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STABILITY OF MERONS IN GRAVITATIONAL MODELS *

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ABSTRACT

The stability properties of merons are investigated in gravitational models by taking the DeAFF model as a theoretical laboratory. We find that in gravitational models containing Yang-Mills fields merons are unstable. Stability might be possible in $N = 4$ supergravity models with $A_\mu = 0$.

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I. INTRODUCTION

The study of the classical solutions to field equations has represented an interesting ground of investigation both for the physical insights that such configurations can offer and also for a deeper understanding of the formal aspects of the theory. Further, much attention has also been devoted to the stability properties of the classical solutions [1]. More recently, semiclassical stability [2-5], i.e. small perturbations around Euclidean vacuum "bounce" solutions has been considered as a new approach to stability of gravity. For example,instability of flat space at finite temperature, stability of gravity with cosmological constant in the de Sitter background and instability of Kaluza-Klein vacuum have been investigated, respectively, by Gross and Perry[3], Abbott and Deser [4] and Witten [5].

The aim of this paper is to present a first discussion of meron solutions in the case of gravitation where one might find a good interpretation for merons. As is well known, merons are the classical solutions of conformal invariant field theories with singularity at the origin as well as at infinity [6], and they are unstable in pure Yang-Mills theories [7] even with fermions present [8] and in CP^2 models [9,10], but stable in the pure spinor models [11].

In order to perform our study we shall take as a theoretical laboratory a model which has been examined by de Alfaro, Fubini and Furlan (DeAFF) [12]. In particular, DeAFF considered a model of gravitation coupled to matter fields, which is just the effective *) part of $N = 4$ Lagrangian for supergravity with $SU(2) \times SU(2)$ local invariance [13], where supersymmetry fixes uniquely the ratio between the cosmological constant and the colour charge. The DeAFF model is also complete from the cosmological point of view [14], and a class of meronic solutions of this model (more details are given in the next section) has recently been found [15].

Since merons are not bounce solutions in Euclidean space, namely they are vacuum solutions with divergent energy in Euclidean space, one has to work in the Minkowski domain where the energy of merons turns out to be real and finite. In Sec.III we shall define the stability conditions which will help us to discuss, at least in a particular case, the stability of merons for the considered model.

*) By effective we mean that the odd parity and spinorial fields are not taken into account, being the corresponding classical configurations vanishing.

In particular, the stability properties will be investigated for both the flat and conformally flat space backgrounds in which merons exist. In Sec.IV we shall comment about the results of this paper.

II. THE MODEL

Let us write the following general (and therefore conformal) invariant Lagrangian [12]:

$$\mathcal{L} = -\frac{1}{4}\sqrt{g}\Big\{R + \frac{3}{2}\lambda^2\varphi^2 + \frac{1}{e^2\varphi^2}\sum_\alpha F^\alpha_{\mu\nu}F^\alpha_{\rho\sigma}g^{\mu\rho}g^{\nu\sigma} + \frac{2\xi}{\varphi^2}g^{\mu\nu}\partial_\mu\varphi\partial_\nu\varphi\Big\} \quad , \tag{2.1}$$

which describes the interaction among the gravitational field, the SU(2) gauge vector fields and a neutral scalar field with a dimensionless cosmological constant λ . The equations of motion which follow from the Lagrangian are:

$$\partial_\mu\left(\sqrt{g}\,g^{\mu\mu'}F_{\mu'\nu}\varphi^{-2}\right) = \frac{\sqrt{g}}{\varphi^2}\left[F_{\mu'\nu}, A_\mu\right]g^{\mu'\mu} \quad , \tag{2.2a}$$

