MATHEMATISCHES FORSCHUNGSINSTITUT OBERWOLFACH

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Linear Operators and Application

7.5. bis 13.5.1995

Die Tagung wurde von I.C. Gohberg (Tel Aviv), B. Gramsch (Mainz) und H.H. Schaefer (Tübingen) geleitet. Im Mittelpunkt des Interesses standen Anwendungen der Operatortheorie auf singuläre Integraloperatoren, Spektraltheorie auf Banachverbänden, Ergebnisse über invariante Unterrräume, Operatorpolynome und Operatoralgebren auf Räumen mit Singularitäten bzw. Quantisierung. In der Operatortheorie auf Banachverbänden wurden neueste Resultate über eine Operatorungleichung (Andô'sche Vermutung), Strassen'sche Disintegration und Stetigkeitseigenschaften des Spektrums bei endlichdimensionaler Approximation vorgestellt. Zu interessanten Diskussionen führte u.a. ein Vortrag wegen einer Diskrepanz zu existierender Literatur im Bereich der Spektralmaße. Toeplitz-Matrizen und Weiterentwicklungen in der Spektraltheorie von Operatorpolynomen und von Matrizen unbeschränkter Operatoren spielten eine wichtige Rolle. Die Anwendung des Konzeptes der invers abgeschlossenen Fréchetoperatoralgebren führte in einigen Vorträgen zu interessanten Ergebnissen und anregendem Gedankenaustausch bezüglich der Operatoranalysis auf singulären Räumen. Die Tagungsleiter bitten um Verständnis dafür, daß bei acht Teilnehmern der Wunsch, einen Vortrag zu halten, im offiziellen Programm nicht erfüllt werden konnte. Es fand ein intensiver Ideenaustausch über neue Entwicklungen in der Operatortheorie statt, und dadurch ergaben sich auch für jüngere Mathematiker Anknüpfungspunkte und weitere Verbindungen.

Vortragsauszüge

Y. A. ABRAMOVICH

Invariant subspace problem for positive operators

This is a short survey of some work by C. D. Aliprantis, O. Burkinshaw and the author. We describe a broad class of operators on Banach lattices which have a (non-trivial, closed) invariant subspace. A sample result: Any positive locally quasinilpotent operator $B : \ell_p \to \ell_p$ has an invariant subspace. Recall that B is locally quasinilpotent if there exists a vector $0 < x_0 \in \ell_p$ satisfying $||B^n x_0||^{\frac{1}{n}} \to 0$.
Problem: Each positive operator on ℓ_p has an invariant subspace.

W. ARENDT

On the boundary of holomorphic semigroups

Given a holomorphic semigroup T with generator A we characterize when iA generates a group U. In that case, $U(s) = \lim_{t\downarrow 0} T(t+is)$ strongly; i.e. U is the *trace* (or *boundary*) of T. Hörmander's result, saying that $i\Delta$ generates a semigroup on $L^p(I\!R^N)$ iff $p = 2$, is an immediate consequence. Main topic are two inverse problems:
PROBLEM 1: Given a group U. When is it a trace? This is joint work with O. El-Mennaoui and M. Hieber.
PROBLEM 2: Given a group U, when does there exist a sectorial operator C such that $U(s) = C^{is}$ (thesis of S. Monniaux).

A. BEN-ARTZI

Inertia theorems for operator pencils and applications

(In joint work with I. Gohberg).
We obtain general infinite dimensional inertia theorems for linear pencils in Hilbert spaces, which cover previously known results for the finite dimensional case and for block weighted shifts. Connections with definite subspaces for contractions in spaces with indefinite metric are discussed.

A. BÖTTCHER

Toeplitz and singular integral operators on general Carleson curves

This talk is based on joint work with Yu. I. Karlovich and is concerned with the spectra of Toeplitz operators with piecewise continuous symbols and with the symbol calculus for singular integral operators with piecewise continuous coefficients on $L^p(\Gamma)$ where $1 < p < \infty$ and Γ is a Carleson Jordan curve. It is well known that piecewise smooth curves lead to the appearance of circular arcs in the essential spectra of Toeplitz operators, and only recently we discovered that certain Carleson curves metamorphose these circular arcs into logarithmic double-spirals. In the present talk we dispose of the matter by determining the local spectra produced by a general Carleson curve. These spectra are of a qualitatively new type and may, in particular, be heavy sets - until now such a phenomenon has only be observed for spaces with general Muckenhoupt weights.

