MATHEMATISCHES FORSCHUNGSINSTITUT OBERWOLFACH

Tagungsbericht 22/1992

Kommutative Algebra und algebraische Geometrie

24.5. bis 30.5.1992

Die Tagung stand unter der Leitung von E. Kunz (Regensburg), H.-J. Nastold (Münster) und L. Szpiro (Paris).

In den Vorträgen wurde über neuere Ergebnisse aus der kommutativen Algebra und algebraischen Geometrie berichtet. Unter den verschiedenen Themenkreisen, die diskutiert wurden, sind folgende besonders hervorzuheben: Eine Reihe von Vorträgen beschäftigte sich mit 0-dimensionalen Unterschemata des $\mathbf{P}^n$, insbesondere mit der Frage, wie sich geometrische Eigenschaften der unterliegenden Punktmengen in den Hilbertfunktionen der Koordinatenringe widerspiegeln. Einen weiteren Schwerpunkt bildeten Referate über neuere Entwicklungen in der Residuen- und Dualitätstheorie. Reges Interesse fand dabei der Vortrag von A.N. Parshin (Moskau) über Beilinsons Residuenkonstruktion. Auf Wunsch des Auditoriums gab Herr Parshin in weiteren informellen Vorträgen Gelegenheit, sich darüber eingehender zu informieren. Ferner berichteten mehrere Redner über Resultate und Fragen aus der arithmetischen algebraischen Geometrie. Von den übrigen Einzelthemen seien noch erwähnt: Logarithmische Strukturen auf Schemata, Fundamentalgruppen von Varietäten, Raumkurven, Chernklassen.

Die hohe Zahl ausländischer Gäste unterstreicht das weltweite Interesse an der Tagung; so kamen -neben den 15 deutschen Teilnehmern- 16 aus europäischen Ländern (davon 4 aus Osteuropa), 17 aus Nordamerika, 2 aus Japan und je einer aus Israel, Brasilien, Saudi-Arabien, Indien und Vietnam.

Vortragsauszüge

S.S. Abhyankar

More about Galois Theory on the Line

In my 1957 paper in the American Journal, I considered the algebraic fundamental group $\pi_A(L_k)$ of the affine line L_k over an algebraically closed ground field k of characteristic $p \neq 0$, and I conjectured that $\pi_A(L_k) = Q(p)$ where $Q(p)$ is the set of all quasi p-groups.

Gefördert durch DFG Deutsche Forschungsgemeinschaft

Here $\pi_A(L_k)$ is defined to be the set of all finite Galois groups of unramified coverings, and by a quasi p–group we mean a finite group which is generated by all its p–Sylow subgroups.

In support of this conjecture, in the 1957 paper, I considered the unramified covering of L_k given by

$$\overline{F}_{n,q,s,a} = Y^n - aX^sY^t + 1 \text{ with } 0 \neq a \in k \text{ and } n - t = q = a \text{ power of } p$$

where s and $n > t \not\equiv 0(p)$ are positive integers, and I suggested that its Galois group $\overline{G}_{n,q,s,a}$ should be computed. Now, with inspiration from Serre and sometimes using CT (=the Classification Theorem of Finite Simple Groups), I have proved the following

(1) $t = 1 \Rightarrow \overline{G}_{n,q,s,a} = PSL(2,q)$.
(2) $q = p > 2 \leq t$ and $p,t) \neq (7,2) \Rightarrow \overline{G}_{n,q,s,a} = A_n$.
(3) $q = p > 2 \leq t$ and $(p,t) = (7,2) \Rightarrow \overline{G}_{n,q,s,a} = PSL(2,8)$.
(4) $q = p = 2 \Rightarrow \overline{G}_{n,q,s,a} = S_n$.
(5) $q < t$ and $p > 2 \Rightarrow \overline{G}_{n,q,s,a} = A_n$.
(6) $p = 2 < q < t \Rightarrow \overline{G}_{n,q,s,a} = A_n$.
(7) $p = 2 < q = 4$ and $t = 3$ (and $n = 7$)$\Rightarrow \overline{G}_{n,q,s,a} = PSL(3,2)$.
(8) $p = 3 < q = 9$ and $t = 2$ (and $n = 11$)$\Rightarrow \overline{G}_{n,q,s,a} = M_{11}$.

Out of this, (6) was proved in collaboration with Ou and Sathaye, (1) and (7) are collaborative work with Serre, and (8) was proved in collaboration with Popp and Seiler. Note that A_n is the alternating group, S_n is the symmetric group, M_{11} is the Mathieu group of degree 11, and $PSL(m,q) = SL(m,q)/(\text{scalar matrices})$ where $SL(m,q)$ = the group of all m by m matrices whose determinant is 1 and whose entries are in the field $GF(q)$ of q elements.

A.G. Aleksandrov

Residuen und Dualtiät für nichtisolierte Singularitäten

Sei $X \subset (C^{n+1},0)$ der Keim einer n–dimensionalen Hyperfläche, Sing(X) der Keim der singulären Punkte von X. Wir betrachten die Garbe Ω^p_X der Keime von holomorphen Differentialformen vom Grade p auf X, die $\mathcal{O}_X$–Torsionsuntergarbe $\operatorname{Tors}\Omega^p_X$ von Ω^p_X und den Raum $T^1(X)$ der infinitesimalen Deformationen von X. Weiter sei codim(Sing $X, X) = 1$. In diesem Fall sind die Dimensionen der $\mathbb{C}$–Vektorräume $\operatorname{Tors}\Omega^1_X$ und $T^1(X)$ unendlich.

