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Topology

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The meeting was organized by M. Kreck (Mainz), A. Ranicki (Edinburgh) and L. Siebenmann (Orsay). About 60 participants from Western and Eastern Europe, North America and Australia attended the conference. The twenty-two talks dealt with recent progress in a wide range of topics in topology. About a third of the presentations were concerned with stable or unstable homotopy theory, including research related to the solution of the Segal conjecture and the progress toward the solution of Sullivan's conjecture.

Other areas discussed included low dimensional topology, knot theory, classical algebraic topology, algebraic K-theory and group actions on spaces.

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Vortragsauszüge

C.-F. BÖDIGHEIMER:

Stable splittings of function spaces

The talk elaborated on two observations concerning configuration spaces $C(M,A;X)$ of particles on a smooth, compact m-manifold M with parameters in a space X; particles are annihilated when they are in $A \subset M$, or when their parameter is the basepoint in X.

First observation. Let M be contained in another smooth m-manifold W. It follows from work of Gromov, Segal and McDuff that $C(M,A;X)$ is homotopy equivalent to the space of sections of a certain $\Sigma^m X$-bundle over W, which are defined outside of A and vanish outside of M, provided (M,A) or X is connected; hence if M is in addition parallelizable, then $C(M,A;X) \simeq \mathrm{map}\ (W \setminus A,\ W \setminus X;\ \Sigma^m X)$.

Second observation. $C = C(M,A;X)$ has a filtration $\{C_k\}$, and the splitting techniques of Snaith et al. give a stable equivalence $\Sigma^\infty C \simeq \Sigma^\infty(\bigvee_{k=1}^{\infty} C_k/C_{k-1})$.

We apply this to mapping spaces of a finite complex $K \subset \mathbb{R}^m$ into a suspension $\Sigma^m X$ as follows. If $K_0 \subset K$ is a subcomplex, choose a regular neighbourhood $(N,N_0) \underset{\alpha}{\overset{r}{\rightleftarrows}} (K,K_0)$ of (K,K_0); for $M = N \setminus N_0$, $A = \partial M$, $W = \mathbb{R}^m$, the considerations above give a stable splitting of map $(\mathrm{int}\ N,\ \mathrm{int}\ N \cap N_0;\ \Sigma^m X) \simeq \mathrm{map}\ (K,K_0;\Sigma^m X)$ with $M/\partial M \wedge X$ as the first summand. This approach gives a unified proof of well-known splitting theorems of James, Snaith, F. Cohen & Taylor, May, Goodwillie et al.

R. BROWN:

Some homotopical applications of a non-abelian tensor product of groups
(Report on joint work with Jean-Louis Loday.)

1. The classical Blakers-Massey triad connectivity theorem gives the critical group $\pi_{p+q-1}(X;A,B)$ as a tensor product $\pi_p(A,C) \otimes \pi_q(B,C)$ if $p,q > 2$ and $\pi_1 C = 0$. This gives the problem of what happens if $p = 2$ or $q = 2$ or $\pi_1 C \neq 0$. Now $\pi_1 C$ acts on $\pi_p(A,C)$ and $\pi_q(B,C)$

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and so

$$\pi_p(A,C) \text{ acts on } \pi_q(B,C) \begin{cases} \text{trivially, if } p > 2 \\ \text{via} \\ \partial : \pi_2(A,C) \to \pi_1 C \text{ if } p = 2 \end{cases}$$

and similarly $\pi_q(B,C)$ acts on $\pi_p(A,C)$.

2. Let G, H be groups such that G acts on H $({}^g h)$ and H acts on G $({}^h g)$, and let any group act on itself by conjugation $({}^y x = y x y^{-1})$. Then $G \otimes H$ is the group with generators $g \otimes h$ and relations

$$g \otimes hh' = (g \otimes h)({}^h g \otimes {}^h h'),$$

$$gg' \otimes h = ({}^g g' \otimes {}^g h)(g \otimes h),$$

for all $g,g' \in G$, $h,h' \in H$.

3. Applications

(a) With this interpretation, the Blakers-Massey determination remains true for $p = 2$ or $q = 2$ or $\pi_1 C \neq 0$.

(b) There is a low-dimensional EHP-sequnece for a connected space X

$$\pi_2 X \xrightarrow{E} \pi_3 SX \xrightarrow{H} \pi_1 X \otimes \pi_1 X \xrightarrow{p=[\,,\,]} \pi_1 X \longrightarrow (\pi_1 X)^{ab} \longrightarrow 0.$$

Also the composition

$$(\pi_1 X)^{ab} \times (\pi_1 X)^{ab} \xrightarrow{\cong} \pi_2 SX \times \pi_2 SX \xrightarrow[\text{product}]{\text{Whitehead}} \pi_3 SX \xrightarrow{H} \pi_1 X \otimes \pi_1 X$$

is given by $([x], [y]) \longmapsto (y \otimes x)(x \otimes y)$, and there is an exact sequence

$$\pi_2 X \xrightarrow{E^2} \pi_4 S^2 X \xrightarrow{H^2} \pi_1 X \tilde{\otimes} \pi_1 X \xrightarrow{[\,,\,]} \pi_1 X \longrightarrow (\pi_1 X)^{ab}$$

where $G \tilde{\otimes} G = (G \otimes G) / \{(x \otimes y)(y \otimes x) = 1 \mid x,y \in G\}$.

(c) An application to amalgamated sums of $K(\pi,1)$'s was given, and this has applications to the homology of discrete groups.

4. Computations

(a) If G,H act trivially on each other then

$$G \otimes H = G^{ab} \otimes H^{ab}.$$

(b) If A is a G-module and A acts trivially on G, then $G \otimes A \cong (IG) \otimes_{\mathbb{Z}G} A$ (D. Gain).

