MATHEMATISCHES FORSCHUNGSINSTITUT OBERWOLFACH

Tagungsbericht 4/1991

Harmonische Analyse und Darstellungstheorie
topologischer Gruppen

27.1. bis 2.2.1991

Die Tagung fand unter der Leitung der Herren R. Howe (New Haven) und E. Kaniuth (Paderborn) statt.
Im Mittelpunkt des Interesses standen zum einen die harmonische Analyse auf symmetrischen Räumen und auf exponentiellen, insbesondere nilpotenten, Lie-Gruppen. Zum anderen nahm die Darstellungstheorie lokalkompakter Gruppen, vor allem der diskreten und der halbeinfachen Gruppen, einen breiten Raum ein. Darüberhinaus wurden Themen wie die Topologie im Dual und C^*-Gruppenalgebren behandelt.

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Vortragsauszüge

M. ANDLER:

Transfer and the Bruhat order

Let G be a complex reductive algebraic connected group. $\Pi(G)$, the set of irreducible admissible $(\mathfrak{g}, K)$-modules, is in 1-1 correspondence with the set $\Phi(G)/{}^LG^c$, where ${}^LG^c$ is the (dual) L-group of G, and $\Phi(G)$ is the set of homomorphisms from $W_{\mathbf{C}} = \mathbf{C}^\times$ to ${}^LG^c$ with semi-simple image. Assume that we have two such groups G and G', and a rational homomorphism r from ${}^LG^c$ to ${}^LG'^c$. This defines a map $\Phi(G) \to \Phi(G')$, thus a map $\Pi(G) \to \Pi(G')$. This is called transfer. To $\varphi \in \Phi(G)$ is associated a standard representation τ_φ and its distinguished irreducible subquotient π_φ. We define the Bruhat order by $\varphi' < \varphi$ iff $\pi_{\varphi'}$ is a subquotient of τ_φ. We have
Theorem Transfer preserves the Bruhat order.

M.E.B. BEKKA:

Translation invariant subalgebras of $B(G)$

(joint work with A.T. Lau and G. Schlichting)

Let G be a locally compact group. Let $B(G)$ (resp. $A(G)$) be the Fourier-Stieltjes (resp. Fourier) algebra of G which is a Banach $*$-algebra. We are interested in the structure of $*$-subalgebras of $B(G)$ which are left and right invariant under translation by elements of G. The main result is as follows: If A is such an algebra and if, in addition, A is $\sigma(B(G), C^*(G))$-closed and point separating, then A always contains $A(G)$. This gives a description of the weak $*$-closed, biinvariant $*$-subalgebras of $B(G)$ (and, equivalently, a description of the so-called subduals of the unitary dual $\widehat{G}$ of G) in case G is amenable, a result which can also be deduced from a paper of Tatsuuma. Some consequences for the structure of norm-closed, biinvariant subalgebras of $B(G)$ are given, and an improvement of Repka's Stone-Weierstraß theorem for group representations is obtained. Moreover, the following result is shown: Let G be a semisimple, non compact Lie group with finite center. Suppose G has Kazhdan's property (T). Then $\widehat{G}$ is not dense in the unitary dual $\widehat{G}_d$ of G_d (the group G with the discrete topology).

F. BIEN:

Homogeneous spaces with a commutative algebra of invariant differential operators

I. Let $G_{\mathbf{C}}$ be a complex connected reductive linear algebraic group. Let $H_{\mathbf{C}}$ be an algebraic (closed) subgroup of $G_{\mathbf{C}}$ and put $X_{\mathbf{C}} = G_{\mathbf{C}}/H_{\mathbf{C}}$. Let τ denote an algebraic character of $H_{\mathbf{C}} \to \mathbf{C}^*$, and let W denote a simple $G_{\mathbf{C}}$-module. The space $\Gamma(X_{\mathbf{C}}, O(\tau))$ of holomorphic sections of the line bundle associated to τ over $X_{\mathbf{C}}$ affords a representation of G. The multiplicity of W in $\Gamma(X_{\mathbf{C}}, O(\tau))$ is defined by

$$m(W, \tau) = \dim \operatorname{Hom}_G(W, \Gamma(X_{\mathbf{C}}, O(\tau))).$$

Let $B_{\mathbf{C}}$ be a Borel subgroup of $G_{\mathbf{C}}$. It is known that the following conditions are equivalent: (i) $m(W, \tau)$ is bounded above for all W and all τ; (ii) $B_{\mathbf{C}}$ has an open orbit in $X_{\mathbf{C}}$. A space satisfying these conditions is called a uniform (or a spherical) space for $G_{\mathbf{C}}$. Examples are all symmetric spaces and flag varieties. Consider the algebra $D(X_{\mathbf{C}}, \tau)$ of G-invariant differential operators on $X_{\mathbf{C}}$ acting in the sections of $O(\tau)$.

Proposition $X_{\mathbf{C}}$ is uniform for $G_{\mathbf{C}}$ if and only if $D(X_{\mathbf{C}}, \tau)$ is commutative for all τ. When $X_{\mathbf{C}}$ is an affine variety or if $H_{\mathbf{C}}$ contains a maximal unipotent subgroup of $G_{\mathbf{C}}$, then we can prove that $D(X_{\mathbf{C}}, \tau)$ is even a polynomial algebra.

II. Let G be a real form for $G_{\mathbf{C}}$, and $H = G \cap H_{\mathbf{C}}, X = G/H$. Let $C^\infty(X, \tau)$ be the space of smooth sections of the line bundle $O(\tau)|X$. Given an irreducible admissible representation V of G, we define its (submodule) multiplicity in $C^\infty(X, \tau)$ by

$$m(V, \tau) = \dim \operatorname{Hom}_{(\mathfrak{g}, K)}(V_{K-fin}, C^\infty_{K-fin}(X, \tau)),$$

where K is a maximal compact subgroup of G. Let P be a minimal parabolic subgroup of G.

