Preface

This work presents the proceedings of the Algebra, Geometry and Mathematical Physics Conference, which was held at the University of Haute Alsace (Mulhouse, France) from 24 to 26 October, 2011. This international conference brought together 126 researchers from 33 different countries, who are working on these topics. In total, there were 12 plenary talks and 10 sessions with 86 contributed talks. We would like to thank all of the conference participants and speakers for making it such a successful and fruitful event.

The specific fields covered by the conference were

- Deformation theory and quantization,
- Hom-algebras and *n*-ary algebraic structures,
- Hopf algebra and quantum algebra,
- Integrable systems and related math structures,
- Jet theory and Weil bundles,
- Lie theory and applications,
- Noncommutative and Lie algebra,
- Number theoretical methods in string theory,
- Spectral and comp methods in physics, and
- Ternary algebras and applications.

This volume collects contributions which are divided into four main parts: Algebra, Geometry, Dynamical Symmetries and Conservation Laws, and a final part dedicated to Mathematical Physics and Applications. The common denominator of all the contributions is that they are mostly based on algebraic tools.

Part I, which is also the largest, includes contributions on Algebra. It covers topics in ring theory, Lie algebras, ternary algebras, and deformation theory. The "Poincaré Duality for Koszul Algebras" offers a complete study of the consequences of the Poincaré duality versus the AS-Gorenstein property for Koszul algebras (homogeneous and nonhomogeneous). The "Quantized Reduced Fusion Elements and Kostant's Problem" provides a partial solution to Kostant's problem concerning a description of the locally finite endomorphisms of highest weight irreducible modules. Two further chapters deal with commuting elements. The first examines the algebraic dependence in the Weyl algebra and generalizations, while the second focuses on centers in a six-parameter family of quadratically linked quantum plane algebras. A description of the $\mathscr{C}^\infty$-algebra on the cohomology of the free two-nilpotent Lie algebra is also provided, drawing on T. Kadeishvili's homotopy transfer theorem. Moreover, we present a study of subalgebra depths, in generalized triangular matrix algebras, within the path algebra of an acyclic quiver.

The proceedings also include papers dedicated to some classes of Lie algebras, such as the anisotropic, regular, minimal nonabelian, algebras of depth two, and symplectic quadratic Lie algebras related to Poisson algebras. Lie algebras generalize naturally to 3-Lie algebras. We highlight a comparison of the structure and the cohomology spaces of Lie algebras with induced 3-Lie algebras and a description of Peirce decomposition for unitary (1,1)-Freudenthal Kantor triple systems. For Hom-algebras, algebras involving a linear map twisting the usual identities, a universal algebra theory is developed, mainly for Hom-associative algebras. It covers the envelopment problem, operads, and the Diamond Lemma. Furthermore, quadratic n-ary Hom-Nambu algebras are studied and various constructions are presented. Afterwards, there is a long series of chapters concerning deformations, the first of which compares Leibniz and Lie algebra cohomology and deformations of a given Lie algebra. The second chapter studies deformations of finite dimensional current Lie algebras and their rigidity. Then, using a functorial point of view, a deformation theory for diagrams is described and noncommutative varieties are constructed using a polynomial matrix algebra and deformations (noncommutative deformation theory), as well as computations of noncommutative deformation. The last chapter in this series provides a geometric classification of four-dimensional superalgebras, based on the concept of degeneration. The purely algebraic contributions in the first part are rounded out with a survey on distributivity in quasigroup theory and in quandle theory, in connection with knot theory.

Part II is more geometrical, even if it also involves several algebraic structures. The contributions concern differential geometry and projective geometry with an algebraic treatment. The "Torsors and Ternary Moufang Loops Arising in Projective Geometry" deals with torsors and ternary Moufang loops, which arise in projective geometry. Concerning differential geometry, we present a study of connections through a graded q-differential algebra of polynomials, a classification of principal connections on a principal prolongation of a principal bundle, and an interpretation of higher order connections. Utilizing a differential geometrical approach, parallel transport on path spaces is studied using representations of categorical groups. A differential geometry of microlinear Frölicher spaces, which is mainly concerned with jet bundles, is presented. Moreover, this part includes a contribution that collects key material on the generic rank of A-modules for the purposes of differential geometrical applications, and closes with a geometrical approach to ghost fields appearing in quantized gauge theory.

