Preface

Introduction
This proceedings volume presents results obtained by the participants of the 6th Baltic-Nordic workshop Algebra, Geometry, Mathematical Physics (AGMP-6) held at the Sven Lovén Centre for Marine Sciences in Tjärnö, Sweden on October 25-30, 2010.

The Baltic-Nordic Network AGMP (http://www.agmp.eu), ”Algebra, Geometry, Mathematical Physics” was initiated in 2005 on the initiative of two Estonian universities, and two Swedish Universities: Tallinn University of Technology represented by Eugen Paal (coordinator of the network), Tartu University represented by Viktor Abramov, Lund University represented by Sergei Silvestrov and Chalmers University of Technology and University of Gothenburg represented by Alexander Stolin with the goal of promoting international and interdisciplinary cooperation between scientists and research groups in the countries of Baltic-Nordic region, in Mathematics and Mathematical Physics with the special emphasize on important role played by algebra and geometry in modern physics, engineering and technologies. The main activities of the AGMP network consist of a series of regular annual international workshops, conferences and research schools. The AGMP network constitutes also an important educational forum for scientific exchange and dissimilation of research results for PhD students and Postdocs. The network has expanded since its creation, and nowadays its activities extend beyond countries in Baltic-Nordic region to universities in other European countries and participants from elsewhere in the world. As one of the important research dissimilation outcomes of activities, the network has a tradition of producing high quality research Proceedings volumes after the network events, publishing them with various international publishers.

AGMP-6 and other AGMP meetings
The international workshop at Tjärnö (AGMP-6) was the 6th workshop in AGMP network workshop series:

- AGMP-7 University of Haute Alsace, Mulhouse, France, October 24-26, 2011 (Organizing Committee: A. Makhlof (Chair), V. Abramov, M. Bordemann, E. Paal, S. Silvestrov, A. Stolin)
- AGMP-6 Sven Lovén Centre for Marine Sciences in Tjärnö, Sweden, October 25-30, 2010 (Organizing Committee: A. Stolin (Chair), V. Abramov, E. Paal, S. Silvestrov)
- AGMP-5 Stefan Banach International Mathematical Center, October 12-16, 2009 (Organizing Committee: A. Tralle (Chair), V. Abramov, J. Grabowski, J. Fuchs, E. Paal, A. Stolin, P. Urbanski)
- AGMP-4 University of Tartu, October 9-11, 2008 (Organizing Committee: V. Abramov (Chair), E. Paal, S. Silvestrov, A. Stolin)
- AGMP-3 Chalmers University of Technology and University of Gothenburg, October 11-13, 2007 (Organizing Committee: A. Stolin (Chair), V. Abramov, E. Paal, S. Silvestrov)
- AGMP-2 Lund University, October 12-14, 2006 (Organizing Committee: S. Silvestrov (Chair), V. Abramov, E. Paal, A. Stolin)
Among other major events organized or to be organized by the AGMP Network recently are:

- AGMP-8, Brno, 12-14 September 2012 (Organizing Committee: M. Kures (Chair), J. Hrdina, E. Paal, P. Sehnalova, A. Stolin, P. Vasik, J. Zatocilova)
- The international conference ”3Quantum: Algebra, Geometry, Information” (QQQ), Tallinn, 10-14 July 2012 (Organizing Committee: E. Paal (Chair), A. Fialowski, J. Fuchs, M. Schlichenmaier, V. Shumeiko, A. Stolin, P. Zusmanovich)
- AGMP&MP2 Summer School, Tjärnö, Sweden, September 05-09, 2011 (Organizing Committee: A. Stolin (Chair), J. Fuchs, H. Johannesson, E. Paal)

Main topics of the AGMP-6 workshop in Tjärnö included, but were not limited to Algebra, Geometry, Lie theory, Representation theory, Deformation theory, Integrable systems, Mathematical methods of high energy physics, Quantum groups, Hopf algebras, Quantum information and applications in physics. The scientific programme of the AGMP-6 workshop in Tjärnö contained more then 63 talks including 11 plenary talks in the following special thematic sessions:

