems, called gauge/gravity duality or AdS/CFT. It is believed that this approach is able to explain all quantum phase transitions of systems using a unique and well-defined dictionary. For example, we can compute the entanglement entropy of a many-body-quantum system using the solutions of gravitational action in a higher dimensional asymptotically AdS space time. Furthermore, quantum information metric or fidelity and other condensed matter phenomena could be explained by this purely geometric approach using the classical black hole solutions. Different experimental data in labs supported this idea to treat strongly correlated quantum systems using the gravitational sector of a weakly coupled system.

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