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LICHTENBAUM-HARTSHORNE VANISHING THEOREM FOR GENERALIZED LOCAL COHOMOLOGY MODULES

ALI FATHI

ABSTRACT. Let R be a commutative Noetherian ring, and let $\mathfrak{a}$ be a proper ideal of R . Let M be a non-zero finitely generated R -module with the finite projective dimension p . Also, let N be a non-zero finitely generated R -module with $N \not\subseteq \mathfrak{a}N$, and assume that c is the greatest non-negative integer with the property that $H_{\mathfrak{a}}^c(N)$, the i -th local cohomology module of N with respect to $\mathfrak{a}$, is non-zero. It is known that $H_{\mathfrak{a}}^i(M, N)$, the i -th generalized local cohomology module of M and N with respect to $\mathfrak{a}$, is zero for all $i > p + c$. In this paper, we obtain the coassociated prime ideals of $H_{\mathfrak{a}}^{p+c}(M, N)$. Using this, in the case when R is a local ring and c is equal to the dimension of N , we give a necessary and sufficient condition for the vanishing of $H_{\mathfrak{a}}^{p+c}(M, N)$ which extends the Lichtenbaum-Hartshorne vanishing theorem for generalized local cohomology modules.

1. Introduction

Throughout this paper, let R be a commutative Noetherian ring with non-zero identity. Let $\mathfrak{a}$ be an ideal of R and N be an R -module. The i -th local cohomology module of N with respect to $\mathfrak{a}$ was defined by Grothendieck as follows:

$$H_{\mathfrak{a}}^i(N) := \varinjlim_{n \in \mathbb{N}} \operatorname{Ext}_R^i(R/\mathfrak{a}^n, N);$$

see [2] for more details. For a pair of R -modules M and N , the i -generalized local cohomology module of M, N with respect to $\mathfrak{a}$ was introduced by Herzog [13] as follows:

$$H_{\mathfrak{a}}^i(M, N) := \varinjlim_{n \in \mathbb{N}} \operatorname{Ext}_R^i(M/\mathfrak{a}^n M, N);$$

see [13, 1] for more details. It is clear that $H_{\mathfrak{a}}^i(R, N) = H_{\mathfrak{a}}^i(N)$. The cohomological dimension of N with respect to $\mathfrak{a}$ and the cohomological dimension of M, N with respect to $\mathfrak{a}$ are defined, respectively, as follow:

$$\operatorname{cd}_{\mathfrak{a}}(N) := \sup\{i \in \mathbb{N}_0 : H_{\mathfrak{a}}^i(N) \neq 0\}$$

and

$$\operatorname{cd}_{\mathfrak{a}}(M, N) := \sup\{i \in \mathbb{N}_0 : H_{\mathfrak{a}}^i(M, N) \neq 0\}.$$

Assume that N is finitely generated with finite dimension d . For each $i > d$, $H_{\mathfrak{a}}^i(N) = 0$ [2, Theorem 6.1.2] (in other words, $\operatorname{cd}_{\mathfrak{a}}(N) \leq d$) and $H_{\mathfrak{a}}^d(N)$ is Artinian

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Table of Contents The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers

1. Understanding the eBook The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers
 - The Rise of Digital Reading The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers
 - Advantages of eBooks Over Traditional Books
2. Identifying The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers
 - User-Friendly Interface
4. Exploring eBook Recommendations from The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers
 - Personalized Recommendations

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- The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers User Reviews and Ratings
- The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers and Bestseller Lists
- 5. Accessing The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers Free and Paid eBooks
 - The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers Public Domain eBooks
 - The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers eBook Subscription Services
 - The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers Budget-Friendly Options
- 6. Navigating The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers eBook Formats
 - ePub, PDF, MOBI, and More
 - The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers Compatibility with Devices
 - The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers
 - Highlighting and Note-Taking The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers
 - Interactive Elements The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers
- 8. Staying Engaged with The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers
- 9. Balancing eBooks and Physical Books The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time

The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers

11. Cultivating a Reading Routine The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers
 - Setting Reading Goals The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers
 - Fact-Checking eBook Content of The Generalized Pontrjagin Cohomology Operations And Rings With Divided Powers
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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