Hier wird erklärt, wie man mit Hilfe des Grothendieckschen Residuensymbol im Sinne von [E.Kunz. Math. Zeit. 152 (1977)] die vollständige Paarung erhält, die analog zu bekannten nicht ausgearteten bilinearen Formen auf Hyperflächen mit isolierter Singularität ist:

$$\operatorname{Tors}\Omega^1_X \times T^1(X) \xrightarrow{\text{res}\,\tau} \Omega^{n-1}_{\tau/C}$$

Hierbei sei τ ein $\mathbb{C}$ umfassender Vertreterkörper in $\hat{\mathcal{O}}_{X,\mathrm{Sing}\,X}$. Es werden die Poincaré-Reihen $P(\mathrm{Tors}(\Omega^p_X);t)$ und $P(T^1(X);t)$ für quasihomogene Hyperflächen berechnet.

D. Eisenbud

Higher Castelnuovo Theory and a theorem of Macaulay

I described recent work with Mark Green and Joe Harris on a new series of conjectures which would extend Castelnuovo theory ("curves of rather large genus for their degree are quite special") on one hand and Macaulay's Theorem ("characterization of Hilbert functions") on the other. An easy piece of these conjectures to state concerns the possible Hilbert functions of graded ideals containing a maximal complete intersection of quadrics: Let $S = k[x_0, \ldots, x_r]$ be a polynomial ring over a field k, and let $I \subset S$ be an ideal sucht that $I \ni Q_1, \ldots, Q_r$, a regular sequence of quadrics. Suppose that

$$\dim_k(S/I)_d = \binom{h_d}{d} + \binom{h_{d-1}}{d-1} + \cdots + \binom{h_1}{1} \quad \text{with} \quad h_d > \cdots > h_1 \geq 0$$

Conjecture:

$$\dim_k(S/I)_{d+1} \leq \binom{h_d}{d+1} + \binom{h_{d-1}}{d} + \cdots + \binom{h_1}{2}$$

G. Frey

Curves of genus two covering elliptic curves

First we made the following remarks about curves C covering the projective line over a global field K: Assume that the d–fold symmetric product of C has infinitely many K–rational points then a result of Faltings implies that there is a K–rational covering $\varphi: C \to \mathbf{P}^1$ of degree $\leq 2d$. It follows that for a prime $N > 120d$ there are only finitely many elliptic curves defined over number a field K of degree $\leq d$ having a K–rational isogeny of degree N.

Next (joint work with E.Kani) we described the moduli space of curves of genus 2 covering an elliptic curve of (minimal degree) N. It is an open part of $X(N) \times X(N)/\mathrm{Sl}(2, \mathbb{Z}/N)$ where $Y(N)$ is the modular curve parametrizing elliptic curves with canonical level-N-structure. It is possible to describe the boundary of the moduli space, and especially it follows that for any elliptic curve E and any $N \geq 2$ there are many curves C of genus 2 covering E of degree N. We showed how this can be used to estimate the height of elliptic curves E by the self-intersection number of the relative canonical sheaf of the arithmetical surface related to curves C of genus 2.

A. V. Geramita (joint work with A. Gimigliano (Genova))

Rational Surfaces and Points in $\mathbf{P}^2$

Let $\mathbf{X} = \{P_1, \ldots, P_s\} \subseteq \mathbf{P}^2(k)$, $k = \bar{k}$ (char $k = 0$), $\mathbf{Y} = \mathbf{P}^2(P_1, \ldots, P_s)$ the blow-up of $\mathbf{P}^2$ at the points $P_1, \ldots, P_s$, $\pi\colon \mathbf{Y} \to \mathbf{P}^2$ the blow-up morphism. Let $\pi^{-1}(P_i) = E_i$, $\pi^{-1}(L) = E_0$ (L a line missing $\mathbf{X}$).

Let $I = \mathfrak{p}_1^{\alpha_1} \cap \cdots \cap \mathfrak{p}_s^{\alpha_s} \subseteq k[x,y,z] = R$. Then I_d is the linear system of plane curves of degree d which have, at P_i, a singularity of multiplicity $\geq \alpha_i$. Let $H(R/I, -)$ denote the Hilbert function of R/I, then for $t >> 0$, $H(R/I,t) = \Sigma \binom{\alpha_i + 1}{2}$. Let $\sigma(I)$=least integer t for which $\Delta H(h/I,t) = 0$.

If $D_d = dE_0 - \Sigma \alpha_i E_i \in \mathrm{Div}(\mathbf{Y})$ then $\dim I_d = h^0(\mathcal{O}_{\mathbf{Y}}(D_d))$ and $\sum_{i=1}^{s} \binom{\alpha_i+1}{2} - H(R/I,d) = h^1(\mathcal{O}_{\mathbf{Y}}(D_d))$ ($h^2(\mathcal{O}_{\mathbf{Y}}(D_d)) = 0$ in any case).

Proposition (Davis-Germita) i) D_t is very ample for $t \geq \sigma + 1$.
ii) D_σ is very ample $\Leftrightarrow$ for E the proper transform of a line in $\mathbf{P}^2$, then $D_\sigma \cdot E > 0$.

Now suppose D_t is very ample for $t \geq \sigma$ and let $N + 1 = h^0(\mathcal{O}_{\mathbf{Y}}(D_t))$. Denote by $\mathcal{V}_t$ the image, in $\mathbf{P}^N$, of the embedding determined by D_t. Then $J_{\mathcal{V}_t} \subseteq k[x_0, \ldots, x_N] = S$ is the homogeneous ideal of $\mathcal{V}_t$ and $A = S/J_{\mathcal{V}_t}$ the homogeneous coordinate ring. Then

Theorem: A is arithmetically Cohen-Macaulay.