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(c) $G \otimes G$ has been computed for dihedral, quaternionic, $\frac{1}{2}$ the metacyclic and all groups of order ≤ 30 (Brown - . Johnson - E.F. Robertson)

(d) exact sequence

$$H_3G \longrightarrow G^{ab} \longrightarrow \mathrm{Ker}\,(G\otimes G \longrightarrow G) \longrightarrow H_2G \longrightarrow 0,$$

so G finite $\Longrightarrow G \otimes G$ finite.

(e) For example if $D_m = gp < x,y \mid x^2 = y^m = x\,yxy = 1 >$, and m is even, then

$$D_m \otimes D_m = \mathbb{Z}_2 \times \mathbb{Z}_m \times \mathbb{Z}_2 \times \mathbb{Z}_2$$

with generators $x \otimes x$, $x \otimes y$, $y \otimes y$, $(x \otimes y)(y \otimes x)$.

5. Explanations

The applications arise from a generalized van Kampen theorem for a functor (due to Loday)

$$\Pi: (\text{n-cubes of spaces}) \longrightarrow \text{cat}^n\text{-groups}.$$

References R. Brown - J.-L. Loday

(1) van Kampen theorems for n-cubes of spaces

(2) Homotopical excision and the Hurewicz theorem for n-cubes of maps.

D. BURGHELEA:

An extension of Euler Poincaré characteristic.

If k is a field of characteristic zero, let $k[u]$ be the ring of polynomials and $k(u)$ the field of rational functions. For any S^1-space $\tilde{X}$ (with underlying space X), $H^*_{S^1}(\tilde{X},k)$ is a $k[u] = H^*_{S^1}(pt;k)$ module and for any k-algebra A, the cyclic cohomology $HC^*(A)$ is a $k[u] = HC^*(k)$-module.

A space X is called of finite type if $\dim H^*(X;k) < \infty$ and an S^1-space X resp. a k-algebra A of S^1-finite type if

$$\dim_{k(u)} (H^*_{S^1}(\tilde{X};k) \otimes_{k[u]} k(u)) < \infty \text{ resp.} \dim_{k(u)} (HC^*(A) \otimes_{k[u]} k(u)) < \infty.$$

We denote by $\tilde{X}^{S^1}$ the free loop space X^{S^1} equipped with the natural

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S^1-action and by $\tilde{\Omega}^2X$ the double loop space Ω^2X equipped with the natural action (induced by the rotation about the north south axis of S^2).

Note: a) If X is of finite type then $\check{X}$ is of S^1-finite type.

b) If $k[\pi_1(x)]$ is of S^1-finite type then $\tilde{X}^{S^1}$ is of finite type.

c) If X is 2-connected and of finite type then $\tilde{\Omega}^2X$ is of finite type.

The usual Euler Poincaré characteristic is defined for any X of finite type. We define $\chi(\check{X})$ if $\check{X}$ is of S^1-finite type as

$$\dim_{k(u)}(H^{even}_{S^1}(X,k) \otimes_{k[u]} k(u)) - \dim_{k(u)}(H^{odd}_{S^1}(H_{S^1}(X;k) \otimes_{k[u]} k(u)$$

Theorem a) $\chi(\check{X})$ satisfies all formal properties of Euler Poincaré characteristic.

b) If X is of finite type then $\chi(\check{X})$ = the Euler Poincaré characteristic of X, hence $\chi(\check{X})$ does not see the action.

c) In general, $\chi(\check{X})$ depends on the action as it follows from $\chi(\tilde{\Omega}^2X)$ = Euler Poincaré characteristic of X if X is 2-connected and of finite type.

d) If $k[G]$ is of S^1-finite type and $\pi_1(X) = G$ then $\chi(\tilde{X}^{S^1})$ depends only on G and if G is "geometric" (for instance the fundamental group of a negatively curved compact manifold) $\chi(\tilde{X}^{S^1})$ is the Euler Poincaré characteristic of G.

The proof depends heavily on the minimal models of $X^{S^1} \times_{S^1} ES^1$ (Burghelea - Michelin Vigré) and of $\Omega^2X \times_{S^1} ES^1$ and uses cyclic cohomology.

J.L. DUPONT:

The dilogarithm as a characteristic class for flat bundles.

For (E,∇) an n-dimensional complex vector bundle over a manifold M with ∇ a flat connection there are defined the Cheeger - Chern - Simons classes

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$\hat{c}_k(\nabla) \in \mathrm{Hom}\,(H_{2k-1}(M),\ \mathbb{C}/\mathbb{Z})$.

Problem: Describe $\hat{c}_k(\nabla)$ in terms of the associated holonomy representation $h\colon\ \pi_1(M) \longrightarrow Gl(n,\mathbb{C})$.

Universally $\hat{c}_k$ gives a homomorphism

$$\hat{c}_k \in \mathrm{Hom}\,(H_{2k-1}(Gl(n,\mathbb{C})^{\delta}),\ \mathbb{C}/\mathbb{Z})$$

where the homology group is the integral group homology group for the discrete group underlying $Gl(n,\mathbb{C})$.

Ex. $k = 1$: $\hat{c}_1 \in \mathrm{Hom}\,(H_1(Gl(n,\mathbb{C})^{\delta}),\ \mathbb{C}/\mathbb{Z})$ is given by

$$c_1(g) = \frac{1}{2\pi i} \log \det (g).$$

We describe $\hat{c}_2 \in \mathrm{Hom}\,(H_3(Sl(2,\mathbb{C})^{\delta}),\ \mathbb{C}/\mathbb{Q})$ in terms of the dilogarithmic function $L(z) = -\frac{1}{2} \int_0^z \left\{ \frac{\log(1-t)}{t} + \frac{\log t}{1-t} \right\} dt$

applied to cross ratios of 4-tuples of points on the Riemann sphere.