B. CARL

Realizations of exact solutions of non-linear differential equations of the solition theory by bounded linear operators

Within the frame of (bounded linear) operators on Banach spaces and operator ideals we give a model for the realization of solutions of several non-linear equations. Let $\mathcal{L}$ denote the ideal of all operators and $\mathcal{A}$ a quasi-normed operator ideal such that all operators on the ideal components $\mathcal{A}(E)$, E being a Banach space, possess absolutely summable eigenvalues. If $A \in \mathcal{L}(E)$ and $B \in \mathcal{A}(E)$ such that rank $(AB + BA) = 1$ then, for example,

$$v = 2\,\frac{(\Pi(1 + \lambda_i(L)))_x}{\Pi(1 + \lambda_i(L))},$$

where $\lambda_i(L)$ are the eigenvalues of $L = e^{Ax+A^3t}B$, is a solution of the PDE $v_t = v_{xxx} + 3v_x^2$.

L. COBURN

Toeplitz operators on spheres S^{2n-1} are really pseudo-differential operators

Using results of Bargmann and Berezin, J. Xia and I have recently shown that the result of the title holds modulo compact operators via a "natural" unitary representation. This representation allows us to consider the C^*-algebra of Toeplitz operators on S^{2n-1} as a "strict deformation quantization" (in the sense of M. Rieffel) of the algebra of continuous functions on the closed unit ball $\overline{B_2n}$.

H. DYM

On maximum entropy interpolants and maximum determinant completions of associated Pick matrices

This talk is based on a paper of the same title by Israel Gohberg and myself which will appear shortly in the journal "Integral Equations and Operator Theory". In this paper it is shown that the "value" of the maximum ω-entropy solution of an interpolation problem of the Nevanlinna-Pick type at the point ω maximizes the determinant of the solution of an associated matrix completion problem. This serves to show that the solutions of two distinct extremal problems coincide.

R. L. ELLIS

Infinite analogues of block Toeplitz matrices and related orthogonal eigenfunctions

The starting point for this lecture are the classical Szegö polynomials, that are orthogonal on the unit circle $\mathbf{T}$ for a given weighted scalar product, which can be written in terms of selfadjoint finite Toeplitz matrices. All the zeros of the Szegö polynomials lie in the open unit disk. M.G. Krein extended these results to the case of an indefinite scalar product, and his results were extended to the block case by Alpay/Gohberg and Gohberg/Lerer. We consider an $r \times r$ matrix-valued inner product on $L_2^{2r\times r}(\mathbf{T})$. It can also be written in terms of a matrix T having four blocks each an infinite block Toeplitz matrix (an operator on $\ell_2^{r\times r}(-\infty,\infty)$). Using submatrices of T, we construct functions that are orthogonal for the inner product. These submatrices are analogous to finite block Toeplitz matrices. For this we develop a theory of orthogonalization in Hilbert modules. We obtain analogues of Krein's theorems and an analogue of the Gohberg-Heinig formula for the inverse of a selfadjoint block Toeplitz matrix. The results for the scalar case appeared in a paper by Ellis and Gohberg in 1988 in the J. of Functional Anal.. For the block case a paper of Ellis, Gohberg and Lay will appear in 1995 in Integral Equations and Operator Theory.

