MATHEMATISCHES FORSCHUNGSINSTITUT OBERWOLFACH

T a g u n g s b e r i c h t 21/1981

Kommutative Algebra und algebraische Geometrie

10. 5. bis 16. 5. 1981

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

Ziel der Tagung war es, Fragen und Methoden aus dem Bereich der kommutativen Algebra und der algebraischen Geometrie darzustellen und insbesondere die sich aus beiden Gebieten gemeinsam ergebenden Gesichtspunkte zu diskutieren.

Folgende Themen fanden besondere Aufmerksamkeit:
Raumkurven, Vektorbündel projektiver Varietäten, Deformation von Singularitäten, Homologie lokaler Ringe, das Syzygienproblem.

Das Interesse an der Tagung läßt sich nicht zuletzt an der großen Zahl ausländischer Gäste ablesen, davon u.a. 10 aus Frankreich, 10 aus Nord- und Südamerika, 5 aus Skandinavien und 2 aus Japan.

Die aktive Mitwirkung von R.Hartshorne, M.Hochster, W.Fulton und A. van de Ven verlieh der Tagung besonderes Gewicht.

Vortragsauszüge

L. AVRAMOV

Invariants of pseudo-reflection groups acting on local rings

Considering a finite group of automorphisms G of a noetherian local ring R, the question arises to establish connections between ring-theoretic properties of R and of R^G. In the case of polynomial rings (over fields of say, characteristic zero), a particularly simple invariant theory characterizes the groups generated by pseudo-reflections: a classical theorem of Chevalley, Shephard and Todd asserts that this property is equivalent to the fact that the invariants form a polynomial algebra. In the local case, a pseudo-reflection g is defined by the conditions:

(a) $g \in H = G^T(m) = \{g \in G \mid g(x)-x \in m \text{ for all } x \in R\}$ and

(b) $\varepsilon(g)$ has n-1 eigenvalues equal to 1, where $\varepsilon : H \to GL(k, m/m^2)$ is the canonical map, and $n = \dim_k(m/m^2)$.

<u>Theorem.</u> Assume the following conditions are satisfied:

(a) $|H|$ is invertible in k; (b) H is generated by pseudo-reflections; (c) for any $\mathfrak{p} \in Ass(R)$, the inertia subgroup $G^T(\mathfrak{p})$ is trivial. Then the following hold:

i) R has a normal basis over R^G, i.e. $R \simeq R^H[H]$ as $R^H[H]$-modules;

ii) $\bar{R} = R/m^G R = R/m^H R$ is a strict complete intersection (strict meaning $gr_m \bar{R}$ is a graded c.i.)

iii) The different $D(R/R^G) = D(R/R^H)$ is characterized by the following equalities:

$$D(R/R^G) = \bigcap_{\substack{\mathfrak{b} \text{ is H-stable and} \\ m^H R \not\supset \mathfrak{b}}} \mathfrak{b} = \prod_{h \in \mathcal{P}} \mathfrak{a}_h$$

where $\mathcal{P}$ is the set of pseudo-reflections contained in G, and $\mathfrak{a}_h$ is the ideal generated by $\{h(x)-x \mid x \in R\}$.

As a corollary, under the hypotheses of the theorem, one sees that R^G is Cohen-Macaulay of type t (resp. Gorenstein, complete intersection) if and only if R has the corresponding property.

L. BADESCU

Rational and non-rational scrolls, ample divisors and applications

Let B be a smooth projective curve over an algebraically closed field k of char. zero, and E a vector bundle of rank ≥ 2 over B. Denote by $Y = \mathbb{P}(E)$ the projective bundle associated to E. One discusses the following problem: if X is a smooth projective variety containing Y as an ample divisor, determine explicitly the structure of X. The most difficult case is when E has rank 2, i.e. when Y is a surface. One shows that there exists an exact sequence of vector bundles over B of the form $0 \to \mathcal{O}_B \to F \overset{\varphi}{\to} E' \to 0$, where F is an ample vector bundle and $E' = E \otimes L$ for a suitable $L \in \mathrm{Pic}(B)$, such that X is isomorphic to $\mathbb{P}(F)$ and $Y \cong \mathbb{P}(E')$ is embedded in X via φ, provided that $Y \not\cong \mathbb{P}^1 \times \mathbb{P}^1$. Separately one determines all X's containing $\mathbb{P}^1 \times \mathbb{P}^1$ as an ample divisor. As an application of these results, one extends to arbitrary dimensions the following theorem of Sommese - van de Ven: if F is a smooth surface and L is a very ample line bundle over F, then $L \otimes \omega_F$ is generated by its global sections except for some particular situations which can be enumerated. This application is due to P.Ionescu.

J. BINGENER

Deformations of Kähler manifolds: An algebraic proof of the Kodaira-Spencer theorem

In 1960, Kodaira and Spencer showed that local deformations of Kähler manifolds are Kähler, using deep results from the elliptic theory. We generalize this result to the singular case, in the following form:

Theorem. Let $f : X \to S$ be a proper holomorphic map and $s \in S$ be a point such that X_s is a Kähler space. If the natural homomorphism $H^2(X_s,\mathbb{R}) \to H^2(X_s,\mathcal{O}_{X_s})$ is surjective, f is weakly Kähler in s.

In particular, the nearby fibres $X_{s'}$ then are Kähler spaces. A somewhat weaker version of this result was announced without proof by Moishezon some years ago. He also showed that the condition on $H^2(X_s,\mathcal{O}_{X_s})$ cannot be dropped. - Our proof uses only a suitable generalization of Grauert's comparison theorem for a certain class of non-coherent sheaves.