One also proves that $\dim(J_{\mathcal{V}_t})_2 = \sum_{i=1}^{s} \binom{\alpha_i}{2}$ and each set of $\binom{\alpha_i}{2}$–quadrics (one set for each i), corresponds to a rational normal scroll of dimension $d - \alpha_i + 1$ (with $(d-\alpha_i)$–dimensional fibres) containging $\mathcal{V}_t$.

D. Goldfeld

Special values of derivatives of L–functions

Let E be an elliptic curve defined over $\mathbf{Q}$ with conductor$(E) = N$. We assume E is modular for $\Gamma_0(N) = \{\begin{pmatrix} a & b \\ c & d \end{pmatrix} \in \mathrm{Sl}(2, \mathbf{Z}) \mid c \equiv 0(N)\}$ which is equivalent to saying that there exist automorphic forms $\alpha(z), \beta(z)$ for $\Gamma_0(N)$ (i.e. $\alpha\left(\frac{az+b}{cz+d}\right) = \alpha(z)$, $\alpha\left(\frac{az+b}{cz+d}\right) = \beta(z)$ for all $\begin{pmatrix} a & b \\ c & d \end{pmatrix} \in \Gamma_0(N)$) such that $\beta(z)^2 = 4\alpha(z)^3 - g_2\alpha(z) - g_3$ where $y^2 = 4x^3 - g_2 x - g_3$ is the Weierstraß form for E. Then $\frac{d\alpha}{\beta} = f(z)dz$ is the pullback of the canonical differential $\frac{dx}{y}$ on E. Define $F(z) := -2\pi i \int_z^{i\infty} f(w)dw$. Then $F(gz) - F(z)$ is independent of z for $g \in \Gamma_0(N)$. Define $\sigma(g) := F(gz) - F(z)$. Then $\sigma\colon \Gamma_0(N) \to$ (period lattice of E9 is a homomorphism $\sigma(g_1 g_2) = \sigma(g_1) + \sigma(g_2)$ with ker (σ) generated by the elliptic, parabolic, and commutators of $\Gamma_0(N)$. Manin proved that there exist finite sets $g_1, g_2, \ldots, g_r \in \Gamma_0(N)$, $c_1, c_2 \ldots, c_r \in \mathbf{Q}$ s.t. $L_E(1) = \sum_{i=1}^{r} c_i \sigma(g_i)$. We generalize Manin's theorem to derivatives of the L–function $L_E(s)$ associated to E. We show that there exists a 1–cocycle $\sigma(g,z)$ for $\Gamma_0(N)$ satisfying $\sigma(g_1,g_2,z) = \sigma(g_1g_2z)+\sigma(g_2,z)$ such that if $L_E(1)=0$ then $L'_E(1) = \sum_{i=1}^{r} c_i\sigma(g_i,z_i)$ where $c_1,c_2,\ldots,c_r \in \mathbf{Q}$, $g_1,g_2,\ldots,g_r \in \Gamma_0(N)$ and $z_1,\ldots,z_r \in \mathrm{Cusps}(\Gamma_0(N))$.

S. Goto

Non-Noetherian symbolic blow-ups for space monomial curves

Let k be a field and let n_1,n_2,n_3 be positive integers with $GCD(n_1,n_2,n_3)=1$. Let $A = k[[X,Y,Z]]$ be a formal power series ring over k and let $\varphi\colon A \to k[[t]]$ denote the k–algebra map defined by $\varphi(X)=t^{n_1}$, $\varphi(Y)=t^{n_2}$, $\varphi(Z)=t^{n_3}$. Let $\mathfrak{p}=\mathfrak{p}(n_1,n_2,n_3)$ be the kernel of φ. Then it remains open whether the symbolic Rees algebra $R_s(\mathfrak{p}) = \bigoplus_{n\geq 0}\mathfrak{p}^{(n)}$ is a Noetherian ring for any such prime ideal $\mathfrak{p}$ of A. The purpose of my talk is to construct counterexamples to the above question. My theorem is

Theorem (joints with K.Nishida and K.-I.Watanabe) Let $n\geq 4$ and $2m > n+1$ and $n_1 = 7m-3$, $n_2 = 5mn-m-n$, $n_3 = 8n-3$ and assume that $GCD(n_1,n_2,n_3)=1$. Let $\mathfrak{p}=\mathfrak{p}(n_1,n_2,n_3)$. Then we have
(i) if ch$k = p > 0$, $\exists h \in \mathfrak{p}^{(3p)}$ s.t. $h = Z^{(7n-3)p} \bmod (X,Y^3)$. Hence $R_s(\mathfrak{p})$ is a Noetherian ring but not a Cohen-Macaulay ring.
(ii) If ch$k=0$, then $R_s(\mathfrak{p})$ is not a Noetherian ring.

The simplest example obtained by this theorem is the ideal

$$\mathfrak{p} = \mathfrak{p}(18,53,29) = I_2\begin{pmatrix} X^3 & Y^2 & Z^7 \\ Y & Z^4 & X^5 \end{pmatrix} = (Z^8 - X^7Y^2, X^{11} - YZ^5, Y^3 - X^4Z^3)A$$

If we consider the same ideal P inside $B = \mathbf{Q}[X,Y,Z]$, then $R_s(\mathfrak{p})$ is not a finitely generated $\mathbf{Q}$–algebra.