J. ESCHMEIER

Invariant subspaces for spherical contractions

A commuting tuple $T = (T_1, \ldots, T_n)$ of operators on a complex Hilbert space H is called a spherical contraction if $\sum_{i=1}^n ||T_i x||^2 \leq ||x||^2$ for each $x \in H$. The Taylor spectrum of a spherical contraction is contained in the closure of the open Euclidian unit ball B in $\mathbb{C}^n$. Under natural positivity conditions, studied by Athavale, Vasilescu, Müller-Vasilescu, spherical contractions possess a dilation to a normal tuple $N \in L(K)^n$ on a larger Hilbert space K with $\sigma(N) \subset \partial B$. Let $T \in L(H)^n$ be a spherical contraction with a normal dilation N. We prove that T possesses an H^∞-functional calculus $\Phi : H^\infty(B) \to L(H)$ if T is completely non-unitary. We prove that T has non-trivial hyperinvariant subspaces if Φ is neither a $C_{0\bullet}$ - nor a $C_{\bullet 0}$ - representation (and T does not consist of multiples of the identity). We indicate that spherical contractions with normal dilations and rich spectrum in B possess non-trivial invariant subspaces.

B. GRAMSCH

Operator theory for Fréchet algebras in the pseudo-differential analysis

The Hörmander classes $\Psi^0_{\rho,\delta}(\mathbb{R}^n)$, $0 \leq \delta \leq \rho \leq 1$, $\delta < 1$, and the Fréchet algebras of order and type zero in the calculus of Boutet de Monvel for boundary value problems on compact manifolds turned out to be submultiplicative Ψ^*-algebras (1992, 1994, work together with Schrohe, Ueberberg, Wagner). Since these inverse closed Fréchet algebras are stable with respect to countable intersections in $\mathcal{L}(H)$, H Hilbert space, they can be used for localizations of C^∞-properties with respect to derivations in the microlocal analysis.

THEOREM: *Let $\mathcal{J}$ be a closed symmetric twosided ideal in the dense Ψ^*-subalgebra A of the C^*-algebra B; let $\mathcal{I}$ be the norm closure of $\mathcal{J}$ in B.*

(α) *With the canonical homomorphism $q : A \to A/\mathcal{J}$ we have*

$$\mathcal{I} \cap A = q^{-1}(rad\ A/\mathcal{J}),$$

where rad denotes the Jacobson radical.

(β) *In the case $\mathcal{J} = \mathcal{I} \cap A$ the Fréchet algebra $A/\mathcal{J}$ is a Ψ^*-subalgebra of $B/\mathcal{I}$.*

The Oka-Arens-Royden principle poses a series of problems if we consider holomorphic, continuous or C^k-maps from a holomorhpy region into direct, analytic Fréchet submanifolds of a submultiplicative Ψ^*-algebra.

It is still an open problem whether every Ψ^*-algebra is submultiplicative. In work together with W. Kaballo the Oka principle has been applied to a sharp multiplicative decomposition of holomorphic Fredholm functions relative to small metric ideals.

JOACHIM JUNG

On an inverse function theorem in special Fréchet algebras

Let $E := \bigcap_{k\geq 0} E_k$ be a projective limit of Banach spaces and dense in E_0. A continuous n-times multilinear map $T_n \in \bigcap_{k\geq 0} \mathcal{L}(E_k, \ldots, E_k; E_k)$ is called *decent*, if

$$|T_n(x_1, \ldots, x_n)|_k \leq C_n \sum_{j=1}^{n} |x_j|_k \prod_{\ell\neq j} |x_\ell|_0 + C_{n,k} \prod_{j=1}^{n} |x_j|_{k-1}$$

for all $k \geq 1$ and $x_1, \ldots, x_n \in E_k$ and C_n is independent of k. If the E_k are Banach algebras, then E is called a *decent* Fréchet algebra if $|xy|_k \leq |x|_k|y|_0 + |x|_0|y|_k + C_k|x|_{k-1}|y|_{k-1}$ for all $k \geq 1$ and $x, y \in E_k$. This notion applies e.g. to certain subalgebras of rotation algebras (in the sense of J. Bellissard, 1994). The following modification of a theorem due to H. Omori holds.

THEOREM: *Let $\Phi : E \longrightarrow E$ be a map of the form*

$$\Phi(x) = x + \sum_{n=2}^{N} T_n(x, \ldots, x),$$

where the T_n are decent. There exist E_0-neighbourhoods U and V of the origin, such that $\Phi : U \cap E \longrightarrow V \cap E$ is a C^∞-diffeomorphism.

