GEOMETRY OF THE SPACE OF ORBITS OF A COXETER GROUP BORIS DUBROVIN pdf

1: Boris Dubrovin Publications

Differential-geometric structures on the space of orbits of a finite Coxeter group, determined by Groth\'endieck residues, are calculated. This gives a construction of a 2D topological field theory for an arbitrary Coxeter group.

We obtain polynomial Frobenius manifolds from classical W -algebras associated to principal nilpotent elements in simple Lie al- gebras. Frobenius manifolds and local bihamiltonian structures 3 2. Principal nilpotent element and opposite Cartan subalgebra 5 3. Drinfeld-Sokolov reduction 9 3. The nondegeneracy condition 12 3. Differential relation 14 4. Some results from Dirac reduction 15 5. Polynomial Frobenius manifold 18 5. Conclusions and remarks 19 References 20 1. Introduction This work is a continuation of [6] where we began to develop a construction of algebraic Frobenius manifolds from Drinfeld-Sokolov reduction to support a Dubrovin conjecture. We say M is semisimple or massive if Tt is semisim- ple for generic t. This structure locally corresponds to a potential satis- fying a system of partial differential equations known in topological field theory as the Witten-Dijkgraaf-Verlinde-Verlinde WDVV equations. We say M is algebraic if, in the flat coordinates, the potential is an algebraic function. Dubrovin conjecture is stated as follows: Semisimple irreducible Mathematics Subject Classification. Primary 37K10; Secondary 35D Key words and phrases. Bihamiltonian geometry, Frobenius manifolds, classical W - algebras, Drinfeld-Sokolov reduction, Slodowy slice. We discussed in [6] how the examples of algebraic Frobenius manifolds constructed from Drinfeld-Sokolov reduction support this conjecture. Let e be a principal nilpotent element in a simple Lie algebra g over C. We prove the following Theorem 1. The Slodowy slice 1. Let us recall some structures related to the principal nilpotent element e. Recall that a bihamiltonian structure on a manifold M is two compatible Pois- son brackets on M. It is well known that the dispersionless limit of a local bihamiltonian structure on the loop space L M of a finite dimensional man- ifold M if it exists always gives a bihamiltonian structure of hydrodynamic type: This in turn gives a flat pencil of met- ij rics g1,2 on M which under some assumptions corresponds to a Frobenius structure on M [12]. To this end we start by defining a bihamiltonian structure P1 and P2 in L g. The Poisson structure P2 is the standard Lie-Poisson structure and P1 depends on the adjoint action of a. In the Drinfeld-Sokolov reduction the space Q will be transversal to an action of the adjoint group of L n on a suitable affine subspace of L g. Here n is the subalgebra M 1. This defines the Drinfeld-Sokolov bihamiltonian structure on Q since the coordinates of Q can be interpreted as generators of the ring R. The second reduced Poisson structure on Q is called the classical W -algebra. We call it principal since it is related to the principal nilpotent element. We then prove that the Drinfeld-Sokolov bihamiltonian structure admits a dispersionless limit and gives the promised polynomial Frobenius manifold. We mention that from the work of Dubrovin [10] and Hetrling [16] semisim- ple polynomial Frobenius manifolds with positive degrees are already clas- sified. They correspond to Coxeter conjugacy classes in Coxeter groups. Dubrovin constructed all these polynomial Frobenius manifolds on the orbit spaces of Coxeter groups using the results of [23]. There is another method to obtain the classical W -algebra associated to principal nilpotent elements known in the literature as Muira type transformation [9]. It was used in [14] see also [7] to prove that the dispersionless limit of the Drinfeld-Sokolov bihamiltonian structure gives the polynomial Frobenius manifold defined on the orbit space of the corresponding Weyl group [10]. The proof depends also on the invariant theory of Coxeter groups. In the present work we give a new method to uniform the construction of polynomial Frobenius mani- folds from Drinfeld-Sokolov reduction which depends only on the theory of opposite Cartan subalgebras. Frobenius manifolds and local bihamiltonian structures. Start- ing we want to recall some definitions and review the construction of Frobe- nius manifolds from local bihamiltonian structure of hydrodynamics type. This structure locally corresponds to a potential F t1 , Here we assume that the quasihomogeneity condition takes the form n X 2. This condition defines the degrees di and the charge d of the Frobenius structure on M. If F t is an algebraic function we call M an algebraic Frobenius manifold. Let L M denote the loop space of M , i. We note that, under the change of coordinates on M the matrices g1ij u ,