Theorem (Bien-Oshima) (i) $m(V, \tau)$ is bounded above for all V and all τ if and only if $X_{\mathbf{C}}$ is a uniform space for $G_{\mathbf{C}}$.
(ii) $m(V, \tau)$ is finite for all V and τ if and only if H has finitely many orbits on G/P.

Examples of real uniform spaces are all affine symmetric spaces, all flag varieties, also G/MN where $P = AMN$. G/N always has finite multiplicities, the same is true for all X, if G is compact.

M. BINDER:

Factorial induced representations of discrete groups

Let G be a locally compact group, H an open subgroup of G and σ a finite dimensional representation of H, and denote by 1 the trivial one dimensional representation of H. We give necessary and sufficient conditions for the induced representation $\mathrm{ind}_H^G 1$ (or more generally, $\mathrm{ind}_H^G \sigma$) to be factorial. Various special cases and examples are examined. E.g., if $G = S_{\mathbb{N}}$ and $H = \prod^* S_{\{2k-1,2k\}}$, then $\mathrm{ind}_H^G 1$ is factorial.

M. COWLING:

Unitary representations of lattices

(joint work with T. Steger)

Let G be a semisimple Lie group with finite centre, and let Γ be an irreducible lattice in G. If π is an irreducible unitary representation of G, then $\pi|_\Gamma$, the restriction of π to Γ, is reducible if π is a discrete series representation of G and irreducible otherwise. Inequivalent non-discrete series representations of G restrict to inequivalent (non-discrete series) representations of Γ. This generalizes the Borel density theorem and shows that the structure of $\widehat{\Gamma}$ is at least as rich as that of $\widehat{G}$.

B. CURRY:

The analytic structure of the dual of a solvable Lie group

Let G be a connected, solvable Lie group. Assuming G is exponential, we define a layering of $\mathfrak{g}^*$ into finitely many G-invariant algebraic sets and, in each layer Ω , we exhibit an explicit algebraic parametrization Σ for Ω/Ad^*G. There is a cone $W \subset \mathfrak{g}^*$ and an analytic Ad^*G-invariant function $P : \Omega \to \Omega$ such that the parametrization $\Sigma = P(\Omega)$, and Ω is naturally a (not necessarily trivial) bundle over Σ with fiber W and projection P. All constructions depend only on the choice of a Jordan-Hölder sequence for $\mathfrak{g}_c$. The parametrization Σ_0 for the Zariski-open layer Ω_0 is a submanifold of $\mathfrak{g}^*$, and gives an explicit Plancherel formula which generalizes that of Pukanszky for nilpotent groups. Finally, we discuss joint work with R. Penney on describing quotient spaces of algebraic, solvable groups.

J. CYGAN:

On magnified curves on nilmanifolds

Let γ be a C^1 curve in a stratified nilpotent Lie group N. We describe properties of γ that guarantee the images on a compact nilmanifold N/Γ of large dilates of γ to tend to uniformly distributed scribbles. The requirements on γ turn out to be a "stratified" form of Strichartz's condition for curves on a flat torus (PAMS 107 (1989), 755-759).

A. DERIGHETTI:

On ideals of A_p with bounded approximate units and certain conditional expectations

(joint work with J.Delaporte)

Let G be an abelian locally compact group and H a closed subgroup. Hauenschild and Ludwig obtained an explicit bijective correspondance between the set of all closed ideals of $L^1(H)$ and the set of all closed ideals of $L^1(G)$ invariant under the pointwise action of $L^\infty(G/H)$.

Given an amenable locally compact group G and a closed normal subgroup H, we prove the existence of a bijection e between the set of all closed ideals of $A_p(G/H)$ (the Figà-Talamanca Herz algebra of G/H) and the set of all closed ideals of $A_p(G)$ invariant under translations by elements of H. We show moreover that a closed ideal I of $A_p(G/H)$ has a bounded approximate unit if and only if $e(I)$ has a bounded approximate unit. The converse part of this assertion is delicate: it requires, in the L^1 case (as shown by Bekka), different tools of integration theory on the dual of G which are missing for G non abelian or for $p \neq 2$. We avoid this by considering $PM_p(G)$, the set of all p-pseudomeasures on G (we recall that for G abelian, $PM_2(G)$ is isomorphic to $L^\infty(\widehat{G})$), and the Banach algebra $\mathrm{Hom}_{A_p(G)}(PM_p(G))$ of all linear norm continuous maps Φ from $PM_p(G)$ into itself such that $\Phi(uT) = u\phi(T)$ for $u \in A_p(G)$ and $T \in PM_p(G)$. There is a natural inclusion of $\mathrm{Hom}_{A_p(G/H)}(PM_p(G/H))$ into $\mathrm{Hom}_{A_p(G)}(PM_p(G))$. We prove the existence of a conditional expectation of $\mathrm{Hom}_{A_p(G)}(PM_p(G))$ onto $\mathrm{Hom}_{A_p(G/H)}(PM_p(G/H))$. This result seems to be new even for G abelian and $p = 2$. As an application we obtain the above mentioned result concering the existence of approximate units in ideals of $A_p(G/H)$ and $A_p(G)$.