COROLLARY: *Let $A \subsetneq A_0$ be a decent Fréchet algebra. Then $A \cap A_0^{-1} = A^{-1}$, i.e. A is spectrally invariant in A_0.*

The theorem applies especially to factorization problems of the form $e - y = (e - T_+x)(e - T_-x)$, where $T_+, T_- : A \longrightarrow A$ are decent linear operators with $T_+ + T_- = I$ and A is a decent Fréchet algebra.
It is also related to nonlinear problems occuring in the context of submanifolds in Ψ^*-algebras (cf. B. Gramsch, 1984, and K. Lorentz, 1992, 1995).

M. A. KAASHOEK
Norm constrained time-variant interpolation problems

This talk describes a general method which allows one to treat interpolation problems of Nevanlinna-Pick and Nehari type for triangular operators as classical interpolation problems for operator-valued functions. The latter may be solved by using standard methods, for instance, by applying the commutant lifting theorem. The reduction from time-variant to time-invariant involves two basic operations, namely diagonally shifting and slashing. A new time-variant version of the commutant lifting theorem is also presented. The talk is based on joint work with C. Foias, A. Frazho and I. Gohberg.

N. J. KRUPNIK
Banach algebras generated by singular integral operators

Let Γ be a contour in the complex plane and $\rho : \Gamma \rightarrow I\!R^+$ a weight such that the singular integral operator

$$S_\Gamma \varphi\,(t) = \frac{1}{\pi i} \int_\Gamma \frac{\varphi\,(\tau)\,d\tau}{\tau - t}$$

is bounded in the space $B = L_p(\Gamma, \rho)$. Denote by $\mathcal{L}(B)$ the algebra of all linear bounded operators acting in B and by $\mathcal{A}$ the smallest subalgebra of $\mathcal{L}(B)$ which contains the operator S_Γ and all operators of multiplication by piecewise continuous functions.

We discuss the methods of construction the matrix Fredholm symbol in algebras $\mathcal{A}$. These methods are based on some general results on Banach algebras with polynomial identities, on Banach algebras which admit generalized Gelfand transform and algebras which admit matrix Fredholm symbol. In the case of a simple contour the problem of constructing the matrix Fredholm symbol is entirely reduced to the problem of finding the essential spectrum of the Toeplitz operator PaP, where P is the projection $P = (I + S_\Gamma)\,/\,2$.

P. LANCASTER
Operator polynomials with real or unimodular spectrum

Let H be a Hilbert space and consider operator polynomials $L(\lambda) = \sum_{j=0}^{\ell} \lambda^j A_j$

where $A_j^* = A_j$, $j = 0, 1, \ldots, \ell$ and A_ℓ is invertible. We consider those polynomials which have only real spectrum and for which this property is retained under small selfadjoint perturbations of the coefficients. They are characterized in three ways: a) a definitizability condition on the linearization, b) intrinsic properties of the spectrum, and c) stable boundedness of the solutions of an associated homogeneous ordinary differential equation. The effect of compact perturbations of the coefficients is also discussed. When

$$L(\lambda) = \sum_{j=0}^{2k} \lambda^j A_j \text{ and } A_j^* = A_{2k-j},\ j = 0, 1, \ldots, 2k,$$

analogous results are presented for polynomials having spectrum on the unit circle. In this case there is an associated homogeneous difference equation. The talk is based on joint work with A. Markus and V. Matsaev.

H. LANGER

A class of λ-rational eigenvalue problems

We consider a pencil L of the form $L(\lambda) = A - \lambda - B(C - \lambda)^{-2} D$ where $A = A^*$ in some Hilbert space H, $C = C^*$ in some Hilbert space $\widehat{H}$ and B is a bounded or unbounded linear operator from $\widehat{H}$ into H. Associated with L is the "linearization".

$$\tilde{A} = \begin{pmatrix} A & B \\ B^* & C \end{pmatrix} \text{ in } \widetilde{H} = H \oplus \widehat{H}.$$