Z. FIEDOROWICZ:

Hermitian K-theory of Homotopy Ring Spaces

This is a preliminary report of joint work with R. Schwänzl and R. Vogt. We define a Hermitian algebra ic K-theory of A_∞ rings with involution which extends the previous theory developed for topological rings by the author and D. Burghelea. Given an A_∞ ring with involution R we define an $\mathcal{F}$-space with involution in the sense of Segal whose underlying space has the homotopy type of $\coprod_{n\geq 0} B(\Omega B_+ M_n(R)),\ M_n(R),\ *)$ with involution or $\Omega B M_n(R)$ corresponding to $A \to A^*$ on matrices and the identity on loop reversal on Ω depending on whether one is defining symmetric or antisymmetric Hermitian algebra K-theory. Taking subfunctions and fibrewise function spaces we obtain an $\mathcal{F}$-space with underlying space of type $\coprod_{n\geq 0} B(F_{\mathbb{Z}/2}\,(E\mathbb{Z}/2,\ \Omega B_+\ Gl_1(R)),\ Gl_n(R),\ *)$ whose associated infinite loop space is defined to be ${}_{\varepsilon}L\,(R)$.

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For this to have good properties we require that R have all path components $\frac{1}{2}$ local. We show that $Q(\Omega X_+)$ with all path components localized away from 2 with involution defined by inversion of loops is an A_∞-ring with involution and we are in the process of proving that there exists an exact sequence in the stable range of the form

$$\rightarrow {}_{\varepsilon}L(QS^0)_{l+1}(M) \otimes \mathbb{Z}[\tfrac{1}{2}] \rightarrow \pi_{l+1}({}_{\varepsilon}L(M)) \otimes \mathbb{Z}[\tfrac{1}{2}]$$
$$\rightarrow \pi_i\left(\frac{H(M, 2M)}{\mathrm{Homeo}(M, 2M)}\right) \otimes \mathbb{Z}[\tfrac{1}{2}] \rightarrow \dots$$

Here M is a compact triangulable 2k-manifold with $= (-1)^k$. This generalizes a rational sequence of the same type obtained by Burghelea and the author.

Th. FISCHER:

<u>K-Theory with Finite Coefficients of Function Rings</u>

For a compact topological space X , we denote by $R = C(X,\mathbb{R})$ the ring of continuous real-valued functions, considered as a discrete ring. Then we prove the following

<u>Theorem:</u> The algebraic K-theory of R with finite coefficients is naturally isomorphic to the (topological) K-theory of the underlying space X with finite coefficients:

$$K_i(R, \mathbb{Z}/_{k\mathbb{Z}}) \cong K^{-i}(X, \mathbb{Z}/_{k\mathbb{Z}}) \quad \text{for} \quad i \geq 0,\ k \quad \mathbb{N}.$$

This result shows that the algebraic K-theory of R with finite coefficients is a generalized cohomology theory on X, and in particular depends only upon the homotopy type of the compact space X.

The proof follows the approach of Suslin in his paper "K-theory of local fields". The basic machinery used consists of a description of the homotopy fibre of the map $BG^{\delta} \rightarrow BG$ for locally convex groups G and a homotopy chain construction, based upon a theorem by Gillet-Thomason and Gabber-Suslin.

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Finally, standard methods are used to translate the obtained homology results into homotopy and K-theory.

H.-W. HENN:

On the growth of homotopy groups

For a simply connected space X of finite type and a prime p define power series

$$P_{\pi_*(X;\mathbb{Z}/_p)} = \sum_n \dim_{\mathbb{Z}/_p} \left[(\pi_n(X;\mathbb{Z}/_p) \otimes \mathbb{Z}/_p \right] \cdot t^n$$

and

$$P_{H_*(\Omega X;\mathbb{Z}/_p)} = \dim_{\mathbb{Z}/_p} \left[H_n(\Omega X;\mathbb{Z}/_p) \right] \cdot t^n$$

Let $R_{\pi_*(X;\mathbb{Z}/_p)}$ and $R_{H_*(\Omega X;\mathbb{Z}/_p}$ denote their radii of convergence.

Conjecture If S is a finite complex, then

$$R_{\pi_*(X;\mathbb{Z}/_p)} = R_{H_*(\Omega X;\mathbb{Z}/_p)} .$$

As evidence for this conjecture we have

Theorem 1 If X is of finite type, then

$$R_{\pi_*(X;\mathbb{Z}/_p)} \geq \min (R_{H_*(\Omega X;\mathbb{Z}/_p)}, C_p)$$

where C_p is a constant only depending on p and $C_p \geq \frac{1}{2}$.

Theorem 2 (Iriye) If X is finite, then

$$R_{H_*(\Omega X;\mathbb{Z}/_p)} \geq R_{\pi_*(X;\mathbb{Z}/_p)} .$$

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J.A. HILLMAN:

Solvable 2-knot groups

Let $K: S^2 \to S^4$ be a TOP locally flat embedding and $G = \pi_1(S^4 \setminus K(S^2))$. Suppose that G is virtually solvable and has a non trivial torsion free abelian normal subgroup. Then

G is f. presentable, $H_1(G) \cong \mathbb{Z}$, $H_2(G) = 0$ and

G has weight 1 (the Kervaire conditions) and either

1) G is torsion free poly ($\mathbb{Z}$ or finite) of Hirsch length 4 and orientable type; or

2) the commutator subgroup G' is finite and has cohomological period 4; or

3) G has presentation $< a, t \mid t a t^{-1} = a^2 >$.

