Tagungsbericht 21/1998

Regulators

17.05.-23.05.1998

The conference was organized by

Spencer Bloch, Chicago
Manfred Kolster, Hamilton
Peter Schneider, Münster
Victor P. Snaith, Southampton

The topic of the conference concentrated on "Regulators", which appear in various forms in Arithmetic Algebraic Geometry and Algebraic Number Theory. Excellent talks about new research results and various interesting discussions gave new evidence about the importance of regulators, in particular in their relation to motives and Galois Module Structure.

VORTRAGSAUSZÜGE

M. KAROUBI

REGULATORS AND MULTIPLICATIVE K-THEORY

The lecture was based on 4 references (K-theory 2 (1988), p.431-463, K-theory 4 (1990), p.55-87, K-theory 8 (1994), p.153-211, Fields Inst. Comm. (1997), p.59-77.)

The scheme underlying the ideas is the following geometric picture

$$\begin{array}{ccccc} (\text{Algebraic K}-\text{theory}) & \longrightarrow & (\text{Multiplicative K}-\text{theory}) & \longrightarrow & (\text{Topological K}-\text{theory}) \\ & & \downarrow & & \downarrow \\ & & (\text{Deligne}-\text{Beilinson cohom.}) & & (\text{Singular cohom.}) \end{array}$$

In a "non-commutative" framework of a Banach (or Fréchet) algebra, one introduces a multiplicative K-theory $\mathcal{K}_n(A)$ which fits into the following commutative 16-term diagram:

$$\begin{array}{ccccccc} K_n^{\text{rel}}(A) & \longrightarrow & K_n(A) & \longrightarrow & K_n^{\text{top}}(A) & \longrightarrow & K_{n-1}^{\text{rel}}(A) \\ \downarrow & & \downarrow & & \downarrow & & \downarrow \\ HC_{n-1}(A) & \longrightarrow & \mathcal{K}_n(A) & \longrightarrow & K_n^{\text{top}}(A) & \longrightarrow & HC_{n-2}(A) \\ \downarrow & & \downarrow & & \downarrow & & \downarrow \\ HC_{n-1}(A) & \longrightarrow & HC_n^-(A) & \longrightarrow & HC_n^{\text{per}}(A) & \longrightarrow & HC_{n-2}(A) \\ \downarrow & & \downarrow & & \downarrow & & \downarrow \\ HC_{n-1}(A) & \longrightarrow & HH_n(A) & \longrightarrow & HC_n(A) & \longrightarrow & HC_{n-2}(A) \end{array}$$

where all HC-groups are variants of cyclic homology (in a topological context) as introduced by A. Connes. Three main examples are of some interest

1) $A = \mathbf{C}$. Then $\mathcal{K}_n(\mathbf{C}) = \mathbf{C}^\times$ if n odd and there is acanonical map $K_n(\mathbf{C}) \longrightarrow \mathbf{C}^\times$ which detects all torsion elements and from which one can detect the Borel regulator.
2) $A = C^\infty(S^1)$. Then $\mathcal{K}_2(\mathbf{C}) \simeq \mathbf{C}^\times$ and the homomorphism $\mathcal{K}_2(A) \longrightarrow \mathbf{C}^\times$ defines the well-known Kac-Moody extension $1 \longrightarrow \mathbf{C}^\times \longrightarrow \Gamma \longrightarrow \mathrm{SL}(C^\infty(S^1)) \longrightarrow 1$.
3) A (as a sheaf of) holomorphic functions on a compact analytic manifold X. The analog of $HC_{n-2}(A)$ is then the following sum $\oplus_r H^{2r-n}(\Omega^\bullet(X)/F^r)$ where F^r is the Hodge filtration and $\Omega^\bullet(X)$ the deRham complex. The group $\mathcal{K}_n(A)$ (denoted also $\mathcal{K}_n(X)$) can be computed thanks to the exact sequence

$$K_{n+1}^{\text{top}}(X) \to \oplus_r H^{2r-n-1}(\Omega^\bullet(X)/F^r) \to \mathcal{K}_n(X) \to K_n^{\text{top}}(X) \to \oplus_r H^{2r-n}(\Omega^\bullet(X)/F^r),$$

where $H^i(\Omega^\bullet(X)/F^r) \simeq \oplus_{\substack{p+q=i \\ p<r}} H^{p,q}(X)$ (Hodge theory). There is a "regulator" $K_n^{hol}(X) \longrightarrow \mathcal{K}_n(X)$.

Many techniques are necessary to construct and prove the previous statements. One feature is the continuation of a model of Eilenberg-MacLane space $K(\mathbf{C}, i)$ as the simplicial abelian group $s \mapsto Z^i(\Delta_s)$ where

$Z^i(\Delta_\bullet)$ is the vector space of closed forms of degree i on the simplex $\Delta_\bullet$. If $G = \mathrm{GL}(\mathbf{C})$, a model of BG is the diagonal in the simplicial set $(EG_n)_p/G_n$ where $G_n = C^\infty(\Delta_n : G)$ and $(EG_n)_p$ is the set of sequences $(g_0, g_1, \ldots, g_n)$ with $G_i \in G_n$. If we put $\Gamma = \sum x_k g_k^{-1} dg_k$, x_k barycentric coordinates in Δ_n, and $R = d\Gamma + \Gamma^2$, the trace of R^m is a closed globally defined form on BG and we define a simplicial map $BG \longrightarrow K(\mathbf{C}, 2m)$ which represents the Chern character.