R. FELIX:

Radon transform on nilpotent Lie groups

Auf einer nilpotenten einfach zusammenhängenden n-dimensionalen Lie-Gruppe N soll eine Radon-Transformation definiert und für diese eine Inversionsformel bewiesen werden. Als zugrundeliegende Punktmenge wird die Lie-Algebra $\mathfrak{n}$ von N gewählt. Nun ist ein System $\mathcal{E}$ von Ebenen in $\mathfrak{n}$ zu bestimmen, auf dem die Radon-Transformierte einer Schwartz-Funktion $f \in \mathcal{S}(\mathfrak{n})$ erklärt werden soll. Dazu konstruiert man unter Verwendung von Pukanszky's Parametrisierung der koadjungierten Bahnen eine Standard-Ebene E in $\mathfrak{n}$, deren Dimension d mit der maximalen Dimension der koadjungierten Bahnen übereinstimmt. Für $\mathcal{E}$ nimmt man jetzt alle Ebenen der Form $E(a,m) := \mathrm{Ad}(m)(a+E)$, wobei m die Menge $M := \mathrm{Exp}\, E$ und a einen zu $\mathcal{E}$ komplementären Unterraum $\mathfrak{a}$ von $\mathfrak{n}$ durchläuft. Obwohl die Menge $\mathcal{E}$ im Fall $d < n-1$ die Menge aller d-dimensionalen Ebenen nicht erschöpft, darf man doch hoffen, daß sie reichhaltig genug ist, eine Inversionsformel zu liefern, da ja das klassische Inversionsproblem für $d < n-1$ überbestimmt ist. Das Lebesgue-Maß auf E liefert ein kanonisches Maß auf $E(a,m)$, so daß durch

$$\mathcal{R}f(a,m) := \int_E f(\mathrm{Ad}(m)(a+z))dz$$

die "Radon-Transformierte" von f definiert werden kann. Die "duale Transformation" wird gegeben durch

$$\mathcal{R}^*\phi(x) := \int_M \phi(\pi_{\mathfrak{a}}\mathrm{Ad}(m^{-1})x), m)dm), \; x \in \mathfrak{n}, \phi \in \mathcal{S}(\mathfrak{a} \times M),$$

wobei $\pi_{\mathfrak{a}}$ die Projektion von $\mathfrak{n}$ auf $\mathfrak{a}$ längs E bezeichnet.
Auf $\mathfrak{a}^*$ existiert ein fundamentales Ad^*-invariantes homogenes Polynom, welches das Plancherel-Maß liefert. Diesem Polynom wird ein Differentialoperator $L_{\mathfrak{a}}$ mit konstanten Koeffizienten auf $\mathfrak{a}$ assoziiert. Die Inversionsformel für die Radon-Transformation $\mathcal{R}$ lautet dann

$$f = \mathcal{R}^*(L_{\mathfrak{a}}(\mathcal{R}f)).$$

M. FLENSTED-JENSEN:

Some remarks on $\mathcal{D}$-modules, distributions and spherical representations

Let $G \subset G_{\mathbb{C}}$ be a connected semisimple Lie group contained in a simply connected algebraic $\mathbb{C}$-linear group $G_{\mathbb{C}}$. Let $P = MAN$ be a minimal parabolic subgroup and $P_{\mathbb{C}}$ the "complexification" of P in $G_{\mathbb{C}}$. For $\lambda \in (\mathfrak{a}^*)_{\mathbb{C}}$, a complex linear funtion on $\mathfrak{a}$, the Lie algebra of A, we define the sheaf $\mathcal{D}_\lambda(X_{\mathbb{C}})$ of twisted holomorphic differential operators on $X_{\mathbb{C}}$ as being generated by multiplication by $\mathcal{O}_{X_{\mathbb{C}}}$, the holomorphic structure sheaf, and the holomorphic action of $\mathfrak{g}_{\mathbb{C}}$ as C^∞-sections of the following $\mathbb{R}$-analytic $\mathbb{C}$-line bundle L_μ over $G_{\mathbb{C}}/P_{\mathbb{C}}$: Let $\lambda_{\mathbb{C}}$ and $\bar{\lambda}_{\mathbb{C}}$ be the holomorphic and antiholomorphic extensions of λ to $\mathfrak{a}_{\mathbb{C}}$, let ρ be as usual ($\rho(H) =$ Trace $_{\mathfrak{n}}(\mathrm{ad} H), H \in \mathfrak{a}$), define $\mu = i\lambda_{\mathbb{C}} + i\bar{\lambda}_{\mathbb{C}} - \rho_{\mathbb{C}} - \bar{\rho}_{\mathbb{C}}$. Then the C^∞-sections are

$$C^\infty_\mu(G_{\mathbb{C}}/P_{\mathbb{C}}) = \{\varphi \in C^\infty(G_{\mathbb{C}}) \mid \varphi(gp) = p^\mu \varphi(g), p \in P_{\mathbb{C}}, g \in G_{\mathbb{C}}\}.$$

It is shown that this sheaf of rings of twisted differential operators $\mathcal{D}_\lambda$ on $X_{\mathbb{C}}$ is isomorphic to the abstractly defined $\mathcal{D}_\lambda$ from algebraic geometry. The point of our definition is that even when $i\lambda_{\mathbb{C}} - \rho_{\mathbb{C}}$ does not lift to a $\mathbb{C}$-character of $P_{\mathbb{C}}$, μ does lift to a $\mathbb{R}$-analytic character of $P_{\mathbb{C}}$, thus the real analytic line bundle defined by μ exists globally. And from a "holomorphic point of view" $i\lambda_{\mathbb{C}} - \rho_{\mathbb{C}}$ and μ are equivalent. It is observed that $\mathcal{D}_\lambda$ in our definition is born with an action on $\mathcal{D}^b_\mu(X_{\mathbb{C}})$, the sheaf of (ordinary) distribution sections of the line bundle L_μ.