$$\xi\,\partial_\mu\left(\sqrt{g}\,g^{\mu\nu}\varphi^{-2}\partial_\nu\varphi\right) = \frac{\sqrt{g}}{4}\Big(3\lambda^2\varphi - \frac{4\xi}{\varphi^3}g^{\mu\nu}\partial_\mu\varphi\partial_\nu\varphi - \frac{2}{e^2\varphi^3}\sum_\alpha F^\alpha_{\mu\nu}F^\alpha_{\lambda\rho}g^{\mu\lambda}g^{\nu\rho}\Big) \quad , \tag{2.2b}$$

$$R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R = -2\,\Theta_{\mu\nu} \tag{2.2c}$$

with the energy momentum tensor

$$\Theta_{\mu\nu} = \frac{1}{e^2\varphi^2}\Big(\sum_\alpha F^\alpha_{\mu\lambda}F^\alpha_{\nu\rho}g^{\lambda\rho} - \frac{1}{4}g_{\mu\nu}\sum_\alpha F^\alpha_{\lambda\rho}F^\alpha_{\lambda'\rho'}g^{\lambda\lambda'}g^{\rho\rho'}\Big) + \frac{\xi}{\varphi^2}\Big(\partial_\mu\varphi\partial_\nu\varphi - \frac{1}{2}g_{\mu\nu}\partial_\lambda\varphi\partial_\rho\varphi g^{\lambda\rho}\Big) - \frac{3\lambda^2\varphi^2}{8}g_{\mu\nu} \quad . \tag{2.2d}$$

The covariance property $\mathcal{L} \to u^2\mathcal{L}$ of the Lagrangian leads to the following class of meron solutions [15]:

$$\begin{aligned} g_{\mu\nu} &= \frac{1}{c^2}\delta_{\mu\nu}\frac{r^{2\gamma}}{r^2} \\ A_\mu &= i\,\sigma_{\mu\nu}\frac{x^\nu}{r^2} \\ \varphi &= c\,a\,r^{-\gamma} \quad , \end{aligned} \tag{2.3}$$

where "a" is a normalization constant which is fixed by the theory, while c remains an arbitrary constant.

Inserting the solutions (2.3) into the equations of motion (2.2a,b,c) we obtain the following algebraic constraints:

$$\begin{aligned} 3\lambda^2/e^2 &= \left[\xi\gamma^2 + 3(\gamma^2-1)\right]\left[(\gamma^2-1) - \xi\gamma^2\right] \\ 1/a^2 &= \xi\gamma^2 - (\gamma^2-1) \\ 4\xi\gamma^2 &= 3/a^2\left(1 - \lambda^2/e^2\right) \quad . \end{aligned} \tag{2.4}$$

Here, one should make some remarks about the reality of solutions (2.3) which are important for the stability criteria. Meron solutions (2.3) take a more convenient form if the singularities from 0 and infinity are displayed in $\pm b_\mu$, $b_\mu \equiv (0,0,0,1)$ by a suitable conformal transformation followed by a Wick rotation to Minkowski space [16] $x_4 = it$

$$r \to \left\{\frac{(x-b)^2}{(x+b)^2}\right\}^{1/2} \to \left\{\frac{(it-1)+r^2}{(it+1)+r^2}\right\} \equiv e^{-i\tau} \quad , \tag{2.5}$$

where

$$\tau = \arctan t_+ + \arctan t_- \; ; \quad (t_\pm = t \pm r) \quad . \tag{2.6}$$

Consequently, taking into account the transformation properties of fields, one gets the following complete Minkowski solutions:

$$g_{\mu\nu} = \frac{\delta_{\mu\nu}}{c^2} \frac{1}{(1+t_+^2)(1+t_-^2)} \exp(-2i\gamma\tau) \quad , \tag{2.7a}$$

$$A_\mu = -i\,\bar{\sigma}_{\mu\nu} S_\nu \quad , \tag{2.7b}$$

where

$$S_\nu = \frac{t_+}{1+t_+^2} y_\nu^+ + \frac{t_-}{1+t_-^2} y_\nu^- \quad ; \quad y_\nu^\pm \equiv \left(1, \pm \frac{\vec{x}}{|\vec{x}|}\right)$$