The homotopy fiber $\mathcal{K}(\mathbf{C})$ of the map $BG \longrightarrow \prod_m K(\mathbf{C}, 2m)$ is the classifying space of the multiplicative K-theory of the complex numbers $\Pi_n(\mathcal{K}_n(\mathbf{C})) =: \mathcal{K}_n(\mathbf{C})$. If G^δ means G with the discrete topology, it is clear that there is a canonical map $BG^\delta \to \mathcal{K}(\mathbf{C})$ inducing the "regulator map" $K_n(\mathbf{C}) \to \mathcal{K}_n(\mathbf{C})$.

More details can be found in the references for the general map $K_n(A) \to \mathcal{K}_n(A)$ where A is a Fréchet algebra.

A. GONCHAROV

MULTIPLE POLYLOGARITHMS AND MODULAR COMPLEXES

Multiple polylog's:

$$Li_{n_1,\ldots,n_m}(z_1, \ldots, z_m) = \sum_{0<k_1<\ldots<k_m} \frac{z_1^{k_1} \cdots z_m^{k_m}}{k_1^{n_1} \cdots k_m^{n_m}}. \qquad (*)$$

We describe the Lie coalgebra $C(N)_{\bullet,\bullet}$ generated by the framed mixed Tate motives corresponding to $(*)$ when $z_i^N = 1$. We introduce a complex $M^\bullet_{(m)}$ of $\mathrm{GL}_m(\mathbf{Z})$-modules of length $m-1$ such that

$$\left(M^\bullet_{(m)} \otimes_{\mathrm{GL}_m(\mathbf{Z})} \mathbf{Q}[t_1, \ldots, t_m]\right) \simeq \bigwedge{}^\bullet(C(1)_{\bullet,\bullet}),$$

where $C(1)_{\bullet,\bullet}$ is the bigraded Lie coalgebra corresponding to $(*)$, and a similar relation for $C(N)_{\bullet,\bullet}$. When $m = 2$, $M_{(2)}$ is the chain complex for the classical triangulation of the hyperbolic plane.

A. HUBER

DEGENERATIONS OF l-ADIC EISENSTEIN CLASSES

(joint work with G. Kings, to appear: Inv. Math.)

Let $B = \mathbf{Q}(\mu_N)$, $N \geq 3$, M the modular curve of elliptic curves with level-N-structure $/B$. It can be compactified

$$M \overset{j}{\hookrightarrow} \overline{M} \leftarrow \text{Cusps} \leftarrow \infty = B\,, \qquad \overline{M} \overset{i}{\leftarrow} \infty.$$

$\mathcal{H}$ the Tate module of the universal elliptic curve. There is a canonical map, the Eisenstein section

$$Eis : \mathbf{Q}_l[\text{Cusp}] = H^0(\text{Cusp}_{\mathbf{Z}}, \mathbf{Q}_l) \to H^1_{\text{et}}(M_{\mathbf{Z}}, \text{Sym}^k \mathcal{H}(1))^G = H^1_{\text{et}}(M, \text{Sym}^k \mathcal{H}(1)) = Ext^1_M(\mathbf{Q}_l, \text{Sym}^k \mathcal{H}(1)).$$

Prop If $\varphi \in \mathbf{Q}_l[\text{Cusp}]$ with $\phi(\infty) = 0$, then $i^* j_* Eis(\varphi) \in Ext^1_B(\mathbf{Q}_l, \mathbf{Q}_l(k+1))$.
We write $Dir(\varphi) \in H^1(B, \mathbf{Q}_l(k+1))$ for this element.
Rem This is a reformulation of Harder's construction of Anderson motives.

Let

$$\rho_k : \mathbf{Q}_l([E[N] - \{0\}]) \longrightarrow \mathbf{Q}_l[\text{Cusps}]$$
$$= \{f \in \mathrm{GL}_2(\mathbf{Z}/N) \to \mathbf{Q}_l \text{ s.t. } f(ug) = f(g) \text{ for } u \in \begin{pmatrix} * & * \\ 0 & 1 \end{pmatrix}, f(-g) = (-1)^k f(g).\}$$

be the horospherical map. It is surjective.

Thm For $\psi \in \mathbf{Q}_l[E[N] - \{0\}]$ with $\rho^k(\psi)(\text{ind}) = 0$ we have

$$Dir(Eis\, \rho^k \psi) = \frac{(-1)^{k+1}}{k!n} \sum_{u \in \mathbf{Z}/N} \psi(u, 0) c^k(\zeta^u),$$

where $c^k(\zeta^u)$ is the Soulé–Deligne element of $H^1(B, \mathbf{Q}_l(k+1))$.

Cor Dir is surjective.

There is a second version of Dir, the cup product construction, which immediately translates to motivic cohomology and absolute cohomology. Hence we also get

Cor Conjecture 6.2 in Bloch-Kato is true (Theorem of Beilinson–Deligne, Huber, Wildeshaus)

The degeneration theorem is proved by relating Eisenstein classes to the elliptic polylog (Beilinson-Levin) and the cyclotomic elements to the classical polylog (Beilinson, Wildeshaus). So the final proof consists in studying the degeneration of the elliptic polylog into the classical one as the elliptic curve degenerates into G_m.

A. WEISS

THE LIFTED ROOT NUMBER CONJECTURE

Let K/k be a finite Galois extension of number fields with Galois group G, S a large set of primes of K, and denote the S-units by E and the kernel of $\mathbf{Z}[S] \to \mathbf{Z}$, $\mathfrak{p} \to 1$, by ΔS. To a G-monomorphism $\phi : \Delta S \to E$ we associate a class Ω_φ in $K_0T(\mathbf{Z}G)$, the Grothendieck group of finite cohomologically trivial G-modules. The conjecture (joint work with R. Gruenberg and J. Ritter) is that Ω_φ is represented, in the Hom-description for $K_0T(\mathbf{Z}G)$, by $\chi \mapsto A_\varphi(\check{\chi})W_{K/k}(\check{\chi})$, where A_φ is as in Stark's conjecture and $W_{K/k}$ represents the root number class. This conjecture, if true, would imply the $\Omega(K/k,3)$ conjecture and the "strong Stark" conjecture of Chinburg, and has the technical advantage of being approachable one prime at a time.

