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Algebraische K-Theorie

August 4th – August 10th, 2002

The meeting was organized by Daniel R. Grayson (Urbana-Champaign), Bruno Kahn (Paris) and Uwe Jannsen (Regensburg). During the meeting, twenty talks were given on topics ranging from the algebraic K-theory of general rings to the motivic cohomology and K-theory of schemes, both of geometric and arithmetic nature.

Abstracts

The obstruction to excision in K-theory and in cyclic homology

Guillermo Cortiñas

This is a report on the contents of the paper [1].

Let $f : A \to B$ be a ring homomorphism of not necessarily unital rings and $I \triangleleft A$ an ideal which is mapped by f isomorphically to an ideal of B. The obstruction to excision in K-theory is the failure of the map between relative K-groups $K_*(A : I) \to K_*(B : f(I))$ to be an isomorphism; it is measured by the birelative groups $K_*(A, B : I)$. We show that these are rationally isomorphic to the corresponding birelative groups for cyclic homology up to a dimension shift. In the particular case when A and B are $\mathbb{Q}$-algebras we obtain an integral isomorphism.

The main theorem was conjectured in [5], where it was called the KABI conjecture. Our proof combines results of Wodzicki [7] and Suslin-Wodzicki [6] with Cuntz-Quillen's proof of the excision theorem in periodic cohomology [4], as well as our own infinitesimal methods [2],[3].

References

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The homotopy limit problem for algebraic K-theory at the prime 2

Andreas Rosenschon

(joint work with Paul Arne Østvær)

Let k be a field of characteristic $\neq 2$, and let k^s be a separable closure. Denote by $vcd(k)$ the 2-cohomological dimension of $k(\mu_4)$ and by G_k the absolute Galois group of k. We show that the natural map

$$\mathcal{K}/2(k) \longrightarrow \mathcal{K}/2(k^s)^{hG_k}$$

is a weak equivalence on $\sup(vcd(k) - 2, -1)$-connected covers.

Relative K-groups and class field theory for arithmetic surfaces

Alexander Schmidt

In the talk we explained the ingredients and methods of proof of the following result:
THEOREM : Let X be an arithmetic surface, i.e. a two-dimensional regular connected scheme, flat and proper over Spec$\mathbb{Z}$, and let Y be the support of a divisor on X. Then there exists a natural isomorphism of finite abelian groups

$$\text{rec} : CH_0(X,Y) \longrightarrow \tilde{\pi}_1^t(X,Y)^{ab}$$

Here $\tilde{\pi}_1^t(X,Y)^{ab}$ is the abelianized modified tame fundamental group which classifies finite abelian étale coverings of $U = X - Y$ that are at most tamely ramified along Y and in which every real point splits completely. $CH_0(X,Y)$ is the relative Chow-group of zero cycles.

Regulators and Arakelov motivic complexes

Alexander Goncharov

Let X be a regular complex projective variety. Denote by $\mathcal{Z}^\bullet(X,n)$ the weight n higher Chow group complex of Bloch. Let $C_{\mathcal{D}}^\bullet(X,n)$ be the Deligne complex of weight n, defined by Deligne as a subcomplex of the Dolbeaux (bi-)complex of currents. We constructed a homomorphism of complexes

$$\mathcal{Z}^\bullet(X,n) \longrightarrow C_{\mathcal{D}}^\bullet(X,n)$$

The cone of this homomorphism, shifted by -1 is, by definition, the weight n Arakelov motivic complex of X, denoted as $C_{\mathcal{A}}^\bullet(X,n)$. Its cohomology is closely related to the arithmetic (Arakelov) Chow groups of Gillet-Soulé.