H. FUJIWARA:

Plancherel formula and Frobenius reciprocity for exponential solvable Lie groups

Let $G = \exp \mathfrak{g}$ be an exponential solvable Lie group with Lie algebra $\mathfrak{g}$, and let $K = \exp \mathfrak{k}$ be an analytic subgroup of G. Being given a $\pi \in \widehat{G}$, we study the restriction $\pi|K$ of π to K, and for $\sigma \in \widehat{K}$, the induced representation $\mathrm{ind}_K^G \sigma$. Our results are described in terms of the orbit method and we observe that a Frobenius reciprocity holds. Then we limit our attention to monomial representations. Let $f \in \mathfrak{g}^*$ such that $f([\mathfrak{k}, \mathfrak{k}]) = 0$. For $\pi \in \widehat{G}$, we denote by $\Omega_G(\pi)$ the corresponding coadjoint orbit of G, and put $\chi_f(\exp X) = e^{if(X)}$ $(X \in \mathfrak{k})$ and $\mathfrak{k}^\perp = \{l \in \mathfrak{g}^*; l|\mathfrak{k} = 0\}$. Then $\tau = \mathrm{ind}_K^G \chi_f = \int_{\widehat{G}}^{\oplus} m_\pi \pi d\nu(\pi)$

with multiplicity $m_\pi = \#\{K -$ orbits in $\Omega_G(\pi) \cap (f + \mathfrak{k}^\perp)\}$. Now we introduce the space $(\mathcal{K}_\pi^{-\infty})^{H,\chi_f \Delta_{G,H}^{1/2}}$ of H-semi-invariant generalized vectors for π, where $\Delta_{G,H} = \Delta_H/\Delta_G$, and we discuss two Plancherel formulas for τ. One is due to Penney and the other to Bonnet. Finally, in special cases, we get another Frobenius reciprocity for τ, namely $m_\pi = \dim(\mathcal{K}_\pi^{-\infty})^{H,\chi_f \Delta_{G,H}^{1/2}}$.

P. GLOWACKI:

Pointwise estimates for densities of semigroups of measures on nilpotent Lie groups

(joint work with W. Hebisch)

The following theorem is proved:

Let $\{\mu_t\}$ be a symmetric α-stable semigroup of probability measures on a homogeneous nilpotent group N $(0 < \alpha < 2)$. Assume that μ_t's have densities h_t's in $L^1(N)$. Then the following conditions are equivalent:

(i) There exists a locally integrable homogeneous function M on $N \setminus \{e\}$ such that

$$h_t(x) \leq tM(x), t > 0, x \in N \setminus \{e\}.$$

(ii) The Lèvy measure ν of $\{\mu_t\}$ has a density k on $N \setminus \{e\}$ such that

$$\int_{1 \leq |x| \leq 2} k(x)(1 + \log^+ k(x))dx < \infty.$$

P. de la HARPE:

On the spectrum of the sum of generators of a finitely generated group

(joint work with G. Robertson and A. Valette)

Let Γ be a finitely generated group, let $S \subseteq \Gamma$ be a finite set of generators, and set $h = \frac{1}{|S|} \sum_{s \in S} s$, viewed in the maximal C^*-algebra $C^*(\Gamma)$ of Γ. Given a unitary representation π of Γ on a Hilbert space

$\mathcal{H}_\pi$, we want to explore the relationships between the spectrum of $\pi(h)$ and properties of Γ, S, π. Define

$$\kappa(\pi, S) = \inf\{\max_{s\in S}||\pi(s)\xi - \xi||); \xi \in \mathcal{H}_\pi,\ ||\pi|| = \infty\},$$

$$\tilde{\kappa}(\Gamma, S) = \inf\{\kappa(\pi, S); \pi \text{ irreducible, non-trivial}\},$$

so that in particular $\kappa(\pi, S) = 0 \Leftrightarrow \pi$ contains weakly the trivial representation, and $\tilde{\kappa}(\Gamma, S) = 0 \Leftrightarrow \Gamma$ has Kazhdan's property (T). Here is a sample of our results (λ denotes the left regular representation of Γ):

<u>Theorem</u> Let Γ, S, π be as above.

(i) The spectrum $\mathrm{Sp}h$ always contains 1, and it contains -1 if and only if there exists a character $\chi_S : \Gamma \to \{\pm 1\}$ such that $\chi_S(S) = \{-1\}$.

(ii) The spectrum $\mathrm{Sp}\lambda(h)$ contains 1 if and only if Γ is amenable. Moreover, $-1 \in \mathrm{Sp}\lambda(h)$ if and only if Γ is amenable and there exists χ_S as in (i).

(iii) If Γ has property (T), the sets

$$\mathrm{Sp}h \cap \{z \in \mathbf{C}; 0 < |z-1| < \frac{1}{2|S|}\tilde{\kappa}(\Gamma, S)^2\},$$

$$\mathrm{Sp}h \cap \{z \in \mathbf{C}; 0 < |z+1| < \frac{1}{2|S|}\tilde{\kappa}(\Gamma, S)^2\}$$

are empty.

(iv) Assume that $S^{-1} = S$, and let $\varepsilon > 0$ such that either $\mathrm{Sp}h \subset [-1, 1-\varepsilon] \cup \{1\}$ or that there exists χ_S as in (i) and that $\mathrm{Sp}h \subseteq \{-1\} \cup [-1+\varepsilon, 1]$. Then Γ has property (T) and $\tilde{\kappa}(\Gamma, S) \geq \sqrt{2\varepsilon}$.

