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Peyman Niroomand, Mohsen Parvizi



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## 2-CAPABILITY AND 2-NILPOTENT MULTIPLIER OF FINITE DIMENSIONAL NILPOTENT LIE ALGEBRAS

PEYMAN NIROOMAND AND MOHSEN PARVIZI

ABSTRACT. In the present context, we investigate to obtain some more results about 2-nilpotent multiplier  $\mathcal{M}^{(2)}(L)$  of a finite dimensional nilpotent Lie algebra  $L$ . For instance, we characterize the structure of  $\mathcal{M}^{(2)}(H)$  when  $H$  is a Heisenberg Lie algebra. Moreover, we give some inequalities on  $\dim \mathcal{M}^{(2)}(L)$  to reduce a well known upper bound on 2-nilpotent multiplier as much as possible. Finally, we show that  $H(m)$  is 2-capable if and only if  $m=1$ .

### 1. INTRODUCTION

For a finite group  $G$ , let  $G$  be the quotient of a free group  $F$  by a normal subgroup  $R$ , then the  $c$ -nilpotent multiplier  $\mathcal{M}^{(c)}(G)$  is defined as

$$R \cap \gamma_{c+1}(F) / \gamma_{c+1}[R, F],$$

in which  $\gamma_{c+1}[R, F] = [\gamma_c[R, F], F]$  for  $c \geq 1$ . It is an especial case of the Baer invariant [3] with respect to the variety of nilpotent groups of class at most  $c$ . When  $c = 1$ , the abelian group  $\mathcal{M}(G) = \mathcal{M}^{(1)}(G)$  is more known as the Schur multiplier of  $G$  and it is much more studied, for instance in [11, 14, 18].

Since determining the  $c$ -nilpotent multiplier of groups can be used for the classification of group into isoclinism classes (see [2]), there are multiple papers concerning this subject.

Recently, several authors investigated to develop some results on the group theory case to Lie algebra. In [22], analogues to the  $c$ -nilpotent multiplier of groups, for a given Lie algebra  $L$ , the  $c$ -nilpotent multiplier of  $L$  is defined as

$$\mathcal{M}^{(c)}(L) = R \cap F^{c+1} / [R, F]^{c+1},$$

in which  $L$  presented as the quotient of a free Lie algebra  $F$  by an ideal  $R$ ,  $F^{c+1} = \gamma_{c+1}(F)$  and  $[R, F]^{c+1} = \gamma_{c+1}[R, F]$ . Similarly, for the case  $c = 1$ , the abelian Lie algebra  $\mathcal{M}(L) = \mathcal{M}^{(1)}(L)$  is more studied by the first author and the others (see for instance [4, 5, 6, 8, 9, 10, 15, 16, 17, 24]).

The  $c$ -nilpotent multiplier of a finite dimensional nilpotent Lie algebra  $L$  is a new field of interest in literature. The present context is involving the 2-nilpotent multiplier of a finite dimensional nilpotent Lie algebra  $L$ . The aim of the current paper is divided into several steps. In [22, Corollary 2.8], by a parallel result to the group theory result, showed for every finite nilpotent Lie algebra  $L$ , we have

$$(1.1) \quad \dim(\mathcal{M}^{(2)}(L)) + \dim(L^3) \leq \frac{1}{3}n(n-1)(n+1).$$

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