M. BRODMANN

Local Cohomology of Rees-Rings

Let $(R,\mathfrak{m})$ be a noetherian local ring. Assume that the local cohomology modules $H^i(R)$ are finitely generated, whenever $i \leq t-1$. $(t \in \mathbb{N})$. Then there is a natural number ν such that for each sequence $x_1,\dots,x_t \in \mathfrak{m}^\nu$ which is regular on Spec(R) - $\{\mathfrak{m}\}$ we have (with $I = (x_1,\dots,x_t)$):

$$H^i_{\mathfrak{m}(I)}(\mathcal{R}(I)) = \begin{cases} [H^0_{\mathfrak{m}}(R)]_0 & , i = 0 \\ 0 & , 0<i\leq \min(2,\max(t,\operatorname{depth}(R/H^0_{\mathfrak{m}}(R)) =: \rho \\ \bigoplus_{j=-i+2}^{-1} [H^{i-1}_{\mathfrak{m}}(R)]_j & , \rho < i \leq \max(t,\operatorname{depth}(R/H^0_{\mathfrak{m}}(R)) =: t' . \end{cases}$$

Moreover $H^{t'+1}_{\mathfrak{m}(I)}(\mathcal{R}(I))$ is not finitely generated. Thereby $\mathcal{R}(I)$ stands for the Rees-algebra, $\mathfrak{m}(I)$ for its homogeneous maximal ideal. If U is an R-module, $[U]_j$ stands for the graded $\mathcal{R}(I)$-module concentrated as U to degree j.

This applies to "Macaulayfication". Moreover we get new characterisations of Buchsbaum-rings in terms of blow up at parameter systems.

Let $t > 1$, $L = (x_1,\dots,x_{t-1})$. Let $D_{\mathfrak{m}}$ be the functor of $\mathfrak{m}$-transform:

$D_{\mathfrak{m}} = \varinjlim_n \mathrm{Hom}(\mathfrak{m}^n, \cdot)$. Then $D_{\mathfrak{m}}(\mathcal{R}(L)) = \bigoplus_{n\geq 0} D_{\mathfrak{m}}(L^n))$ is a (module-) finite algebra over $\mathcal{R}(L)$ and it holds

$$H^i_{\mathfrak{m}(L)}(D_{\mathfrak{m}}(\mathcal{R}(L)) = \begin{cases} 0 & , i \leq \min(3,t') \\ \bigoplus_{j=-i+2}^{-1} [H^{i-1}_{\mathfrak{m}}(R)]_j, & \min(3,t') < i \leq t'. \end{cases}$$

Moreover $H^{t'+1}_{\mathfrak{m}(L)}(D_{\mathfrak{m}}(\mathcal{R}(L))$ is not finitely generated.

Using Flenners local version of the Bertini theorems we get:

Let R be normal, excellent and of dimension $d \geq 2$. Assume that Spec(R) - $\{\mathfrak{m}\}$ is CM. Then there is a natural number ν such that for almost each partial system of parameter $x_1,\ldots,x_{d-1} \in \mathfrak{m}^\nu$ $\mathrm{Proj}(\mathcal{R}(\sqrt{(x_1,\ldots,x_{d-1})}))$ is CM and arithmetically normal.

(In fact, this holds for a generic partial system of parameters $x_1,\ldots,x_{d-1} \in \mathfrak{m}^\nu$).

D. BUCHSBAUM

(A report on joint work with K.Akin and J.Weyman.)

<u>Schur functors and complexes</u>

Definition of Schur functors and Schur complexes. Applications to resolutions of powers of the ideal generated by the minors of maximal order of a suitably generic matrix, and the submaximal minors of the generic matrix.

R.-O. BUCHWEITZ

<u>Exactness and Rigidity</u>

Let $BE_k\binom{a,b,c}{r_1,r_2}$ be the Buchsbaum-Eisenbud variety of complexes over k, $k^a \xrightarrow{\varphi_1} k^b \xrightarrow{\varphi_2} k^c$ with rk $\varphi_i \leq r_i$. Let H(a,b,c) the variety obtained from $BE_k\binom{a,b,c}{a,b-a}$ by adjoining the so called multipliers. Hochster had shown that H(a,b,c) is generic for modules of projective dimension two and Betti-numbers a,b,c.

Theorem. Let k be a field.

1) $BE_k\binom{a,b,c}{r_1,r_2}$, $r_1+r_2 = b$ is rigid (i.e. admits no non-trivial deformations) except for $b = a+c$, $r_1 = a$, (in which case it is a complete intersection)
2) H(a,b,c) is rigid for $a+c \leq b+1$
3) $BE_k\binom{a,b,c}{1,1}$ is rigid, except for those obvious cases where the singular locus is generically a complete intersection.

E.D. DAVIS

Affine curves on which all points are set-theoretic complete intersections

(joint work with P.Maroscia)

For an affine curve (absolutely reduced and irreducible) over a field k, let SCI denote the property of the title; and let WSCI denote the following weak form of that property: The removal of a finite number of simple points results in a SCI curve.

If char k = 0 and $k = \bar{k}$, then (Murthy-Pedrini): WSCI ⇔ SCI ⇔ rational and nonsingular. This talk considers the relaxation of these hypotheses with a view toward determining the singular (W)SCI curves. Since in any case the curve is SCI if $k \subset \bar{\mathbb{F}}_p$, we assume the ground field is not of this form. Our main observation is: WSCI ⇒ normalization is WSCI and: (1) all singularities are geometrically unibranch; (2) if char k = 0 and the curve has singularities, then $[k:\mathbb{Q}] < \infty$. With this result and the help of the Mordell-Weil theorem we can, in a rather precise way, describe all singular (W)SCI curves.

D. EISENBUD

Normal Bundles of Rational Space Curves

(joint work with A. van de Ven)

Let S_n be the 4n-dimensional family of smooth rational curves of degree n in $\mathbb{P}^3_{\mathbb{C}}$, with $n \geq 4$.

Theorem. If $C \in S_n$ then the normal bundle N_C of C splits as

$$N_C \cong \mathcal{O}(2n-1-a) \oplus \mathcal{O}(2n-1+a),$$

with $0 \leq a \leq n-4$. If we write $S_{n,a}$ for the space of all C with splitting as above, then $S_{n,o}$ is an open set in S_n, and for $1 \leq a \leq n-4$, $S_{n,a}$ is an irreducible variety of dimension 4n-2a+1.

Certain parts of the above result have also been obtained by Chione and Sacchiero.