H. HILGERT:

<u>Wiener-Hopf operators on ordered symmetric spaces</u>

(joint work with K.H. Neeb)

Following the approach of Muhly and Renault one can associate a C^*-algebra of Wiener-Hopf operators to any ordered homogeneous space. It is a quotient of a groupoid C^*-algebra for a groupoid constructed from the homogeneous space. Its orbit structure yields

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informations on the ideal structure of the C^*-algebra. In general this orbit structure can not be determined since the construction of the groupoid involves a functional analytic compactification of the homogeneous space which one cannot get hold on. In the case of an ordered symmetric space with compact order intervals it is possible to give a complete description using the fact that for such spaces one can describe the order via a specific semigroup of contractions. The result is that one can read of the orbit structure from the set of restricted roots with respect to a Cartan subspace.

A. HULANICKI:

Maximal functions related to Poisson integrals on solvable Lie groups

(joint work with E. Damek)

Let N be a homogeneous group and $A = \mathbb{R}^+$ the group of dilations of N. Let $S = NA$ be the split extension of N by A. Let L be a degenerate elliptic operator of second order on S which is left invariant. Such an operator can be written in the form

$$L = \partial_a^2 - \kappa\partial_a + \sum_1^k a_{ij} e^{a(d_i+d_j)} X_i X_j + \sum \beta_j e^{ad_j} X_j,$$

where $X_1, \ldots, X_n$ form a homogeneous basis of the Lie algebra of N and $d_1, \ldots, d_n$ are defined by $\delta_{e^a} X_j = e^{ad_j} X_j$, the matrix (a_{ij}) is strictly positive definite. Let $S_a = \{xe^b : b > a\}$. We identify ∂S_a with $N \times \{e^a\}$. We say that F is harmonic on S_a if $LF = 0$.

If $\kappa \geq 0$, then every bounded harmonic function on S_a is of the form

$$F(xe^b) = \int f(y)\mu_a^{b,x}(dy) = P_a^b f(x),$$

where $f \in L^\infty(N)$ and $\mu_a^{b,x}(dy)$ is a probability measure. Let

$$Mf(x) = \sup_{b>a} P_a^b f(x).$$

Theorem If $X_1, \ldots, X_k$ generate the Lie algebra, $\kappa > 0$ and $\beta_j = 0$ if X_j is not a linear combination of $X_1, \ldots, X_k$ and $(X_s, X_t), 1 \leq$

$s,t \leq k$, the maximal function M is of weak type (1,1).

W.P. JAKOBSEN:

Indecomposable representations and covariant differential operators

1) Let $D = G_0/K_0$ be an irreducible hermitian symmetric space of the non-compact type. Let $\mathfrak{g} = \mathrm{Lie}(G_0)^{\mathbf{C}}, \mathfrak{g} = \mathfrak{p}^- \oplus \mathfrak{k} \oplus \mathfrak{p}^+$. Let (π_0, λ) be a 1-parameter family of representations of $\mathfrak{k} \oplus \mathfrak{p}^+$, differing only on the center of $\mathfrak{k}$. Let

$$M(\pi, \lambda) = U(\mathfrak{g}) \otimes_{U(\mathfrak{k} \otimes \mathfrak{p}^+)} V(\pi, \lambda).$$

The set of equivariant maps between C^∞ sections of vector bundles over the Shilov boundary of $\mathcal{D}$ ($\mathcal{D}$ tube type) is parametrized by the space of homomorphisms between modules of the form $M(\pi_0, \lambda)$. For all but finitely many λ's, $M(\pi_0, \lambda)$ is a direct sum of modules $M(\tilde{\pi}_0, \tilde{\lambda})$ where $(\tilde{\pi}_0, \tilde{\lambda})$ is trivial on $\mathfrak{p}^+$.
2) Using a diagram presentation of Δ_1^+ we have now been able to give an intrinsic, non-inductive determination of the full set of unitary highest weight modules. All known results about annihilators and covariant differential operators in connection with such representations follow easily.

P. JOLISSAINT:

Rapidly decreasing functions in group C*-algebras I

(joint work with A. Valette)
Let G be a locally compact group equipped with a length-function L. The space $H_L^\infty(G)$ of rapidly decreasing functions on G is the set of functions f such that $f(1+L)^s \in L^2(G)$ for every $s \in \mathbb{R}$. G has property (RD) if the left regular representation λ of G extends continuously to $H_L^\infty(G)$. In this case, $H_L^\infty(G)$ is a convolution algebra contained in $C_\lambda^*(G)$.
Theorem If G belongs to one of the following classes then it has property (RD):
(1) $G \in \{SO(1,n), SU(1,n), Sp(1,u), F_{4(-20)}; n \geq 1\}$;

(2) G is a hyperbolic group in Gromov's sense;
(3) G acts properly with finite quotient graph on a locally finite tree.
Property (RD) is used to solve some problems in K-theory and to prove the existence of approximate units in the Fourier algebra.

P.E.T. JORGENSEN:

Locally defined positive definite functions on Lie groups

It is well known that locally defined positive definite functions on Lie groups G generally do not extend to positive definite functions which are defined on the whole group. We introduce two stronger positivity concepts for locally defined functions, and show that they are equivalent to extendibility. We then apply this to the case when G is the Heisenberg group. When an additional symmetry is imposed, we obtain a complete spectral analysis of the (locally defined) positive definite functions. The methods of proof are based on unitary dilation techniques (i.e., carefully chosen extensions of some underlying Hilbert space associated to the problem), and on spectral theory for noncommuting operators.