All the groups of type (1) and (2) may be realized by fibred knots. If G is poly-$\mathbb{Z}$ then it determines the exterior $S^4 \setminus K(S^2)$ up to homeomorphism. (This is true for all knots of type (1) if the strong Novikov conjecture holds). (Eg. the Cappell-Shaneson knots, with $G' = \mathbb{Z}^3$).

In case (3) G' is not finitely generated. However, this group is the group of a ribbon 2-knot.

F.E.A. JOHNSON:

Aspherical manifolds, rational division algebras and class field theory

The finite dimensional division algebras over the field $\mathbb{Q}$ have been classified by Hasse-Brauer-Noether-Albert. They can be described by 3 parameters $(K, \mathbb{E}, \gamma)$ where

i) $\mathbb{E}$ is a finite algebraic extension of $\mathbb{Q}$.

ii) K is a cyclic extension of $\mathbb{E}$ with $S \in \mathrm{Gal}(K/\mathbb{E})$ a generator, $\mathrm{Gal}(K/\mathbb{E}) \cong C_n$.

iii) γ is a "well chosen" element of $\mathbb{E}$.

With these parameters, the associative algebra $<K, S, \gamma>$ is the free K-

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module on $\{1, y, \dots, y^{n-1}\}$ with relations (a) $y^n = \gamma$ (b) $y\lambda = s(\lambda)y$, $\lambda \in K$.

For simplicity, suppose n is odd, and consider the algebraic group scheme.

$$\mathbb{G}(A) = \mathrm{Ker}(\langle K,S,r\rangle \otimes_{\mathbb{Q}} A \xrightarrow{N\otimes 1} \mathbb{E} \otimes_{\mathbb{Q}} A),$$

where $N: \langle K,S,r\rangle \longrightarrow \mathbb{E}$ is reduced norm, $N(x) = \det(y \mapsto xy)$.

Then $\mathbb{G}$ is $\mathbb{Q}$-simple and $\mathbb{Q}$-anisotropic (Fujisaki's Thm) and if Γ is an arithmetic subgroup of $\mathbb{G}_{\mathbb{Q}}$ then Γ is a cocompact irreducible lattice in the Lie group

$$SL_n(\mathbb{R})^a \times SL_n(\mathbb{C})^b \quad \text{where} \quad \mathbb{E} \otimes_{\mathbb{Q}} \mathbb{R} \cong \mathbb{R}^a \times \mathbb{C}^b.$$

T. KADEISHVILI:

<u>$A(\infty)$-algebra structure in cohomology and its applications</u>

For an arbitrary differential algebra C with free $H_i(C)$ the set of operations $\{m_i: H(C) \otimes \dots (i) \dots \otimes H(C) \longrightarrow H(C),\ i = 2,3,\dots\}$ is constructed, which forms on $H(C)$ the $A(\infty)$-algebra structure in the sense of Stasheff. This set of operations defines the perturbed differential $d_m: B(H(C)) \longrightarrow B(H(C))$ on the Bar-construction $B(H(C))$, for which there exists a homology isomorphism $f: (B(H(C)),d_m) \longrightarrow B(C)$ to the usual Bar-construction of C.

Taking $C = C^*(B,\Lambda)$ we obtain an $A(\infty)$-algebra structure on $H^*(B,\Lambda)$ for an arbitrary space B with free $H^i(B,\Lambda)$. As an application, we have that the $A(\infty)$-algebra $(H^*(B,\Lambda),\{m_i\})$ defines cohomology of a loop space ΩB.

In the case of rational coefficients the set of operations $\{m_i\}$ can be constructed in such a way, that $(B(H(C)),d_m)$ becomes a differential Hopf algebra and f becomes a multiplicative map. Thus, in this case $A(\infty)$-algebra $(H^*(B,\mathbb{Q}),\{m_i\})$ defines $H^*(\Omega B,\mathbb{Q})$ as an algebra, hence it defines also rational homotopy groups $\pi_*(B) \otimes \mathbb{Q}$.

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C. KEARTON:

Integer invariants of certain even-dimensional knots

An n-knot k is an oriented, smooth or locally-flat PL pair (S^{n+2}, Σ^n), where Σ^n is homeomorphic to S^n. If K is the closed complement of a tubular neighbourhood of Σ^n, then k is simple if $\pi_i(K) \cong \pi_i(S^1)$ for $1 \leq i < \left[\frac{n+1}{2}\right]$. In 1972 the simple (2q-1)-knots, $q \geq 2$, were classified in terms of homology modules and the Blanchfield duality pairing. Various invariants are available, such as ideal classes, Alexander polynomials, and the Milnor signatures. In 1980 the simple 2q-knots, $q \geq 4$, were classified in terms of homology and homotopy mudules and a hermitian pairing, together with a short exact sequence, under the additional assumption that $\pi_q(K)$ is $\mathbb{Z}$-torsion-free. (This assumption has since been removed by M.S. Farber.) In this talk it is indicated how some computable invariants, with values in $\mathbb{Z}$, may be defined in certain cases; and that some of these must vanish (mod 2) in the case of a doubly-sliced knot.

T. KOZNIEWSKI:

Proper group actions on acyclic complexes

Let Γ be a discrete group which has virtually finite cohomological dimension. In 1971 Serre proved that for such Γ there exists a finite dimensional, contractible, proper Γ complex. We consider the following questions.

Question 1: When does there exist a contractible proper Γ complex X such that X/Γ is finite?

Question 2: When does there exist a contractible proper Γ complex X such that dim X = $\mathrm{vcd}\,\Gamma$?