E.G. EVANS

The Syzygy Problem

Let R be a regular local ring containing a field and let M be a kth syzygy of rank less than k, then M is free. The proof proceeds by considering the ideals. $o_M(x) = \{f(x) \mid f \in \mathrm{Hom}(M,R)\}$. On the one hand in the minimal counterexample the height of $o_M(x)$ is less than k for every $x \in M-m\,M$. On the other hand if M is any kth syzygy and $x \in M-m\,M$, then the height of $o_M(x)$ is at least k. This latter step requires the existence of maximal Cohen-Macaulay modules over $R/o_M(x)$. Hence the need for the field. A corollary is that if M is a vector bundle on $\mathbb{P}^n$ which is not a sum of line bundles and of rank $k < n$, then one of the cohomology groups $H^i(o(m)) \neq 0$ for some $1 \leq i \leq k-1$ and some m.

G. FALTINGS

Eichler-Shimura Theorems for hermitian locally symmetric spaces

Suppose $X_o = G/K$ is a hermitian symmetric space (G = semisimple, K = max.compact), $\Gamma \subset G$ is discrete and torsionfree, $X = \Gamma\backslash X_o$
If $V = V(\lambda)$ is an irreduzible G-module, we construct a resolution

$$0 \to \underline{V} \to W(\lambda) \to \bigoplus_{l(w)=1} W(w(\lambda+1)-1) \to \dots$$

of V by coherent homogeneous sheaves. Hence we obtain a spectral sequence

$$E_1^{p,q} = H^q(X, \bigoplus_{l(w)=p} W(w(\lambda+p)-p)) \Rightarrow H^{p+q}(X,\underline{V}) = H^{p+q}(\Gamma, V(\lambda))$$

If X is compact, this spectral sequence degenerates.

H. FLENNER

Relative $\mathcal{E}xt$-Sheaves

Let $f : X \to Y$ be a morphism of complex spaces and $\mathcal{F}, \mathcal{G}$ coherent $\mathcal{O}_X$-modules such that $\mathcal{G}$ is $\mathcal{O}_Y$-flat and the support of $\mathcal{F}$ or of $\mathcal{G}$ is proper over Y. Then it was shown: Locally in Y there exists a complex $\mathcal{P}^\bullet$ of free coherent $\mathcal{O}_Y$-modules bounded below such that there are natural isomorphims

$$\mathcal{E}xt_p^q(\mathcal{F},\mathcal{G} \otimes f^*(\mathcal{N})) \cong H^q(\mathcal{P}^\bullet \otimes \mathcal{N})$$

for all coherent $\mathcal{O}_Y$-modules $\mathcal{N}$. Here $\mathcal{E}xt_f^q(-,-)$ denotes the relative $\mathcal{E}xt$-sheaves i.e. the cohomology of the complex $Rf_*R\mathcal{H}om_X(-,-)$. Moreover the complex $\mathcal{P}^\bullet$ and the isomorphisms are compatible with base change. Under additional hypothesis this result has been shown by Banica/Putinar/Schuhmacher. The idea of the proof is quite simple. Rewriting the isomorphism in the language of derived categories, it suffices to look for a complex $\mathcal{M}^\bullet$ such that

$$Rf_* R\mathcal{H}om_X(\mathcal{F},\mathcal{O} \otimes f^*(\mathcal{N})) \cong R\mathcal{H}om_Y(\mathcal{M}^\bullet,\mathcal{N}).$$

If $\mathcal{N}$ is the dualizing complex $K_Y^\bullet$ on Y one obtains:

$$Rf_* R\mathcal{H}om_X(\mathcal{F},\mathcal{O} \otimes f^*(K_Y^\bullet)) \cong R\mathcal{H}om_Y(\mathcal{M},K_Y^\bullet).$$

Dualizing this we get

$$\mathcal{M}^\bullet \cong R\mathcal{H}om_Y(Rf_* R\mathcal{H}om_X(\mathcal{F},\mathcal{O} \otimes f^*(K_Y^\bullet)),K_Y^\bullet),$$

and it can be shown, that this complex satisfies the assertion.

W. FULTON

Solutions of algebraic equations

(A sampling of applications of the intersection theory developed with R. MacPherson)

Theorem 1. Let X be smooth over a field k, $V_1,\dots,V_r$ irreducible subvarieties of X, $m = \dim X - \Sigma \operatorname{codim}(V_i,X) \geq 0$. Then there are m-dimensional subvarieties W_α of $\bigcap_{i=1}^{r} V_i$ and integers I_α so that the cycle $\Sigma I_\alpha W_\alpha$ represents the intersection class $V_1 \cdot\ldots\cdot V_r$. Each m-dimensional component of $\cap V_i$ occurs with coefficient equal to the intersection multiplicity. If T_X is generated by its section, one may take all $I_\alpha > 0$. For $X = \mathbb{P}^n$, each irreducible component Z of $\cap V_i$ contributes a cycle to $\Sigma I_\alpha W_\alpha$ whose degree is $\geq \deg(Z)$.

Corollary 1. For any subvarieties $V_1,\dots,V_r$ of $\mathbb{P}^n$, if $Z_1,\dots,Z_t$ are the irreducible components of $\cap V_i$, then $\sum_{i=1}^{t} \deg Z_i \leq \prod_{j=1}^{r} \deg V_j$.

Corollary 2. If m=0, X complete, and all finite extensions of k have order a power of a prime p (e.g $k=\mathbb{R}$), and $P_1,\dots,P_s$ are isolated points of $\cap V_i$ with intersection multiplicities $I_1,\dots,I_s$, and if $\deg(V_1 \cdot\ldots\cdot V_r) - \sum_{i=1}^{s} I_i[k(P_i):k]$ is prime to p, then $\cap V_i$ contains k-rational points distinct from $P_1,\dots,P_s$.

Theorem 2. X smooth /k, $P \in X$, $V_1,\ldots,V_r$ irreducible subvarieties of X meeting properly only at P. Let $\hat{X}$, $\hat{V}_i$ be the blow-ups of X,V_i at P, $E \subset \hat{X}$ the exceptional divisor. Then

(1) $V_1 \cdot \ldots \cdot V_r = e_p(V_1) \cdot \ldots \cdot e_p(V_r) + \hat{V}_1 \cdot \ldots \cdot \hat{V}_r$

(2) If $Z_1,\ldots,Z_t$ are the irreducible components of $\hat{V}_1 \cap \ldots \cap \hat{V}_r$, then $\hat{V}_1 \cdot \ldots \cdot \hat{V}_r \geq \sum_{i=1}^{t} \deg Z_i$.