and

$$\varphi = ca \exp(i\gamma\tau) \quad . \tag{2.7c}$$

For the meron solutions (2.3) the energy-momentum tensor is

$$\Theta_{\mu\nu} = \frac{1}{(x^2)^2}\left\{\frac{1}{4a^2} - \frac{\Upsilon\gamma^2}{2} - \frac{3a^2}{4e^2}\right\}\delta_{\mu\nu} + \left(\Upsilon\gamma^2 - \frac{1}{a^2}\right)\frac{x_\mu x_\nu}{x^2}\Big\} \quad , \tag{2.8}$$

which is conserved in the covariant sense

$$\left(\Theta_\mu^\nu\right)_{;\nu} = 0 \quad . \tag{2.9}$$

The energy-momentum (2.8) can be improved by means of the conformal transformation which gives finite energy in Minkowksi space

$$E \propto (\text{positive const.})\left[\frac{\gamma^2\Upsilon}{2} - \frac{2}{4}\left(\frac{1}{a^2} - \frac{a^2}{e^2}\right)\right] \quad . \tag{2.10}$$

III. STABILITY OF MERONS

A) Definition of stability for merons

Before starting to investigate the stability of the meron solutions (2.3) in the gravitational DeAFF model, we shall recall the definition of stability for merons in the Minkowski domain. By this we mean that the quantities (co-ordinates, scalar, vectorial and tensorial fields) are transformed from Euclidean space to Minkowski space by using a combined conformal transformation, translation-inversion-translation (TIT), followed by a Wick

rotation, i.e. improved quantities in Minkowski space [16]. As is well known, meron solutions have finite improved energy and action, and they are invariant under the compact $O(4) \times O(2)$ subgroup of the $O(4,2)$ Minkowski conformal group in Minkowski domain. These improved meron properties allow us to study the stability of merons in the gravitational field theories.

Now let us define the stability for merons: by making the ansatz $\exp(-ik\tau)$ with the proper time τ in Eq.(2.6) for the small perturbations around the meron solutions (2.7) in the Minkowski domain, stability or instability will be determined by k being real or complex. On the other hand, the small fluctuations in the Euclidean space are also corresponding to the small fluctuations in Minkowski domain by conformal transformation (TIT), so for the small fluctuations around Euclidean solutions (2.3) we can take the ansatz r^k which turns out to be, as given in Eq.(2.5),

$$r^k \longrightarrow e^{-ik\tau}$$

in Minkowski domain which leads one to work in Euclidean space.

If one examines the stability of merons in CP^2 and pure Yang-Mills models by using the above instability definitions in Minkowski domain, the results are same, unstable, as in Refs.7 and 9 [10].

Now let us investigate the stability of merons in the DeAFF model.

B) Stability of merons

For this study we should like to investigate two special cases of the solutions (2.4); the first one is the conformally flat space, which by substituting $\gamma = 0$ leads to the constraint $\lambda^2 = e^2$. Consequences of this constraint have been recently discussed by Cervero [14]. The second one is the flat space (which corresponds to $\gamma = 1$ in the solutions (2.3)) with the constraint $\lambda^2 = e^2\xi^2/3$ which coincides with the prediction of $N = 4$ extended supergravity on the cosmological constant λ [17].

i) Conformally flat space

Substituting $\gamma = 0$, the solutions (2.3) take the form

$$g_{\mu\nu}^{(0)} = \frac{1}{c^2}\bar{R}^2(x)\delta_{\mu\nu} \quad , \quad A_\mu^{(0)} = i\bar{R}^2(x)\bar{\sigma}_{\mu\nu}x_\nu \quad ,$$

$$\varphi^{(0)} = ca \quad , \tag{3.1}$$

where $\bar{h}^2(x) = 1/x^2$ and the solution (3.1) has finite improved energy in Minkowski space which is positive for $a^4 > e^2$.

