氏　　　　　名	アルダベルゲノフ　イェルメク Aldabergenov, Yermek
所　　　　　属	理工学研究科　物理学専攻
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学位論文題名	Inflationary models in supergravity with inflaton in a vector multiplet, and spontaneous breaking of supersymmetry and R-symmetry after inflation ベクトル多重項にインフラトン場を持つ超重力理論におけるインフレーションモデルおよびインフレーション後の超対称性およびR対称性の自発的破れ（英文）
論文審査委員	主査　准教授　セルゲイ　ケトフ 委員　教　授　安田　修 委員　教　授　政井　邦昭 委員　教　授　安倍　博之(早稲田大学)

【論文の内容の要旨】

The inflationary paradigm solves initial-condition problems of the pre-inflationary cosmology (like e.g. flatness problem, horizon problem, monopole problem) and remarkably agrees with CMB observations (COBE, WMAP, PLANCK). On the other hand, supergravity (or SUGRA for short), as well as its flat-space-time limit -- rigid supersymmetry (SUSY), is a well-motivated framework for building UV-extensions of the Standard Model. Moreover, it is a necessary step if one considers unification of the Standard Model and General Relativity in the only known consistent framework of quantum gravity - superstring theories. It is known from countless experiments that supersymmetry, if exists, cannot be exact, it must be spontaneously broken at some high-enough scale in order to generate large masses of superpartners of the Standard Model particles, as we don’t see them at presently available energies. One can build a theory with various numbers (N) of supersymmetries, that would result in existence of several distinct superpartners of the same particle. For instance, in 4 space-time dimensions, maximum number of supersymmetries for a gauge theory (where particle spin is no higher than 1) is N=4, while for supergravity (where maximal spin is 2), N=8. However, N>1 supersymmetric theories are non-chiral, and for that reason they cannot be used as immediate extensions of the Standard Model, which is a chiral theory. One of the most promising candidates for beyond-the-Standard-Model theory is the Minimal Supersymmetric Standard Model, which implements N=1 supersymmetry.

This motivates us to consider inflationary model building in the framework of N=1 supergravity. However, realising inflationary potentials in supergravity was met with difficulties. One of them, called the "eta"-problem, is related to the dangerous exponential factor in the F-term potential, which leads to the large effective mass of the would-be inflaton, and ruins the slow-roll regime required for successful inflation. Another problem arises if we assume that inflation was caused by a chiral superfield. Since the lowest component of a chiral superfield is a complex scalar, it provides two real degrees of freedom, one of which should be stabilised while the other drives the inflation. These problems can be avoided if we consider massive vector multiplet causing the inflation. Since a massive vector multiplet has only one real (dynamical) scalar, there is no need for stabilisation, and since the inflationary potential comes from the D-term, this may resolve the eta-problem.

In generic inflationary models, although supersymmetry is spontaneously broken during the inflation (since either D- or F-term potentials must have non-vanishing effective vacuum expectation values), in the end of the inflation it is restored, and thus must be broken again by some mechanism. My current research involves minimally extending the simplest models of inflation with a massive vector multiplet, to include a model of supersymmetry breaking due to Polonyi, and see how the inflaton and SUSY-breaking field (in our case the Polonyi field) affect each other. Based on this, we develop a class of models, where we obtain a Minkowski vacuum with broken SUSY, and although there is a non-minimal coupling between vector multiplet and (Polonyi) chiral multiplet, we show that the Polonyi field does not affect the inflation. We then show an alternative formulation of our models with a U(1) massless vector superfield gauge-coupled to the Higgs chiral superfield. We also introduce a (small) cosmological constant, and show that the vacuum (either Minkowski or de Sittr) is stable and non-negative.

Finally, we focus on a specific representative of our class of models (called Polonyi-Starobinsky supergravity), that leads to the Starobinsky inflationary potential. We discover that the simplest known way to obtain the Starobinsky potential leads to instability, and find a way to remove it by adding a Fayet-Iliopoulos term. This leads to modification of the previously found Polonyi vacuum.

The results of this dissertation were published as

1. Aldabergenov, Yermek and Ketov, Sergei V.; Phys.Lett. B761 (2016) 115-118 arXiv:1607.05366 [hep-th]
2. Aldabergenov, Yermek and Ketov, Sergei V.; Eur.Phys.J. C77 (2017) no.4, 233 arXiv:1701.08240 [hep-th]