Reviewer report on the proposed new BLTP theme
"Modern mathematical physics: Gravity, Supersymmetry and Strings"

The proposed theme "Modern mathematical physics: Gravity, supersymmetry and strings" is in line with the traditional research of the Bogolyubov Laboratory of Theoretical Physics. Essential to the theme are the development of mathematical methods required for dealing with fundamental problems of modern theoretical physics.

The new theme continues and extends studies performed within the previous BLTP theme "Modern mathematical physics: strings and gravity, supersymmetry and integrability" (2014-2018) that was focused on various areas of mathematical physics. These include new methods in integrable models including their exact classical and quantum solutions. (Integrable models were studied, in particular in Russia since the end of the 70s, and received a renewed interest recently as a kind of "avatar" of what Nobel laureate David Gross calls "the Strings framework."). That requires the analysis of a wide variety of problems in the superstring and superbrane framework and includes the study of non-pertubative regimes of supersymmetric gauge theories, the construction of a microscopic description of black holes, and the development of cosmological models of early Universe.

In the previous stage of this work the scientists of BLTP obtained a wide variety of results that were presented in more than 180 journal publications and in a number of prestigious international conferences. The leading role of theoreticians of the Dubna BLTP group, working in the area of modem mathematical physics, is highlighted by the organization of 40 international conferences and workshops in Dubna.

One should stress that the research under the theme "Modern mathematical physics" was conducted in collaboration with many international centers dealing with theoretical and mathematical physics, including the Center for theoretical physics at Marseille University, Ecole Normale Supérieure (Lyon), SISSA (Trieste), University of Torino, Institute of Theoretical Physics of Hannover University, INFN (with departments in Torino, Pisa, Padova and Frascati) and the Max Planck Institutes in Bonn and Munich, and a number of well-known scientists such as Luis Alvarez-Gaumé (formerly at CERN, now Director of the Simons Center for Geometry and Physics at SUNY Stony Brook, USA). The group has also productive scientific links with the Theory Department of Lebedev Physical Institute (Moscow).

Further development of physics will certainly require an adequate development of new mathematical tools instrumental for the study of fundamental problems in modern theoretical and mathematical physics. The research to be carried out under the proposed theme includes elucidating the nature of symmetries of fundamental interactions and an analysis of effective field models arising in the theory of strings and other extended objects, a better understanding of the geometric description of quantum symmetries and their spontaneous breakdown, as well as the (so far elusive) search for a unified theory of fundamental interactions, including quantum gravity.

It can reasonably be expected that results and papers by scientists working in the new BLTP theme "Modern mathematical physics" will have an important impact on theoretical physics. This is guaranteed by the high scientific level and international recognition of the main researchers participating in the team. Their program is certainly at the frontier of modern developments. My personal suggestion would be that they give some thought to going even further by questioning the bases of what is done elsewhere and dare to try and develop an even more original approach, based on new mathematics with potential far reaching physical implications.

To summarize, I consider that it is absolutely necessary to continue and expand this direction of research at JINR, by opening the new theme "Modern mathematical physics: gravity, supersymmetry and strings" for a period of 5 years, with first priority.

Daniel Sternheimer,
Rikkyo University, Tokyo, Japan & Université de Bourgogne, Dijon, France
Honorary Professor of Physics, St. Petersburg State University

Dubna, 3 May 2018