Cosmic relics from fundamental physics

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The description of Nature at its fundamental level provided by the standard models of particle physics and cosmology is vastly incomplete. Within the established theoretical picture of the universe, we have no fundamental understanding of the origin of the observed luminous matter, not to saying the mysterious dark matter, the role of quantum gravity and aspects of particle physics beyond the approximation within the perturbation theory. The current most advanced collider experiments at energy (Large Hadron Collider) or intensity frontiers (Belle 2) are incapable to provide the necessary empirical input to resolve some of the abovementioned problems. In this regard, I argue that high-energy astrophysical and accurate cosmological observations may play a critical role in probing the new physics beyond the standard model by detecting certain cosmic relics – stable objects that has been produced in the early universe and survived till today. In particular, I will focus on hypothetical isolated magnetic charges (magnetic monopoles) and primordial black holes. I will argue that monopoles are predicted within a non-perturbative sector of the well-established standard model of particle physics [1] and may play a crucial role in generation of luminous matter in the universe [2]. I will also show that the properties of primordial black holes critically depend on their modelling in the early universe [3,4] as well as subtle quantum effects induced by quantum matter within the classical theory of gravitation [5,6].

[1] S. Arunasalam and A. Kobakhidze, ``Electroweak monopoles and the electroweak phase transition," Eur. Phys. J. C 77, no.7, 444 (2017).

[2] S. Arunasalam, D. Collison and A. Kobakhidze, ``Electroweak monopoles and electroweak baryogenesis," [arXiv:1810.10696 [hep-ph]].

[3] C. Boehm, A. Kobakhidze, C. A. J. O'Hare, Z. S. C. Picker and M. Sakellariadou, ``Eliminating the LIGO bounds on primordial black hole dark matter," JCAP 03, 078 (2021).

[4] A. Kobakhidze and Z. S. C. Picker, ``Apparent horizons of the Thakurta spacetime and the description of cosmological black holes," Eur. Phys. J. C 82, no.4, 347 (2022).

[5] Y. Kim and A. Kobakhidze, ``Topologically induced black hole charge and its astrophysical manifestations," [arXiv:2008.04506 [gr-qc]].

[6] Y. Kim and A. Kobakhidze, ``Non-Schwarzschild Primordial Black Holes as Dark Matter in Quadratic Gravity," [arXiv:2106.11764 [gr-qc]].