- Algebraic deformation theory (Organized by A. Siqveland)
- Integrable systems (Organized by H. Johannesson and P. Kulish)
- Noncommutative algebra (Organized by N. Iyudu and A. Laudal)
- Quantum algebra (Organized by S. Caenepeel and H. Rosengren)
- Categorical methods in physics (Organized by I. Burban)
- Operator algebras, dynamics, applications (Organized by S. Eilers, S. Silvestrov and L. Turowska)
- Number theoretical methods in string theory (Organized by B. E. W. Nilsson)
- Quantum information (Organized by T. Dorlas)
- Generalized Lie theory (Organized by A. Makhlouf and S. Silvestrov)
- Geometry (Organized by M. Kures)
- Spectral problems in quantum mechanics (Organized by G. Rozenbloum)
- Spectral and comp methods for Maxwell equations (Organized by L. Beilina and Y. Shestopalov)

In total, 79 scientists from Belgium, Brazil, Czech Republic, Denmark, Estonia, France, Germany, Hungary, Iran, Ireland, Italy, Japan, Norway, Portugal, Spain, Romania, Russia, Sweden, Uganda, UK, Ukraine, USA, Switzerland have taken part in the conference together making the conference a highly successful event.

Review of AGMP-6 Proceedings

The research articles selected for this volume cover a wide range of topics representing the main directions of the workshop and the topics of the special thematic sessions. All articles submitted for this volume were refereed, and the Editors take this opportunity to thank all the referees for their work. Among contributors to the volume there are 42 researchers from different countries around the world making this proceedings volume into an important international interdisciplinary publication.