G. Gotzmann

Invariants of Hilbert-schemes – a few examples

Let $H_{d,g} = \mathrm{Hilb}^P(\mathbf{P}^3_{\mathbf{C}})$, $P(T) = dT-g+1$ denote the Hilbert scheme of space curves. Only the first two cohomology groups are known in general:
$H^0(H_{d,g};\mathbf{Z}) = \mathbf{Z}, H^1(H_{d,g};\mathbf{Z}) = 0$ (and in the case char $k = p > 0$
$H^1_{\text{et}}(H_{d,g};\mathbf{Z}/n\mathbf{Z}) = 0$ if we further suppose $p \geq d$). So it is natural and interesting to ask what the group $H^2(H_{d,g},\mathbf{Z})$ might be. In the talk a method was presented which enables one to show (by direct computation) that $H^2(H_{4,2};\mathbf{Z})$ is equal to $\mathbf{Z}^4$ and that $H^2(H_{3,0},\mathbf{Z})$ is equal to $\mathbf{Z}^3$ or to $\mathbf{Z}^4$.

R. Hartshorne

Algebraic Space Curves

We study algebraic curves in a projective 3–space $\mathbf{P}_k^3$ over an algebraically closed field k. While the original curves of interest are the irreducible non-singular curves, it has become clear from recent work that the natural context for the problem is to study all **curves** which are equi-1–dimensional closed subschemes of $\mathbf{P}^3$ without embedded points. In the same way by **surface** we will mean an equi-2–dimensional closed subscheme of $\mathbf{P}^3$ without embedded components.

It is convenient to regard a curve on a surface as a divisor. Our curves need not, of course, be Cartier divisors. So we introduce a theory of **generalized divisors**. For any locally Gorenstein scheme X (or more generally a scheme X satisfying G_1 ("Gorenstein in codimension one") and S_2 (condition S_2 of Serre) we define generalized divisors, in such a way that every pure codimension 1 closed subscheme without embedded points becomes an effective generalized divisor. One must be careful only that generalized divisors do not form a group. However one has a large subgroup of "almost Cartier divisor" which acts on the set of generalized divisors. Otherwise the familiar theory extends to generalized divisors: associated sheaf $\mathcal{L}(D)$ to a divisor D, which is a reflexive sheaf on X; for an effective divisor D, the exact sequence

$$0 \to \mathcal{L}(-D) \to \mathcal{O}_X \to \mathcal{O}_D \to 0$$

linear equivalence, etc.

Now one can conveniently define liaison (linkage) of curves as follows: C and C' are linked if they lie on a surface F, and as divisors on F, $C' \sim mH - C$, for some $m \geq 0$, where H denotes the hyperplane section.

In my talk I reviewed the results over the last ten years or so about linkage classes of curves determined by the Rao module $M_C = \bigoplus_{n \in \mathbb{Z}} H^1(\mathcal{O}_C(n))$, and the results of Deschamps, Perrin, Ballico, Bolondi, Migliore giving the structure of the even liasion classes of curves in $\mathbf{P}^3$ in terms of their minimal curves.

These results suggest that the problem of determining the postulation of all possible curves in $\mathbf{P}^3$ is perhaps not as impossible as it seemed before.

As a modest beginning, I mentioned my recent calculations of the postulation of all possible curves on surfaces of degree 2. Of course curves on the nonsingular quadric surface and on the quadric cone are well-known, so it is the curves on the union of two planes $H_1 \cup H_2$ or a doubled plane $2H$ which are of new interest. Here also the theory of generalized divisors becomes useful.

C. Huneke

Uniform Artin-Rees

We talk about the following two theorems:

Theorem 1: Let R be a noetherian ring which satisfies one of the following three conditions:

i) R is essentially of finite type over a noetherian local ring or over $\mathbb{Z}$.

ii) $\operatorname{char} R = p > 0$ and R is finite over R^p.

iii) R is an excellent domain and $\dim R \leq 3$.

Then for all finitely generated R-modules $N \subseteq M$ there exists a $K = K(N, M)$ such that

$$I^n M \cap N \subseteq I^{n-k} N \quad \text{for all } n \geq k$$

and for all ideals $I \subseteq R$.

We say that R has the **uniform Artin-Rees** property in this case.

The proof needs other information about uniform behaviour and in particular we also prove:

Theorem 2: Let R be a reduced ring satisfying one of the following conditions:

i) R is essentially of finite type over an excellent local ring or over $\mathbb{Z}$.

ii) $\operatorname{char}(R) = p > 0$ and R is finite over R^p.

iii) R is a domain, is excellent, and $\dim R \leq 2$.

Then there exists a k such that for all ideals $I \subseteq R$,

$$\overline{I^n} \subseteq I^{n-k}$$

Here $\overline{I^n}$ = integral closure of I^n.

The techniques to prove these two theorems come from a variety of sources, but mainly one from tight closure theory, resolution of singularities, and work related to the Briancon-Skoda theorem, especially that of Lipman and Sathaye.

A. Iarrobino

Graded Ideals in $K[x, y]$ and Ramification (joint work with J.Yameogo)

We consider $X = \mathbf{P}^1$, the projective line, and graded ideals I in $R = k[x, y] = \bigoplus_{i=0}^{\infty} \Gamma_X(\mathcal{O}_X(i))$. The ramification sequence $p(I_i, x)$ is a sequence of integers specifying the order of vanishing of a well-chosen basis of I_i at $x = 0$ on $\mathbf{P}^1$. The ramification $p(I, x) = (\cdots, p(I_i, x), \cdots)$, is the collection of ramification sequences of I_i at x, for all i. There is a unique monomial ideal E_I with the same ramification sequence as I at x. We let $V(E) = \{\text{Ideals } I \subset R \mid E_I = E\}$. Our goal is to study $V(E) = V(E, x)$ (at the point $x = 0$) and the intersections $V(E, x) \cap V(E', x')$ of ramification conditions at different points x, x' of $\mathbf{P}^1$.

