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Algebraic and Geometric Methods of Analysis

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List of topics

- Algebraic methods in geometry
- Differential geometry in the large
- Geometry and topology of differentiable manifolds
- General and algebraic topology
- Dynamical systems and their applications
- Geometric and topological methods in natural sciences

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The role of topological invariants in the study of the early evolution of the Universe

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Questions of the evolution of the Universe, the nature of forces and physical processes at an early stage of the evolution of the Universe are the most relevant in theoretical high-energy physics. The evolution of the Universe is connected with phase transitions in vacuum, represented by alternating minima and maxima of the potential. The discovery of the Higgs boson led to the problem of a metastable vacuum in the mechanism of electroweak symmetry breaking and confirmed the hypothesis that a vacuum decay took place. Such a transition in vacuum between two minima can be represented in D-brane language. D-brane approach is realized through Planck brane in the left minimum of potential and TeV brane in the right minimum of potential. Every D-brane presented in terms of vector bundle is characterized by topological invariant, [1]. So, the calculation of topological invariants informs us about the possibility of phase transitions between different states of vacuum.

We considered two universal bundles $\alpha_2^5 : (V_2(R^5), p, G_2(R^5)), \alpha_2^6 : (V_2(R^6), p, G_2(R^6))$ which are isomorphic to vector bundles, γ_2^5, γ_2^6 correspondingly. Taking into account the theorem on the existence of a vector bundle $V_{\rho(n)+1}(R^n) \to S^{n-1}$, [2] for $n > 4$, and using the fact

$$\frac{PR^{n-1}}{PR^{n-2}} \to V_1(R^n) = S^{n-1}$$

we presented the exact sequence

$$0 \to \pi_3(V_1(R^4)) \to \pi_4(V_1(R^5)) = Z.$$

We used the equivalence of homotopic groups

$$\pi_3(V_1(R^4)) = \pi_3(V_2(R^5))$$
$$\pi_4(V_1(R^5)) = \pi_4(V_2(R^6))$$

according to [2] with $F = R, c = 1, k = 1$.

Using the fact that D-branes can be represented as a vector bundles with a base - a sphere and using the embedding of spheres, $S^4 \subset S^5$, we observe a transition from one solitonic state in the form of D5-brane to D4-brane with the corresponding equidistant set of energy levels. The obtained result signals about the possibility of phase transitions in the form of vacuum decay from Planck brane to TeV brane.

References

[1] Paul S. Aspinwall. *D-Branes on Calabi-Yau Manifolds*, arXiv:hep-th/0403166.
[2] D.Husemoller. *Fibre bundles, McGraw-Hill Book Co., New York-London-Sidney*, 1966.

Зміст