A. JUHL:

n-cohomology, zetafunctions and index formulas for ergodic families of elliptic operators

Es wird gezeigt, wie die (dynamische) Ruelle Zeta-Funktion mit einer natürlichen Kohomologietheorie zusammenhängt. In Analogie zur Theorie der Weil Zeta-Funktion gilt hier eine allgemeine Lefschetz-Formel für verallgemeinerte geodätische Flüsse lokal-symmetrischer Räume. Die Verbindung dieser Lefschetz-Formeln mit der Selbergschen Spurformel führt auf Identitäten, die zu interpretieren sind als Indexsätze für gewisse Familien elliptischer Operatoren. Typisches Beispiel für den Parameterraum dieser Familien ist der Raum der Horosphären in einem kompakten lokal-symmetrischen Raum vom Rang 1: Anders interpretiert erhalten wir kohomologisch-topologische Formeln für das Verhalten der Zeta-Funktionen an ausgezeichneten Stellen bzw. Identitäten für die Dimensionen von Räumen autormorpher Formen.

A. KORANYI:

Hypergeometric functions of several variables

It is known that to homogeneous symmetric cones in $\mathbb{R}^n$ one can associate generalized hypergeometric functions. They can be defined by expansions in spherical polynomials associated to the cone, and they give spherical functions on the complex symmetric domains that belong to the cone, i.e. on symmetric spaces which have higher rank than the cone one starts with.
Given the root system A_{r-1} and an arbitrary not necessarily integral multiplicity, Macdonald showed that the so-called Jack polynomials are "spherical", i.e. they are hypergeometric functions for A_{r-1} in the Heckman-Opdam sense. It turns out possible to use these to construct series which give hypergeometric functions (again in the general sense) for BC_r. A number of symmetry properties and explicit formulas can be proved.

G. KUHN:

A characterization of the spherical series representations of the free group

(joint work with T. Steger)
We give a definition (up to an equivalence relation for the choice of generators) of the spherical series of a finitely generated free group. We characterize representations of the spherical series by means of symmetry conditions of matrix coefficients (i.e. invariance under the stabilizer of a finite subtree).

J. LUDWIG:

Convexity of the moment map for Lie groups

Let G be a Lie group, and let π be a unitary representation of G on a Hilbert space $\mathcal{H}$. The moment map Ψ_π of π assigns to every C^∞ vector $\xi \neq 0$ in $\mathcal{H}$ the linear functional $\Psi_\pi(\xi)$ of the Lie algebra $\mathfrak{g}$ of G defined by

$$\psi_\pi(\xi)(X) = \frac{1}{i}||\xi||^{-2} < d\pi(X), \xi >_{\mathcal{H}}, X \in \mathfrak{g}.$$

We give results on the moment set I_π, i.e. the closure of the image of Ψ_π. For solvable G, I_π is always convex and if in addition π is irreducible, then I_π is the closure in $\mathfrak{g}^*$ of the convex hull of the Kirillov-Pukanszky orbit of π. If G is compact and π is irreducible, then I_π is the convex hull of the highest weight Λ of π if and only if $\prod_{i=1}^n < 2\Lambda - \alpha_i, \alpha_i > \neq 0$, where $\alpha_1, \dots, \alpha_n$ denote the simple roots of $\mathfrak{g}$. These results are joint work with D. Arnal, and the proofs use ideas of N. Wildberger, who introduced this notion of moment map.

M. NAZAROV:

Semigroup mantle of the infinite dimensional sympletic group

The Weil representation of the sympletic group $Sp(\mathbb{R}^{2n})$ is continued onto a certain semigroup of Lagrangian subspaces in $\mathbb{C}^{2n} \oplus \mathbb{C}^{2n}$, the multiplication being that of linear relations $\mathbb{C}^{2n} \to \mathbb{C}^{2n}$. The image of the representation so obtained contains the Howe's oscillator semigroup as an open subset. A p-adic version of this semigroup is also provided. Instead of the subspaces in $\mathbb{C}^{2n} \oplus \mathbb{C}^{2n}$ one should consider $\mathbb{Z}_p$-submodules in $\mathbb{Q}_p^{2n} \oplus \mathbb{Q}_p^{2n}$.

J. NOURRIGAT:

Spectral theory and representations of nilpotent Lie groups

(joint work with P. Levy-Bruhl and A. Mohamed)
Let $\mathfrak{g}$ be a "stratified" nilpotent Lie algebra, and let P be the sum of the square of a system of generators. Let π be a unitary irreducible representation of the group $\exp \mathfrak{g}$ and $\mathcal{O}_\pi$ be the corresponding orbit in the coadjoint representation, with the invariant measure μ. Let $|||\ |||$ be a homogeneous norm in the dual $\mathfrak{g}^*$. We prove estimates comparing the number $N(\lambda)$ of eigenvalues of $\pi(P)$ that are

smaller than a positive number λ, with the volume (for the measure μ) of the set of $l \in \mathcal{O}_\pi$ such that $|||l|||^2 \leq \lambda$. We prove similar inequalities for the trace of $\exp(-t\pi(P))$.

N. OBATA:

Irreducible representations of amalgams of discrete abelian groups

Let $G = *_Z G_i$ be an amalgam of discrete abelian groups $G_i, i \in I$, with a common subgroup Z being amalgamated. Assume the condition (A) $|G_i : Z| = \infty$ if $|G_i| = \infty$. Let $\mathfrak{M}_\infty(G)$ denote the set of maximal abelian subgroups $H \subset G$ such that $|H| = \infty$. Then the structure of each $H \in \mathfrak{M}_\infty(G)$ can be studied and we come to the following result:

Theorem Let χ and ψ be 1-dimensional unitary representations of H and K in $\mathfrak{M}_\infty(G)$, respectively. Then

(i) $\mathrm{Ind}_H^G \chi$ and $\mathrm{Ind}_K^G \psi$ are equivalent or disjoint.