L.Göttsche determined the dimension $\dim V(E)$, and showed that $V(E)$ is an affine cell, using the method of Bialynicki-Birula. J.Yameogo has noted that $V(E)$ is also a "vertical cell" of the family G_T of graded ideals in R, sucht that the Hilbert function $T(R/I) = T(R/E)$ - a concept studied previously by J.Briancon et al.

Our first main result is to determine the dimension $\dim V(E)$ in a more natural manner, using a sequence of partitions that encodes how one constructs the standard cobasis E^C for E. As a consequence, we show that the homology $H^{\cdot}(G_T)$ satisfies, there is an additive isomorphism

$$\varphi: H^{\cdot}(G_T) \underset{\text{add}}{\cong} \prod H^{\cdot}(\text{small Grassmanians})$$

But φ is not an isomorphism of rings.

Our second main result is to determine the ring $H^{\cdot}(G_T)$ for Hilbert functions $T = (1, 2, \ldots, d, d, \ldots, d, 1)$. As a consequence, we can determine the homology class dimension and multiplicity of the intersection of ramification conditions $V(E, x) \cap V(E', x')$ for E, E' monomial ideals in G_T.

Although such G_T are well behaved, when $T = (12321)$, the cells do not satisfy the frontier condition, do not intersect property, and are not dual bases in complementary dimensions.

L. Illusie

An Introduction to logarithmic algebraic geometry

Logarithmic algebraic geometry arose from the work of Hyodo-Kato on the Fontaine-Jannsen conjecture on the structure of the de Rham cohomology of X_K/K for proper schemes X over a complete discrete valuation ring A of mixed characteristics, with fraction field K, having semistable reduction. A log scheme is a scheme X endowed with a sheaf of monoids M and a homomorphism $\alpha: M \to \mathcal{O}_X$ (multiplicative) such that $\alpha: \alpha^{-1}(\mathcal{O}_X^*) \xrightarrow{\sim} \mathcal{O}_X^*$. Maps are defined in the obvious way. There are nice finiteness conditions ("fineness") giving rise to a notion of smoothness extending the range of smoothness in classical algebraic geometry. For example, an affine toric variety X/k is log smooth for a natural log structure on X. A map X/S with semistable reduction as above is log smooth for certain canonical log structure on X/S. There is a theory of differential calculus in this context, and of crystalline cohomology developed by Hyodo-Kato. Recent developments of the theory include Dieudonné theory for "log" degenerating p-divisible gorups and the description of Chai-Faltings compactifications as solutions of certain log moduli problems. The basic facts on logarithmic algebraic geometry are in K. Kato, Logarithmic structures of Fontaine-Illusie, in "Algebraic Analysis, Geometry and Number Theory", The John Hopkins University Press (1989).

C. Ionescu

Symbolic powers of prime ideals in polynomial rings

Let k be a field, $R = k[x_1, \ldots, x_n]$ be the polynomial ring over k, P a prime ideal in R. For $f \in P$ it is interesting how to decide when f belongs to a symbolic power $P^{(k)}$ of P. In the case of k being of characteristic zero or the power being less than the characteristic one can use a filtration given by ordinary derivations, otherwise one should use a filtration obtained by high differentials. Then $f \in P^{(k)}$ if all partial derivatives of f, until order $k-1$, belongs to P. Similar results are known from Zariski, Tognoli, Seibt.

F. Ischebeck

A principal ideal domain A such that $SL(A)$ is not generated by elemantary matrices

$SL(A) := \lim_{n\to\infty} SL_n(A)$, $E(A)$ is the subgroup generated by elementary matrices, $SK_1(A) := SL(A)/E(A)$. (SK_1 is a direct summand of K_1.) If A is a Euclidean domain, then (trivially) $SK_1(A) = 0$. This need not be so, if A is a general principal ideal domain; the first example was given by Bass. The example given here is the following: $A := S^{-1}\mathbf{R}[X,Y]$, where S is generated by
$\{$ all f without real zeroes $\} \cup \{X^2 + Y^2 - a \mid a \geq 0\}$. (One may also choose S generated by

$$\{\text{all } f \text{ without real zeroes}\} \cup \{(X-n)^2 + (Y-m)^2 \mid n,m \in \mathbf{Z}\} \cup \{X - a \mid a \in \mathbf{R} \setminus \mathbf{Z}\} \cup \{Y - b \mid b \in \mathbf{R} \setminus \mathbf{Z}\}$$

In this case one even has $SK_1(A_f) = 0$ for all $f \in A - \{0\}$.).

J.P. Jouanolou

Inertia forms and applications

First we define the notion of inertia forms in the weighted case and show that it appears naturally on apparently not related cases of elimination (embeddings, reduced resultants,...). Giving an explicit version of the local duality for homogeneous complete intersections, we can exhibit in certain general cases a complete list of the inertia forms. It permits us to give explicit formulas for multivariate resultants (for instance for three polynomials of any degree), and parallely for the Grothendieck residues. It works also in some weighted cases, covering the geometric problems mentioned at the beginning (equations of the image of embeddings $\mathbf{P}^2 \to \mathbf{P}^3$ for instance).

M. Kreuzer

On the Canonical Module of a Zerodimensional Scheme

Let $X \subseteq \mathbf{P}^d$ be a 0–dimensional scheme, R its homogeneous coordinate ring, and ω_R the canonical module of R. We examined the question how geometrical properties of X are reflected by the algebraic structure of ω_R. In particular, using the multiplication maps $R_n \otimes (\omega_R)_{-n} \to (\omega_R)_0$ we characterized the following geometrical notions: Cayley-Bacharach schemes, locally Gorenstein Cayley-Bacharach schemes, Δ_X–uniform schemes, schemes with higher uniformities (including schemes in uniform position), schemes in linearly general position, schemes in higher order general position, and cohomologically non-split schemes. Applications included inequalities for the Hilbert functions of zero-dimensional schemes, and a characterization of schemes with almost linear resolution.