Homology stability for unitary groups

Wilberd van der Kallen
(joint work with B. Mirzaii)

THEOREM : $H_i(U_{2n}^\epsilon(R,\Lambda),\mathbb{Z}) \cong H_i(U_{2n+2}^\epsilon(R,\Lambda),\mathbb{Z})$ for $n \geq 2i + usr(R) + 3$.
Here Λ is a form parameter, $\epsilon = \pm 1$, and the unitary group $U_{2n}^\epsilon(R,\Lambda)$ is the automorphism group of an orthogonal direct sum of n hyperbolic planes. For instance, it could be the symplectic group $\mathrm{Sp}_{2n}(R)$ or the orthogonal group $\mathrm{O}_{2n}(R)$ with respect to the form of maximal Witt index. The unitary stable range $usr(R)$ is defined to be the least $M \geq 1$ so that

(1) For any $r \in R$ the elementary group $\mathrm{E}_{2m+2}^\epsilon(R,\Lambda)$ acts transitively on unimodular vectors v of a certain length;
(2) (Bass's stable range condition) For every $v \in R^n$ with $n \geq m+1$ and v unimodular, there is $w \in e_1 + \mathrm{span}(e_2, ..., e_m + 1)$ such that (v,w) is unimodular.

The proof of the theorem uses a "nerve theorem" concerning connectedness of a poset covered by subposets that are indexed by a poset. It confirms a conjecture of Charney concerning high connectivity of a poset of unimodular sequences that span isotropic summands of R^{2n}.

Weil-étale cohomology

Thomas Geisser

For a smooth variety X over a finite field $\mathbb{F}_q$, we discuss a new Grothendieck topology introduced by Lichtenbaum, called Weil-étale topology. There is a morphism of topoi $\gamma : \mathcal{T}_W \to \mathcal{T}_{et}$ from the Weil-étale topos to the étale topos, and we calculate the derived complex $\mathbf{R}\gamma_*\mathcal{F}$ for a Weil-étale sheaf $\mathcal{F}$. In case $\mathcal{G}$ is a complex of étale sheaves, the calculation simplifies to $\mathbf{R}\gamma_*\gamma^*\mathcal{G} \cong \mathbf{R}\gamma_*\mathbb{Z} \otimes \mathcal{G}$. We also give a calculation of $\mathbf{R}\gamma_*\mathbb{Z}$, it is a 2-term complex with $\gamma_*\mathbb{Z} = \mathbb{Z}$ and $\mathbf{R}^1\gamma_*\mathbb{Z} = \mathbb{Q}$.

Applying this with $\mathcal{G}$ the motivic complex, one sees logical connections between the following conjectures (this is based on ideas of Bruno Kahn):

Fix a smooth projective variety X over $\mathbb{F}_q$ and an integer n. Denote by $\bar{X}$ the base change of X to the algebraic closure of $\mathbb{F}_q$.

L(X,n): $H^i_W(X, \mathbb{Z}(n))$ is finitely generated for all i

C(X,n): $H^i_W(X, \mathbb{Z}(n)) \otimes \mathbb{Z}_l \cong H^i_{cont}(X, \mathbb{Z}_l(n))$ for all i and all primes l

T(X,n):
- $CH^n(X) \otimes \mathbb{Q}_l \to H^{2n}_{cont}(X, \mathbb{Q}_l(n))$ is surjective
- $H^{2n}_{cont}(\bar{X}, \mathbb{Q}_l(n))$ is semisimple at 1 for the Frobenius action
- numerical and rational equivalence agree on $A^n(X) \otimes \mathbb{Q}$

Then C(X,n) and C(X,dim(X)-n) $\Rightarrow$ L(X, n) $\Rightarrow$ T(X, n). Conversely, if T(X,n) hold for all X and n then so do C(X,n) and L(X,n). Moreover, provided C(X,n) and C(X,dim(X)-n) both hold, there are formulae (expected by Lichtenbaum) for special values of the L-function of X.

Thomason's localization theorem for non-commutative rings

Amnon Neeman

Thomason's key lemma, in his Grothendieck Festschrift paper, asserts the following : Let X be a scheme, U an open subscheme. The bounded derived category of vector bundles on U is , up to splitting idempotents, the quotient of the bounded derived category of vector bundles on X. In a 1992 paper I proved that the key lemma may be viewed as a special case of a formal statement about triangulated categories . In recent work with Ranicki, we applied this to deduce a localization theorem in the K-theory of non-commutative rings.

$\mathbb{A}^1$-representability of hermitian K-theory and Witt groups and Morel's conjectures on $\mathbb{A}^1$-homotopy groups of spheres

Jens Hornbostel

We show that hermitian K-theory and Balmer Witt groups are representable both in the unstable and stable $\mathbb{A}^1$-homotopy category. In particular, Witt groups can be nicely expressed as homotopy groups of a topological space. The proof of the stable $\mathbb{A}^1$-representability of hermitian K-theory relies on a motivic version of real Bott periodicity.