(Here $e_p(V_i)$ is the multiplicity of V_i at P, $V_1 \cdot \ldots \cdot V_r$ is the intersection number of $V_1,\ldots,V_r$ at P, $\hat{V}_1 \cdot \ldots \cdot \hat{V}_r$ is the degree of the intersection class of $\hat{V}_1,\ldots,\hat{V}_r$ -a well-defined class on E- $\deg Z_i$ is the degree of Z_i as a subvariety of $E = \mathbb{P}^{n-1}$).
Formula (1) can be proved for arbitrary regular local rings, and one may strengthen Serre's conjecture to ask if (2) is also valid in this generality.

A.V. GERAMITA

The Ideal of Forms Vanishing at a Finite Set of Points in $\mathbb{P}^n$

Let $P_1,\ldots,P_s$ be points of $\mathbb{P}^n(k)$, $k = \bar{k}$, and let
$P_i \leftrightarrow \wp_i \subset k[x_0,\ldots,x_n]$, $I = \wp_1 \cap \ldots \cap \wp_s$, $A = k[x_0,\ldots,x_n]/I$.
The general problem is: Find $\nu(I)$, the minimal number of generators of I.
Write $A = \sum_{i=0}^{\infty} A_i$ and $\chi(i) = \dim_k A_i$. Consider the growth (for fixed s) of χ: If $\chi(i) = i+1$, $0 \leq i \leq s-1$, $\chi(i) = s$, $i \geq s$ (the slowest possible growth) then this is equivalent to saying; $P_1,\ldots,P_s$ lie on a line in $\mathbb{P}^n$. If $\chi(i) = \min(s,\binom{i+n}{n})$, $\forall_i \geq 0$ (the fastest possible growth) then we say $P_1,\ldots,P_s$ are in generic s-position.

Proposition: If $P_1,\ldots,P_s$ are in generic s-position in $\mathbb{P}^n$ and d = least integer such that $\binom{d+n}{n} > s$ then if $I = I_d \oplus I_{d+1} \oplus \ldots$

(as above) then $I_d \neq (0)$ and $I = \langle I_d, I_{d+1}\rangle$. If $s = \binom{(d-1)+n}{n}$ then $I = \langle I_d\rangle$ and $\nu(I) = \binom{(d-1)+n}{n-1}$.

In general, (for $P_1,\ldots,P_s$ in generic s-position) if we set W = subspace of I_{d+1} generated by I_d then $\nu(I) = \dim_k I_d + \dim_k(I_{d+1}/W)$.

If $\mathcal{C}$ is an irred. curve in $\mathbb{A}^{n+1}(k)$ with a singularity at the origin (of multiplicity =s) and $\mathfrak{p} \subset R = k[x_0,\ldots,x_n]$ be the ideal of $\mathcal{C}$. Let $M = (x_0,\ldots,x_n)$ and $(\mathcal{O},m)$ the local ring, at the origin, of $\mathcal{C}$, and suppose $gr_{\mathfrak{m}}(\mathcal{O}) = k[x_0,\ldots,x_n]/\mathfrak{p}_1 \cap\ldots\cap \mathfrak{p}_s = I$. Let $\mathfrak{p}_i \leftrightarrow P_i \in \mathbb{P}^n$.

<u>Theorem</u> (w/Orecchia) If $P_1,\ldots,P_s$ are in generic s-position then

$$\nu(\mathfrak{p}R_M) = \nu(I).$$

From these observations it is possible to give a new proof for the existence of prime ideals in $k[x,y,z]$, of ht. = 2, requiring (even locally) large numbers of generators.

We suppose that $\dim_k W$ (as above) <u>should</u> be "generically" as large as possible ie. $\dim_k W = \min((n+1)\dim_k I_d, \dim_k I_{d+1})$.

<u>Theorem</u> (w/Maroscia) This last is true for n=2, ie. for points in $\mathbb{P}^2$.

J. GIRAUD

<u>Improvement of Grauert Riemenschneider Vanishing Theorem for a normal surface</u>

Let $f : X \to Y$ be a desingularisation of a normal surface. Let E_i be the irreducible components of the exceptional divisor. For a line bundle L on X, we write $L \gg 0$ if $\deg(L|E_\alpha) \leq 0$ for any E_α. One can prove the existence of $[L] = \Sigma a_\alpha E_\alpha$, $a_\alpha \in \mathbb{Z}$, such that $L(-[L]) \ll 0$ and $[L]$ minimal for this property. Then we have

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that (i) [L] $\gg$ 0 implies $H^1_E(X,L) = 0$, (ii) [L] $\geq$ 0 implies $f_*(L)$ is reflexive, (iii) $[K_X - L] \gg 0$ implies $R^1 f_*(L) = 0$. - Out of this one can deduce a managable formula for the genus of a Weil divisor on a normal surface.

S. GRECO

Weak Normality and Hyperplane Sections

(joint work with C.Cumino and M.Manaresi)

An algebraic variety X is said to be weakly normal (WN) if whenever $f : X' \to X$ is a morphism and a homeomorphism, then f is an isomorphism.

Theorem. Let $X \subset \mathbb{P}^n_k$ be a locally closed WN subvariety of $\mathbb{P}^n_k$, where k is a field of characteristic zero. Let $F_o, \ldots, F_n \in k[X_o, \ldots, X_n]$ be forms of the same degree and put $Y = V(F_o, \ldots, F_n) \cap X$ and $\lambda = (\lambda_o, \ldots, \lambda_n)$. Let $F_\lambda : \Sigma \lambda_i F_i = 0$. Then there is a non empty open $V \subset k^n$ such that for all $\lambda \in V$ $F_\lambda \cap (X-Y)$ is WN.

