Abstracts of Plenary Addresses

Local-Global principle for generalized local cohomology modules

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Suppose that $\mathfrak{a}$ and $\mathfrak{b}$ are ideals of R and that M, N are R-modules. Then we set $f_{\mathfrak{a}}^{\mathfrak{b}}(M,N) := \inf\ \{i \in \mathbb{N}_0 \mid \mathfrak{b} \nsubseteq \sqrt{(0:_R H_{\mathfrak{a}}^i(M,N))}\ \}$, and we prove that $f_{\mathfrak{a}}^{\mathfrak{b}}(N) \leqslant f_{\mathfrak{a}}^{\mathfrak{b}}(M,N)$. We have also obtained a generalization of Faltings'Lemma in the context of generalized local cohomology modules.

A combinatorial condition on an infinite ring to be commutative

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Let R be an infinite ring. We prove that R is commutative if and only if $XY \cap YX \neq \varnothing$ for all infinite subsets X and Y, where $AB = \{ab \mid a \in A \text{ and } b \in B\}$ for any two nonempty subsets A and B of R. We also prove that in an infinite ring S, an element $a \in S$ is central if and only if $aX \cap Xa \neq \varnothing$ for all infinite subsets X of S. This work has been done in collaboration with H.E. Bell and A.A. Klein.

A generalization of Auslander's delta invariant using injectives

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Benson and Carlson [BS], Mislin [M], and Vogel [G] independently developed a generalization of Tate-Farrell cohomology applicable to all pairs of modules over associative rings. There is an alternative approach to the theory, based on injectives. In this talk, we first briefly review the injective complete cohomology theory. As an application we introduce some new homological invariants of modules over arbitrary commutative noetherian local rings that detect Gorenstein property of the underlying ring and that would generalize Auslander's delta invariant.

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[G] F. Goichot, *Homologie de Tate-Vogel équivariante,* J. Pure Appl. Algebra **82** (1992), 39-64.

[M] G. Mislin, *Tate cohomology for arbitrary groups via satellites,* Topology Appl. **56** (1994), 293-300.

Classical prime modules over commutative rings

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An R-module M is called classical prime module if the annihilator of any nonzero submodule of M is a prime ideal and a proper submodule P of M is called classical prime submodule if the quotient module M/P is a classical prime module. This notion is introduced and extensively studied. The module in which, classical prime submodules and the prime submodules coincide, are studied, and it is shown that multiplicative modules have this property called compatibility property. It is also shown that each R-module is compatible if and only if each prime ideal is maximal or if and only if the R-module $R \oplus R$ is compatible. Modules in which every proper submodule(proper nonzero submodules) is classical prime are characterized. It is proved that if $\dim(R) < \infty$, then each R-module has a prime submodule if and only if it has classical prime submodule. Modules without prime submodules will be called primeless. Primeless modules are also Characterized. Finally we define classical prime radicals of modules and we determine the classical prime radical of any module over a commutative domain R with $\dim(R) \leq 1$. Also, we show that over commutative domain R with $\dim(R) \leq 1$, every semiprime submodule of any module is an intersection of classical prime submodules.

Local cohomology and the Intersection Theorem

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Let R be a commutative Noetherian ring and let $\mathfrak{a}$ be an ideal of R. For complexes X and Y of R–modules we investigate the invariant $\inf \mathbf{R}\Gamma_{\mathfrak{a}}(\mathbf{R}\mathrm{Hom}_R(X,Y))$ in certain cases. It is shown that, for bounded complexes X and Y with finite homology, $\dim Y \leq \dim \mathbf{R}\mathrm{Hom}_R(X,Y) \leq \mathrm{proj.dim} X + \dim(X \otimes^{\mathbf{L}}_R Y) + \sup X$ which strengthen the Intersection Theorem. Here $\inf X$ and $\sup X$ denote the homological infimum, and supremum of the complex X, respectively.

Associated primes of local cohomology modules of weakly Laskerian modules

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The results which I will mention to them during my talk are based on the articles [DE], [DM2] and [DM3]. These articles are joint works with A. Mafi and M.A. Esmkhani.