In the article ”Weil jets theory, connections and curvature tensor”, R. J. Alonso-Blanco and J. Muñoz-Díaz describe connections in the framework of Weil jets theory which consist of considering jets as ideals and refer all the operations to the ring of functions of the base
manifold. With this approach they obtain a new perspective of the curvature tensor and point out as an application, that the Ricci tensor is obtained in a way somewhat more direct than usual, which could be interesting for a better understanding of this important object. M. Bacovský, M. Havlíček and S. Posa, in their article ”Central dependencies in quantum algebras”, analyze the structure of the center of the quantum algebra $U_q(sl_2)$ in detail for both cases when deformation parameter $q$ is or is not a root of unity, obtaining description of the center and its generators in a purely algebraic way without considering representation theory. In the article ”Categorical Non-commutative Geometry”, P. Bertozzini, R. Conti and W. Lewkeeratiyutkul outline the current status of some recent research programs aiming at a categorification of parts of A.Connes non-commutative geometry and provide an outlook on some possible future developments in categorical non-commutative geometry. S. Burciu, in his article ”Normal coideal subalgebras of semisimple Hopf algebras”, shows that the restriction functor from the category of representations of a semisimple Hopf algebra to the category of representations of a normal coideal subalgebra has a similar behavior to the restriction functor to the category of representations of a normal Hopf subalgebra. Commutator subalgebras as normal left (right) coideal subalgebras are also studied. R. Conti, J. H. Hong and W. Szymański, in their expository article ”Analysis of endomorphisms”, discuss the recent progress in the study of endomorphisms and automorphisms of the Cuntz algebras and, more generally graph $C^*$-algebras (or Cuntz-Krieger algebras), and in particular, the definition and properties of both the full and the restricted Weyl group of such an algebra. The authors outline a powerful combinatorial approach to analysis of endomorphisms arising from permutation unitaries, emphasize that the restricted Weyl group consists of automorphisms of this type, discuss the action of the restricted Weyl group on the diagonal MASA and its relationship with the automorphism group of the full two-sided $n$-shift and present several open problems. In the article ”Representations of posets: Linear versus Unitary”, V. Futorny, Y. Samoilenko and K. Yusenko, consider the representation theory of partially ordered sets in unitary spaces with the so called orthoscalar relation. Such theory generalizes the classical theory which studies the representations of partially ordered sets in linear spaces. In the article ”Remarks on rational solutions of Yang-Baxter equations”, T. Henrich studies the unitary rational solutions of the associative Yang-Baxter equation with three spectral parameters, explains how such solutions arise from the geometry of vector bundles on a cuspidal cubic curve, and moreover investigates how these solutions are related to the quantum and classical Yang-Baxter equations. S. Hohenegger, in his article ”Automorphic products, generalized Kac-Moody algebras and string amplitudes”, reviews automorphic products and generalized Kac-Moody algebras from a physics point of view, discuss the appearance of automorphic products in BPS-saturated one-loop quantities in heterotic string theory and review particular examples of this extension for compactifications with $N = 2$ and $N = 4$ space-time supersymmetry. J. Hrdina, in his article ”Geometric properties of Frobenius algebras” discusses the properties of algebras and their modules proving that the study of generic rank reduces to the study of Frobenius algebras. In his article ”Subring depth below an ideal” by L. Kadison, a minimum depth is assigned to a ring homomorphism and a bimodule over its codomain; when the homomorphism is an inclusion and the bimodule is the codomain, the recent notion of depth of a subring by Boltje-Danz-Külshammer is recovered, and it is pointed out that subring depth below an ideal gives a lower bound for BDK’s subring depth of a group algebra pair or a semisimple complex algebra pair. In the article ”The Belavin-Drinfeld theorem on non-degenerate solutions of the classical Yang-Baxter equation”, L. Kierans and B. Kreussler give a coordinate free proof of Belavin and Drinfeld’s Theorem about the classification of non-degenerate solutions of the classical Yang-Baxter equation, and the equivalence of different characterizations of non-degeneracy is also shown in such a way. In the article ”Tensor powers for non-simply laced Lie algebras $B_2$-case”, P. P. Kulish, V. D. Lyakhovsky and O. V. Postnova study the decomposition problem for tensor powers of $B_2$-fundamental modules. To solve this problem singular weight
technique and injection fan algorithms are applied. Properties of multiplicity coefficients are formulated in terms of multiplicity functions. These functions are constructed showing explicitly the dependence of multiplicity coefficients on the highest weight coordinates and the tensor power parameter. It is thus possible to study general properties of multiplicity coefficients for powers of the fundamental $B_2$-modules. In the article ”Initial-boundary value problems for linear equations of electrodynamics with nonlinear boundary conditions” by K. Lukin, a new class of electromagnetic (EM) problems is introduced, initial-boundary value problem for linear wave equation with nonlinear boundary conditions, and methods for their solution are elaborated. Theory of nonlinear 1D maps and difference-differential equations have been applied to solve the problem, and it has been shown that spatiotemporal dynamics of EM field in a resonator with nonlinear reflecting surfaces may be either regular