In the case where Γ is torsion-free the answers to these questions are known (Eilenberg-Ganea, Wall). To answer the first question in general case we show that every group Γ (which satisfies suitable finiteness conditions) defines for each prime p a sequence of obstructions $\pi_p(\Gamma)_i \in \tilde{K}_0(\mathbb{Z}/_p N_i)$ where $H_1, \ldots H_k$ is a complete set of representatives of conjugacy classes of finite, non-trivial p-subgroups of Γ and where N_i denotes $N(H_i)/H_i$. These obstructions have the property given in

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Theorem. (There exists a finite Γ complex X of prime power type and such that for every prime p and every finite, nontrivial p-subgroup P in Γ X^P is $\mathbb{Z}/_p$ acyclic) $\Leftrightarrow$ (All $\pi_p(\Gamma)_i$ are 0).

(By finite Γ complex we understand here a Γ complex X such that X/Γ is finite.)

If all $\pi_p(\Gamma)_i$ are 0 then there exists a further obstruction:

$$\pi(\Gamma) \in K_0(\mathbb{Z}\Gamma) / \sum_{H \in \mathcal{P}(\Gamma)} T_H(\mathbb{Z}\Gamma)$$

where $\mathcal{P}(\Gamma)$ denotes the set of all subgroups in Γ of prime powerorder and for every finite subgroup H in Γ : $T_H(\mathbb{Z}\Gamma) = \mathrm{Ind}_{N(H)} T_H(\mathbb{Z}(N(H)))$ and $T_H(\mathbb{Z}(N(H)))$ denotes the image of the boudary homomorphism δ : $K_1(\mathbb{Z}/_{|H|}(N(H)/H)) \to K_0(\mathbb{Z}(N(H)))$ in the Mayer-Vietoris sequence corresponding to H and $N(H)$. Then we have

Theorem: Assume all $\pi_p(\Gamma)_i = 0$. Then:

(There exists a contradictible, finite Γ complex X of prime powertype) $\Leftrightarrow \pi(\Gamma) = 0$.

The answer to the second question is given in terms of cohomology of posets of finite p subgroups of Γ.

J. LANNES:

On the mod. 2 cohomology of elementary abelian 2-groups.

We describe some properties of the mod 2 cohomology H^*V of an elementary abelian 2-group V both as an unstable module and algebra over the Steenrod algebra A. Let be the category of unstable A-modules and $T : \mathcal{U} \rightsquigarrow \mathcal{U}$ be the left adjoint functor of the functor: $\mathcal{U} \rightsquigarrow \mathcal{U}$, $M \mapsto H^*V \otimes M$. Then T is exact and commutes with tensor products. Now let M and N be two unstable A-algebras, then the above properties of T imply that TM is also an A-algebra and that the following adjunction formula holds:

(F) $\mathrm{Ext}^s_{\mathcal{K}}(M, \Sigma^t H^*V \otimes N) = \mathrm{Ext}^s_{\mathcal{K}}(TM, \Sigma^t N)$; $t \geq 1$ or $s = t = 0$,

$\mathcal{K}$ denoting the category of unstable A-algebras. The formula (F) implies that a map from BV into a 1-connected complex Y of finite type which

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induces zero in mod 2 reduced cohomology is null-homotopic. Furthermore, recent work of A.K. Bousfield leads to a suitable generalization of (F) which implies that the natural map : BV, Y $\to$ Hom (H^*Y, H^*BV) is a bijection as conjectured by H. Miller. We show also that (F) implies the Sullivan conjecture and the Segal conjecture for elementary abelian 2-groups.

I. MADSEN:

Homotopy theory of groups of automorphisms of representations
(joint work with M. Rothenberg)

The study of group actions on locally linear manifolds requires information about the automorphism space $A_G(V)$ where V is an $\mathbb{R}G$-module and A = GL, PL or TOP in the three usual manifold categories.

For a G-space X write $\mathrm{Iso}(X)$ for the conjugacy classes of isotopy subgroups on X. Call X stable if $2 \dim X^H < \dim X^K$ if $K \subsetneq H$, $K,H \in \mathrm{Iso}(X)$. Let $V \subseteq U$ be stable $\mathbb{R}G$-modules.

Theorem: $|G|$ odd

i) $\pi_r(PL_G(V) \to PL_G(U)) = 0$ for $r \leq \dim V^G - 1$

ii) $\pi_r(TOP_G(V) \to TOG_G(U)) = 0$ for $r = \dim V^G - 2$

iii) If $\dim U^G > \dim V^G$, then

$$\pi_r(TOP_G(V) \to TOP_G(U)) = \mathcal{K}_{-1}(G;V) \Big/ \sum_{H \neq G} K_1\,(H,V)$$

for $r = \dim V^G - 1$

Here $\mathcal{K}_{-1}(G;V) = \sum K_{-1}(\mathbb{Z}[N\Gamma/\Gamma])$, $\Gamma \in \mathrm{Iso}(V)$.

Application: Given a PL G - $\mathbb{R}^n$ bundle ξ over X and a G-map $f: M \to \xi$. Suppose

i) M^H, X^H is 1-connected for each H

ii) $T_xM = V \oplus \xi_y$ as $\mathbb{R}G$-modules where $x \in M^G$ and $y \in X$.

Then f is G-homotopic to a G-transversal map provided V and T_xM are stable.

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M. MAHOWALD:

Report on the nilpotence Theorem of Devenatz, Hopkins and Smith.

The purpose of this talk is to describe some of the recent work of Ethan Devenatz, Michael Hopkins and Jeff Smith concerning the nilpotency of maps. Their main theorem is:

Theorem. 1) Let R be any ring spectrum. Then

$$\ker \{ \pi_* R \to MU_* R \}$$

is a nil ideal (consists of nilpotent elements).