Much of the talk was a discussion of the simplest nontrivial example (joint work with J. Ritter) in which K/Q is cyclic of prime order l with r ramified primes, all different from l. A special map φ is constructed which induces an isomorphism $\mathbf{Z}_l \otimes \Delta S \to \mathbf{Z}_l \times E$ and gives a Tate sequence by pushout of an explicit sequence. The construction is closely related to Euler systems: this leads to a proof of the conjecture when $r \leq 2$.

J. WILDESHAUS

POLYLOGARITHMS AND REGULATORS FROM A SHEAF-THEORETICAL POINT OF VIEW

Theorem (1) Beilinson | Neukirch, Esnault; 2) Deninger, 3) Beilinson, Deligne | Huber, Wildeshaus; 4) Huber, Kings)

$d \geq 2, K := \mathbf{Q}(\mu_d)$, $\mu_d^o := \{\omega \in \mu_d \text{ primitive}\}$, $n \geq 1$.

$$r_{\mathcal{H}} : K_{2n-1}(K) \otimes \mathbf{Q} \longrightarrow \bigoplus_{\sigma : K \hookrightarrow \mathbf{C}} \mathbf{C}/(2\pi i)^n \mathbf{R}$$

the regulator in absolute Hodge cohomology. Then $\exists$ maps (unique for $n \geq 2$)

$$\epsilon_n : \mu_d^o \longrightarrow K_{2n-1}(K) \otimes \mathbf{Q} \quad \text{s.t.}$$

$$\forall \omega \in \mu_d^o : \; r_{\mathcal{H}}(\epsilon_n(\omega)) = \Big(-Li_n(\sigma\omega) \Big)_\sigma , \qquad (Li_n(z) = \sum_{k \geq 1} \frac{z^k}{k^n}).$$

The larger part of the talk concentrated on a survey of the sheaf theoretic input necessary for the proof of the above. Special emphasis was put on the classification theorem for unipotent variations (due to Hain & Zucker). The second part consisted of a discussion of the *logarithmic sheaf* and the *polylogarithmic extension* in a more general geometric context.

A. BESSER

p-ADIC REGULATORS AND p-ADIC INTEGRATION

Let $[K;\mathbf{Q}] < \infty$, $Z/\mathcal{O}_K$ quasi-projective and smooth. Then Gros and Niziol define a syntomic regulator $K_j(Z) \xrightarrow{\mathrm{ch}_{i,j}} H^{2i-j}_{\mathrm{syn}}(Z,i)$ (called by other names at other places).

Let $C/\mathbf{C}_p$ be projective and smooth with good reduction

$$K_2(C) \longrightarrow K_2(\mathbf{C}_p(C)) \xrightarrow{r_p} Hom_{\mathbf{C}_p}(\Omega^1(C/\mathbf{C}_p), \mathbf{C}_p),$$

(call the composite $r_{C,p}$), defined by

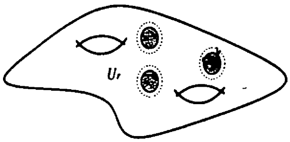
$$r_p(\{f,g\})(\omega) = \int_{(f)} \log g \cdot \omega := \sum n_i F_{\log g \cdot \omega}(x_i),$$

where $(f) = \sum n_i(x_i)$ is the divisor of f and $F_{\log g \cdot \omega}$ is the Coleman integral of $\log g \cdot \omega$, which is unique up to constant. The main theorem we prove is

Theorem 1 If $Z/\mathcal{O}_k$ is projective, smooth, of relative dimension 1, and $C = Z \otimes \mathbf{C}_p$, then the following diagram commutes:

$$\begin{array}{ccccc} K_2(Z) & \xrightarrow{\mathrm{ch}_{2,2}} & H^2_{\mathrm{syn}}(Z,2) & \cong & H^1_{dR}(Z_k/K) \\ \downarrow & & & & \downarrow \\ K_2(C) & \xrightarrow{r_p} & Hom(\Omega^1(C/\mathbf{C}_p), \mathbf{C}_p) & \xrightarrow{\text{Poincaré}} & H^1_{dR}(C/\mathbf{C}_p) \end{array}$$

The main ingredient in the proof is the theory of local indexes at the ends of a (so-called) "basic wide open" of Coleman.



This is a complement in C of a finite number of "radius R" discs, with $r \to 1$. The corresponding annuli are called the ends of U. One can define "local indexes" at the ends: for 2 Coleman functions F, G on an annulus e, such that dF and dG are analytic forms on e, $ind_e(F,G)$ is the unique anti-symmetric form extending $Res_e F\, dG$ when this makes sense. We have:

Residue Theorem If F is a Coleman function on U with dF analytic on U, and F is analytic on U, then

$$\sum_{e \in End(U)} ind_e(F, \log f) = 0.$$

The theory of local indexes allows one to define an intermediate regulator,

$$\rho(f,g)(\omega) = \sum_{e \in End(U)} ind_e\Big(\log f, \int (d \log g\, F_\omega)\Big).$$

We show that this is the same as the syntomic regulator, interpreted via the above diagram, and that up to logs of tame symbols it is also the same as the Coleman–de Shalit regulator.

