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Position: ICRANet, Faculty Member

Period covered: December 2016 -December 2017

I. Scientific Work

1. Large part of scientific work during 2017 have been dedicated to finishing the text and to complete all technical work for the book "The Cosmological Singularity" by V.Belinski and M.Henneaux (Cambridge University Press). The book have been published 26 October 2017 (hard copy) and now is available at ICRANet (see Ref.1).

Abstract of the book. Written for researchers focusing on general relativity, supergravity, and cosmology, this is a self-contained exposition of the structure of the cosmological singularity in generic solutions of the Einstein equations, and an up-to-date mathematical derivation of the theory underlying the Belinski–Khalatnikov–Lifshitz (BKL) conjecture on this field. Part I provides a comprehensive review of the theory underlying the BKL conjecture. The generic asymptotic behavior near the cosmological singularity of the gravitational field, and fields describing other kinds of matter, is explained in detail. Part II focuses on the billiard reformulation of the BKL behavior. Taking a general approach, this section does not assume any simplifying symmetry conditions and applies to theories involving a range of matter fields and space-time dimensions, including supergravities. Overall, this book will equip theoretical and mathematical physicists with the theoretical fundamentals of the Big Bang, Big Crunch, Black Hole singularities, the billiard description, and emergent mathematical structures.

2. In 2014 ICRANet started the new program "Exact solutions in the super-symmetric General Relativity" in collaboration with the group of Prof. Hermann Nicolai at Albert Einstein Institute at Potsdam (Germany). In 2017 in the framework of this program the new work has been done dedicated to the exactly integrable models in supergravity. It was continued the general way of extension of the pure gravity inverse scattering integration technique to the case when fermions (introduced on the base of supersymmetry) are present. In this year the integrability technique for simple (N=1) supergravity in two space-time dimensions coupled to the matter fields taking values in the Lie algebra of $E8(+8)$ group was developed. This theory contains matter living only in one Weyl representation of SO (16) and represents the reduction to two dimensions of the three-dimensional simple supergravity constructed earlier by H. Nishino and S. Rajpoot (2002). The proposed spectral linear problem use superspace and covers the complete set of principal bosonic and fermionic equations of motion. This linear system, as in pure gravity, contains only the first order poles with respect to the spectral parameter. The procedure of constructing the exact super-solitonic solutions is outlined (see Ref. 2).

3. It was proposed a new alternative (with respect to the accelerated universe paradigm) explanation of the discrepancy between values of the distances to the far galaxies following from the observations and

from the standard Friedmann model. Observations show that these distances are a little bit larger in comparison with what is predicted by the usual Friedmann cosmology. However, this standard theory does not take into account traces the strong gravitational waves of cosmological origin leave in space. We show that such traces can be a cause for the aforementioned discrepancy. The sources of cosmological waves are inhomogeneities of a solitonic type of the gravitational field near the Big Bang. Due to expansion of the universe these inhomogeneities decay but each of them expels solitonic gravitational waves which also decay in course of propagation through the expanding space transfering, however, their energies to the Friedmann background making the distances different compared with those which would be observed without such waves. This effect has been described earlier (V. Belinski, 1979) by example of single-soliton cylindrical wave propagating on the Friedmann background. Now the same phenomenon has been confirmed for double-soliton waves both for cylindrical and planar symmetries (see Ref. 3).

II. Publications

[1] V. Belinski and M. Henneaux "The Cosmological Singularity", Cambridge University Press, October 2017.
[2] V. Belinski "On the integrable gravity coupled to fermions", Phys. Lett. **B 769**, 100 (2017).
[3] V. Belinski and G. Vereshchagin "On the cosmological gravitational waves and cosmological distances", arXiv:1710.11588 [gr-qc]; submitted for publication.