or chaotic in spite of the major part of the system is formed by linear media. The author points out that the approach may be used for analysis of chaotic processes in many electromagnetic and electronic devices. In the article ”On $\varepsilon;\delta$-Freudenthal Kantor triple systems and anti-structurable algebras with certain conditions”, N. Kamiya, D. Mondoc and S. Okubo discuss a characterization of anti-structurable algebras in connection with their relation with $(-1;1)$-Freudenthal Kantor triple systems. In the article ”Mal’tsev algebras and triality” by E. Paal, a concept of the Mal’tsev pair is presented based on the generalized Maurer-Cartan equations of a local analytic Moufang loop. The triality can be seen as a fundamental property of such pairs. Based on triality, the Yamagutian is constructed and properties of the Yamagutian are studied. In the article ”Automorphic Instanton Partition Functions on Calabi-Yau Threefolds”, D. Persson surveys recent results on quantum corrections to the hypermultiplet moduli space in type $IIA/B$ string theory on a compact Calabi-Yau threefold, or, equivalently, the vector multiplet moduli space in type $IIB/A$ on $X \times S^1$. In the article ”Four ways across the wall” B. Pioline considers an important question in the study of $N = 2$ supersymmetric string or field theories is to compute the jump of the BPS spectrum across walls of marginal stability in the space of parameters or vacua. The author surveys four apparently different answers for this problem, two of which are based on the mathematics of generalized Donaldson-Thomas invariants (the Kontsevich-Soibelman and the Joyce-Song formulae), while the other two are based on the physics of multi-centered black hole solutions (the Coulomb branch and the Higgs branch formulae, discovered in joint work with Jan Manschot and Ashoke Sen). The author points out also that explicit computations indicate that these formulae are equivalent, though a combinatorial proof is currently lacking. In the article ”New approach for solving Maxwell equations with strong singularity”, V. A. Rukavishnikov and A. O. Mosolapov introduce a notion of $R_\nu$-generalized solution to Maxwell equations with strong singularity in a 2D nonconvex polygonal domain, develop a new weighted edge finite element method (FEM) based on the conception of $R_\nu$-generalized solution of the Maxwell equations with strong singularity due to a reentrant corner on the boundary, and point out that the results of numerical experiments prove the efficiency of this method. Y. Shestopalov and Y. Smirnov, in their article ”Inverse scattering in guides”, present statements and a method of solution to the inverse scattering problem of reconstructing permittivity of a dielectric inclusion in a 2D or 3D waveguide from the transmission characteristics, establish the unique solvability of a volume singular integral equation (VSIE), demonstrate that the inverse problem is solved by the method of iterations applied to VSIE and prove the convergence of the method. In the article ”Some formulas for Legendre functions related to the Poisson transform and Lorentz group representation”, I. A. Shilin and A. I. Nizhnikov consider the representation of Lorentz group in the spaces of homogeneous functions on cone and hyperboloid. Using the Poisson transform, which maps a function from the first space into the corresponding function from the second space, the authors derive some new formulas containing Legendre functions, and show that using the restriction of the representation in the first space on a one-parameter subgroup of hyperbolic rotations another new formula for Legendre functions can be obtained. In the article
"Burchnall-Chaundy annihilating polynomials for commuting elements in Ore extension rings" by J. Richter and S. D. Silvestrov, further progress is made in extending the Burchnall-Chaundy type determinant construction of annihilating polynomial for commuting elements to broader classes of rings and algebras by deducing an explicit general formula for the coefficients of the annihilating polynomial obtained by the Burchnall-Chaundy type determinant construction in Ore extension rings. It is also demonstrated how this formula can be used to compute the annihilating polynomials in several examples of commuting elements in Ore extensions. Also it is demonstrated that additional properties which may be possessed by the endomorphism, such as for example injectivity, may influence strongly the annihilating polynomial. J. Vajakas, in his article "Some Generalizations of the Hewitt Extension", introduces two extensions of a Tychonoff space that generalize the notions of the Hewitt extension and the generalized Hewitt extension introduced by Bachman, Beckenstein, Narici and Warner. The extensions are determined by sets of continuous functions. In particular, the author studies the extensions determined by all continuous functions and the extensions determined by all continuous bounded functions and shows that these can be regarded as epireflective functors. The author also discusses the possibility of using these extensions to describe the characters of function algebras. In the article "Tangent structures: sector-forms, jets and connections", M. Rahula, P. Vašík and N. Voicu point out that while to define a higher order connection on a fibered manifold one can use the sections of nonholonomic jet prolongations, a more natural approach seems to be the one assuming the structure of a higher-order tangent bundle and using White's sector-forms on these bundles.

This international interdisciplinary volume will be a source of inspiration for a broad spectrum of researchers and for research students, as the contributions lie at the intersection of the research directions and interests of several large research communities and research groups on modern Mathematics and Physics.

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