Let R be a commutative Noetherian ring with identity, $\mathfrak{a}$ an ideal of R, and M an R-module. For each $i \geq 0$, the i-th local cohomology module of M with respect to $\mathfrak{a}$ is defined as

$$H^i_{\mathfrak{a}}(M) = \varinjlim_n \mathrm{Ext}^i_R(R/\mathfrak{a}^n, M).$$

The reader can refer to [BS] for basic properties of local cohomology. In [Ha], Hartshorne defined an R-module M to be $\mathfrak{a}$-cofinite if $\mathrm{Supp}_R M \subseteq \mathrm{V}(\mathfrak{a})$ and $\mathrm{Ext}^i_R(R/\mathfrak{a}, M)$ is finitely generated for all $i \geq 0$. He then asked when the local cohomology modules of a finitely generated module are $\mathfrak{a}$-cofinite. In this regard, the best known result is that for a finitely generated R-module M if either $\mathfrak{a}$ is principal or R is local and $\dim R/\mathfrak{a} = 1$, then the $H^i(M)$'s are $\mathfrak{a}$-cofinite. These results are proved in [K, Theorem 1] and [DM1, Theorem 1], respectively.

It is easy to see that an $\mathfrak{a}$-cofinite module has only finitely many associated primes. Huneke [Hu] raised the following question: If M is a finitely generated R-module, then the set of associated primes of $H^i_{\mathfrak{a}}(M)$ is finite for all ideals $\mathfrak{a}$ of R and all $i \geq 0$. Singh [S] gives a counter-example to this question (also see [SS] for some other counter-examples). On the other hand, Brodmann and Lashgari [BL, Theorem 2.2] showed that if for a finitely generated R-module M and an integer t, the local cohomology module $H^i_{\mathfrak{a}}(M)$ is finitely generated for all $i < t$, then $\mathrm{Ass}_R(H^t_{\mathfrak{a}}(M))$ is finite. For another proof of this result, see [KS].

The notion of weakly Laskerian modules was introduced recently by Divaani-Aazar and Mafi. As in [DM2], an R-module M is called weakly Laskerian if $\mathrm{Ass}_R(M/N)$ is finite for all submodules N. Let M be a weakly Laskerian module and $t \in \mathbb{N}$. In [DM2], we proved the set of associated primes of the first non $\mathfrak{a}$-cofinite local cohomology module of M is finite. That clearly implies the result mentioned above due to Brodmann and Lashgari. Also regarding the Artinianness of local cohomology, it is shown in [DE], that in many cases weakly Laskerian modules behave similar to finitely generated modules.

In [DM3], we continue studying the set of associated primes of local cohomology of weakly Laskerian modules. By providing some examples, we shows that the class of weakly Laskerian modules is much larger than that of Noetherian modules. Our main aim is to show that in conjunction with finiteness properties of local cohomology, in many cases weakly Laskerian modules behave similar to finitely generated modules. By applying the known techniques we can get the analogues of some finiteness results for finitely generated modules for weakly Laskerian modules. Let M be a weakly Laskerian module. It is shown that if $\mathfrak{a}$ is principal, then the set of associated primes of the local cohomology module $H^i_{\mathfrak{a}}(M)$ is finite for all $i \geq 0$. We also prove that when R is local, then $\mathrm{Ass}_R(H^i_{\mathfrak{a}}(M))$ is finite for all $i \geq 0$ in the following cases: (1) $\dim R \leq 3$, (2) $\dim R/\mathfrak{a} \leq 1$, (3) M is Cohen-Macaulay and for any ideal $\mathfrak{b}$, with $l = \mathrm{grade}(\mathfrak{b}, M)$, $\mathrm{Hom}_R(R/\mathfrak{b}, H^{l+1}_{\mathfrak{b}}(M))$ is weakly Laskerian.

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Bear Criterion for injectivity of projection algebras

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Projection algebras are M-sets for the monoid $M = (\mathbb{N}^{\infty}, min)$ which are used by computer scientists for algebraic specification of process algebras. In contrast to the case of modules it is well-known that the Bear Criterion does not generally hold for injectivity of M-sets for an arbitrary monoid M.