2) Let F be any finite spectrum and X any spectrum.
If $f : F \to X$ satisfies

$$id_{MU} \wedge f \sim * : MU \wedge F \to MU \wedge X$$

then some smash product of f, $f \wedge \ldots \wedge f : F \wedge \ldots \wedge F \to X \wedge \ldots \wedge X$ is contracible.

3) Let $\ldots \to X_n \xrightarrow{f_n} X_{n+1} \to \ldots$ be a sequence of connected spectra. Let

$-\ C_n = \text{Conn } X_{n+1} - \text{Conn } X_n$ and Adams Novikov filtration of $\pi_* f_n > d_n$. If

$$\limsup_n \left\{ \frac{cn}{dn} \right\} < \infty \text{ then homlim } X_n \simeq * .$$

This theorem establishes some of the conjectures of Ravenel in "Localization and Periodicity", Am. J. 1984. Several others are consequences. In particular if X is a finite complex then X has a self map $f: \Sigma^j X \to X$ such that all iterates of f are essential. f can be choosen to be in the center of $[X,X]_*$.

Z. MIMINOSHVILI:

Generalization of Milnor and Cohen-Vogt formulas, relations between shape theoreis.

I.) We give a construction of exact homology theory on the category of arbitrary spaces, which is contained between two classical homology theories, - Alexandrov-Cech and Kolmogoroff homologies. More precisely, we

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construct a sequence of homology theories:

$$\check{H} = \check{H}^0 \leftarrow \check{H}^1 \leftarrow \dots \leftarrow \varprojlim_k \check{H}^k \leftarrow \overset{s}{H} \leftarrow \varinjlim_k \hat{H}^k \leftarrow \dots \leftarrow \hat{H}^1 \leftarrow \hat{H}^0 = \hat{H},$$

where $\check{H}$ is Alexandrov-Cech homology and $\hat{H}$-Kolmogoroff homology.

Th. 1: Let $\underline{C}$ be an inverse system of chain complexes and chain mappings, then there exist the following exact sequences:

a) $0 \to \varprojlim^{(1)} H_{n+1}(\underline{C}) \to \check{H}^1_n(\underline{C}) \to \check{H}^0_n(\underline{C}) \to \varprojlim^{(2)} H_{n+1}(\underline{C}) \to \check{H}^2_{n-1}(\underline{C}) \quad H^1_{n-1}(C)$

$\check{H}^0_n(\underline{C}) \cong \lim H_n(C)$

$\lim^{(3)} H_{n+2}(\underline{C}) \quad \dots$

b) $0 \to \varprojlim_k{}^{(1)} \check{H}^k_{n+1}(\underline{C}) \to \overset{s}{H}_n(\underline{C}) \to \varprojlim_k H^k_n(\underline{C}) \to 0$

c) $\dots \to H_{n+k+2}(\varprojlim^{(k+1)} \underline{C}) \to \hat{H}^k_n(\underline{C}) \to \hat{H}^{k+1}_n(\underline{C}) \to H_{n+k+1}(\lim^{(k+1)} \underline{C}) \to \dots,$

the same formulas hold when we consider top spaces and inverse systems.

Th. 2: The homology $\overset{s}{H}$ is equal to (1) singular homology, on the category of CW spaces (2) Kolmogoroff homology, on the category of compact spaces (3) Steenrod-Sitnikoff homology on the category of metr. compact spaces.

II.) Th. 3: The strong shape theory in the sense of Mardešic and Lisica, Cathey, Porter, Miminoshvili are isomorphic to the strong shape theory of Edwards-Hastings.

Th. 4: The canonical map s-sh $\to$ sh is not on to on the category of uncountable systems of spaces $\Rightarrow$ this is a negative answer to the question of Edwards-Hastings.

III.) A definition of a strongly fibrant and cofibrant systems is given.

Th. 5: If $\bar{X}$ is str. cofibrant dir. system, $\underline{Y}$-str. fibrant inv. system, then we have an exact sequence: $* \to \varprojlim^{(1)} [\Sigma\bar{X};\underline{Y}] \to [\varinjlim \bar{X}, \varprojlim \underline{Y}] \to \varprojlim [\bar{X}; \underline{Y}] \to *$, for $\bar{X} = X$ we have a generalization of Cohen-Vogt formula, for $\underline{Y} = Y$ - a gen. of Milnor formula.

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Th. 6: If $\underline{X},\underline{Y}$ are str. fibrant inv. systems, $\lim\underline{X}$ is str. associated with $\underline{X}$, then there is an exact sequence:

$$* \to \varprojlim{}^{(1)} \varinjlim\, [\Sigma\underline{X};\underline{Y}] \to [\varprojlim\underline{X};\ \varprojlim\underline{Y}] \to \varprojlim\varinjlim\,[\underline{X};\underline{Y}] \to * .$$

Th. 7: If $\overline{X},\overline{Y}$ are str.cofibrant dir. systems and $\varinjlim\overline{Y}$ is str. associated with $\overline{Y}$, then there is an exact sequence:

$$* \to \varprojlim{}^{(1)} \varinjlim\, [\Sigma\overline{X};\overline{Y}] \to [\varinjlim\overline{X};\ \varinjlim\overline{Y}] \to \varprojlim\ \varinjlim\,[\overline{X};\ \overline{Y}] \to * .$$

K. PAWALOWSKI:

Fixed point sets and their equivariant normal bundles for smooth group actions on disks and Euclidean spaces.

Let G be a compact Lie group whose identity connected component G_0 is abelian, and assume that G/G_0 has a nilpotent subquotient with three or more noncyclic Sylow subgroups (resp., G/G_0 has a nilpotent subquotient not of prime power order).

