Gillioz, Marc; **von Manteuffel, Andreas**; **Schwaller, Pedro**; **Wyler, Daniel**
The little skyrmion: new dark matter for little Higgs models. (English) Zbl 1301.81342
J. High Energy Phys. 2011, No. 3, Paper No. 048, 28 p. (2011).

Summary: We study skyrmions in the littlest Higgs model and discuss their possible role as dark matter candidates. Stable massive skyrmions can exist in the littlest Higgs model also in absence of an exact parity symmetry, since they carry a conserved topological charge due to the non-trivial third homotopy group of the SU(5)/SO(5) coset. We find a spherically symmetric skyrmion solution in this coset. The effects of gauge fields on the skyrmion solutions are analyzed and found to lead to an upper bound on the skyrmion mass. The relic abundance is in agreement with the observed dark matter density for reasonable parameter choices.

MSC:

81V22 Unified quantum theories
35C08 Soliton solutions
14D21 Applications of vector bundles and moduli spaces in mathematical physics (twistor theory, instantons, quantum field theory)
14F35 Homotopy theory and fundamental groups in algebraic geometry
83F05 Cosmology

Keywords:

solitons monopoles and instantons; technicolor and composite models

Full Text: DOI arXiv

References:

[1] Arkani-Hamed, N.; Cohen, AG; Katz, E.; Nelson, AE, The littlest Higgs, JHEP, 07, 034, (2002)
[2] Arkani-Hamed, N.; etal., The minimal moose for a little Higgs, JHEP, 08, 021, (2002)
[3] Low, I.; Skiba, W.; Tucker-Smith, D., Little higgses from an antisymmetric condensate, Phys. Rev., D 66, 072001, (2002)
[4] Chang, S.; Wacker, JG, Little Higgs and custodial SU(2), Phys. Rev., D 69, 035002, (2004)
[5] Schmaltz, M.; Stolarski, D.; Thaler, J., The bestest little Higgs, JHEP, 09, 018, (2010)
[6] Trodden, M.; Vachaspati, T., Topology in the little Higgs models, Phys. Rev., D 70, 065008, (2004)
[7] Hill, CT; Hill, RJ, T\^{}\{−\} parity violation by anomalies, Phys. Rev., D 76, 115014, (2007)
[8] Skyrme, THR, A nonlinear field theory, Proc. Roy. Soc. Lond., A 260, 127, (1961)
[9] Adkins, GS; Nappi, CR; Witten, E., Static properties of nucleons in the Skyrme model, Nucl. Phys., B 228, 552, (1983)
[10] Murayama, H.; Shu, J., Topological dark matter, Phys. Lett., B 686, 162, (2010)
[11] Cheng, H-C; Low, I., Little hierarchy, little higgses and a little symmetry, JHEP, 08, 061, (2004)
[12] Hill, CT; Hill, RJ, Topological physics of little Higgs bosons, Phys. Rev., D 75, 115009, (2007)
[13] Barger, V.; Keung, W-Y; Gao, Y., T-anomaly induced LHC signals, Phys. Lett., B 655, 228, (2007)
[14] Freitas, A.; Schwaller, P.; Wyler, D., Consequences of T-parity breaking in the littlest Higgs model, JHEP, 09, 013, (2008)
[15] Birkedal-Hansen, A.; Wacker, JG, Scalar dark matter from theory space, Phys. Rev., D 69, 065022, (2004)
[16] Krohn, D.; Yavin, I., Anomalies in fermionic UV completions of little Higgs models, JHEP, 06, 092, (2008)
[17] Csáki, C.; Heinonen, J.; Perelstein, M.; Spethmann, C., A weakly coupled ultraviolet completion of the littlest Higgs with T-parity, Phys. Rev., D 79, 035014, (2009)
[18] Freitas, A.; Schwaller, P.; Wyler, D., A little Higgs model with exact dark matter parity, JHEP, 12, 027, (2009)
[19] T. Brown, C. Frugiuele and T. Gregoire, \textit{UV friendly T-parity in the} SU\textit{(6)/}Sp\textit{(6) little Higgs model}, arXiv:1012.2060 [SPIRES].
[20] Joseph, A.; Rajeev, SG, Topological dark matter in the little Higgs models, Phys. Rev., D 80, 074009, (2009)
[21] Hubisz, J.; Meade, P., Phenomenology of the littlest Higgs with T-parity, Phys. Rev., D 71, 035016, (2005)

