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Recent results on localized structures

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Localized structures usually appear in Field Theory under the action of scalar fields. In 2003, a new class of global defects was introduced by D. Bazeia, J. Menezes and R. Menezes in [Phys. Rev. Lett. 91, 241601 (2003)], where they presented a procedure to circumvent Derrick's theorem in $(D,1)$ spacetime dimensions. This motivated us to use the scalar field to modify other localized structures. In this talk, we present some recent results in this direction. In particular, we consider the study of planar vortices in models with $U(1)\times Z_2$ symmetry, in which the magnetic permeability of the system is controlled by a neutral scalar field [D. Bazeia, M.A. Marques and R. Menezes, Phys. Lett. B 780, 485 (2018)]. In this case, using first order differential equations, the neutral scalar field decouples from the other ones, working as an independent structure, so it can be seen as a source for the vortex. In this sense, we show that it may modify the geometry of the vortex in a significant manner, generating an internal structure in its magnetic field, with ringlike configurations. Using a similar approach, and also considering a model with $U(1)\times U(1)$ symmetry, we can also get multilayered vortices, with several rings in the magnetic field [D. Bazeia, M.A. Liao, M.A. Marques and R. Menezes, Phys. Rev. Research 1, 033053 (2019)]. Other investigation to be presented in the talk concerns the inclusion of the neutral scalar field to control the dynamical terms in the Lagrangian density associated to magnetic monopoles, with $SU(2)\times Z_2$ models [D. Bazeia, M.A. Marques and R. Menezes, Phys. Rev. D 97, 105024 (2018)]. In this situation, using first order differential equations, we have found that not only the additional scalar field is capable of inducing an internal structure in the magnetic monopole, but also of modifying the behavior of its tail, leading to compact monopoles. These results also encouraged us to investigate novel configurations of monopole. In [D. Bazeia, M.A. Marques and Gonzalo J. Olmo, Phys. Rev. D 98, 025017 (2018)] we have found minimum energy solutions that leads to unusual monopole profiles, being small or hollow. In particular, the small monopole is described by analytical solutions. We also show some results of the work done in [D. Bazeia, M.A. Marques and R. Menezes, Phys. Rev. D 98, 065003 (2018)], in which we have replaced the additional Z_2 symmetry by a $SU(2)$ one, so the scalar fields was exchanged by a set of scalar and gauge fields. In this case, the additional fields are decoupled, so they can be understood as an independent monopole that interacts with the other one and modify it. Using small, hollow and the standard monopoles, we proposed composite structures, formed by a core and a shell or by two shells, which we have called bimagnetic monopoles. We also present the recent investigation in electrically charged structures, where the scalar field is used to control the electric permittivity of the medium in which a single charge is placed [D. Bazeia, M.A. Marques and R. Menezes, Eur. Phys. J. C 81, 94 (2021)].

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