G.-M. GREUEL

On the topology of deformations of isolated singularities

(joint work with J.Steenbrink)

We prove the following theorem, conjectured by J.Wahl: Let X_o be (the germ of) a normal, isolated, smoothable singularity and X_t the Milnor fiber of a smoothing, then the first Betti number $b_1(X_t)$ is zero.

Examples show that $\pi_1(X_t)$ need not be zero and that the hypothesis of normality is necessary.

Our proof uses the fact that $b_i(X_t) = \dim_{\mathbb{C}} \mathbb{H}^i(\tilde{X}_o, \Omega_{X/D}\langle\tilde{X}_o\rangle \otimes \mathcal{O}_{\tilde{X}_o})$ where $\tilde{X} \xrightarrow{\pi} X$ is a resolution of the singularity of X, the total space of the smoothing $X \xrightarrow{f} D$, s.t. $\tilde{X}_o = (f \circ \pi)^{-1}(0)$ is a reduced divisor of smooth components with normal crossings. The result follows by carefully analyzing the spectral sequence converging to the hypercohomology. Another conjecture of J.Wahl says that if X_o is a normal, smoothable, Gorenstein surface singularity with good $\mathbb{C}^*$-action then $b_2(X_t)$ = dim of the smoothing component of the semiuniversal deformation of X_o over which X_t lies. We prove this under the additional assumption that $\Omega^1_{X_o}$, the module of Kähler differentials, has no torsion.

R. HARTSHORNE

Cohomology of a general instanton bundle

(joint work with A.Hirschowitz)

We prove the following

Theorem. For $c_1 = 0$, $c_2 > 0$ or for $c_1 = -1$, $c_2 \geq 6$, c_2 even, there exists a rank 2 vector bundle $\mathcal{E}$ in $\mathbb{P}^3$ with Chern classes c_1 and c_2 which has natural cohomology, i.e. for each $n \in \mathbb{Z}$, at most one of the form groups $H^i(\mathcal{E}(n))$ is nonzero. The bundle $\mathcal{E}$ is necessarily stable.

In the case $c_1 = -1$, $c_2 = 2,4$, there are stable bundles, but none with natural cohomology.

The proof involves studying the deformation theory of the unstable torsion-free sheaf $\mathcal{E}_o = \mathcal{O}(-a) \oplus \mathcal{O}_{Y_o}$, where Y_o is a disjoint union of lines (resp. conics) in $\mathbb{P}^3$, and $a = 2$ (resp. 3) if $c_1 = 0$ (resp. $c_1 = -1$). The key point is in establishing certain properties of lines and conics in sufficiently general position in $\mathbb{P}^3$.

R. HARTSHORNE

Existence of space curves of all degree and genus predicted by Halphen

This talk is a report on the new preprint of L.Gruson and C.Peskine, "Genre des courbes de l'espace projectif,II". In this paper they prove the existence of an irreducible non-singular curve $C \subseteq \mathbb{P}^3$ for any degree d and genus g satisfying $0 \leq g \leq \frac{1}{6} d(d-3)+1$. The proof involves studying curves on cubic and quartic rational surfaces in $\mathbb{P}^3$.

Außerhalb des eigentlichen Programms berichtete R.Hartshorne noch in informeller Weise über "Stable reflexive sheaves and space curves".

M. HOCHSTER

Direct summands, the syzygy problem, and associated graded rings derived from integrally closed ideals

Several questions related to the local homological conjecture were discussed. Several forms of the direct summand conjecture were given, including the impossibility of solving $x_1^t \ldots x_n^t = \sum_{i=1}^{n} y_i x_i^{t+1}$ in a local ring with system of parameters $x_1,\ldots,x_n$. The idea of the proof that the equation $x_1^a \ldots x_n^a = \sum_{i=1}^{n} y_i x_i^b$ cannot be solved for $n \geq 3$ unless $a/b > 2/n$ was sketched. This involved studing an associated graded ring graded by the nonnegative rational numbers. A proof that the direct summand conjecture implies the Evans-Griffith syzygy theorem was given.

F. ISCHEBECK

Binary Forms and Prime Ideals

The following theorems are known:

a) Let K be a global field, $f \in K[X]$ separabel. There is an infinity of valuations v, such that f splits into linear factors over K_v.

b) Let k be a non algebraically closed field, A an integral affine k-Algebra. The ring $\bigcap_{A/\mathfrak{m}=k} A_{\mathfrak{m}}$ is of the form $S^{-1}A$.

c) Let X be a normal $\mathbb{R}$-variety. Neglecting all prime divisors, which have not "many" real points, one gets a "small" divisor class group $C^{\mathbb{R}}(X)$ (a quotient of C(X)). This $C^{\mathbb{R}}(X)$ is a $\mathbb{Z}/2$-vector space.

A common method to prove such results is given.

W. LÜTKEBOHMERT

Rigidity-theorem for Mumford curves

Let $k \supset \mathbb{Q}_p$ be a discrete valued p-adic field with valuation ring V. A Mumford curve S over k is a non-singular, complete, algebraic curve over k which has an uniformisation $S = \Omega_\Gamma/\Gamma$ where $\Gamma \subset PGL(2,k)$ is a discontinuous, finitely generated subgroup without elements of finite order, $\Omega_\Gamma \subset \mathbb{P}^1(k)$ the set of ordinary points of Γ. To a Mumford curve S one can associate a graph $\mathcal{G}(S)$ which is isomorphic to the coincidence graph of the components of C_s where $C \to \operatorname{Spec} V$ is the stable curve with generic fibre $C_\eta = S$ and special fibre C_s. Let $\mathcal{M}_g(\mathcal{G})$ the set of Mumford curves with canonical graph $\mathcal{G}$. By a theorem of Gerritzen $\mathcal{M}_g(\mathcal{G})$ can set-theoretically be descripted as a quotient of an analytic polyhedron $\overline{\mathcal{B}_g(\mathcal{G})} \subset k^{3g-3}$ by a finite group operation, the automorphism group of the graph $\mathcal{G}$.