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F1ij u change as a 2, 0 -tensors. The matrix F1ij u defines a Poisson structure on M. By nondegenerate Poisson bracket of hydrody- namic type we mean those with the metric g1ij is nondegenerate. In addition, assume the corresponding Poisson brackets of hydrodynamics type are nondegenerate. Then by definition g1ij u and g2ij u form what is called flat pencil of metrics [12], i. Here for example LE denote the Lie derivative along the vector field E and , 1 denote the metric defined by the matrix g1ij. The connection between the theory of Frobenius manifolds and flat pencil of metrics is encoded in the following theorem Theorem 2. It is well known that from a Frobenius manifold we always have a flat pencil of metrics but it does not necessary satisfy the regularity condition 2. In the notations of 2. Furthermore we have X 2. Principal nilpotent element and opposite Cartan subalgebra. We review some facts about principal nilpotent elements in simple Lie al- gebra we need to perform the Drinfeld-Sokolov reduction. In particular, we recall the concept of the opposite Cartan subalgebra introduced by Kostant which is the main ingredient in this work. Let g be a simple Lie algebra over C of rank r. By definition a nilpotent element is called principal if ge: The element h define a Z-grading on g called the Dynkin grading given as follows 2. We normalize the invariant bilinear from h. Consider the restriction of the adjoint representation of g to A. Under this restriction g decomposes to irreducible A-submodules 2. We normalize this decomposition by using the following proposition Proposition 2. The proof that one could compose the Lie algebra as irreducible A- submodules satisfying 2. Hence the proof is reduced to the case of irreducible A-submodules of the same dimension. But there is at most two irreducible submodules of the same dimension. But it obvious that the restriction of the invariant bilinear form to X0i1 and X0i2 is nondegenerate. It remains to obtain the normalization 2. From the invariance of the bilinear form we have 2. This ends the proof. It is easy to see that 2. Hence the subalgebra gf: It is transversal to the orbit of e under the adjoint group action. We summarize Kostant results about the relation between the principal nilpotent element e and Coxeter conjugacy class in Weyl group of g. De- note h the Cartan subalgebra containing y1 , i. We assume the basis yi are normalized such that 2. Form construction this normalization does not effect y1. The following proposition summarize some useful properties we need in the following sections. The matrix Aij is nondegenerate since the restriction of the invariant bilinear form to a Cartan subalgebra is nondegenerate. Drinfeld-Sokolov reduction We will review the standard Drinfeld-Sokolov reduction associated with the principal nilpotent element [9] see also [6]. We introduce the following bilinear form on the loop algebra L g: Let us introduce a bihamiltonian structure on L g by means of Poisson tensors 1 3. We consider the gauge transformation of the adjoint group G of L g given by 3. Following Drinfeld and Sokolov [9], we consider the restriction of this action to the adjoint group N of L n. It admits a momentum map J to be the projection J: We take e as regular value of J. It follows from the Dynking grading that the isotropy group of e is N. Recall that the space Q is defined as 3. Which allows us to define the set R of functionals on Q as functionals on S which have densities in the ring R. The entries of z x are generators of the ring R of differential polynomials on S invariant under the action of N. The reduced Poisson structure P2Q is called a classical W - algebra. For a formal definition of classical W -algebras see [19]. We obtain the reduced bihamiltonian structure by using lemma 3. We write the coordinates of Q as differential polynomials in the coordinates of S by means of equation 3.

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2: Compatible Poisson brackets of hydrodynamic type - IOPscience

Authors: Boris Dubrovin (Submitted on 27 Mar) Abstract: Differential-geometric structures on the space of orbits of a finite Coxeter group, determined by Groth\'endieck residues, are calculated.

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4: [hep-th/] Geometry of 2d topological field theories

By Boris Dubrovin Abstract Differential-geometric structures on the space of orbits of a finite Coxeter group, determined by Groth\'endieck residues, are calculated.

5: [hep-th/] Differential geometry of the space of orbits of a Coxeter group

Differential-geometric structures on the space of orbits of a finite Coxeter group, determined by Groth\'endieck residues, are calculated. This gives a construction of a 2D topological field.

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8: Geometry of 2-D topological field theories - INSPIRE-HEP

Boris Dubrovin; Chapter. Dubrovin B., Geometry and integrability of topological Differential geometry of the space of orbits of a Coxeter group, Preprint.

9: A Simple model of the integrable Hamiltonian equation - INSPIRE-HEP

{Appendix I.} Determination of a superpotential of a Frobenius manifold. Lecture 4. Frobenius structure on the space of orbits of a Coxeter group. {Appendix J.} Extended complex crystallographic groups and twisted Frobenius manifolds. Lecture 5. Differential geometry of Hurwitz spaces. Lecture 6. Frobenius manifolds and integrable hierarchies.

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