B. EREZ

Ω-INVARIANTS FOR MOTIVES

The aim of the talk was to present recent work of D.Burns & M.Flach. This work brings together two lines of research: Galois module theory à la Chinburg–namely the study of certain invariants inside class groups–and the theory of special values of L-functions following Bloch, Kato, Fontaine and Perrin-Riou.

The starting point is a motive M over a number field K with coefficients in a (not necessarily commutative) semisimple algebra $A/\mathbf{Q}$. Under suitable assumptions one defines an element $T\Omega(A,M)$ in the group $K_0(\mathcal{A},\mathbf{R})$ (or $K_0(\mathcal{A},\mathbf{Q})$), where $\mathcal{A} \subset A$ is an order $/\mathbf{Z}$ in A and $K_0(\mathcal{A},\mathbf{R})$ is the relative Grothendieck group of projective $\mathcal{A}$-modules of finite generation w.r.t. the/a map $\mathbf{Z} \to \mathbf{R}$. This element is defined as being the class of a triple $(\Theta(M)_{\mathbf{Z}}, \widehat{\theta}_\infty, \mathcal{A})$ where $\Theta(M)_{\mathbf{Z}}$ is an invertible module in the "fundamental line"$/\mathcal{A}$ of Fontaine and Perrin-Riou, and where $\widehat{\theta}_\infty$ is defined using the leading term of the $A_{\mathbf{R}}$-valued L-function $L(M,s)$; $\widehat{\theta}_\infty$ defines an isomorphism between $\Theta(M)_{\mathbf{Z}} \otimes \mathbf{R}$ and $\mathcal{A} \otimes \mathbf{R}$ [this is the construction in the commutative case; D. Burns sketched the construction in general in his talk].

The talk emphasized the ways in which $T\Omega(\mathcal{A},M)$ is related to other invariants and what the consequences are of the *Equivariant Tamagawa number conjecture* which says/predicts that $T\Omega(\mathbf{Q},M) = 0$. This conjecture generalizes the Bloch-Kato conjecture, the Kato conjecture for motives of weight ≤ 1 with coefficients in $\mathbf{Z}G$ (G abelian). Evidence for the ETNC independent of that for these two conjectures is given by work in Galois module theory (Greenberg-Ritter-Weiss, Chinburg-Kolster-Pappas-Snaith and Burns-Flach). Note for instance that ETNC $\Leftrightarrow$ Lifted Root number conjecture (for Tate motives).

C. GREITHER

FITTING IDEALS OF CLASS GROUPS OF REAL CYCLOTOMIC FIELDS

This talk reported on recent joint work with Pietro Cornacchia. The main result is as follows: Let K be a subfield of $\mathbf{Q}(\zeta_{l^n})^+$, $G = \mathrm{Gal}(K/\mathbf{Q})$. Let E_K (C_K) be the group of units (of cyclotomic units, resp.) in K. Then

$$\mathrm{Fit}_{\mathbf{Z}G}(E_K/C_K) = \mathrm{Fit}_{\mathbf{Z}G}(CL(K)).$$

Here Fit denotes the first Fitting ideal.

The main points of the proof are an application of the Main Conjecture in Iwasawa theory, and a lemma which says that "Fit" is multiplicative on exact sequences $0 \to N \to A \to B \to M \to 0$ where the middle terms A and B are of finite projective dimension. It is worth mentioning that the modules E_k/C_K and $CL(K)$ are **not** of finite projective dimension in general.

A. LANGER

ON THE IMAGE OF P-ADIC REGULATORS FOR HILBERT-BLUMENTHAL SURFACES

Let Y be a smooth projective variety over a local field L with good reduction. Then the image of $H^1(Y,K_2)\otimes\mathbf{Q}_p$ in $H^1(\mathrm{GL}, H^2(\overline{Y},\mathbf{Q}_p(2))$ under the étale cycle class map can be controlled by what Bloch and Kato call the local points of the motive $H^2(Y)(2)$. To show that the map $H^1(Y,K_2)\otimes\mathbf{Q}_p \to H^1_g(\mathrm{GL}, H^2(\overline{Y},\mathbf{Q}_p(2))/H^1_f$ is in fact surjective, one has to show the Tate conjecture in char p performed for certain Hilbert-Blumenthal surfaces X over $\mathbf{Q}_p$ where p is a split good reduction prime in $F = \mathbf{Q}(\sqrt{q})$, $q \equiv 1(4)$ the discriminant of F. We assume that $h_F = 1$ and that all Hilbert modular cusp forms for the full Hilbert modular groups $\mathrm{SL}_2(\mathcal{O}_F)$ are lifts of one-variable modular forms. Then the Tate conjecture holds in char p. The idea is to study the reduction of certain Hirzebruch-Zagier cycles mod p and give a modular description of them. For each isotypical component ν_f in the cuspidal cohomology under the action of the Hecke algebra, one gets in this way two linearly independent cycles F^f, U^f, that generate the space of local Tate classes.

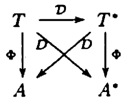
J. NEKOVÁŘ

DUALITY THEOREMS IN GALOIS COHOMOLOGY

This talk was about a generalization of Tate(-Poitou) duality theorems for Galois cohomology over local and global fields to "big Galois representations".

Let p be a prime, K a number field (totally complex if $p = 2$), $S \supset S_p \supset S_\infty$ a finite set of primes of K, K_S/K the maximal extension of K unramified outside S, $G_S = \mathrm{Gal}(K_S/K)$. Let R be a complete local noetherian ring with finite residue field $k = R/m = \mathbf{F}_{p^N}$ of $\mathrm{char}(k) = p$. We define a suitable category $(R[G_S]^{\mathrm{ad}} - \mathrm{Mod})$ of admissible $R[G_S]$-modules (which includes R-modules M of finite (resp. cofinite) type over R with an R-linear action of G_S, continuous w.r.t. the m-adic (resp. discrete) topology on M).