Let us now take small fluctuations around the solution (3.1)

$$g_{\mu\nu} = g^{(0)}_{\mu\nu} + \delta g_{\mu\nu} \;, \quad A_\mu = A^{(0)}_\mu + \delta A_\mu \;, \quad \varphi = \varphi^{(0)} + \delta\varphi \quad . \tag{3.2}$$

Owing to the mathematical difficulties of a general treatment we shall limit ourselves for a very preliminary indication for the particular simple case where the fluctuations in $g_{\mu\nu}$ and A_μ are assumed to be generated as a result of a variation in $\bar{h}(x) = \frac{1}{\sqrt{x^2}}$ of the form

$$h = \bar{h} + \delta h \quad . \tag{3.3}$$

Namely, our fluctuations are still in the flat or conformally flat space. Then, according to the above assumption, we find

$$\delta g_{\mu\nu} = (2\bar{h}\,\delta h)\,\delta_{\mu\nu} \quad , \tag{3.4}$$

$$\delta F_{\mu\nu} = i\left\{2\bar{h}(x\cdot\partial)\delta h\,\sigma_{\mu\nu} - B_{\lambda\nu}\sigma_{\mu\lambda} + B_{\lambda\mu}\sigma_{\nu\lambda}\right\} \quad , \tag{3.5}$$

where

$$\sigma_{\mu\nu} = \frac{1}{4i}\left(s_\mu \bar{s}_\nu - s_\nu \bar{s}_\mu\right) \tag{3.6}$$

with

$$s_\mu = (1, i\vec{\sigma}) \quad , \quad \bar{s}_\mu = (1, -i\vec{\sigma}) \tag{3.7}$$

and

$$B_{\lambda\nu} = x_\lambda x_\nu \bar{h}^3 \delta h + 2x_\lambda \bar{h}\,\partial_\nu \delta h + 2x_\nu \bar{h}\,\partial_\lambda \delta h + \bar{h}^{-1}\partial_\nu \partial_\lambda \delta h \quad . \tag{3.8}$$

We shall also use the result

$$\{F_{\mu\nu}, \delta F_{\mu\nu}\} = 2\bar{h}\,\Box\delta h - 2\bar{h}^3 (x\cdot\partial)^2 \delta h - 4\bar{h}^3 (x\cdot\partial)\delta h \quad . \tag{3.9}$$

Substituting the results above in the equation of motion (2.2b) and taking the variation of the resulting equations with respect to h and φ, we get

$$\begin{aligned} a\bar{h}^2 \Box^2 \delta\varphi - 2a\bar{h}^4 (x\cdot\partial)\delta\varphi = {} & 6a^2 \bar{h}^5 \delta h + \frac{3}{2}\bar{h}^4 \delta\varphi + 3\bar{h}^3 \delta h \\ & - \frac{9}{2a}\bar{h}^4 \delta\varphi - \bar{h}\,\Box\delta h + \bar{h}^3 (x\cdot\partial)^2 \delta h + 2\bar{h}^3 (x\cdot\partial)\delta h \\ & - 3\bar{h}^3 \delta h \quad . \end{aligned} \tag{3.10}$$

Similarly Eq.(2.2c) becomes

$$\bar{h}^{-2}\Box\delta h + 3\delta h + a\bar{h}\,\delta\varphi = 0 \quad , \tag{3.11}$$

where $a = \sqrt{2e^2}$ and the arbitrary constant c is taken to be equal to 1.