[22] Bryan, JA; Carroll, SM; Pyne, T., A texture bestiary, Phys. Rev., D 50, 2806, (1994)

[23] Peskin, ME; Takeuchi, T., A new constraint on a strongly interacting Higgs sector, Phys. Rev. Lett., 65, 964, (1990)

[24] Peskin, ME; Takeuchi, T., Estimation of oblique electroweak corrections, Phys. Rev., D 46, 381, (1992)

[25] Adkins, GS; Nappi, CR, Stabilization of chiral solitons via vector mesons, Phys. Lett., B 137, 251, (1984)

[26] Jackson, A.; Jackson, AD; Goldhaber, AS; Brown, GE; Castillejo, LC, A modified skyrmion, Phys. Lett., B 154, 101, (1985)

[27] Piette, BMAG; Tchrakian, DH, Topologically stable soliton in the U(1) gauged Skyrme model, Phys. Rev., D 62, 025020, (2000)

[28] N.S. Manton and P. Sutcliffe, \textit{Topological solitons}, Cambridge University Press, Cambridge U.K. (2004).

[29] D'Hoker, E.; Farhi, E., The decay of the skyrmion, Phys. Lett., B 134, 86, (1984)

[30] 't Hooft, G., Symmetry breaking through Bell-Jackiw anomalies, Phys. Rev. Lett., 37, 8, (1976)

[31] 't Hooft, G., Computation of the quantum effects due to a four-dimensional pseudoparticle, Phys. Rev., D 14, 3432, (1976)

[32] Bolognesi, S.; Shifman, M., The Hopf skyrmion in QCD with adjoint quarks, Phys. Rev., D 75, 065020, (2007)

[33] Auzzi, R.; Bolognesi, S.; Shifman, M., Skyrmions in Yang-Mills theories with massless adjoint quarks, Phys. Rev., D 77, 125029, (2008)

[34] 't Hooft, G., Magnetic monopoles in unified gauge theories, Nucl. Phys., B 79, 276, (1974)

[35] Polyakov, AM, Particle spectrum in quantum field theory, JETP Lett., 20, 194, (1974)

[36] Julia, B.; Zee, A., Poles with both magnetic and electric charges in nonabelian gauge theory, Phys. Rev., D 11, 2227, (1975)

[37] Weinberg, EJ; Guth, AH, Nonexistence of spherically symmetric monopoles with multiple magnetic charge, Phys. Rev., D 14, 1660, (1976)

[38] Balachandran, AP; Nair, VP; Panchapakesan, N.; Rajeev, SG, Low mass solitons from fractional charges in QCD, Phys. Rev., D 28, 2830, (1983)

[39] Brihaye, Y.; Hill, CT; Zachos, CK, Bounding gauged skyrmion masses, Phys. Rev., D 70, 111502, (2004)

[40] Rubakov, VA; Stern, BE; Tinyakov, PG, On the electroweak decay of a technibaryon in the soliton model, Phys. Lett., B 160, 292, (1985)

[41] Meier, F.; Walliser, H., Quantum corrections to baryon properties in chiral soliton models, Phys. Rept., 289, 383, (1997)

[42] Jackson, A.; Jackson, AD; Pasquier, V., The skyrmion-skyrmion interaction, Nucl. Phys., A 432, 567, (1985)

[43] Particle Data Group collaboration; Nakamura, K.; etal., Review of particle physics, J. Phys., G 37, 075021, (2010)

[44] Belyaev, A.; Chen, C-R; Tobe, K.; Yuan, CP, Phenomenology of littlest Higgs model with T\^{}\{−\} parity: including effects of T\^{}\{−\} odd fermions, Phys. Rev., D 74, 115020, (2006)

[45] Bélanger, G.; etal., Indirect search for dark matter with micromegas2.4, Comput. Phys. Commun., 182, 842, (2011)

[46] Griest, K.; Kamionkowski, M., Unitarity limits on the mass and radius of dark matter particles, Phys. Rev. Lett., 64, 615, (1990)

[47] Nussinov, S., Technocosmology: could a technibaryon excess provide a 'natural' missing mass candidate?, Phys. Lett., B 165, 55, (1985)