<u>Theorem 1.</u> $\overline{\mathcal{B}_g(\mathcal{G})}/\mathrm{Aut}(\mathcal{G})$ is the coarse module space for Mumford curves with canonical graph $\mathcal{G}$.

<u>Theorem 2.</u> Let $\pi : X \to S$ be a family of Mumford curves of genus $g \geq 1$, i.e. π proper, flat and $X_s = \pi^{-1}(s)$ Mumford curves of genus g for all $s \in S$. If S is a Mumford curve minus finitely many points and $p > g+1$, then the family must be constant:

$X_s \cong X_t$ for all $s,t \in S$.

<u>Conjecture.</u> Theorem 2 is true for all n.s., complete, algebraic curves S?

H. MATSUMURA

<u>On p-basis</u>

The following "Conjecture of Kunz", which remained unsolved for 10 or 15 years, was solved very recently by Kimura-Niitsuma.

"Let R be a regular local ring of char. $p > 0$ and S a regular local subring containing $R^p = \{a^p | a \in R\}$ such that R is a finite S-module. Then R has a p-basis over S."

This amounts to proving the following very concrete statement:

(+) "Let k be a field of char. p, and consider an intermediate ring S between $k[[X_1,\ldots,X_n]]$ and $k[[X_1^p,\ldots,X_n^p]]$. If S is regular then (after change of variables) S is of the form $k[[X_1,\ldots,X_r,X_{r+1}^p,\ldots,X_n^p]]$."

The proof depends heavily on papers by Harper (TAMS vol. 100, 1960) and Yuan (ibid. 1970) and uses Lie algebra of derivations.

The polynomial analogue of (+) is much harder and has been proved only in dimension ≤ 2 (Ganong).

L. MORET-BAILLY

Pencils of abelian varieties

(joint work with L.Szpiro)

Let C be a complete smooth curve over a field. We study the pairs (A,L) where A is an abelian scheme over C of fixed relative dimension g, and L is a relatively ample invertible sheaf on A, with fixed relative degree of prime to char(k). Let E be the relative Lie algebra of A over C. Then:

(1) deg E $\leq$ 0 and if deg E = 0, then A $\to$ C is isotrivial.

(2) the set of $(A,L)_s^{\prime}$ with given d,g, and deg(E), is a limited family

(3) if char(k) = 0 then $(g-g_o)(1-q) \leq$ deg E $\leq$ 0 where g_o is the dimension of the fixed part of A, and q = genus of C.

The main tools in the proof are the relative Riemann-Roch theorem for A $\xrightarrow{f}$ C, and the fact that after a finite êtale base change, $f_*(L)$ becomes isomorphic to V $\otimes \mathcal{M}$ where V is free and $\mathcal{M}$ is an invertible sheaf. A corollary (due to Raynaud) states that (in char. p > 0) if A is an abelian scheme over C whose fibres are all ordinary abelian varieties, then A is trivial.

J.E. ROOS

Recent results about the homology of local rings

Let $(R,\mathfrak{m})$ be a local, commutative noetherian ring with residue field $k = R/\mathfrak{m}$ and let $\mathrm{Ext}_R^*(k,k) = \{\mathrm{Ext}_R^i(k,k)\}_{i\geq 0}$ be the Ext-groups of R, equipped with the Yoneda product which makes $\mathrm{Ext}_R^*(k,k)$ into a graded connected algebra. Indeed, $\mathrm{Ext}_R^*(k,k)$ is even a Hopf algebra, which is the enveloping algebra of a certain unique graded Lie algebra $G = \bigoplus_{i \geq 1} G_i$. It seems difficult to determine those G's that can occur here, but if $\mathfrak{m}^3 = 0$, and if A is the subalgebra, generated by $Ext^1_R(k,k)$ in $Ext^*_R(k,k) = B$, then A is <u>also</u> a Hopf algebra, which is the enveloping algebra of another unique graded Lie algebra $\eta = \bigoplus_{i \geq 1} \eta_i$, and those η's that occur here are exactly those finitely presented graded Lie algebras, that can be presented by generators in degree 1, and relations in degree 2 (called (1,2)-presented Lie algebras), <u>and</u> R <u>can be reconstructed from</u> η. In fact, A and B are closely related: If we introduce $B(Z) = \sum_{i \geq 0} \dim_k B_i \cdot Z^i$ (often called the Poincaré-Betti series of $(R,\mathfrak{m})$, and often denoted by $P_R(Z)$), and similarly A(Z), we have

$$B(Z)^{-1} = (1+Z^{-1})A(Z)^{-1} - Z^{-1} \sum_{i \geq 0} \dim_k \mathfrak{m}^i/\mathfrak{m}^{i+1} \cdot (-Z)^i$$

so that A(Z) and B(Z) are rational (or transcendental) at the same time. Also, one can e.g. show (graded Tor's)

$$Tor_1^B(k,k)_* = Tor_1^A(k,k)_* \oplus Tor_3^A(k,k)_{*+1}$$

so that a minimal set of generators of $B = Ext^*_R(k,k)$, contains generators of degree 1, <u>and</u> extra generators, corresponding to a basis of $Tor_3^A(k,k)_{*+1}$.

It follows that if we can construct (1,2)-presented graded Lie algebras η with e.g. ($A = U(\eta)$, the enveloping algebra of η)

(1) A(Z) transcendental <u>or</u> (2) $Tor_3^A(k,k)_*(Z) = \sum_{i \geq 0} \dim_k Tor_3^A(k,k)_i Z^i$ transcendental, then we obtain:

(1) local rings $(R,\mathfrak{m})$ with $P_R(Z)$ transcendental, <u>and</u>

(2) local rings $(R,\mathfrak{m})$ such that $Ext^*_R(k,k)$ has a minimal set of generators $\{\zeta_i\}_{i \geq 1}$ with $\sum_{i \geq 1} Z^{\deg \zeta_i}$ transcendental.

Such constructions can be made, using the theory of extensions of graded Lie algebras, giving e.g.:

$$(*)\quad R = \frac{k[X_1,X_2,X_3,X_4,X_5]}{(X_1^2,X_2^2,X_3^2,X_4^2,X_1X_2,X_3X_4,X_1X_3+X_2X_5+X_4X_5,\mathfrak{m}^3)} \quad (\mathfrak{m} = (X_1,\dots,X_5))$$

as an example of (1) (we could also take X_5^2 as a relation in (*). Then we get a slightly different example, and it is not necessary to divide with $\mathfrak{m}^3$).