One has duality functors D, $\mathcal{D}$

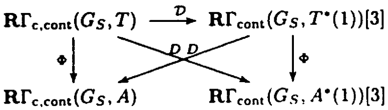


$T, T^\bullet \in D^b_{R-\mathrm{ft}}(R[G_S]^{\mathrm{ad}} - \mathrm{Mod})$, $A, A^\bullet \in D^b_{R-\mathrm{coft}}(R[G_S]^{\mathrm{ad}} - \mathrm{Mod})$, such that, after forgetting the G_S-action, $\mathcal{D}(-) = \mathbf{R}Hom_R(-, \omega_R^\bullet)$ is the Grothendieck dual and $D(-)$ is the Pontryagin(=Matlis) dual. For a bounded below complex M of admissible $R[G_S]$-modules one defines a complex $\mathbf{C}^\bullet_{\mathrm{cont}}(G_S, M)$ of continuous cochains and a complex of continuous cochains with compact support

$$\mathbf{C}^\bullet_{c,\mathrm{cont}}(G_S, M) = \mathrm{Cone}\Big(\mathbf{C}^\bullet_{\mathrm{cont}}(G_S, M) \longrightarrow \bigoplus_{v \in S - S_\infty} \mathbf{C}^\bullet_{\mathrm{cont}}(G_v, M)\Big)[-1], \qquad (G_v = G(\overline{K_v}/K_v)).$$

These complexes define functors $\mathbf{R\Gamma}_{\mathrm{cont}}(G_S, -)$, $\mathbf{R\Gamma}_{c,\mathrm{cont}}(G_S, -)$.

Poitou-Tate duality can be generalised as follows: for $T, A, T^\bullet, A^\bullet$ as in the above diagram, the functors D, $\mathcal{D}$ and Φ interchange the cohomology



Similar results can be proved over K_v and for suitable "Selmer complexes".

D. BURNS

TAMAGAWA NUMBER CONJECTURES FOR NON-COMMUTATIVE COEFFICIENTS

This talk described a "Tamagawa Number Conjecture" (of Bloch-Kato type) for motives with (non-commutative) coefficients. If M is a motive over a number field K which admits an action of a finite dimensional semisimple $\mathbf{Q}$-algebra A, and $\mathcal{A}$ is a $\mathbf{Z}$-order in A which is "tame" for M (i.e. there is a projective $\mathcal{A}$ lattice "in M") then we can conjecturally define an element $T\Omega(\mathcal{A}, M)$ of the relative K-group $K_0(\mathcal{A}, \mathbf{R})$. The conjecture of Beilinson et.al. implies that $T\Omega(\mathcal{A}, M) \in K_0(\mathcal{A}, \mathbf{R})$ and the "Equivariant Tamagawa Number Conjecture" asserts that $T\Omega(\mathcal{A}, M) = 0$. If $A = \mathbf{Q}$, $\mathcal{A} = \mathbf{Z}$ and M has weight ≤ -1 this is the original conjecture of Bloch-Kato (Grothendieck Festschrift). In other cases the conjecture refines existing conjectures of Gross, Tate, Rubin, Chinburg etc. We also described some evidence for the general conjecture.

U. JANNSEN

CLASS FIELD THEORY AND FINITENESS RESULTS FOR SURFACES OVER LOCAL FIELDS

The talk reported on joint work with Shuji Saito, concerning properties of the regulator maps

$$\rho : H^d(X\mathcal{K}_{d+1}) \longrightarrow H^{2d+1}_{\acute{e}t}(X, \mathbf{Z}_l(d+1))$$

for a smooth projective variety over a local or global number field k. Here $d = \dim X$ and $H^d(X, \mathcal{K}_{d+1}) = \mathrm{Coker}\Big(\bigoplus_{x\in X_1} K_2(k(x)) \stackrel{\text{tame}}{\longrightarrow} \bigoplus_{x\in X_0} k(x)\Big)$, where X_i denotes the set of points of dimension i of X and $k(x)$ is the residue field of $x \in X_1$. If k is local, then $H^{2d+1}_{\acute{e}t}(X, \mathbf{Z}_l(d+1)) \cong \pi_1(X)^{ab}$, the abelianized fundamental group, and ρ is the reciprocity map of higher-dimensional class field theory. The case ofcurves is well understood, mainly by work of K. Kato and S. Saito in the 80's. For a surface X we prove: Assume that the Milnor-Kato conjecture holds for $K_3^M(k(x))$ and the prime l (resp. for all primes l) [this is valid for $l = 2$ by work of Rost / Merkuriev-Suslin, or for all l for rational or ruled surfaces].

