Title:	On representations and structures of infinite-dimensional Lie algebras
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Abstract:	In this thesis, we study two aspects of infinite dimensional Lie algebras. In the first part, we study the fusion product modules for current Lie algebras of type A 2 . Fusion products of finite-dimensional cyclic modules, that were defined in [23], form an important class of graded representations of current Lie algebras. In [16], a family of finite- dimensional indecomposable graded representations of the current Lie algebra called the Chari-Venkatesh(CV) modules, were introduced via generators and relations, and it was shown that these modules are related to fusion products. We study a class of CV modules for current Lie algebras of type A 2 . By constructing a series of short exact sequences, we obtain a graded decomposition for them and show that they are isomorphic to fusion products of two finite-dimensional irreducible modules for current Lie algebras of sl 3 . Further, using the graded character of these CV-modules, we obtain an algebraic characterization of the Littlewood-Richardson coefficients that appear in the decomposition of tensor products of irreducible sl 3 (C)-modules. In the second part, we study the free root spaces of Borcherds-Kac-Moody Lie superalgebras. Let L be a Borcherds-Kac-Moody Lie superalgebra (BKM superalgebra in short) with the associated graph G. Any such L is constructed from a free Lie superalgebra by introducing three different sets of relations on the generators: (1) Chevalley relations, (2) Serre relations, and (3) Commutation relations coming from the graph G. By Chevalley relations we get a triangular decomposition L = n + □ h □ n − and each roots space L α is either contained in n + or n − . In particular, each L α involves only the relations (2) and (3). We study the rootxii spaces of L which are independent of the Serre relations. We call these roots the free roots of L. Since these root spaces involve only commutation relations coming from the graph, G we can study them combinatorially.We construct two different bases for these root spaces of, L using combinatorics of Lyndon heaps and super Lyndon words. Finally, we relate the k-chromatic polynomial with root multiplicities of BKM superalgebras.
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