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Editorial

Editorial for the Special Issue "Relativistic Astrophysics"

Francesco De Paolis [1,2,*], Achille A. Nucita [1,2] and Alexander F. Zakharov [3]

[1] Dipartimento di Matematica e Fisica "Ennio De Giorgi", Università del Salento, CP 193, 73100 Lecce, Italy; nucita@le.infn.it
[2] INFN, Sezione di Lecce, Via per Arnesano, 73100 Lecce, Italy
[3] Bogoliubov Laboratory for Theoretical Physics, JINR, 141980 Dubna, Russia; alex_f_zakharov5@mail.ru
* Correspondence: depaolis@le.infn.it

Relativistic Astrophysics is the branch of astrophysics that studies astronomical phenomena and celestial bodies, for which classical mechanics and Newton's law of gravitation are inapplicable to creation of suitable models and we have to generalize these approaches following general relativistic prescriptions. The field of relativistic astrophysics began with Schwarzschild's solution of Einstein's field equations and still continues to grow very rapidly, more of a century after the birth of general relativity theory. A modern cosmology is based on a general relativistic approach proposed by A. Einstein in 1917 for the static universe model and this approach was generalized by A. Friedmann in 1922 to develop a dynamical universe model. In the last few years, four epochal confirmations of general relativity have finally been achieved: the discovery of gravitational waves from merging massive black holes and neutron stars, the first image of the supermassive black hole in the center of the M87 galaxy by the EHT set of instruments, the Keck and GRAVITY discoveries of gravitational redshift near the S2 star pericenter passage in May 2018 and the discovery of the Schwarzschild precession of S2 star with the GRAVITY interferometer. However, in spite of the enormous progress made in recent years, mainly due to the novel observation facilities, many questions remain open, and many queries have been raised by observations.

In particular, in a paper [1] of this Special Issue the phase-space portrait of homogeneous and isotropic universes is studied by considering different coupling functions between dark energy models and bulk viscous dark matter. After defining useful dimensionless quantities an autonomous set of equations, to analyze the stability of the universe, is established. The critical points and the respective eigenvalues are then studied assuming different dynamical quantities.

In paper [2] the β^--decay half-life for selected even–even nuclei decaying through electron emission is analyzed. The kinematical portion of their half-life is performed using a recently introduced technique for computation of phase space factors (PSFs). The dynamical portion of the calculation is instead conducted in the framework of the proton–neutron quasi-particle random phase approximation (pn-QRPA model). Six different nuclei, i.e., ^{20}O, ^{24}Ne, ^{34}Si, ^{54}Ti, ^{62}Fe, and ^{98}Zr, have been considered and the calculated PSFs are compared with the results obtained previously. In particular, the Dirac equation was numerically solved by employing a Coulomb potential, taking into account both the finite size of the nucleus and the diffuse nuclear surface corrections. Moreover, a screened Coulomb potential was constructed to account for the effect of atomic screening. The half-live values calculated with that method were found to be in **a good** agreement with the results obtained through laboratory experiments. In paper [3] it is presented a detailed study of the motion of magnetized particles around black holes in conformal gravity theories. The behavior of magnetic fields near the horizon of black holes in conformal gravity **has** been also analyzed, showing that by increasing the values of the conformal parameters L and N the value of angular component of the magnetic field at the stellar surface tends to decrease. The maximum value of the effective potential corresponding to circular motion of the magnetized particle is found to increase by increasing the values

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of the conformal parameters. It has been also established that for any case of collision involving either neutral, charged or magnetized particles in the black hole environment, the center-of-mass energy decreases with the increase in the conformal parameters. In the case of either magnetized and negatively charged particle collisions, the innermost collision point with the maximum center-of-mass energy comes closer to the central object due to the effects of the conformal gravity parameters. The authors also apply these results to some realistic astrophysical scenario considering a pulsar, treated as a magnetized particle, which orbits around the super-massive black hole (SMBH) Sgr A* which harbor in the center of the Milky Way. The main aim is that of estimating the orbital parameters of the magnetized compact object. It is remarkable that the detection of pulsars near the Sgr A* SMBH might provide strong constraints on the SMBH physical parameters even if some degeneracy exists between the spin of the SMBH and the surrounding magnetic fields. Therefore, it has to be noticed that the interaction of a magnetic field value about 10^2 Gauss with the magnetic moment of the magnetized neutron star can in principle mimic the spin of a Kerr SMBH.

In paper [4] the wormhole solution is investigated in the framework of the $f(R)$ alternative gravity theory. Under the assumption of a spherically symmetric and static spacetime geometry, the wormhole solution is explored assuming anisotropic fluid source and different equations of state to describe the properties of the shape-function of the wormhole geometry. The stability analysis is also performed for specific shape-functions indicating that the obtained results are stable and realistic.

The Guest Editors of this Special Issue hope that it will be useful for further progress and stimulate new research directions.

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