With G as above, we show that a compact (resp., closed) smooth manifold F is diffeomorphic to the fixed point set of a smooth action of G on a disk (resp., Euclidean space) if and only if the tangent bundle of F stably admits a complex structure; in particular, F is orientable and all connected components of F are either even or odd dimensional.

The necessity of this condition is well-known. The sufficiency is shown using an equivariant thickening procedure which enables us to get information about the equivariant normal bundle of the fixed point set.

E.K. PEDERSEN:

Algebraic K-Homology theory, (joint work with C. Weibel).

Let X be a metric space and $\mathfrak{A}$ an additive category (e.g. f.g. free R-modules). The category $\mathcal{C}_X(\mathfrak{A})$ is defined as follows: An object A is a collection of $\mathfrak{A}$-objects $A(x)$, one for each $x \in X$ satisfying that in each ball in X only finitely many are non zero. A morphism $\varphi : A \to B$ is a collection of $\mathfrak{A}$-morphisms $\varphi_y^x : A(x) \to B(y)$ satisfying that there exists

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$k = k(\varphi)$ so that $\varphi_y^x = 0$ for $d(x,y) > k$. Composition is given by

$$(\psi \cdot \varphi)_y^x = \sum_{z \in X} \psi_y^z \cdot \varphi_z^x$$

(Note this is a finite sum). With a suitable notion of morphism, $\mathcal{C}_-(-)$ is a functor in 2 variables. Now consider $X \subset S^n$ a PL-subkomplex of a sphere and let $\theta(X) = \{(t,\underline{x}) \in \mathbb{R}^{n+1} / t \in [0,\infty), \underline{x} \in X\}$. We prove

<u>Theorem</u> $K_*(\mathcal{C}_{\theta(X)}(\mathfrak{A})) = h_*(X;$ nonconn. Alg. K-th. of $\mathfrak{A})$.

Here K_* is the K-theoery of an additive category by restricting to isomorphisms and the right hand side is the homology theory given by nonconnective alg. K-theory of the category $\mathfrak{A}$.

D. PUPPE:

<u>Invariants of the Lusternik-Schnirelmann type and the topology of critical sets</u> (joint work with Mônica Clapp)

The Lusternik-Schnirelmann category cat X is the smallest k such that the space X can be covered by k open sets X_j for which $X_j \hookrightarrow X$ factors through a one point space P up to homotopy. Replacing P by other spaces (e.g. q-dimensional or q-connected spaces for a given q) one obtains other invariants which like the classical one give information on the topology of the critical set of a differentiable function. The new invariants have similar properties as L.-S. category and there are nice proofs which lead to improvements even in the classical case. A theorem of Ganea says that if X is p-connected, cat $X = k \geq 2$ and $\dim X \leq (k+1)(p+1)-3$ then X has the weak homotopy type of a CW-complex which can be covered by k contractible subcomplexes. We replace the bound on dim X by $(2k-1)(p+1)-3$.

Everything can also be done in a G-equivariant setting where G is a compact Lie group.

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E.E. SKURICHIN:

Cohomological theories connected with sheaves on Grothendieck topologies.

We denote by OX, CX, FOX, FCX, respectively, the categories of all open, closed, functionally open and functionally closed subsets of X with the inclusions $A \subset B$ as morphisms. We also set $A \in DX :\Leftrightarrow A = \cup\{A_i \subset X \mid i \in I\}$, where $\{A_i \mid i \in I\}$ is "numerably" locally finite with respect to X family of sets, $A_i = B_i \cap C_i$, $B_i \in FCX$, C_i is a closed set, such that any neighbourhood of it is functional.

Let $\mathcal{T}_0X$, $\mathcal{T}_1X$, $\mathcal{T}_2X$, $\mathcal{T}_3X$ and $\mathcal{T}_4^YX$ denote the classes of all coverings of X by subsets, belonging, respectively to OX,OX,CX, FCX, DX, by an open, normal open (= numerable), locally finite closed, "numerably" locally finite in X and functionally closed, and a "numerably" locally finite in Y DY-covering of X DY. Let T be a category of all topological spaces and continuous maps.

Theorem 1: The totality $\{T, \mathcal{T}_1X \mid X \in T\}$ forms a pretopology (in the sense of Verdier). If $\mathcal{A}$ is a $\mathcal{T}_1$-sheaf on T , then the Grothendieck cohomology groups $H_1^*(X,\mathcal{A})$ and the Aleksandrov-Cech cohomology groups $\check{H}_1^*(X,\mathcal{A})$ with respect to pretopology $\mathcal{T}_1$, are isomorphic as cohomological functors from the category of $\mathcal{T}_1$-sheaves to the category of presheaves on T.

Theorem 2: $\{DX, \mathcal{T}_4^X A \mid A \in DX\}$ and $\{OX, \mathcal{T}_1V \mid V \in OX\}$ form pretopologies. There is an exact functor $\mathcal{A} \mapsto \bar{\mathcal{A}}$ from the category of $\mathcal{T}_1$-sheaves on OX ot the category of $\mathcal{T}_4$-sheaves on DX such that the Aleksandrov-Cech cohomology groups $\check{H}_1^n(A,\mathcal{A})$ and the Grothendieck cohomology groups $H_4^n(A,\bar{\mathcal{A}})$ are isomorphic as cohomological functors from the category of $\mathcal{T}_1$-sheaves on OX to the category of presheaves on DX.