Thm.1 Let k be local. Then

$$\rho_{l^\nu} = \rho_{X,l^\nu} : H^2(X, \mathcal{K}_3)/l^\nu \stackrel{\sim}{\longrightarrow} H^5_{\acute{e}t}(X, \mathbf{Z}/l^\nu(n+1)) \qquad \forall \nu > 0$$

if X has good reduction. If X has semistable reduction, there is an exact sequence ($l \neq$residue characteristic unless X is ordinary semi-stable),

$$H_2(\Gamma_Y, \mathbf{Z}/l^\nu) \longrightarrow H^2(X, \mathcal{K}_3)/l^\nu \stackrel{\rho_{l^\nu}}{\longrightarrow} H^5_{\acute{e}t}(X, \mathbf{Z}/l^\nu(n+1)) \longrightarrow H_1(\Gamma_Y, \mathbf{Z}/l^\nu) \longrightarrow 0,$$

where Γ_Y is the simplicial complex associated to the special fibre Y. In general, the family of groups $(\ker \rho_{l^\nu})_{\nu\geq 0}$ has bounded order (resp. the family $(\ker \rho_n)_{n\in\mathbf{N}}$ is bounded), and similarly $\big(V(X)/l^\nu\big)_{\nu\geq 0}$ (resp. $(V(X)/n)_{n\in\mathbf{N}})$ is bounded for

$$V(X) = \ker\Big(H^2(X, \mathcal{K}_3) \stackrel{N}{\longrightarrow} k^\times\Big).$$

Thm.2 Let k be global. Then the families $(\ker \rho_{l^\nu})_{\nu\geq 0}$ and $\big(V(\mathcal{X}, \mathbf{Z}/l^\nu)\big)_{\nu\geq 0}$ (resp. $(\ker \rho_n)_{n\in\mathbf{N}}$ and $\big(V(\mathcal{X}, \mathbf{Z}/n)\big)_{n\in\mathbf{N}}$ are bounded, where

$$V(\mathcal{X}, \mathbf{Z}/n) = \ker\Big(V(X)/n \longrightarrow \bigoplus_{v\in V} CH_0(Y_v)/n\Big),$$

$\mathcal{X} \longrightarrow U$ being a smooth and projective model of X over an open part $U \subset \mathrm{Spec}\,\mathcal{O}_k$, $\mathcal{O}_k$= ring of integers of k, Y_v= fibre of $\mathcal{X}$ over $v \in U$.

The proof uses several complexes of Bloch-Ogus type introduced by Kato and requires to prove some of Kato's conjectures on these complexes.

D. DELBOURGO

p-ADIC HEIGHTS

Given a modular elliptic curve, $E/\mathbf{Q}$ such that $L(E,1) = 0$, then it can be shown via Kato's Euler system that $\mathrm{Sel}(E/\mathbf{Z}_p$-extension) is cotorsion over the Iwasawa algebra, Λ, at primes $p > 3$ such that $p^2 | \mathrm{cond}(E)$ & p is potentially ordinary. Then one can find a formula for $\mathrm{char}_\Lambda\big(\mathrm{Sel}(E/\mathbf{Z}_p\text{-extension})\big)$ if $\#Ш_{p^\infty} < \infty$. This formula involves a "bad" p-adic regulator and the usual suspects.

H. GANGL

REGULATOR CALCULATIONS AND THE LICHTENBAUM CONJECTURE

We exhibit non-trivial elements in the higher Bloch groups (as defined by Zagier and also by Goncharov) $B_m(F)$ of number fields F (of degree up to 8 over $\mathbf{Q}$, not necessarily Galois) with the help of a computer. Since $B_m(F)$ is conjectured to be an explicit model for $K_{2m-1}\mathcal{O}_F$ (and known for $m = 2$ and to some extent for $m = 3$) and one can compute a certain one-valued version of the mth polylogarithm, $\mathcal{L}_m : \mathbf{C} \longrightarrow \mathbf{R}$, which plays the role of the Borel regulator map for this model, we obtain conjectural information about the regulator.

This in turn enables us to establish numerical evidence for both Lichtenbaum's and Zagier's conjecture for small m ($2 \leq m \leq 6$) and predict orders of even K-groups $K_{2m-2}\mathcal{O}_F$ (at least up to primes $\leq m$). For $m = 2$, it is known that $\mathcal{L}_2(B_2(F))$ forms a lattice, and the corresponding form of the Lichtenbaum conjecture (with numerical support) reads:

$$\pi^{(m-1)r_2}\zeta_F^*(-1) \;=\; \frac{\#K_2\mathcal{O}_F}{w_2(F)} \cdot \mathrm{covol}\Big(\mathcal{L}_2(B_2(F))\Big).$$

The computations helped to detect certain superfluous Euler factors in a proof of Lichtenbaum's conjecture for a class of abelian fields and to give a clue how to get rid of them; a prominent role is played by distribution relations for polylogarithms.

J. D. LEWIS

INDECOMPOSABLE MOTIVIC COHOMOLOGY CLASSES

Let $X/\mathbf{C}$ be a projective algebraic manifold, and $CH^k(X,m)$ = Bloch's higher Chow group. Our primary interest is the study of the following objects, using Hodge theory methods:

Definition. 1.) The space of **decomposables** is given by the image

$$CH^k_{\mathcal{D}}(X,m)_{\mathbf{Q}} := \mathrm{Im}\{(B\mathbf{C}^\times)^{\otimes m} \otimes CH^{k-m}(X,0)_{\mathbf{Q}} \longrightarrow CH^k(X,m)_{\mathbf{Q}}\},$$

where $\mathbf{C}^\times$ is identified with $CH^1(X,1)$.