(ii) $\mathrm{Ind}_H^G \chi \simeq \mathrm{Ind}_K^G \psi \iff \exists\, g \in G$ such that $H = K^g, \chi = \psi^g$.

(iii) A necessary and sufficient condition for $\mathrm{Ind}_H^G \chi$ being irreducible can be written down explicitly.

(iv) If $\mathrm{Ind}_H^G \chi$ is not irreducible, it is decomposed into a direct sum of two irreducible representations which are not equivalent.

Furthermore, irreducible decompositions of the regular representation of G are discussed. (For details see J. Math. Soc. Japan 42 (1990), 585-603).

G. OLAFSSON:

Spherical distributions on symmetric spaces

(joint work with B. Ørsted)

Let G/H be a semisimple symmetric space, $\tau : G \to G$ the corresponding involution, $H = G^\tau$ and $G \subset G_c$. Then G/H is causal if and only if there is an H-invariant regular cone in $\mathfrak{q} = (-1)$-eigenspace of τ. G/H is compactly causal or of Hermitian type if $C^0 \cap \mathfrak{k} \neq \emptyset$ and globally hyperbolic and ordered if $C^0 \cap \mathfrak{p} \neq \emptyset$. Here $\mathfrak{g} = \mathfrak{k} \oplus \mathfrak{p}$ is a τ-stable Cartan decomposition. Those types are dual to each other via $\mathfrak{h} \oplus \mathfrak{q} \leftrightarrow \mathfrak{h} \oplus i\mathfrak{q}$. Let G/H be compactly causal. Define $\Gamma := H\exp(-iC)$, a closed semigroup in the dual group G^c, and $\Xi := \Gamma \cdot G/H \subset G_c/H_c$. Let $\mathcal{H}_2 \subset O(\Xi)$ be the Hardy space of G/H. Then $\mathcal{H}_2 = \oplus \mathcal{E}_\pi, \mathcal{E}_\pi$ the C-admissable holomorphic discrete series of G/H. The H-invariant spherical distribution Θ_π of $\mathcal{E}_\pi$ extends to a holomorphic function f_π on Ξ given by a 'convolution' formula over the bounded domain G/K. We have $K(z) = \sum f_\pi$ where K is the Cauchy-Szegö kernel, Θ_π is the boundary value of f_π (Fatou lemma) and the restriction of f_π to the future set $\Gamma \cdot m_0 \subset G^c/H$ is a spherical function given by a Poisson integral over H.

D. POGUNTKE:

Representations of two step nilpotent groups

The primitive ideal space PrivC^*G of a general locally compact two step nilpotent group G can be parametrized by unitary characters of certain subgroups (Howe, Kaniuth). For compactly generated (non-) connected Lie groups G with the property that there exists a continuous homomorphism $\rho : [G,G]^- \to ZG$ such that $\rho(x)^2 = x$ it is presented a "Kirillov picture" of Priv$C^*(G)$. More specifically, ρ allows to introduce the structure of an abelian group on G. With each abelian unitary character χ on G one can associate a finite set F_χ of functions on G (coboundaries). The space $\mathfrak{P} = \{(\chi, g) | \chi$ as above, $g \in F_\chi\}$ can be given a T_1-topology and a continuous action of $G \times (G/2G \cdot ZG)\hat{}$ such that the quasi-orbits in $\mathfrak{P}$ are in bijective correspondence with PrivC^*G. This correspondence is a homeomorphism. Moreover, there is a trace formula, analogous to the Kirillov formula.

T. PRZEBINDA:

Characters, dual pairs and unipotent representations

We use Howe's duality theorem to construct irreducible unitary representations of classical groups over $\mathbb{R}$. Then for some of these representations we obtain a "Rossmann-Kirillov" character formula with support on the closure of a single nilpotent coadjoint orbit.

W. ROSSMANN:

Fourier transforms of nilpotent orbits in a real semisimple Lie algebra

Let $\mathfrak{g}_{\mathbb{R}}$ be a semisimple real Lie algebra, v a nilpotent element in $\mathfrak{g}^{+}_{\mathbb{R}}$. Let $\mathfrak{h}_{\mathbb{R}}$ be a cartan subalgebra of $\mathfrak{g}_{\mathbb{R}}, G_{\mathbb{R}} =$ Ad $(\mathfrak{g}_{\mathbb{R}})$, and $\mathfrak{g}, G$ the corresponding complex Lie algebra and group. Suppose there is a chamber $C \subseteq \mathfrak{h}^{*}_{\mathbb{R}}$ for the imaginary roots of $(\mathfrak{g}, \mathfrak{h}_{\mathbb{R}})$ so that $G_{\mathbb{R}} \cdot v$ is the only $G_{\mathbb{R}}$-orbit in the complex orbit $G \cdot v \cap \mathfrak{g}^{*}_{\mathbb{R}}$ which contains an element of the form $\lim_k t_k g_k \cdot u$ with $g_k \in G_{\mathbb{R}}$ and $t_k \to o$ in $\mathbb{R}$. Let p be any polynomial on $\mathfrak{h}$, homogeneous of degree $\dim(\mathfrak{g}/\mathfrak{h}) - \dim(\mathfrak{g}/\mathfrak{g}_v)$, which transforms according to the irreducible Springer character $\chi_{v,1}$ under the Weyl group W. Then

$$\lim_{\lambda \to o(C)} p(\partial_\lambda)\, \mu_\lambda = \kappa\, \mu_v,$$

where μ_λ is the canonical measure on $G_{\mathbb{R}} \cdot \lambda$ for regular $\lambda \in C, \mu_v$ the canonical measure on $G_{\mathbb{R}} \cdot v$ and κ a constant. Further, $\kappa \neq 0$ if and only if $\chi_{v,1}$ occurs in the W-module generated by the coherent family $\Theta(C, \lambda)$ of invariant eigendistributions associated to C.