For the reason of the stability definition of merons, as mentioned in Subsec.3.A, we can take the following ansatz for the fluctuation part:

$$\delta h = r^{-k} Y_\ell \quad , \tag{3.12}$$

where Y_ℓ depends on the three polar angles in four dimensions.

$$\bar{h}^{-2}\Box\delta h = \left[(k+1)^2 - (\ell+1)^2\right]\delta h \tag{3.13}$$

and

$$(x\cdot\partial)\delta h = k\,\delta h \quad . \tag{3.14}$$

Eq.(3.11) becomes

$$\left[(k+1)^2-(\ell+1)^2\right]r^k Y_\ell + 3r^k Y_\ell + \frac{a}{r}\delta\varphi = 0 \qquad (3.15)$$

giving

$$\delta\varphi = \frac{1}{a}\left[(k+1)^2-(\ell+1)^2-3\right]r^{k+1}Y_\ell = 0 \quad . \qquad (3.16)$$

Substituting this in Eq.(3.10) we get for the $\ell = 0$ ground state the following quartic equation

$$k^4 + 4k^3 + \left(\frac{9}{4\lambda^2}+\frac{1}{2}\right)k^2 + \left(\frac{9}{2\lambda^2}-7\right)k + \left(\frac{3}{2}-\frac{29}{4\lambda^2}-12\lambda^2\right) = 0 \qquad (3.17)$$

which with the substitution $k = x - 1$ simplifies to

$$x^4 + \left(\frac{9}{4\lambda^2}-\frac{11}{2}\right)x^2 + \left(6-12\lambda^2-\frac{9}{\lambda^2}\right) = 0 \qquad (3.18)$$

a quadratic equation in x^2. Its discriminant can be expanded into the form

$$576\lambda^6 + 100\lambda^4 + 180\lambda^2 + 81 = 0. \qquad (3.19)$$

This cubic in λ^2 has no positive root. It has one real root plus a pair of complex roots with the approximate values $\lambda^2 = -0.343$ and $\lambda^2 = 0.107 \pm 0.544i$. For $\lambda^2 < -0.343$ roots of Eq.(3.18) for x^2 are both complex. Hence the quartic Eq.(3.17) has four complex roots. For $\lambda^2 \geq -0.343$ roots of Eq.(3.18) for x^2 are both real. They are given by

$$2x^2 = -\left(\frac{9}{4\lambda^2}-\frac{11}{2}\right) \pm \sqrt{\left(\frac{9}{4\lambda^2}-\frac{11}{2}\right)^2 - 4\left(6-12\lambda^2-\frac{9}{\lambda^2}\right)} \quad . \qquad (3.20)$$

To ensure stability, all four roots for x must be real. This, in turn, requires that the two values for x^2 in Eq.(3.20) be positive. This latter condition implies that

$$\frac{11}{2} > \frac{9}{4\lambda^2} \quad \text{or} \quad \lambda^2 > \frac{9}{22} \qquad (3.21)$$

and

$$\sqrt{\left(\frac{9}{4\lambda^2}-\frac{11}{2}\right)^2 - 4\left(6-12\lambda^2-\frac{9}{\lambda^2}\right)} < \frac{9}{4\lambda^2}-\frac{11}{2} \quad , \qquad (3.22)$$

which requires

$$-\frac{11}{4} - \left(2\lambda^2-\frac{1}{2}\right)^2 > 0 \quad , \qquad (3.23)$$

i.e. a contradiction. Hence at least one root for x^2 is guaranteed to be negative and the quartic Eq.(3.17) either has four complex roots or a pair of real and a pair of complex roots. Thus there are no absolutely stable solutions.

ii) Flat space

Substituting $\gamma = 1$ the solutions (2.3) take the form

$$g^{(1)}_{\mu\nu} = \delta_{\mu\nu} \quad , \quad A^{(1)}_\mu = -i\,\sigma_{\mu\nu}\frac{x_\nu}{x^2} \quad , \quad \varphi^{(1)} = \sqrt{\frac{2}{e^2}}\,\frac{1}{\sqrt{x^2}} \quad . \qquad (3.24)$$

The flat space solution (3.24) has also finite improved energy in Minkowski space which is positive for $\frac{2}{3} > \frac{e^2-a^4}{a^2e^2}$.