Consequences include new results related to the projective line, blow ups and homotopy purity. Moreover, this should become part of a proof of Morel's conjecture on certain $\mathbb{A}^1$-homotopy groups of spheres, saying in particular that the endomorphism ring of the motivic sphere spectrum should be isomorphic to the Grothendieck-Witt group of the base field.

Equivariant K-theory for actions of diagonalizable group schemes

Gabriele Vezzosi
(joint work with A. Vistoli)

Let S be a separated connected noetherian base scheme, G a diagonalizable group scheme of finite type over S acting on a regular noetherian separated algebraic space X over S. If X_r denotes the locus in X where the dimension of the stabilizers is r, then we prove that the injections $\{X_r \hookrightarrow X\}_{r\geq 0}$ induce an injection of rings

$$K_*(X,G) \longrightarrow \prod_r K_*(X_r,G)$$

whose image is a fiber product of the rings $\{K_*(X_r,G)\}_r$ whose structure maps are pullbacks and specialization maps. This theorem on reconstruction from the strata can be applied to give a very refined localization theorem and to the study of the K-theory (equivariant and non-equivariant) of smooth toric varieties.

K-theory of smooth toric varieties

Angelo Vistoli
(joint work with G. Vezzosi)

We give formulas for the equivariant K-theory ring of a smooth toric variety, both as a subring of rings representations and by generators and relations. We also introduce a class of toric varieties, called combinatorially complete, for which the Merkurjev spectral sequence, linking equivariant and ordinary K-theory, degenerates, giving a presentation of the ordinary K-theory ring of these varieties.

Vector bundles on $S^2\mathbb{P}^2$

Charles Weibel

If k is a field of characteristic zero, we show that $K_0(S^2\mathbb{P}^2) \cong \mathbb{Z}^6$ injects into $K_0(\mathbb{P}^2 \times \mathbb{P}^2) \cong \mathbb{Z}^9$ and up to a factor of 2, the image equals the invariant subring under the action of the symmetric group Σ_2.

The main technical calculation is the K-theory of $\Lambda = k[t_1,t_2,z]/(t_1t_2 = z^2)$, which is a 2-dimensional normal domain. This is done by blowing up the regular sequence (t_1,t_2) and applying theorems of Cortiñas and Thomason. A Zariski descent calculation shows that $K_0(S^2\mathbb{P}^2) = K_0(S^2\mathbb{P}^2 \times \mathbb{A}^n)$, so that $K_0(S^2\mathbb{P}^2)$ equals the homotopy K-group $KH_0(S^2\mathbb{P}^2)$.

Localization in hermitian K-theory

Marco Schlichting
(joint work with Jens Hornbostel)

If A is a ring with involution in which 2 is invertible, and $S \subset A$ is a multiplicative set of nonzero divisors, then there is a homotopy fibration

$$_\epsilon\mathcal{U}(\mathcal{T}_S) \longrightarrow {}_\epsilon\, \mathcal{K}^h(A) \longrightarrow {}_\epsilon\, \mathcal{K}^h(S^{-1}A)$$

where $_\epsilon\mathcal{K}^h$ stands for Karoubi's ϵ-hermitian K-theory space, $_\epsilon\mathcal{U}(\mathcal{T}_S) = \Omega_\epsilon W(\mathcal{T}_S)$ with $_\epsilon W(\mathcal{T}_S)$ the hermitian analogue of Quillen's Q-construction applied to the exact category $\mathcal{T}_S$ of finitely generated S-torsion modules of projective dimension at most 1 and duality $\mathrm{Ext}^1_A(-,A) : \mathcal{T}_S^{op} \longrightarrow \mathcal{T}_S$.