(**) A local ring (S,m) with Hilbert series $1 + 27z + 210z^2$ giving an example of (2). [A "loop space" variant of (**) gives a negative answer to a question of Lemaire [4]].

There are also Gorenstein rings (with $m^4 = 0$) having transcendent $P_R(Z)$'s, but it should also be remarked that no examples of local domains or of local rings of the form $k[[X_1,\dots,X_n]]/(\text{monomial})$ are known for which $P_R(Z)$ is transcendental. A study of the deformations of the local rings (*), (**), and their variants, is probably difficult, but perhaps rewarding.

[1] D.Anick, Thesis MIT, 1980, [2] R.Bøgvad (Univ. of Stockholm) Paper subm. to Math.Scand., [3] C.Jacobsson (Univ. of Stockholm) Paper subm. to Math.Scand., [4] J.-M.Lemaire, Springer Lecture Notes 196, p. 114-120, [5] Löfwall-Roos, Comptes rendus, 290, 1980, p. 733-736, [6] Löfwall-Roos (to appear). [7] J.-E.Roos, Springer Lecture Notes, 740, p. 285-312, 1979. [8] J.-E.Roos, Homology of loop spaces and of local rings (to appear in Proc.18th Scand. M., Birkhäuser 198?). [In [8] a historical survey is given, indicating the important role played by Anick's paper [1]. After [8], the papers [2] (Gorenstein rings) and [3] (Lemaire's problem) have been written.]

Ch. ROTTHAUS

Completions of excellent rings

We sketch the proof of the following theorems:

Theorem 1. Let A be a noetherian ring with geometrically regular formal fibres. Let I be an ideal in the Jacobson radical of A, such that A/I is quasiexcellent. If $A \supseteq \mathbb{Q}$, then A is quasiexcellent.

Theorem 2. Let A be a finite dimensional universally catenarian ring with $A \supseteq \mathbb{Q}$. Let I be an ideal in the Jacobson radical of A such that

(i) A is I-adically complete

(ii) A/I is excellent.

Then A is excellent.

J. SALLY

Hilbert functions of local Cohen-Macaulay rings

Let $(R,\mathfrak{m})$ be a d-dimensional local Cohen-Macaulay ring of multiplicity e. Let grR denote the associated graded ring $R/\mathfrak{m} \oplus \mathfrak{m}/\mathfrak{m}^2 \oplus \ldots$ and let $H_R(n)$ denote the Hilbert function $H_R(n) = \dim_{R/\mathfrak{m}} \mathfrak{m}^n/\mathfrak{m}^{n+1}$. If the embedding dimension v of R is e+d-1 (it is always true that $v \le e+d-1$) then grR is Cohen-Macaulay and $H_R(n) = \binom{n+d-2}{n-1}e + \binom{n+d-2}{n}$ for all $n \ge 0$ if $d > 0$.

We sketch the proof of the following

Theorem. Let $(R,\mathfrak{m})$ be a d-dimensional local CM ring of embedding dimension $v = e+d-2$, $e > 3$. Assume that type $R \neq e-2$. Then depth grR $\ge d-1$ and if $x_1,\ldots,x_d$ is any minimal reduction of $\mathfrak{m}$, $\mathfrak{m}^4 = \mathfrak{x}\mathfrak{m}^3$. Furthermore, if depth grR $= d-1$,

$H_R(n) = \binom{n+d-2}{n-1}e - \binom{n+d-5}{n-3}$ for $d > 0$ and $n \ge 3$. If depth grR $= d$,

$H_R(n) = \binom{n+d-2}{n-1}e + \binom{n+d-3}{n}$ for $d > 0$ and $n \ge 2$.

A. SIMIS

Some results on symmetric algebras

(joint work with W.Vasconcelos, J.Herzog, J.F.Andrade)

Let R be a noetherian ring, M a f•g R-module with (generic) rank. Given a presentation $R^m \overset{\varphi}{\to} R^n \to M \to 0$, we have $S(M) \cong R[X_1,\ldots,X_n]/J$. ($S(M)$ = symm.alg. of M; J = ideal of linear forms derived from φ).

Proposition. $rk(\varphi) - t_o(\varphi) + 1 \leq grade(J) \leq rk(\varphi)$, where

$$t_o(\varphi) = \inf\{t \geq 1 \mid grade\ I_s(\varphi) \geq rk(\varphi) - s+1\ \forall s \geq t\}.$$

(Appendix: $grade(J) = rk(\varphi) \Rightarrow t_o(\varphi) = 1$).

Some applications follow:

Proposition. The following are equivalent:

(i) J is a complete intersection

(ii) φ is injective and $grade\ I_t(\varphi) \geq rk(\varphi) - t+1,\ 1 \leq t \leq rk(\varphi)$.

Proposition. $J = (\ell_j)$, $\ell_j = a_{1j} + a_{2j}X_2 + \ldots + a_{nj}X_n$, $j=1,\ldots,m$, $m \geq n$. Let $\varphi = (a_{ij})$. Then:

$$grade\ I_t(\varphi) \geq m-t+1,\ 1 \leq t \leq n \Rightarrow J \text{ is a complete intersection}$$

Proposition. Let R be Cohen-Macaulay local, $I \subset R$ an ideal of ht > 0. Let $N \subset R$ be a perfect ideal. If S(I) is Cohen-Macaulay then the following are equivalent:

(i) S(I/NI) is Cohen-Macaulay

(ii) $\nu(I_P) \leq ht(P/N) + 1$, all primes $P \supset N$

(N.B. $\nu(-)$ = minimal # generators of -).