Let us again take a small fluctuation around the solution (3.24)

$$g_{\mu\nu} = g^{(1)}_{\mu\nu} + \delta g_{\mu\nu} \quad , \quad A_\mu = A^{(1)}_\mu + \delta A_\mu \quad , \quad \varphi = \varphi^{(1)} + \delta\varphi \quad , \qquad (3.25)$$

where the fluctuations in φ and A_μ are also assumed to be generated as a variation (3.3) and $\delta g_{\mu\nu} = \delta g\, \delta_{\mu\nu}$. These give the following results:

$$\delta\varphi = \sqrt{\frac{2}{e^2}}\,\delta h \quad , \qquad (3.26)$$

$$\delta F_{\mu\nu} = i\left(2\bar{h}(x\cdot\partial)\delta h\,\sigma_{\mu\nu} - B_{\lambda\nu}\sigma_{\mu\lambda} + B_{\lambda\mu}\sigma_{\nu\lambda}\right) \qquad (3.27)$$

with

$$\{F_{\mu\nu}, \delta F_{\mu\nu}\} = 2\bar{h}\,\Box\,\delta h - 2\bar{h}^3 (x\cdot\partial)^2 \delta h - 4\bar{h}^3 (x\cdot\partial)\,\delta h \quad . \tag{3.28}$$

We next get

$$\begin{aligned}&(1+\tfrac{a}{2})\bar{h}^{-2}\,\Box\,\delta h - \tfrac{a}{2}(x\cdot\partial)^2\delta h + (4-\tfrac{2}{a}-a)(x\cdot\partial)\,\delta h \\ &- 3\bar{h}\,(x\cdot\partial)\,\delta g + (\tfrac{13a}{8}+2-\tfrac{3}{a})\,\delta h + (\tfrac{3}{a}-\tfrac{a}{2})\bar{h}\,\delta g = 0 \quad .\end{aligned} \tag{3.29}$$

Similarly, the equation of motion (2.2c) becomes

$$6\bar{h}^2\,\Box\,\delta h + 18\,\delta h + 10\bar{h}^3\,\delta g - 12\bar{h}^2\,\delta h - 4\bar{h}^2 (x\cdot\partial)\,\delta h = 0 \quad . \tag{3.30}$$

Taking the same ansatz (3.12) in (3.30) we obtain for $\ell = 0$,

$$\delta g = \frac{1}{5}\left[(6-2k)\,r^{k+1} - (3k^2+6k+9)\,r^{k+3}\right] \quad . \tag{3.31}$$

Substituting in (3.30) gives

$$\begin{aligned}&\Big[(1+\tfrac{a}{2})k(k+2) - \tfrac{a}{2}k^2 + (4-\tfrac{2}{a}-a)k - \tfrac{3}{5}(6-2k)(k+1) \\ &+ \tfrac{13a}{8} + 2 - \tfrac{3}{a} + \tfrac{1}{5}(\tfrac{3}{a}-\tfrac{a}{2})(6-2k)\Big]r^k + \Big[\tfrac{3}{5}(3k^2+ \\ &6k+9)(k+3) - \tfrac{1}{5}(\tfrac{3}{a}-\tfrac{a}{2})(3k^2+6k+9)\Big]r^{k+2} = 0\end{aligned} \tag{3.32}$$

the coefficients of r^k and r^{k+2} must then be equal to zero

$$k^2 - (42-\tfrac{16}{a}+a)k - 28 - \tfrac{41a}{8} - \tfrac{3}{a} = 0 \quad , \tag{3.33a}$$

$$(3k^2+6k+9)(3k+9-\tfrac{3}{a}+\tfrac{a}{2}) = 0 \quad , \tag{3.33b}$$

where $a = \sqrt{\frac{2}{e^2}}$. This again gives solutions with complex k, hence the solutions are not stable for this case as well.