If there is some $\alpha \in I\!R$ such that $C \ll \alpha \ll A$, the spectral subspaces of $\tilde{A}$ corresponding to (α, ∞) and $(-\infty, \alpha)$ can be represented by means of an "angular operator" which is strictly contractive. This implies statements about completeness and Riesz basisness of parts of the spectrum of L if A has a compact resolvent. These results apply e.g. to Sturm Liouville problems of the form

$$-y'' - \lambda y - \frac{qy}{u - \lambda} = 0 \text{ or } \Big(- a \frac{(\hat{w}_1 - \lambda) \cdots (\hat{w}_n - \lambda)}{(w_1 - \lambda) \cdots (w_n - \lambda)}\, y' \Big)' - (\lambda - w_0)\, y = 0$$

on $[0, 1]$, $y(0) = y(1) = 0$.
(Joint work with V. Adamjan and R. Mennicken).

R. LAUTER

A multidimensional holomorphic functional calculus for certain Fréchet operator algebras

Ψ^*-algebras, i.e. symmetric, spectrally invariant Fréchet subalgebras A of $\mathcal{L}(H)$ (H a Hilbert space) were introduced by B. Gramsch in 1981. The functional calculus of J.L. Taylor applies to Ψ^*-algebras in the following sense:

THEOREM 1: *Let* $a = (a_1, \ldots, a_n) \in A^n \subseteq \mathcal{L}(H)^n$ *be a commuting system and* $\Theta_a : \mathcal{O}(\sigma_T(a, H)) \to \mathcal{L}(H)$ *be the multidimensional holomorphic functional calculus of J.L. Taylor, then one has*

$$\Theta_a(\mathcal{O}(\sigma_T(a, H))) \subseteq A.$$

As an application the following theorem was discussed.

THEOREM 2: *Let* X *be a smooth compact manifold with boundary. Then there exists a* Ψ^**-algebra* $\mathcal{A}_\infty \subseteq \mathcal{L}(L^2(X, {}^b\Omega^{\frac{1}{2}}))$ *which contains the small Melrose algebra* $\Psi^0_{b,cl}(X, {}^b\Omega^{\frac{1}{2}})$ *of classical totally characteristic pseudo-differential operators (1981), such that the following holds:*

1. *The homogeneous principal symbol* ${}^b\sigma^0_\psi$ *extends from* $\Psi^0_{b,cl}(X, {}^b\Omega^{\frac{1}{2}})$ *to a* $*$*-algebra homomorphism* $\widehat{{}^b\sigma^0_\psi} : \mathcal{A}_\infty \to C^\infty({}^bS^*X)$.

2. *The indicial family* I *extends from* $\Psi^0_{b,cl}(X, {}^b\Omega^{\frac{1}{2}})$ *to a* $*$*-algebra homomorphism* $\hat{I} : \mathcal{A}_\infty \to C^\infty_b(\mathbb{R}, \mathcal{P}^0_{cl}(\partial X, \Omega^{\frac{1}{2}}))$.

3. *The Fredholm property of* $a \in \mathcal{A}_\infty$ *on* $L^2(X, {}^b\Omega^{\frac{1}{2}})$ *is characterized by* $\widehat{{}^b\sigma^0_\psi}(a)$ *and* $\hat{I}_a$.

4. $\varphi, \psi \in C^\infty_0(\overset{\circ}{X}), a \in \mathcal{A}_\infty \Longrightarrow \varphi a \psi \in \Psi^0(\overset{\circ}{X}, \Omega^{\frac{1}{2}})$.

5. $\mathcal{A}_\infty$ *acts on a scale of Sobolev-spaces.*

6. $a = (a_1, \ldots, a_n) \in \mathcal{A}^n_\infty$ *commuting,*

$$f \in \mathcal{O}(\sigma_T(a, L^2(X, {}^b\Omega^{\frac{1}{2}}))) \Longrightarrow \hat{I}_{f(a)}(\lambda) = f(\hat{I}_a(\lambda)) \quad \forall \lambda \in \mathbb{R}.$$

The ideas of the proof for Theorem 1 involve also results of Cordes (1969) and Plamenevskii (1986) related to the C^*-quantization of the Mellin transform. In another direction Mantlik considered recently C^*-closures in $\mathcal{L}(H^s)$ for the cone algebra in the calculus of Schulze (1986). Of course, the Ψ^*-property has been considered recently by many mathematicians in other interesting cases.