R.Y. SHARP

Cohen-Macaulay properties for balanced big Cohen-Macaulay modules

Let M be a module over the (commutative, Noetherian) local ring A. If M is a big Cohen-Macaulay module with respect to some system of parameters for A, then in general one cannot expect M to have all the properties of finitely generated Cohen-Macaulay A-modules. This talk was concerned with balanced big Cohen-Macaulay modules: M is a balanced big Cohen-Macaulay A-module if every system of parameters for A is an M-sequence. Hochster has shown that A possesses such a module if A contains a field as a subring. In this talk it was explained why many of the "classical" properties of finitely generated Cohen-Macaulay modules have analogues for a balanced big Cohen-Macaulay A-module M. In particular, the following results and theories were described:

(i) for all M-sequences $a_1,\ldots,a_i$, the set $\mathrm{Ass}(M/(a_1,\ldots,a_i)M)$ is finite and $\dim A/\mathfrak{p} = \dim A - i$ for every $\mathfrak{p} \in \mathrm{Ass}(M/(a_1,\ldots,a_i)M)$;

(ii) a satisfactory theory of depth (with respect to M) can be developed;

(iii) with the aid of the (possibly proper) subset $\mathrm{Supersupp}(M) = \{\mathfrak{p} \in \mathrm{Spec}(A) : \mu^j(\mathfrak{p},M) \neq 0 \text{ for some } j \geq 0\}$ of $\mathrm{Supp}(M)$, we can introduce the M-height ($\mathrm{ht}_M \mathfrak{a}$) of a proper ideal $\mathfrak{a}$ of A, and prove that $\mathrm{ht}_M \mathfrak{a} = \mathrm{depth}(\mathfrak{a};M)$.

A Cousin complex characterization of balanced big Cohen-Macaulay modules was also presented.

B. ULRICH

The torsion of the module of differentials

General estimations for the length of a module respectively of the torsion of a module with finite homological dimension over a one-dimensional local Cohen-Macaulay-ring are given by means of certain ideals defined by determinants. As an application we proof in some cases a conjecture due to R.Berger: Let R be a reduced local ring of an algebraic or algebroid curve over a perfect field k, let edim(R) its embedding dimension, d(R) its deviation and $D(\frac{R}{k})$ its module of differentials.

<u>Theorem 1.</u> If edim(R) $\leq$ 3 or d(R) $\leq$ 3, then $D(\frac{R}{k})$ is not torsion free iff R is not regular.

<u>Theorem 2.</u> If edim(R) $\leq$ 4 or d(R) $\leq$ 2, then R is not rigid iff R is not regular.

W.V. VASCONCELOS

<u>Approximation Complexes</u>

(joint work with J.Herzog and A.Simis)

We discussed certain differential graded algebras derived from a double Koszul complex. They occur in the comparison between the symmetric Sym(I) of an ideal I and its Rees algebra R(I). One of its optimal uses depends on information on the depth properties of the homology modules of the ordinary Koszul complex associated to I. For instance:

<u>Theorem.</u> Let R be a Cohen-Macaulay ring and let I be an ideal. Assume: (a) The homology modules of a Koszul complex associated to I are Cohen-Macaulay modules; (b) For each prime ideal P $\supset$ I, I_P can be generated by height (P) elements. Then Sym(I) = R(I) and $Sym(I/I^2) = gr_I(R)$ and both algebras are Cohen-Macaulay. Furthermore, if R is Gorenstein, then $gr_I(R)$ is also Gorenstein (R(I) may not be such).

The framework of this theorem also allows for other applications, in particular to the questions of Cohen-Macaulayfication and linear resolutions.

K. WATANABE

Rational singularities with k*-action

Let $R = \bigoplus_{n \geq 0} R_n$ be a normal graded ring f·g over $k = R_0$ (a field) (ch k = 0). Then, by Demazure, $R \cong \bigoplus_{n \geq 0} H^0(X, \mathcal{O}_X(nD))$, where $X = \mathrm{Proj}(R)$ and $D = \Sigma \frac{p_\nu}{q_\nu} \cdot \nu$. $((p_\nu, q_\nu) = 1, q_\nu > 0)$ is a rational coefficient Weil divisor which satisfies the condition:

"ND is an ample Cartier divisor for some N > 0, integer."

Then we have $H^i_m(R) \cong \bigoplus_{n \in \mathbb{Z}} H^{i-1}(X, \mathcal{O}_X(nD))$ $(i \geq 2)$.

R : C-M. $\Leftrightarrow H^i(X, \mathcal{O}_X(nD)) = 0$ $(0 < i < \dim X,\ n \in \mathbb{Z})$.

R : Gorenstein $\Leftrightarrow$ R : C-M and $K_X + \Sigma \frac{q_\nu - 1}{q_\nu} \cdot \nu \equiv aD$ for some $a \in \mathbb{Z}$.

If we define the integer a(R) by $a(R) = \max\{n \mid (H^d_m(R))_n \neq 0\}$ (d=dim R), we have

Theorem. R is a rational singularity iff R satisfies the following conditions. (1) R is C.-M. (2) Spec(R)-{m} has rational singularities (3) a(R) < 0. (This theorem was also proved by Flenner).

We prove this by using Boutot's theorem, which is a consequence of Grauert-Riemenschneider vanishing theorem. Also, we can get some conditions concerning the condition (2) of the Theorem.

Berichterstatter: R.Waldi

Als Preprint haben ausgelegen (außer den Preprints, über deren Inhalt in Vorträgen berichtet wurde):

M.BRODMANN : Blow-up and Asymptotic Depth of Higher Conormal Modules

W.BRUNS : The Eisenbud-Evans Generalized Principal Ideal Theorem and Determinantal Ideals

D.FERRAND : Trivialization de modules projectif. La methode de Kronecker

G.M.GREUEL : On Deformations of Curves and a Formula of Deligne

J.HANSEN : Singularities under Projection

J.HERZOG : Approximation Complexes and Proper Sequences

K.H.KIYEK : Anwendung von Ideal-Transformationen

M.MARTIN-DESCHAMPS/R.LEWIN-MENEGAUX: Surface de type general dominées par une varieté fixe

K.LANGMANN : Treuflacher Limes noetherscher Ringe

H.LINDEL : On Projective Modules over Polynomial Rings over Regular Rings

J.E.ROOS : Homology of Loop Spaces and of Local Rings

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