2.) The space of *decomposables* is given by

$$CH^k_{\mathrm{ind}}(X,m)_{\mathbf{Q}} = CH^k(X,m)_{\mathbf{Q}}/CH^k_{\mathcal{D}}(X,m)_{\mathbf{Q}}.$$

There are cycle class maps $c_{k,m} : CH^k(X,m)_{\mathbf{Q}} \longrightarrow H^{2k-m}_{\mathcal{D}}(X,\mathbf{Q}(k))$, and correspondingly induced maps

$$\underline{c}_{k,1} : CH^k_{\mathrm{ind}}(X,1)_{\mathbf{Q}} \longrightarrow H^{2k-1}_{\mathcal{D}}(X,\mathbf{Q}(k))/\mathbf{C}^\times_{\mathbf{Q}} \otimes Hg^{k-1}(X)_{\mathbf{Q}}$$

where $Hg^{k-1}(X)_{\mathbf{Q}}$ is the Hodge group), and for $m \geq 2$

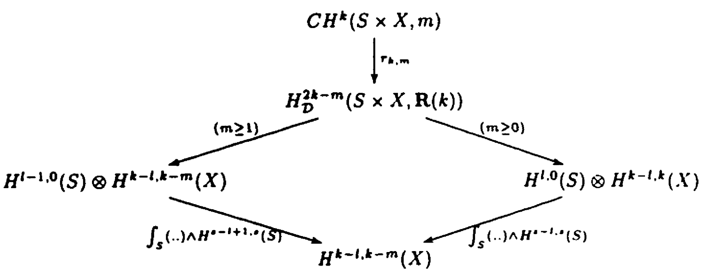
$$\underline{c}_{k,m} : CH^k_{\mathrm{ind}}(X,m)_{\mathbf{Q}} \longrightarrow H^{2k-m}_{\mathcal{D}}(X,\mathbf{Q}(k)).$$

By rigidity, $\mathrm{Im}(\underline{c}_{k,m})$ is countable for $m \geq 1$.

Definition. $\mathrm{Level}(CH^k(X,m)_{\mathbf{Q}}) = \min\{r \geq 0 | CH^k(X,m)_{\mathbf{Q}} \overset{\text{restriction}}{\longrightarrow} CH^k(X-Y,m)_{\mathbf{Q}}$ is zero for some closed $Y \subset X$, where $\mathrm{codim}_X(Y) = k - r - m.\}$.

Similarly, one can define $\mathrm{Level}(CH^k_{\mathcal{D}}(X,m)_{\mathbf{Q}})$ and $\mathrm{Level}(CH^k_{\mathrm{ind}}(X,m)_{\mathbf{Q}})$.

Let $S/\mathbf{C}$ be a smooth projective variety of dimension s. We introduce the following 'diamond':



Definition. $H^{\{k,l,m\}}(X)$ = C-subspace of $H^{k-l,k-m}(X)$ generated by the images of $CH^k(S \times X, m)$, over all S.

We have the following theorem:

Theorem. Assume either $m \leq 2$, or for $m \geq 3$, there exist a projective algebraic manifold $B/\mathbf{C}$ of dimension $m-1$, and a class $\gamma \in H^{m-1}(B, \mathbf{R}(m-1))$ with $\gamma^{m-1,0} \neq 0$, in the image of the regulator map

$$r_{m,m} : H^m_{\mathcal{M}}(B, \mathbf{Q}(m))_{\mathbf{R}} \longrightarrow H^m_{\mathcal{D}}(B, \mathbf{R}(m)) \simeq H^{m-1}(B, \mathbf{R}(m-1)).$$

Then 1. $H^{\{k-m,l-m,0\}}(X) \subset H^{\{k,l,m\}}(X)$

2. $H^{\{k-m,l-m,0\}}(X) \neq 0 \Rightarrow \text{Level}(CH^k_{\mathcal{D}}(X,m)_{\mathbf{Q}}) \geq l-m$,

3. $H^{\{k,l,m\}}(X)/H^{\{k-m,l-m,0\}}(X) \neq 0 \Rightarrow \text{Level}(CH^k_{\text{ind}}(X,m)_{\mathbf{Q}}) \geq l-m$.

Note. One can show that $l-m \geq 1$ in 3. implies $CH^k_{\text{ind}}(X,m)_{\mathbf{Q}}$ is uncountable. Thus, by rigidity, one would have an uncountable number of indecomposables in the kernel of the regulator map $c_{k,m}$.

Finally, in joint work with B. Brent Gordon, we have:

Theorem. Let $X = E_1 \times E_2 \times E_3$ be a sufficiently general product of three mutually non-isogenous elliptic curves. Then $\text{Level}(CH^3_{\text{ind}}(X,1)_{\mathbf{Q}}) \geq 1$.

T. CHINBURG

GALOIS STRUCTURE OF K-GROUPS AND THE MAIN CONJECTURE OF IWASAWA THEORY

Suppose N/K os a finite Galois extension of global fields with $G = \text{Gal}(N/K)$, and that $1 \leq n \in \mathbf{Z}$. This talk was about the application of Wiles' proos of the Main Conjecture of Iwasawa Theory to study an invariant $\Omega_n(N/K)$ in the class group $Cl(\mathbf{Z}G)$ which measures the difference between the G-structure of $K_{2n+1}(O_{N,S})$ and $K_2(O_{N,S})$ when S is a large G-stable set of places of N. (For the definition see "Galois structure of K-groups of rings of integers," C.R.Acad.Sci.Paris t.320 Sér I(1995), p.1435-1440.) Conjecturally, $\Omega_n(N/K)$ is equal to a certain root number class $\omega_{N/K}$ defined by Fröhlich and Cassou-Noguès. This is knon if N is a function field of characteristic not dividing $\#G$, and also if n is odd and N is a totally real field up to classes in the kernel group $D(\mathbf{Z}G)$ and classes of modules of 2-power order. Let $\omega_{n+1}(N) = \prod_p \#(\mu_{p^\infty}^{\otimes(n+1)})^{\text{Gal}(\overline{N}/N)}$ and let $\omega_{n+1}(N,G)$ be the product of those primes l dividing $\omega_{n+1}(N)$ for which the l-Sylow of G is not cyclic. We discusse. how to use Wiles' work to show that if N is totally real, n is odd and G is abelian, then $\Omega_n(N/K) = \omega_{N/K}$ up to classes of modules of 2-power order and classes in $D(\mathbf{Z}G)$ represented by finite modules supported on $\omega_{n+1}(N,G)$.