C. A. Laudal

Kodaira-Spencer classes for modules and Lie algebras

Let S be any k–algebra, k a field. Consider an S–algebra A, an S–module M or a Lie algebra $\mathfrak{g}$ defined on S. There are Kodaira-Spencer classes $C(A) \in H^1(S; A; A \otimes \Omega_S)$, $C(M) \in \mathrm{Ext}^1_S(M, M \otimes_S \Omega_S)$, $C(\mathfrak{g}) \in H^2(S; \mathfrak{g}; \mathfrak{g})$ defining corresponding Kodaira-Spencer maps, and giving birth to Chern classes and Gauß-Manin connections etc.

(1) If $\pi\colon S \to A$ is the versal family of an isolated hypersurface singularity the isomorphism relation $\cong$ on Spec S is defined by the integral subvarieties of $\mathbf{V}$ = kernel of the K-S. map.

(2) There is a corresponding result for Lie algebras. This is used to prove the existence of a fine moduli space for Lie algebras of with fixed dimensions of $H^i(\mathfrak{g}, \mathfrak{g})$, $i = 0, \ldots, \dim \mathfrak{g}$ and to prove that in special cases there is an immersion of the moduli space of hypersurface singularities into the moduli space of Lie algebras.

The goal of this research is to gain some insight in the global structure of the "Moduli Suite" of singularities, see L.Pfister. SLN 1310 and Bjas-Laudal: Compositio 75 (1990).

J. Lipman

Pseudofunctorial structure on modules with 0–dimensional support

For each complete local ring R, let Z_R be the category of R–modules supported at the maximal ideal. A **pseudofunctor** assicates to each local homomorphism $f\colon R \to S$ a functor $f_.\colon Z_R \to Z_S$, and to each composition $R \xrightarrow{f} S \xrightarrow{g} T$ a functorial isomorphism $c_{f,g}\colon (gf)_. \xrightarrow{\sim} g_.f_.$, with natural compatibility properties relative to a composition of three maps. For example, restricting to residually finite maps (i.e., $[S/m_S : R/m_R] < \infty$), we can set $f_\# M := \mathrm{Hom}^c_R(S, M)$, the homomorphisms whose kernel contains a power of m_S, with obvious $c_{f,g}$. Or, for formally smooth f of relative dimension d and residual transcendence degree t, we can set $f_\times M = H^d_{m_S}(\Omega^{n+t}_{S/R} \otimes_R M)$, with less obvious $c_{f,g}$.

Both $f_\#$ and $f_\times$ take injectives to injectives, and, in particular, injective hulls of R/m_R to injective hulls of S/m_S. For residually finite smooth maps, the functors $f_\#$ and $f_\times$ are canonically isomorphic, compatibly with the respective $c_{f,g}$'s (a form of Local Duality).

The main result of the recent thesis of I.-Chan Huang is that there is an essentially unique pseudofunctor on all residually finitely generated ($r.f.g.$) maps, restricting to $f_\#$ and $f_\times$ on residually finite and formally smooth maps respectively. (Uniqueness holds because any $r.f.g.$ map factors as "surjection ∘ formally smooth". The existence comes by pasting $f_\#$ and $f_\times$ via such –non-unique– factorizations. There are many compatiblities to be checked in doing so, and this involves a good deal of the theory of residues.)

It is expected that a similar process will yield a purely local pseudofunctorial structure on Cousin complexes with acyclic (for local cohomology) terms, corresponding to the global theory of $f^!$ which underlies Grothendieck Duality.

W. Lütkebohmert

Riemann's Existence Problem for a p–adic Field

Riemann posed the problem if any finite étale morphism from a Riemann surface to an (affine) algebraic curve over $\mathbb{C}$ is induced by an algebraic morphism. Nowadays it is well-known that this question has an affirmative answer. In their paper "Komplexe Räume" Grauert and Remmert settled this problem in higher dimension. It could be solved due to Serre's GAGA-principle by an extension theorem for finite étale coverings. A crucial point in their proof is the fact that any étale covering of a pointed disc extends to a finite covering of the whole disc.

In the talk I treated a similar question for rigid-analytic coverings in the sense of Tate. This problem has an affirmative answer without further restrictions on the covering in the case where the base field has characteristic zero and residue characteristic p. The problem can be reduced to the following theorem:

Let $\varphi\colon X \to A(r,R) = \{z \in K^*, r \leq |z| \leq R\}$ be a finite étale covering of degree d. Then there exists a number $b = b(d,p) \in \mathbb{N}$ depending only on the degree d of φ and on the residue characteristic p such that φ is of Kummer type over $A(r', R')$ where $r' = r/|p|^b$ and $R' = |p|^b R$.

In positive characteristic, $\operatorname{char} K > 0$, there exist examples of non-extendable finite étale coverings of a pointed disc. But Riemann's existence problem has an affirmative answer in positive characteristic if one sticks to Galois coverings whose degree is prime to the characteristic. Such a result is of interest for Drinfeld's work, since it implies a comparison theorem between the rigid étale and the algebraic étale cohomology of an algebraic variety over a p–adic field in positive characteristic.

T.C. Nguyen

Macaulyfication of Noetherian schemes

Let X be a Noetherian scheme. By Macaulyfication we mean a pair $\{\tilde{X}, \pi\}$ of a Cohen-Macaulay scheme $\tilde{X}$ and a birational proper morphism $\pi: \tilde{X} \to X$. This problem has been studied first by M. Brodmann and G. Faltings. Faltings proved that if X is a quasi-projective scheme over a Noetherian ring R, where R has a dualizing complex and the non-Cohen-Macaulay locus of X is of dimension ≤ 1, then X admits a Macaulayfication.

