Review

scientific adviser for the dissertation work Serikbolova Albina Askarovna "Branes and monopoles in modified gravities and Yang-Mills theories", submitted for the degree of Philosophy Doctor (PhD) in the specialty "8D05306-Physics"

Serikbolova A.A. considers one of the topical issues in modified gravitational theories: the existence of vacuum flat-symmetric solutions describing Branes in multidimensional space-time.

Currently, modified theories of gravity are of great interest in cosmology, providing a viable model of dark energy responsible for the current expansion of the Universe. There are a list of popular modified gravity theories: theories with exra fields, theories with higher order derivatives, non-local theories, theories with higher dimensions. One of the most remarkable features of the modified theory of gravity is that the density of the Lagrangian is no the scalar curvature R (as in GR), but has more complicated dependence on the curvature tensor and possibly further fields. A particular attractive set of models related to the theories with higher order derivatives are $\mathcal{F}(R)$ gravity, which were studied by Serikbolova A.A.

In general theory of realtivity, various kinds of matter are used to obtain brane solutions. With a high degree of certainty, we can say that in the general theory of relativity, vacuum brane solutions do not exist. This raises the question of the possibility of the existence of vacuum brane solutions. Serikbolova A.A. shows that this question can be solved positively, but for this it is necessary to modify gravity.

After the appearance of the general theory of relativity, created by A. Einstein, its 5-dimensional generalization appeared, which is now called the Kaluza-Klein theory. A remarkable feature of this multidimensional theory of gravity is the fact that it combines Maxwell's general theory of relativity and electrodynamics. In later works in this direction, the ideas of Kaluza and Klein were generalized to extra- dimensions. At the end of the last century, the idea that our universe is a brane embedded in 5-dimensional space-time arose. This idea helps to explain the problem of hierarchies in particle physics: why are the masses of elementary particles are different from the Planck mass?

The PhD student showed that vacuum brane solutions with codim=1 exist for $\mathcal{F}(R)$ gravities. She studied in detail the properties of these brane solutions and established requirements on the metric parameters for which there exist regular solutions with AdS asymptotics.

Another very important problem in theoretical physics is the problem of the mass gap. This problem appears in quantum chromodynamics, and it is that there is an energy gap between the vacuum state and the first ground state. At present, this problem is one of the most important problems in modern theoretical physics and this problem has not been solved at present.

In the second part of her dissertation, Serikbolova A. A. conducted a very interesting study of a monopole-like solutions in SU(2) Yang-Mills theory, where the source of SU(2) gauge fields is a nonlinear spinor field.
The dissertation shows that:

(a) the energy spectrum of such an object has an absolute minimum, interpreted as a mass gap;

(b) the value of the mass gap is mainly determined by the nonlinear spinor field described by the nonlinear Dirac equation;

(c) the position of the mass gap is practically independent of the interaction constant.

(d) asymptotic behavior of the radial magnetic field is $H_r^a \sim \frac{2f_\infty}{gr^3}$. It is seen from this expression that the system monopole-plus-nonlinear-spinor-fields differs in principle from the 't Hooft-Polyakov monopole, whose magnetic field decreases as r^{-2}.

This result is a significant achievement for understanding the nature of the appearance and existence of a mass gap. Based on the results obtained in the dissertation, we see that in the considered case, the mass gap appears due to the presence of a nonlinear spinor field. This allows us to make the assumption that in quantum chromodynamics sea quarks can be approximately described using a nonlinear spinor field and lead to the appearance of the desired mass gap.

During performing her dissertation, Serikbolova A.A. showed initiative and independence in conducting research. With Serikbolova A.A. we have been working from bachelor's degree. Over the years, she has shown herself as a responsible specialist who is able to solve various complex problems in the field of scientific research of a theoretical nature. The work is written logically, consistently and clearly.

I believe that the dissertation work of Serikbolova A. A. “Branes and monopoles in modified gravities and Yang-Mills theories”, meets the qualification requirements for dissertations for the degree of philosophy (PhD), and its author deserves to be awarded the degree of Philosophy Doctor (PhD) in the specialty "8D05306-Physics".

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