IV. CONCLUSIONS

In this paper we have investigated, in a very particular case, the stability properties of the DeAFF model around the improved meron solutions in the flat space and in the conformally flat space. Our results indicate that particular forms of these solutions are unstable for all the values of cosmological constant and thus cannot be interpreted as possible candidates for a true ground state,

For the flat space case ($\lambda^2 = -e^2/3$) the term $\lambda^2\varphi^2$ is added to the Lagrangian with the same sign as the kinetic energy term of the scalar field (note that $x_4 = it$). Since a Minkowskian theory corresponds to a negative definite potential perhaps it is not surprising that the theory is unstable. However for the conformally flat space solutions with $\lambda^2 = e^2$, the corresponding potential is positive and one might guess that the stability of the theory is maintained. Hence at least in this case it seems that there should exist stable solutions.

Our work also seems to indicate that the appropriate form of the solutions for the Yang-Mills field may be the simple one $A_\mu = 0$ rather than the meron. This is not that surprising since the meron solution is unstable for pure Yang-Mills theory [7]. In any case, it would be interesting to investigate whether the DeAFF model has any stable solution which does not correspond to a Yang-Mills vacuum (i.e. pure gauge) solution. This might be possible when the fermion fields and their quantum corrections (note that the merons are stable in pure fermionic field theories [11]) were present in the DeAFF Lagrangian which is N = 4 supergravity model.

One must however keep in mind that this work is a first step to examine the meron stability for gravitational models. Since the fluctuations for metrics were still in the flat space, i.e. $g_{\mu\nu} = \delta_{\mu\nu}(h + \delta h)$, our results are very particular. General forms should be considered following, for instance, the recent work of Abbott and Deser [4] as adapted to our problem.

Finally, our work may also lead one to study the meron decay problem in the DeAFF model, since they are not the ground state vacuum solutions with positive energy and are unstable. We leave these problems for future work.

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REFERENCES

[1] For a review see R. Jackiw and P. Rossi, Phys. Rev. 21D, 426 (1980).

[2] S. Coleman, Phys. Rev. 15D, 2929 (1977);
S. Coleman and C.G. Callan, Phys. Rev. 16D, 1762 (1977).

[3] D.J. Gross and M.J. Perry, Phys. Rev. 25D, 330 (1982).

[4] L.F. Abbott and S. Deser, Nucl. Phys. 195B, 76 (1982).

[5] E. Witten, Princeton preprint (1982).

[6] See, for instance, Reviews, R. Jackiw, C, Nahl and C. Rebbi,"Particles and fields",in Proceedings of the Barff Summer Institute, Eds. D.H. Baal and A.W. Kanel (New York, N.Y. 1979);
A. Actor, Rev. Mod. Phys. 51, 461 (1979) and references therein.

[7] M. Arik and P.G. Williams, Z. Phys. 3C, 377 (1980).

[8] G.C. Callan Jr., R. Dashen and D.J. Gross, Phys. Rev. 17D, 2717 (1978).

[9] E. Abdalla, Phys. Rev. 21D, 2365 (1980).

[10] G. Mariuzza, Tesi di Laurea, Trieste University (1980), (unpublished).

[11] K.G. Akdeniz and M. Hortaçsu, Phys. Lett. 114B, 254 (1982).

[12] V. de Alfaro, S. Fubini and G. Furlan, Phys. Lett. 97B, 67 (1980);
for a review see also Acta Physica Austrica Suppl. XXII, 51 (1980).

[13] D.Z. Freedman and J.H. Schwartz, Nucl. Phys. 137B, 333 (1980).

[14] J. Cervero, Univ. of Salamanca, preprint (1981) and Phys. Lett. 108B, 108 (1982).

[15] K.G. Akdeniz and O. Oguz, Lett. al Nuovo Cimento 28, 343 (1980).

[16] V. de Alfaro, S. Fubini and G. Furlan, Phys. Lett. 65B, 163 (1976).

[17] V. de Alfaro, S. Fubini and G. Furlan, Phys. Lett. 94B, 41 (1980).

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