G. SCHLICHTING:

Graphs with polynomial growth

Let $\mathfrak{G} = (V, \mathfrak{E})$ be a graph, i.e. a set V of vertices and a set $\mathfrak{E}$ of edges given by 2-element subsets of V. We suppose that $\mathfrak{G}$ is locally finite, connected and that there exists a transitive subgroup G of the group $S(V)$ of all permutations of V such that $G \subseteq \mathrm{Aut}\mathfrak{G}$. Consider $\mathfrak{G}_n(x) = \{y \in V \,|d(y,x) \leq n\}$ relative to the natural distance d on V.

Theorem (Trofimov '84) Under the above assumptions there is an integer d and a $C > 0$ such that $|\mathfrak{G}_n(x)| \leq Cn^d$ for all n if and only if there is a G-invariant partition of V into finite blocks such that G acts on the blocks as a finitely generated nilpotent group with finite stabilizers of points.

We give a short proof of this theorem by showing that $\mathrm{Aut}\mathfrak{G}$ (as well as $\bar{G}$, the closure of G in $\mathrm{Aut}\mathfrak{G}$) is a compactly generated, locally compact totally disconnected group of polynomial growth and then applying a theorem of Losert. As an application we can prove

Theorem Let G be a torsion free group and E a finite set of generators. Then there are at most finitely many permutations $\tau : G \to G$ such that $\tau(xE) = \tau(x)E$ for all $x \in G$.

S. SAHI:

The capelli identity and unitary representations

Let G/K be an irreducible hermitian symmetric space of tube type and rank n. Its Shilov boundary is of the form G/P where $P = LN$ is a maximal parabolic subgroup of G; and $\mathfrak{n} = \mathrm{Lie}(N)$ is an abelian Lie algebra with a natural Jordan algebra structure. The Jordan norm on $\mathfrak{n}$ is a polynomial φ (of degree n) which transforms by a positive character ν^{-2} of L. Let $\bar{P} = L\bar{N}$ be the opposite parabolic subgroup and consider $I(t) := \mathrm{Ind}_{\bar{P}}^{G}(\nu^t \oplus 1)$. By the Gelfand-Naimark decomposition, there is an imbedding of $I(t)$ in $C^\infty(\mathfrak{n})$. If D is the differential operator $\partial(\varphi)$, then it is known that D^m intertwines $I(m)$ with its hermitian dual $I(-m)$. Thus for

$f_1, f_2 \in I(m)$, the inner product $(f_1, D^m f_2)$ is an invariant hermitian form on $I(m)$. Using the generalized Capelli identity (as developed in joint work with B. Kostant) I obtain an explicit formula for this form on each K-type. This shows that certain constituents of $I(m)$ are unitarizable.

A. VALETTE:

Rapidly decreasing functions in group C^*-algebras II

(joint work with P. Jolissaint)

Property (RD) is applied to some questions in harmonic analysis: characterizations of positive definite functions that are weakly associated to the left regular representation, approximation properties of the Fourier algebra, construction of n-positive maps on the reduced C^*-algebra $C_r^*(G)$ that have no positive extension to $\mathcal{L}(L^2(G))$. Examples and open questions are mentioned.

N.J. WILDBERGER:

Hypergroups and Kirillov theory

We propose a new approach to the study of the unitary dual $G^\wedge$ of a group G. This program consists of the following steps.

1. Determince $\mathcal{C}(\mathcal{G})$, the hypergroup of conjugacy classes of G.
2. Determine $\mathcal{C}(\mathcal{G})^\wedge$ by (abelian) harmonic analysis on $\mathcal{C}(\mathcal{G})$.
3. Use a version of the fact $\mathcal{C}(\mathcal{G})^\wedge = \mathcal{C}(\mathcal{G}^\wedge)$ valid for finite groups.

For G compact Lie, we show how this program works by relating $\mathcal{C}(\mathcal{G})$ to $\mathcal{C}(\mathfrak{g})$, the hypergroup of adjoint orbits of $\mathfrak{g}$ under abelian convolution. We use

Theorem (Dooley, Wildberger) Let $\mathcal{O}_1, \mathcal{O}_2$ be two adjoint orbits of a compact Lie group G and μ_1, μ_2 the invariant measures on $\mathcal{O}_1, \mathcal{O}_2$, respectively. For a measure μ on $\mathfrak{g}$ define $\phi(\mu)$, , a measure on G, by $< \phi(\mu), f >=< \mu, j\tilde{f} >$, where for $f \in C^\infty(G), \tilde{f}(X) = f(\exp X)$ and $j = \sqrt{\det \exp}$. Then

$$\phi(\mu_1 * \mu_2) = \phi(\mu_2) * \phi(\mu_2).$$

[This theorem can also be used to establish Vergne's Poisson summation formula and a global Kirillov character formula]. We describe completely the hypergroup structure of $\mathcal{C}(\mathfrak{g})$. This is joint work with A.H. Dooley and J. Repka. For nilpotent G, we suggest the conjecture: $\mathcal{C}(\mathfrak{g}) \simeq \mathcal{C}(G)$.

Theorem (Wildberger) Let $\mathcal{O}_1, \mathcal{O}_2$ be adjoint orbits in $\mathfrak{g}$ ($\mathfrak{g}$ nilpotent). Then

$$\exp(\mathcal{O}_1 + \mathcal{O}_2) = \exp \mathcal{O}_1 \cdot \exp \mathcal{O}_2.$$

We loosely describe $\mathcal{C}(\mathfrak{g})$ for $\mathfrak{g}$ the Heisenberg Lie algebra.

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