N. SCHAPPACHER

On $K_2(E)$

Let F be a number field, E an elliptic curve defined over F and $\mathcal{E}/O_F$ the regular minimal model of E over the ring of integers of F. One conjectures (without being able to prove a single instance) that the groups $H^0(E, \mathcal{K}_2)/K_2(F)$ and $K_2(\mathcal{E}/O_F)$ are finitely generated abelian groups. On the other hand, there is the problem of constructing explicit elements in $K_2(\mathcal{E}/O_F)$—with a view to verifying Beilinson's conjectures for $L(E/F,2)$—resp. for the derivative $L'(E/F,0)$.

In the talk, we reported on the elementary proofs given for recent progress on the second problem, obtained by Goncharov/Levin (Inventiones 132) as well as Wildeshaus (Duke 87); these elementary arguments were published in Crelle 495(1998), by Rolshausen and N.Sch. They rely as much as possible on the classical theory of elliptic functions according to Eisenstein, Kronecker and Weierstrass.

At the end of the talk, we drew attention to Don Zagier's remark about how desirable it would be, in this and similar contexts, to have a group bigger than $E(F)$, but much smaller than the $G(\overline{\mathbf{Q}}/F)$-invariant divisors on $E(\mathbf{Q})$, at one's disposal...

R. DE JEU

TOWARDS REGULATOR FORMULAE FOR THE K-THEORY OF CURVES OVER NUMBER FIELDS

Let k be a number field, and let C be a smooth, proper, geometrically irreducible curve over k. The Beilinson conjectures give a relation between the image of the regulator map $K_{2n}^{(n+1)}(C) \longrightarrow H^1_{\mathrm{dR}}(C \otimes_{\mathbf{Q}} \mathbf{C}; (2\pi i)^n \mathbf{R})$ and $L(C, 2-(n+1))^*$, the first non-vanishing coefficient of $L(C,s)$ at $s = 2-(n+1)$, for $n \geq 2$. (For $n = 1$ there is an extra condition on elements of $K_{2n}^{(n+1)}(C)$ for this.) Based on complexes conjectured by Goncharov, we construct a double complex $\mathcal{M}_{(n+1)}(C)$ in terms of $F = k(C)$ and $k(x)$, where x runs through the closed points of C, with maps of the cohomology of the double complexes to the K-theory of the curve, depending on some general conjecture for high n.

For $n = 2, 3$, we can show that after applying the regulator to the image, we obtain all of the image of the K-theory $(K_{2n}^{(n+1)}(C))$ under the regulator in $H^1_{\mathrm{dR}}(C \otimes_{\mathbf{Q}} \mathbf{C}; (2\pi i)^n \mathbf{R})$, independent of any conjectures. This provides evidence for the correctness of Goncharov's conjectures.

S. LICHTENBAUM

REGULATOR PAIRINGS WITH VALUES IN QUOTIENTS OF IDELE CLASS GROUPS

We give two examples to illustrate the philosophy that values of zeta-functions should be essentially given by étale Euler characteristics, involving a regulator pairing into a quotient of the idèle class group.

I. Let F be a number field, O_F the ring of integers in F. Let $X = \operatorname{Spec} O_F$, $\bar{X}$ = the completion of X obtained by adjoining the infinite primes, $\varphi : X \to \bar{X}$. We consider $\bar{X}$ with the étale site.

We have the formula:

$$\zeta^*(O_F, 0) = -\frac{hR}{w} = -\chi(\bar{X}, \varphi_! \mathbf{Z}).$$

Here

$$\chi(\bar{X}, \varphi_! \mathbf{Z}) = \frac{\# H^0(\bar{X}, \varphi_! \mathbf{Z})}{\# H^1(\bar{X}, \varphi_! \mathbf{Z})_{\mathrm{tor}}} \cdot \frac{\# H^2(\bar{X}, \varphi_! \mathbf{Z})}{\# H^3(\bar{X}, \varphi_! \mathbf{Z})_{\mathrm{cotor}}} \cdot \mathrm{Reg}_{\bar{X}}.$$

The regulator is obtained by pairing $H^1(\bar{X}, \varphi_! \mathbf{Z})$ with the dual of $H^3(\bar{X}, \varphi_! \mathbf{Z})$ (the units of F). The units are described as $\mathrm{Hom}_{\bar{X}}(\varphi_! \mathbf{Z}, \varphi_! G_m)$, and hence we obtained a pairing into $H^1(\bar{X}, \varphi_! G_m)$ which maps to $H^1(\bar{X}, \varphi_! \mathbf{Z})$. $H^1(\bar{X}, \varphi_! \mathbf{Z})$ is dense in the quotient of the idèle class group of F divided by the unit idèles. The classical regulator is obtained by composing this pairing with $\log|\cdot| \longrightarrow \mathbf{R}$ and then taking determinants.

II. Let E be an elliptic curve over $\mathbf{Q}$ with Néron model $\mathcal{E}$ over $\mathbf{Z}$. The conjecture of Birch and Swinnerton-Dyer for E can be restated as saying:

$$L^*(E, 1) = \chi(\bar{X}, \varphi_* \mathcal{E})^{-1} \omega,$$

where ω is the real period. Here the regulator is the determinant of the pairing from $H^0(\bar{X}, \varphi_! \mathbf{Z}) \times \mathrm{Ext}^1_{\bar{X}}(\varphi_* \mathcal{E}, G_m) \longrightarrow H^1(\bar{X}, G_m) \longrightarrow \mathbf{R}$, which is the height pairing on the elliptic curve.

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