In case that $f \in A$ such that A and $A/(f)$ are both regular and $S = \{F^n\}$ we have that $_\epsilon\mathcal{U}(\mathcal{T}_S) \simeq_\epsilon \mathcal{U}(A/(f))$ (the latter being Karoubi's U-theory). In case that A is a Dedekind domain and $S = A - \{0\}$, we have $_\epsilon\mathcal{U}_i(\mathcal{T}_S) \cong \bigoplus_{\mathfrak{p}} {}_\epsilon\mathcal{U}_i(A/\mathfrak{p})$. If R is a ring, there is a homotopy fibration

$$_\epsilon\mathcal{U}(R) \longrightarrow \mathcal{K}(R) \longrightarrow {}_\epsilon\, \mathcal{K}^h(R)$$

where the second map is the hyperbolic map.

Isovariant étale descent and Riemann-Roch for algebraic stacks

Roy Joshua

We extend Thomason's descent spectral sequence to algebraic stacks that are finitely presented over a nice base scheme. Applications to Riemann-Roch for Artin stacks and definition of finer cohomology theories for algebraic stacks are also discussed.

Twisting quadratic bundles

Boas Erez
(joint work with M. J. Taylor and P. Cassou-Nogues)

Let G be a finite group and let $X \to Y$ be a G-cover of schemes over $\mathbb{Z}[1/2]$. Assume $X \to Y$ is tame with odd ramification and suppose we are given a quadratic bundle E over Y and an orthogonal representation $\rho : G \to O(E)$. We discuss work in which we show

(1) how to define a quadratic bundle E_ρ (the twist)
(2) how to relate the cohomological invariants of E_ρ to those of E and ρ.

The novel feature is the appearance of a class involving the action of inertia and the action on the restriction of E to the generic point of the branch divisor. In a sense this class is an equivariant decomposition of the ramification class which appeared first in the work of Serre and Esnault-Kahn-Viehweg.

Galois structure of Zariski cohomology on curves

Bernhard Köck

Let X be a smooth projective curve over an algebraically closed field k, G a finite subgroup of the automorphism group $\mathrm{Aut}(X/k)$ and $\mathcal{E}$ a G-equivariant locally free sheaf on X. We gave a formula for the equivariant Euler characteristic $\chi(G,X,\mathcal{E}) := [H^0(X,\mathcal{E})] - [H^1(X,\mathcal{E})]$ (considered as an element of the Grothendieck group $G_0(k[G])$ of all f. g. $k[G]$-modules) in terms of the degree and rank of $\mathcal{E}$, the genus of the quotient curve $Y := X/G$ and certain local ramification data associated with the canonical projection $\pi : X \to Y$. Furthermore, if π is weakly ramified, we used this formula to express $\chi(G,X,\mathcal{O}_X(D))$ as an integral linear combination of the classes of certain explicitly defined projective $k[G]$-modules (in the Grothendieck group $K_0(k[G])$ of all f. g. projective $k[G]$-modules), under a certain assumption on the equivariant divisor D on X. This result generalizes a theorem of Nakajima from the tamely to the weakly ramified case. Finally, we applied this result to explicitly determine the $k[G]$-module structure of the space $H^0(X,\Omega_X(S))$ of global meromorphic differentials which are logarithmic along a G-stable non-empty finite set S of points on X containing all ramified points. This latter result generalizes a result of Kani again from the tamely to the weakly ramified case.

On arithmetic resolution for étale cohomology

Kirill Zainoulline

Let X be a smooth affine variety over a field k. Let $x = \{x_1, ..., x_n\}$ be a finite subset of pionts of X. Let $U = \mathrm{Spec}\mathcal{O}_{X,x}$ be the local scheme at x and $K = k(X)$ the generic point. Let $\mathcal{G}$ be a bounded complex of locally constant constructible sheaves of $\mathbb{Z}/n\mathbb{Z}$-modules on the étale site of X, with $(n, \mathrm{char}(k)) = 1$. Then the Gersten-type complex for étale hypercohomology with supports

$$0 \to H^q(U,\mathcal{G}) \to H^q(K,\mathcal{G}) \to \coprod_{u\in U^{(1)}} H_u^{q+1}(U,\mathcal{G}) \to \coprod_{u\in U^{(2)}} H_u^{q+2}(U,\mathcal{G}) \to ...$$

is exact.

This generalizes previously known results concerning Gersten resolution for étale cohomology.