Here, introducing a closure operator, we prove that the Bear Criterion does hold for injectivity of projection algebras.

The role of embedded components in the intersection of algebraic varieties

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In classical algebraic geometry the structure of algebraic variety of the intersection of two algebraic varieties $V(I)$ and $V(J)$, where I and J are homogeneous ideals of the ring $S = k[x_0, \cdots, x_n]$, is given by $V(I + J)$ or equivalently by $\sqrt{I + J}$, but scheme theoretically $V(I) \cap V(J)$, may has irreducible components which are not reduced, or has irreducible components Z_i which set theoretically is contained in another irreducible component $V(I) \cap V(J)$. Algebraically these facts can be stated in terms of the primary decomposition of $I + J = \mathfrak{q_o} \cap \mathfrak{q_1} \cdots \cap \mathfrak{q_s} \cap \mathfrak{q_{s+1}} \cdots \cap \mathfrak{q_r}$ where $\sqrt{\mathfrak{q_o}} = (x_0, \cdots, x_n)$ is the irrelevant ideal, $\sqrt{\mathfrak{q_i}} \neq \sqrt{\mathfrak{q_j}}$ for $0 < i, j < s + 1$ and $i \neq j$, are embedded components and for each $t, s < t \leq r$, there exist an i_0, with $0 < i_0 < s + 1$ such that $\sqrt{\mathfrak{q_t}} \subset \sqrt{\mathfrak{q_{i_o}}}$. With the invent of new notion of length multiplicity ([BM], see also [EH], [H]) the role of irrelevant ideal as well as the role of embedded components in the primary decomposition of $I + J$ or the scheme structure of $V(I) \cap V(J)$ can be described in terms of a new invariant.

The geometric notions which is used to describe the role of each of the irrelevant, isolated and embedded components are classical degree, geometric degree and arithmetic degree. In this area, one of the important questions is to find bounds for these degrees in terms of the generators of the ideal which they are defined for it.

In this talk we will try to use these notions to describe some properties of intersected varieties, such as their relationship with effective Nullstellensatz, Castelnuovo-Mumford regularity as well as m-regularity,in particular the effect of iterated hyperplane sections of a projective variety, with defining ideal I, to count down the classical degree and how this process would tend to find a regular sequence for the module S/I.

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Associated primes of graded components of generalized local cohomology modules

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We show that the i-th generalized local cohomology module of finitely generated graded modules M and N over a standard positive graded commutative Noetherian ring R, with respect to the irrelevant ideal R_+, is itself graded; all its graded components are finitely generated modules over R_0, the component of R of degree 0. Also we prove that the n-th component of $H^i_{R_+}(M,N)_n$ of this generalized local cohomology module $H^i_{R_+}(M,N)$ is zero for all $n \gg 0$. Moreover, in this paper, we study the asymptotic behaviour of $\mathrm{Ass}_{R_0}(H^i_{R_+}(M,N)_n)$ as $n \longrightarrow -\infty$ in the following cases:
(i) i is the least integer j for which $H^j_{R_+}(M,N)$ is not finitely generated.
(ii) The base ring R_0 is local of dimension at most one and for all $i \geq 0$.

Some results of local cohomology modules

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Let R be a commutative Noetherian ring, $\mathfrak{a}$ an ideal of R, and let M be a finitely generated R-module. For a non-negative integer t, we prove that $H^t_{\mathfrak{a}}(M)$ is $\mathfrak{a}$-cofinite whenever $H^t_{\mathfrak{a}}(M)$ is Artinian and $H^i_{\mathfrak{a}}(M)$ is $\mathfrak{a}$-cofinite for all $i < t$. This result, in particular, characterize $\mathfrak{a}$-cofiniteness property of local cohomology modules of certain regular local rings. Also, we show that for a local ring $(R,\mathfrak{m})$, $f-\mathrm{depth}(\mathfrak{a},M)$ is the least integer i such that $H^i_{\mathfrak{a}}(M) \ncong H^i_{\mathfrak{m}}(M)$. This result in conjunction with first one, yields some interesting consequences. Finally, we extend the non- vanishing Grothendieck's Theorem for $\mathfrak{a}$-cofinite modules.

