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Representations of the full toroidal Lie algebras

This talk will be an introduction to the theory of the toroidal Lie algebras and their representations. Toroidal Lie algebras are the natural multi-variable generalizations of the affine Kac-Moody algebras. We will present two approaches to the representation theory of these algebras - an abstract construction using the Verma module technique, and an approach based on the theory of the vertex operator algebras, which allows us to give explicit realizations for the irreducible modules and obtain their characters. For the subalgebra of the toroidal Lie algebra, corresponding to the divergence-free vector fields, we obtain a result that has a striking resemblance to the formula for the critical dimension in bosonic string theory. Let $V_{\mathrm{aff}}(c)$ be an affine vertex algebra at level c, V_{hyp}^{+} be a subalgebra of the hyperbolic lattice vertex algebra and let $V_{\mathrm{Vir}}(c_1)$ be a Virasoro vertex algebra of rank c_1. Then the tensor product

$$V_{\mathrm{aff}}(c) \otimes V_{\mathrm{hyp}}^{+} \otimes V_{\mathrm{Vir}}(c_1)$$

has a structure of an irreducible module for an $(N+1)$-toroidal Lie algebra when

$$\frac{c \dim(g)}{c + \check{h}} + 2(N+1) + c_1 = 26.$$