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Searching for new particles with astrophysical compact objects

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Dark matter remains a central mystery of modern-day science. The elusiveness of dark matter candidates in colliders suggests we further search for its true nature where it was first unveiled
- in astrophysics via its gravitational effects. In particular, the new golden age in strong gravity
- with the gravitational wave era and remarkable new electromagnetic observations of compact objects -
is providing intriguing hints on fuzzy dark matter. Such phenomenological studies start from the construction of appropriate compact objects where such fuzzy dark matter plays a key role, both new types of black holes and horizonless compact objects. The goal of this thesis is to go beyond the simplest fuzzy dark matter models, based on Abelian fields. A dark sector, like the visible one, may contain non-Abelian fields. The impact of such fields on the phenomenology of compact objects, connecting it to gravitational waves and electromagnetic observations, is the central goal of this thesis.
Then, the main goal of this thesis is two-fold: construction of new solutions describing bosonic stars and hairy black holes, to construct new bosonic star solutions, both static and spinning, based on non-Abelian (nA) global or gauge symmetries suggested by simple BSM extensions and study their basic mathematical and physical properties and phenomenology. Also, we intend to study hairy black hole solutions in the same models, which are counterparts of the spinning bosonic stars and the phenomenon of superradiance in this context. In particular, we shall consider models that copy the electroweak sector of the standard model and could thus, be interpreted in that context.

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