Zero divisor graph of a commutative semigroup

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For a commutative semigroup S with 0, the zero divisor graph of S denoted by $\Gamma(S)$, is the graph whose vertices are nonzero zero-divisor of S, and two vertices x, y are adjacent in case $xy = 0$ in S.Three major problems in this area would at this time be: characterize the resulting graphs; when do two semigroups have isomorphic graphs; relate the structure of the graph to that of the semigroup.

Here we state a few results on the third problem, and some related results on the chromatic number of the zero divisor graph. Also The properties of $\Gamma(S)$ when $\Gamma(S)$ is k-partite are studied.

Superficial elements for modules

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We extend the concept of the superficial elements for modules and give several bounds on number of generators of submodules in a finitely generated module.

Local cohomology and integral closures

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Let $(R, \mathfrak{m})$ be a formally equidimensional local ring of dimension d. Suppose that Φ is a system of non-zero ideals of R such that for all minimal prime ideals $\mathfrak{p}$ of R, $\mathfrak{a} + \mathfrak{p}$ is $\mathfrak{m}$-primary for every $\mathfrak{a} \in \Phi$. In this paper, the main result asserts that for any ideal $\mathfrak{b}$ of R, the integral closure $\mathfrak{b}^{*(H^d_\Phi(R))}$ of $\mathfrak{b}$ with respect to the Artinian R-module $H^d_\Phi(R)$ is equal to $\mathfrak{b}_a$, the classical Northcott-Rees integral closure of $\mathfrak{b}$. This generalizes the main result of [STY] concerning the question raised by D. Rees.

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Strength of tensor products of vector spaces

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Let n be a positive integer and a be an integer. Gauss proved that $\sum_{d|n} \mu(n/d)a^d \equiv 0 \pmod{n}$, where μ is the Möbius function. This result generalizes both Fermat's little theorem and Euler's theorem. In this talk, a generalization of this result to finite groups is proved by methods of tensor products of vector spaces.

Scarf toric varieties

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A minimal free resolution offers a microscope used for enlarging the peculiarities of a variety through its defining ideal or equations. So it is worth studying varieties whose minimal free resolutions can be explicitly written down from their equations. A well-known example of such varieties is complete intersections whose minimal free resolutions are Koszul complexes. Yet there are other varieties whose minimal free resolutions are derived from combinatorial data hidden in minimal generators of their defining ideals. Scarf toric varieties will give us such varieties which are appeared in the toric geometry. In [PS], Peeva and Sturmfels introduced the notion of genericity of toric varieties. The main goal of this talk is to show that for toric (monomial) curves, the notion of Scarfness coincides with the notion of genericity.

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Complete cohomology and Gorensteinness of schemes

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Classical Tate cohomology goes back to the Tate's observation [T] that the $\mathbb{Z}G$-module $\mathbb{Z}$ with the trivial action, when G is a finite group, admits a totally acyclic resolution. He showed that this complex is a homotopy invariant of $\mathbb{Z}$ and so used it to define Tate cohomology $\widehat{\mathrm{Ext}}^n_{\mathbb{Z}G}(\mathbb{Z},\ )$. It was extended by Buchweitz to two sided noetherian Gorenstein rings [Bu]. More recently, Vogel generalized the theory to arbitrary rings [G]. A good source for background and details of the theory is Kropholler's survey [K]. There is an alternative approach to the theory, see e.g. [N]. In this talk, we introduce and study Vogel cohomology in the category of sheaves of $\mathcal{O}_X$-modules over a scheme X. Among other things, we show that this theory can provide a numerical characterization for Gorenstein schemes.