Now our main result is to give a generalization of Faltings' result as follows:

Theorem: Let X be a Noetherian scheme of finite dimension satisfying the following conditions:

(i) X admits a dualizing complex;

(ii) $\dim \mathcal{O}_{X,x} = \dim X$ for all closed points of X.

Then X admits a dualizing complex.

A.N. Parshin

Beilinsons's approach to the residues

Let $K = k((t_1)) \cdots ((t_n))$ be an n–dimensional local field of equal characteristics. The author has defined a residue maps $\Omega^n_{K/k} \to k$ which generalize a classical definition for $n = 1$. J. Tate has expressed the residue map (for $n = 1$) in terms of traces of linear operators belonging to $\mathrm{End}_k(K)$. Beilinson has got a generalization of this construction to the case of arbitrary n. We describe the ingredients of his construction: some Lie algebra decompositions inside $\mathrm{End}_k(K)$, complexes related with Koszul complex of infinite-dimensional Lie algebra, chain complex of local systems over n–dimensional cube (defined in terms of cubic structure).

P. Roberts

Chern Classes of Matrices

The theory of "localized Chern characters" of Baum, Fulton and MacPherson has been an important tool in answering several homological questions in Commutative Algebra. However, they have been difficult to compute in an algebraic context. We present a method of computing the Chern character of a complex of free modules with support in the maximal ideal of a local ring, using the Rees ring of an ideal defined by the determinants of each matrix of the resolution. There are several questions which arise and involve the contributions of the individual matrices of a resolution, including whether the contributions of a resolution of a module of finite length over a regular local ring are positive, and questions on a closure operation on ideals defined by requiring that the Chern characters take on the maximum possible value.

P. Sastry

Residues and Duality (joint work with Yekutieli)

For each reduced scheme $\pi : X \to k$, of finite type over a perfect field k, Yekutieli defines a complex $K_X^{\cdot}$ living in degrees $[-\dim X, 0]$. $K_X^{\cdot}$ is a complex of injectives, in fact it is a "residual complex", i.e. $\bigoplus_{p \in \mathbf{Z}} K_x^p \cong \bigoplus_{x \in X} J(x)$ where $J(x)$ is the sheaf which is the constant sheaf consisting of the injective hull of $k(x)$ over $\mathcal{O}_{x,X}$ on $\overline{\{x\}}$, and zero outside $\overline{\{x\}}$, and further $K_X^{\cdot}$ has coherent cohomology sheaves.

Moreover Yekutieli in his thesis (and in a forthcoming publication) shows that for each closed point $x \in X$, there is a natural map $\tau_x : \Gamma_x(K_x^{\cdot}) \to k$, such that if X is proper, the resulting map $\mathrm{Tr}_\pi = \Sigma \tau_x : \Gamma(X, K_X^{\cdot}) \to k$ gives a map of complexes $\pi_* K_X^{\cdot} \to k$. This leads one to believe that $K_K^{\cdot} \xrightarrow{\sim} E(\pi^! k)$ where $\pi^!$ is the duality functor defined in Hartshorne's book "Residues and Duality" [RD]. Yekutieli shows this is true if X is quasi-projective. In our joint work we show this to be true for all X, using arguments from Deligne's appendix to [RD], and a version of "local duality". Moreover Yekutieli's map Tr_π (for π proper), is shown to play the role of $\int_\pi$.

R.Y. Sharp

Bass Numbers of Local Cohomology Modules

This lecture reported on recent work (joint with C.Huneke) about the local cohomology modules of a regular local ring $(A, \mathfrak{m})$ of characteristic $p > 0$ with respect to an arbitrary proper ideal I of A.

Results about the effect of the Frobenius functor on injective A-modules were used to prove the following two theorems.

Theorem. For all $i, j \geq 0$ and for alle $\mathfrak{p} \in \mathrm{Spec}(A)$, the Bass number $\mu^i(\mathfrak{p}, H_I^j(A))$ is finite. In fact, $\mu^i(\mathfrak{p}, H_I^j(A)) \leq \mu^i(\mathfrak{p}, \mathrm{Ext}_A^j(A/I, A))$.

Theorem. If, for some $j \geq 0$, the local cohomology module $H_I^j(A)$ is Artinian, then it is injective.

A consequence of the first theorem is that $\mathrm{Ass}(H_I^j(A))$ is finite for all $j \geq 0$.

The special case of the second theorem in which A contains its residue field which is perfect was proved in 1977 by Hartshorne and Speiser. The methods used in this lecture can also be used to prove the following.

Theorem. For all $i, j \geq 0$, $H_{\mathfrak{m}}^i(H_I^j(A))$ is injective; for all $j \geq 0$, $\Gamma_{\mathfrak{m}}(H_I^j(A))$ is an injective direct summand of $H_I^j(A)$.

J. Strooker

On the Monomial Conjecture

Let A be a Noetherian local ring and $x_1, \dots, x_d$ be a system of parameters. The monomial conjecture asserts that there is no identity $x_1^t \cdot \dots \cdot x_d^t = \sum_{i=1}^{d} a_i x_i^{t+1}$ with $a_i \in A$ and $t \geq 1$.

Theorem. The monomial conjecture holds for all d–dimensional local ring A in a certain characteristic if and only if for no d–dimensional complete intersection in the same characteristic there is a component of zero contained in a parameter ideal.

The lecture ended with questions on parameter ideals, Auslander's delta invariant and linkage.

