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A family of new simple modules over the Schrödinger-Virasoro algebra *

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Abstract: In this article, a large class of simple modules over the Schrödinger-Virasoro algebra $\mathcal{G}$ are constructed, which include highest weight modules and Whittaker modules. These modules are determined by the simple modules over the finite-dimensional quotient algebras of some subalgebras. Moreover, we show that all simple modules of $\mathcal{G}$ with locally finite actions of elements in a certain positive part belong to this class of simple modules. Similarly, a large class of simple modules over the W-algebra $W(2,2)$ are constructed.

Key words: Schrödinger-Virasoro algebra, W-algebra, Highest weight module, Whittaker module, Simple module.

Mathematics Subject Classification (2010): 17B10, 17B20, 17B65, 17B66, 17B68.

1 Introduction

Throughout this paper, we denote by $\mathbb{C}, \mathbb{Z}, \mathbb{N}$ and $\mathbb{Z}_+$ the sets of complex numbers, integers, nonnegative integers and positive integers, respectively. All vector spaces and Lie algebras are over $\mathbb{C}$. For a Lie algebra $\mathcal{L}$, we denote by $\mathcal{U}(\mathcal{L})$ the universal enveloping algebra of $\mathcal{L}$.

The Schrödinger-Virasoro algebra is an extension of the Virasoro Lie algebra by a nilpotent Lie algebra formed with a bosonic current of weight $\frac{3}{2}$ and a bosonic current of weight 1. It was introduced in the context of non-equilibrium statistical physics during the process of investigating the free Schrödinger equations (see [6]). From then on, the Schrödinger-Virasoro algebra attracted a lot of attention from researchers (see, e.g., [7, 12, 19–21, 24]). Now we recall the definition of the *Schrödinger-Virasoro algebra* $\mathcal{G}$, which is an infinite-dimensional Lie algebra with the $\mathbb{C}$-basis $\{M_m, Y_{m+\frac{1}{2}}, L_m, C \mid m \in \mathbb{Z}\}$ and the following Lie brackets:

$$\begin{aligned}
&[L_m, L_n] = (n-m)L_{m+n} + \delta_{m+n,0}\frac{m^3-m}{12}C,\\
&[L_m, Y_{n+\frac{1}{2}}] = \Big(n + \frac{1-m}{2}\Big)Y_{m+n+\frac{1}{2}},\ \ [Y_{m+\frac{1}{2}}, Y_{n+\frac{1}{2}}] = (n-m)M_{m+n+1},\\
&[L_m, M_n] = nM_{m+n},\ \ [M_m, M_n] = [M_m, Y_{n+\frac{1}{2}}] = [\mathcal{G}, C] = 0, \quad \forall m, n \in \mathbb{Z}.
\end{aligned} \tag{1.1}$$

Note that the center of $\mathcal{G}$ is spanned by $\{M_0, C\}$. In addition, the Schrödinger-Virasoro algebra is a special case for the generalized Schrödinger-Virasoro algebra (see [20]).

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