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Hilbert-Kirby polynomial and graded local cohomology modules

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Let M be a finitely generated graded module over a Noetherian homogeneous ring R with local base ring $(R_0, \mathfrak{m}_0)$. Then, the n-th graded component $H^i_{R_+}(M)_n$ of the i-th local cohomology module of M with respect to the irrelevant ideal R_+ of R is a finitely generated R_0-module which vanishes for all $n \gg 0$. In various situations we show that, for an $\mathfrak{m}_0$-primary ideal $\mathfrak{q}_0 \subseteq R_0$, the multiplicity $e_{\mathfrak{q}_0}(H^i_{R_+}(M)_n)$ of $H^i_{R_+}(M)_n$ is antipolynomial in n of degree less than i. In particular we consider the two cases $i < g(M)$ and $i = g(M)$ where $g(M)$ is the so called cohomological finite length dimension of M. In these cases we express the degree and the leading coefficient of the representing polynomial in terms of local cohomological data of M (e.g. the sheaf induced by M) on $\mathrm{Proj}(R)$. We also show that the lengths of the graded components of various graded submodules of $H^i_{R_+}(M)$ are antipolynomial of degree less than i and prove invariance results on these degrees.

Differential operators attached to commutative algebra

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The purpose of this talk is to give a brief introduction to Grothendieck's algebraic definition of differential operators attached to a commutative algebra and the recent interest in the subject.

Different kinds of purity

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The concept of purity for Abelian groups can be generalized to modules over arbitrary rings in several ways of which the well-known is Cohen's purity. We intend to investigate some variants of purity.

A Theorem of Bass: Past, present, and future

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In this talk we will give a survey on some recent research on a Theorem of Bass. Some open questions and further directions of research are presented.

Seminormality of generic projections with canonical forms

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Let A be a ring and B an integral over ring of A. The *seminormalization of A in B* is the largest subring A' of B containing A such that the following conditions hold:
(i) For each $P \in \mathrm{Spec}(A)$, there is exactly one $P' \in \mathrm{Spec}(A')$ lying over P.
(ii) The canonical homomorphism of residue fields $k(P) \longrightarrow k(P')$ is an isomorphism.

The seminormalization of A in B is denoted by A_B^+. If $A_B^+ = A$, then A is said to be *seminormal in B*. When B is the integral closure of A in its total ring of fractions, A_B^+ is denoted by A^+ and it is called *seminormalization of A*. If $A^+ = A$, then A is said to be *seminormal* (SN). Seminormality is a local property. More precisely, a ring A is SN if and only if A_P is SN for every prime ideal P of A such that $\mathrm{depth}(A_P) = 1$ (see [GT]). A variety is said to be seminormal if all its local rings are SN.

Let X be a smooth projective variety of dimension r over an algebraically closed field k. Let $\pi : X \longrightarrow \mathbb{P}^m$ be a generic linear projection, where $r+1 \leq m \leq 2r$. It turns out that it is also a finite birational map onto $X' = \pi(X)$.

An old conjecture of Andreotti, Bombieri and Holm relates the above two concepts: it states that the variety X' obtained by a generic projection is SN (see [B] and [AH]). For $m = r+1$ it is known that X' is seminormal (see [GT]) and [RZ]). For $m > r+1$ the conjecture has been answered in a few cases (see [Z]). All available approaches heavily depend on the explicit defining equations for the arising singularities and the computation of depth of their local rings (see [A, Introduction]). Recently, the explicit defining equations and the depth of the local rings are obtained for generic projections with canonical forms at all analytically irreducible singularities [SZ]. The aim of the present paper is to extend this result to all singularities of X' at all points on an open set $U \subset X'$ where π has a canonical form in the sense of [R] and to prove their seminormality. The net result is that if $V = \mathrm{Spec}(A) \subset U$ is any affine open subset of X' and if $P \in \mathrm{Spec}(A) \cap \mathrm{Sing}(X')$ then $\mathrm{depth}(A_P) = 1$ if and only if P is a generic point of $\mathrm{Sing}(X')$. This immediately implies seminormality.

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Domination ideal of a graph

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For any graph G with vertex set $\{v_1, \ldots, v_n\}$, an ideal $I(G)$ of height $\gamma(G)$ in $R(G) = k[x_1, \ldots, x_n]$, the ring of polynomials over a field k, is associated, where $\gamma(G)$ is the domination number of G. In this talk, we will present some properties of the ideal and its Alexander dual. Also some algorithms to compute all dominating sets and domination number of a graph will be drown using Alexander duality of the domination ideal.