Below we give the other definition of cohomological functor. By a cohomological functor on a category K we mean a collection of presheaves $F = \{F^n : K^o \to \mathcal{Ab} \mid n \in \mathbb{Z}\}$ such that there is a Grothendieck topology $\mathcal{T}$ on K and $\mathcal{T}$-sheaf $\mathcal{A}$ for which $(R^n i)(\mathcal{A})$ and F^n are isomorphic for all n. Here $R^n i$ is the n-th right derived functor for the functor of embedding the category of $\mathcal{T}$-sheaves in the category of presheaves on K; $\mathcal{Ab}$ is the category of abelian groups.

If F is a cohomological functor, $M \subset Mor(K)$, $k \in ob(K)$, we denote by $d_{F,M}(k)$ the least number n, such that $F^n(k) \to F^n(l)$ is surjective for any

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morphism $1 \to k$ from M. If there is no such n, then we set $d_{F,M}(k) = \infty$. Let C be the category of all compact spaces, M the totality of all inclusions.

<u>Theorem 3:</u> There is a cohomological functor F on C, such that

a) if $\dim X = n < \infty$, then $d_{F,M}(X) = \dim X$ (covering dimension)

b) if $\dim X = \infty$ and X contains finite-dimensional subspaces of arbitrary large dimension, then $d_{F,M}(X) = \dim X = \infty$

c) if $\dim X = \infty$ and n_0 is the maximal dimension of finite-dimensional compact subspaces of X, then $n_0 \leq d_{F,M}(X) \leq n_0 + 1$.

The last theorem gives an answer to Aleksandrov's extended problem, which can be stated as follows. Given a class of cohomological functors, is there a functor within this class, that characterizes the covering dimension of all finite-dimensional compact spaces, but for which there is an ∞-dimensional compact space with finite cohomological F-dimension?

Thus, these results demonstrate both the usefulness of the analysis of various cohomological functors on topological categories for deeper investigation or generalization of classical results, and the possibility of constructing cohomological functors with given properties. This is evidently most valuable from the point of view of applications of homological algebra to topological and geometric problems, and its realization in specific cases is an important task.

V. TURAEV:

<u>Bordisms of normal maps in dimension 3.</u>

We give a complete description of the set (N) of bordism classes of normal maps

$$\begin{array}{ccc} \nu(M) & \to & \xi \\ \downarrow & & \downarrow \\ M & \to & N \end{array}$$

, where N is a (fixed) orientable closed 3-manifold, in terms of spin structures on 3-manifolds and their Rochlin invariants. Note that the set $\mathrm{Spin}(M)$ of spin structures on M is an affine space over $H^1(M;\mathbb{Z}/2)$. Assigning to each spin structure on M its Rochlin invariant we get the "Rochlin function" $R_M\colon \mathrm{Spin}(M) \quad \mathbb{Z}/16\mathbb{Z}$ which is known to be a cubic polynomial (see my paper in Math. USSR sbornik 48:1, 1984, 65-79).

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For each normal map $f: \begin{array}{ccc} \nu(M) & \to & \xi \\ \downarrow & & \downarrow \\ M & \to & N \end{array}$ (where ξ is a vector bundle over N)

we define geometrically a mapping $f^*: \mathrm{Spin}(N) \to \mathrm{Spin}(M)$. The difference $\mu = R_N - (R_M \circ f^*)$ turns out to be a linear function $\mathrm{Spin}\, N \to \mathbb{Z}/2 \subset \mathbb{Z}/16$ (i.e. $\mu(\alpha) - \mu(\alpha + x) - \mu(\alpha + y) + \mu(\alpha + x + y) = 0$ for any $\alpha \in \mathrm{Spin}\, N$ and $x, y \in H^1(N;Z/2)$). Therefore, the function $x \mapsto \mu(\alpha) - \mu(\alpha + x): H^1(N;\mathbb{Z}/2)$ $(=H_2(N;\mathbb{Z}/2)) \to \mathbb{Z}/2$ is correctly defined and linear and gives rise to an element $a(f) \in H^2(N;\mathbb{Z}/2)$. We prove that the mapping $f \longmapsto a(f): \mathcal{T}(N) \longrightarrow$ $H^2(N;\mathbb{Z}/2)$ is bijective. As corollaries we prove that: Each homotopy equivalence $f: M \to N$ has zero normal invariant (i.e. f is normally bordant to a diffeomorphism). If $f: M \to N$ is a simple homot. equivalence then $f \times \mathrm{id}: M \times S^n \to N \times S^n$ where $n \geq 2$ is homotopic to a diffeomorphism. The natural Wall mapping $\mathcal{T}(N) \to L_3(\pi_1(N))$ is a split injection.

S. ZARATI:

On the U-injectives. (Joint work with J. Lannes)
This article discusses injectives in the category U of unstable A-modules (for short: U-injectives), A denoting the Steenrod algebra modulo a prime p, the importance of which in algebraic topology has been recently emphasized in the work of H. Miller about the Sullivan conjecture and in the work of G. Carlsson about the Segal conjecture for elementary abelian 2-groups.
We show the following theorem.

Theorem: Let J and K be two U-injectives such that:
(i) J or K is gradually finite, i.e. a finite dimensional $\mathbb{Z}/p$-vector space in each degree.
(ii) $\mathrm{Hom}_U(\Sigma M, K) = 0$ for every $M \in U$ ($\Sigma: U \rightsquigarrow U$ is the suspension functor), then $J \otimes K$ is U-injective.
As a consequence we get:
Corollary: Let V be an elementary abelian p-group, then $H^*(V;\mathbb{Z}/p)$ is U-injective, $(V \approx (\mathbb{Z}/p)^k)$.
This result and those of "Derived functors of the Destabilisation" (J. Lannes & S. Zavati), (to compare with W.M. Singer) allow us to give another proof of the Segal conjecture for elementary abelian p-groups. Other homotopical applications are given in Lannes's talk.

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