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Finite-dimensional integrable systems: a collection of research problems

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Abstract

This article suggests a series of problems related to various algebraic and geometric aspects of integrability. They reflect some recent developments in the theory of finite-dimensional integrable systems such as bi-Poisson linear algebra, Jordan-Kronecker invariants of finite dimensional Lie algebras, the interplay between singularities of Lagrangian fibrations and compatible Poisson brackets, and new techniques in projective geometry.

1 Introduction

The idea to publish such a paper was on the one hand inspired by our discussions with both the organisers and the participants of the conference “Finite Dimensional Integrable Systems in Geometry and Mathematical Physics (FDIS 2015)” held in July 2015 at the Mathematical Research and Conference Center (MRCC) in Beđlewo. On the other, for a number of years our research group has been working on a list of open problems [7] published in Russian and almost unavailable for the general audience. That list included about 70 problems with various levels of difficulty — from M.Sc. and Ph.D. levels to serious conjectures which could rather be considered as possible directions for further research. The present paper is based on [7] and is to some extent a part of it. The problems offered herein are selected and extended according to our preferences and adapted for publication as a journal paper. So, first of all, we would like to acknowledge the contribution of Andrey Konyaev and Andrey Oshemkov, our co-authors in [7] with whom we are currently working on the English version of the latter. It will contain a background section for beginners, comments and updates and, hopefully, will soon appear on the arXiv. For a similar paper of open problems the reader may wish to refer to a recently published work by S. Rosemann and K. Schöbel [39].

The immediate goal of this paper is to introduce the reader to a bunch of interesting open problems. There is no section with preliminaries but we have tried all our best to define the main concepts as well as to properly motivate the problems to follow. Our selection of problems concerns *bi-poisson algebra and geometry*, *Jordan-Kronecker invariants*, *applications to projective geometry*, and *singular Lagrangian fibrations*. It is worth mentioning that many of the problems under discussion are, directly or indirectly, related to the argument shift method [34] which originated from a two-page note by

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