G. Valla

Bounds for the regularity index of fat points in $\mathbf{P}^n$

Let $X \subseteq \mathbf{P}^n$ be a set of points, $X = \{P_1, \dots, P_s\}$. If $\mathfrak{p}_1, \dots, \mathfrak{p}_s$ are the corresponding prime ideals in $R := k[X_0, \dots, X_n]$, the 0–dimensional scheme defined by the ideal $I := \mathfrak{p}_1^{m_1} \cap \dots \cap \mathfrak{p}_j^{m_j}$ is called a set of "fat" points with multiplicities the given integers $m_1 \geq m_2 \geq \dots \geq m_j \geq 1$. If Z is a set of fat points, the regularity index of Z is defined to be the least integer t such that $H_Z(t) = \deg(Z)$ and written as $r(Z)$. In this talk I report on joint work with M.V.Catalisano and N.V.Trung where the following results have been proved:

1. If the points $P_1, \dots, P_s$ are in linear general position, then

$$r(Z) \leq \max\{m_1 + m_2 - 1, [(\sum_{i=1}^{s} m_i + n - 2) : n]\}$$

2. The bound is sharp. Every set of points on a rational normal curve in $\mathbf{P}^n$ reaches the bound.
3. The bound is sharp also for points with the Uniform Position Property.
4. If the points are generic and t ist the least integer such that

$$\sum_{i=1}^{s-1} \binom{m_i + n - 1}{n} < \binom{n+t}{n}$$

then

$$r(Z) \leq \max\{m_1 + m_2 - 1, t + m_{n+3} - 1\}$$

U. Vetter

Generic maps

Let B a noetherian ring, $X = (X_{ij})$ an $m \times n$ matrix of indeterminates X_{ij} over B, and r an integer, $0 \leq r \leq \min(m,n)$. Put $R = R_{r+1} = B[X]/I_{r+1}(X)$ where $I_{r+1}(X)$ is the ideal in $B[X]$ generated by the $(r+1)$–minors of X. Consider the "generic map" $x\colon R^m \to R^n$ induced by $X\colon B[X]^m \to B[X]^n$.

Theorem. Let $1 \leq g \leq r$, and denote by $C^{(g)}$ the cokernel of the g–th exterior power of x. Then

(a) $C^{(g)}$ is an almost perfect $B[X]$–module (i.e. $\mathrm{pd}_{B[X]}(C^{(g)}) \leq \mathrm{grade}_{B[X]}(C^{(g)}) + 1$).

(b) $C^{(g)}$ is perfect if and only if $m \geq n$.

Special cases of the theorem are due to Buchsbaum and Eisenbud ($m \geq n = r$) and Bruns ($q = 1$) respectively. The proof uses the Hodge-algebra structure of R.

J.F. Voloch

The conjectures of Mordell and Lang in positive characteristics

The Mordell-Lang conjecture in characteristic zero states that if X is a subvariety of a semiabelian variety A which is not a translate of a subgroup variety and Γ is a subgroup of A with $\dim_{\mathbb{Q}} \Gamma \otimes \mathbb{Q}$ finite, then $X \cap \Gamma$ is not Zariski dense in X. In positive characteristics one should add the condition that X is not weakly isotrivial (that is it is not purley inseparably covered by a variety defined over a finite field) to hope that the conjecture is valid.

I reported on joint work with D. Abramovich where we tackle the above conjecture in characteristic $p > 0$ under the hypothesis that $\mathrm{rk}_{\mathbb{Z}_{(p)}} \Gamma \otimes \mathbb{Z}_{(p)}$ is finite. With this condition we can prove that the conjecture is true in many (e.g. if X is a curve or if A is ordinary) but not all cases.

A. Yekutieli

An Explicit Construction of Grothendieck's Residue Complex

Let k be a perfect field, X a reduced k–scheme of finite type, with structural morphism π. The residue complex is by definition the cousin complex associated to $\pi^! k$ (in the sense of "Residues and Duality"). We construct a complex $K^{\cdot}_X$, which in the affine case is shown to be isomorphic to $\pi^! k$. Together with P. Sastry we produce a canoncial isomorphism for all X.

The construction uses the following methods: Beilinson's completions, semi-topological rings and Parshin-Lomadze residues. A very brief sketch: For $x \in X$ set $\omega(x) := \Omega^d_{k(x)/k}$, the top degree differential forms. A saturated chain $\xi = (x_0, \ldots, x_n)$ is a chain of immediate sepcializations. For a coefficient field $\sigma\colon k(x) \to \hat{\mathcal{O}}_{X,x}$ set

$K(x) = \mathrm{Hom}^{\mathrm{cont.}}_{k(x)}(\hat{\mathcal{O}}_{X,x}, \omega(x))$. Given a saturated chain $\xi = (x, \ldots, y)$ and a coefficient field σ for y, we have the Parshin residue map $\mathrm{Res}_{\xi,\sigma}\colon \omega(x) \to \omega(y)$. Now suppose τ, σ are coefficient fields for x, y resp., which are compatible. We get a map $\delta_{\xi,\tau,\sigma}\colon K(\tau) \to K(\sigma)$.

The various $K(\sigma)$, σ coefficient field for x, can be identified to give a module $K(x)$. For a chain ξ as above, we have $\delta_\xi\colon K(x) \to K(y)$. We get a complex by setting $K_X^{-q} := \bigoplus_{\dim x = q} K(x)$; $\delta(x) := \sum_{(x,y)} \delta_{(x,y)}$ is the coboundary. Using its intrinsic properties (for X smooth, for finite morphisms, e.t.c.), we show that $K^{\cdot}_X$ is a residual complex in the sense of "Residues and Duality".

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Gefördert durch
DFG Deutsche Forschungsgemeinschaft