Syntomic regulators on the algebraic K-theory of fields and curves

Rob de Jeu

Syntomic regulators are defined on the K-theory of a large class of varieties over the spectrum of a discrete valuation ring R (with field of fractions K of characteristic 0). We compute the syntomic regulator on certain subgroups of the K-groups of fields and curves. For number fields, this means that on a large part of $K_{2n-1}^{(n)}$, for $n \geq 2$, the syntomic regulator is given by Coleman's p-adic polylogarithm, and conjecturally this should be the case for the whole of $K_{2n-1}^{(n)}$. For a curve C over a number field $k \subset K$ and a fixed element $\alpha \in K_4^{(3)}(k)$ of certain type (conjecturally, everything) the syntomic regulator of this element followed by pairing with a global 1-form ω on C and the trace to K can be expressed as a Coleman integral over C (involving ω and the ingredients of α) at least for almost all completions K of k. For a finite number of completions, other technical assumptions may be necessary.

Semitopological spectral sequence

Christian Häsemeyer
(joint work with E. Friedlander and M. Walker)

A spectral sequence $E_2^{p,q}(sst) = L^{-q}H^{p-q}(X) \Rightarrow K^{sst}_{-p-q}(X)$ is defined for any smooth quasiprojective variety X over the complex numbers, and we give natural transformations of spectral sequences and abutments from the motivic spectral sequence to the semitopological above to the Atiyah-Hirzebruch spectral sequence of the analytic space associated to X. Here L^*H^* denotes the morphic cohomology of Friedlander and Lawson and K^{sst} the singular semitopological K-theory of Friedlander and Walker. We also give some applications of this result.

Algebraic K-theory and trace invariants

Lars Hesselholt

Let V_0 be a discrete valuation ring with quotient field K_0 of characteristic 0 and perfect residue field k_0 of odd characteristic p. Let X be a smooth V_0-scheme, and let i (resp. j) denote the inclusion of the special (resp. generic) fiber. We show—in collaboration with Thomas Geisser—that there is a natural exact sequence of sheaves of pro-abelian groups on the small étale site of Y,

$$0 \to i^*R^qj_*\mathbb{Z}/p\mathbb{Z}(q) \to i^*\bar{W}.\Omega^q_{(X,M)} \xrightarrow{1-F} i^*\bar{W}.\Omega^q_{(X,M)} \to 0.$$

Here $W.\Omega^*_{(X,M)} = W.\Omega^*_X(\log Y)$ is the de Rham-Witt complex of X with the log structure given by the special fiber, and

$$\bar{W}_n\Omega^q_{(X,M)} = W_n\Omega^q_{(X,M)}/pW_n\Omega^q_{(X,M)}$$

is the reduction modulo p. (The quotient of $i^*W_n\Omega^*_{(X,M)}$ by the log-differential graded ideal generated by $W_n(\mathfrak{m}_0\mathcal{O}_X)$ is the de Rham-Witt complex $W_n\Omega^*_{(Y,M_Y)}$ of Y with the induced log structure.)

Let V be the henselian local ring of X at a generic point of Y, and suppose that the quotient field K contains the p^vth roots of unity. Then we use the exact sequence above—in combination with results on topological cyclic homology obtained in collaboration with Ib Madsen—to show that the canonical map

$$K^M_*(K) \otimes_{\mathbb{Z}} S_{\mathbb{Z}/p^v}(\mu_{p^v}) \xrightarrow{\sim} K_*(K, \mathbb{Z}/p^v),$$

which takes $\zeta \in \mu_{p^v}$ to the corresponding Bott element $b_\zeta \in K_2(K, \mathbb{Z}/p^v)$, is an isomorphism. This is the value of the Quillen K-groups predicted by the Beilinson-Licthenbaum conjectures (which refine the Licthenbaum-Quillen conjecture).

Perfect forms and the K-theory of $\mathbb{Z}$

Herbert Gangl

(joint work with P. Elbaz-Vincent and C. Soulé)

For $N = 5$ and $N = 6$, we compute the Voronoi cell complex attached to real N-dimensional quadratic forms – which is provided by the so-called perfect forms – and we obtain the homology of $GL_N(\mathbb{Z})$ with trivial coefficients, up to small primes. We also prove that $K_5(\mathbb{Z}) = \mathbb{Z}$ and $K_6(\mathbb{Z})$ has only 3-torsion.

Edited by Christian Häsemeyer

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