Part III is concerned with dynamical symmetries and conservation laws. The idea of a conservation law can be traced back to the fields of mechanics and physics. Many physical theories and "laws of nature" are usually expressed as systems of nonlinear differential equations. The "Causality from Dynamical

Symmetry: An Example from Local Scale-Invariance" studies causality from dynamical symmetry and provides an example from local scale-invariance. Subsequently, various systems are discussed: reaction-diffusion systems with constant diffusivities, an inverse problem of reconstructing permittivity of an n-sectional diaphragm in a rectangular waveguide, a class of Hamilton–Jacobi–Bellman equations, and a generalized Dullin–Gottwald–Holm equation. Moreover, the heat-mass transfer problem is studied using a group theoretical approach, and Sinykov equations of the geodesic mappings of Riemannian manifolds are analyzed using the curvature operator of the second kind.

The last part concerns various applications of mathematics to physics. It starts with a realization of the affine Lie algebra $A_1^{(1)}$ and the relevant Z-algebra at negative level k in terms of parafermions. Then, invariance and symmetries of cubic and ternary algebras are discussed and a relationship of this construction with the operators defining quark states is demonstrated. We then present a calculation of decay times for simple modules, using the mathematical model of the physical process of decay suggested by Laudal. As an application of number theory to cryptography, an algorithmic study of the detection of permutation polynomials follows. In connection with cosmology, we include a study on scalar-tensor and multiscalar-tensor gravity and cosmological models. The last contribution deals with quantum gravity and the quantum nature of the probes used to unravel spacetime geometry.

One of the plenary speakers was Jean-Louis Loday, who gave a fascinating talk on "Divided power algebras." He has since, to our great sadness, passed away. Jean-Louis Loday was a great mathematician with broad interests in mathematics, such as the study of the interplay between algebraic K-theory and cyclic homology, as well as the applications of the theory of algebraic operads. He was a great mind and had a very generous spirit. We will always remember him, and we would like to dedicate this volume to his memory.

We would like to thank the Region of Alsace, the City of Mulhouse and the University of Haute Alsace for their financial support, as well as the AGMP network for its technical support (http://www.astralgo.com/cweb/agmp). We are grateful to the Faculty of Science and Technology and Dean Christophe Krembel for the use of their facilities, our secretary Liliane Fricker for the great job she did in organizing the conference, and Olivier Elchinger for his valued technical assistance in the preparation of this volume.

Mulhouse, May 2013

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Jean-Louis Loday (1946–2012)

Jean-Louis Loday was a French mathematician born in 1946 in Brittany (France). After attending the high school Clémenceau in Nantes, he went to the famous Lycée Louis-le-Grand to prepare for the competition to join the even more prestigious Ecole Normale Supérieure, which he did in 1965. He passed the *Agrégation* in 1969 before completing his Ph.D. under the guidance of Max Karoubi in 1975. He would later become "Directeur de Recherche" at the CNRS. He spent his entire career at the IRMA, part of the Department of Mathematics of the University of Strasbourg, where he later served as director.

His works deal with Algebra and Topology. He began by studying algebraic K-theory in the 1970s, the golden age for this field. He then worked on algebraic homotopy, most notably with Ronnie Brown. In the early 1980s, his focus shifted to cyclic homology, the additive version of K-theory. Six months after its introduction by Alain Connes, he and Dan Quillen discovered a seminal application in the domain of matrix Lie algebra cohomology (a result found independently by Boris Tsygan). The 1990s brought him into contact with the notion of algebraic operads, which he developed until his death. Thanks to operads, he introduced and studied in detail many types of algebras, including Leibniz algebras, dendriform algebras, and generalized bialgebras. He was very much interested in combinatorial Hopf algebras, like those appearing in renormalization theory, and was fascinated by the Stasheff polytopes, also known as associahedra, which encode associative algebras up to homotopy.

Over the course of his career Jean-Louis published 75 papers and two reference books, one on cyclic homology and the other on algebraic operads. He supervised 15 Ph.D. theses and invited many postdoctoral students to Strasbourg, organizing countless conferences and projects. Having recognized that research in mathematics does not consist in individual researchers working on their own, he was open and generous in sharing his time and ideas. Passionate about his work, not only did he always find time for his students and colleagues, he was also unable to refuse invitations to give a talk or a series of lectures, even if it meant traveling halfway around the globe (e.g. to Montréal, Chile, Kazakhstan, and China over the last few years).

Those of us mathematicians who were fortunate enough to meet him will always remember him as a wonderful person with a great sense of humor, a wealth of humanity, and an enduring love for mathematics.

Bruno Vallette

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