G. LUMER

Singular transitions in parabolic problems and stable convergence of hyperfunctions

We treat the singular parabolic transition problem (ITP)

$$u' = Au, \quad u(0) = f$$
$$(sti)\ u\ (0) = \sigma, \text{ where } \sigma \in B_0 = \{X\text{-valued hyperfunctions on } \mathbb{R} \text{ with support at } 0\}$$
$$Bu(t) = \phi(t),\ t > 0,$$

in a Banach space X, (where A is assumed to generate an *irregular* bounded *analytic* semigroup $Q(t)$) via asymptotic solutions u_η of $u_\eta' = Au_\eta$, $u_\eta(0) = f$, $Bu_\eta(t) = \overline{\phi}_\eta(t)$, corresponding to an η-depending family of smooth transitions of the boundary conditions from their value at $t = 0_-$ to their value at $t = \eta$, $\phi(\eta)$, the "very fast variation" being described by $\{\overline{\psi}_\eta\}$ with support in the "small" intervals $[0, \eta]$, $\eta \to 0$, $(\overline{\psi}_\eta + \phi = \overline{\phi}_\eta)$. A canonical topology on the X-valued hyperfunctions on $I\!R$ with compact support, $\tilde{B}$, exists, such that when $\overline{\psi}'_\eta \to c_0\delta + \sigma'(c_0 = \phi(0_+) - \phi(0_-)$, $\phi(0_-) = Bf)$, $u_\eta \to u$ uniformly on compacta of $]0, \infty[$ (in X-norm), and

$$u(t) = \phi(t) + Q(t)(f - Bf) - \int_0^t Q(t-s)\, \phi'(s)\, ds - \sum_{k=0}^{\infty} Q^{(k)}(t)\, c_k$$

where $\sigma = \sum_{k=1}^{\infty} c_k \delta^{(k-1)}$ is the standard representation of the $\sigma \in B_0$ above (in (ITP)), and c_0 was defined earlier. One has in particular the

THEOREM: *If $\overline{\phi}_\eta$ is always ≥ 0 then $c_k = 0$ for $k \geq 2$ (i.e. in the "heat case", in addition to $c_0\delta$ - a shock -, there can only exist a "heat explosion" term $c_1\delta'$). Otherwise all $c_k \neq 0$ can occur.*

Besides mathematical applications, we give applications to physics and engineering.

W. A. J. LUXEMBURG

Andô's conjecture, the diagonal of positive operators and renewal sequences

At the "Tagung" devoted to the theory of Riesz spaces and order-bounded linear operators held during the week of June 18, 1977, T. Andô conjectured the following result: If T is a positive linear operator of an o-complete Banach lattice E, then for all $|\lambda| > r(T)$, the spectral radius of T, the resolvent $R(\lambda, T) := (\lambda I - T)^{-1}$ satifies $|TR\,(\lambda, T)| \leq |\lambda R\,(\lambda, T)|$, where $|\cdot|$ denotes the modulus of an order bounded operator. A proof of this inequality will be presented and a number of its consequences. In particular, if D denotes the diagonal projection of the lattice ordered Banach algebra $\mathcal{L}_r(E)$ of the order-bounded linear operators of E, then the sequence $\{D\,(T^{|n|})\}_{n \in \mathbb{Z}}$, where $0 \leq T \in \mathcal{L}_r$, is positive definite and in fact a renewal sequence in the sense of Feller. These results and other results are contained in a joint paper with B. de Pagter and A. Schep and is published in A. C. Zaanen's "Festschrift" as vol. 75 of the series Operator Theory, Advances and applications, Birkhäuser, Basel-Boston-Berlin, 1995.

V. MATSAEV

Definite spectrum of operators in indefinite inner product spaces

The point $\lambda \in \sigma(A)$ is called a point of positive type of operator A, which is selfadjoint in a Hilbert space with a G-inner product $[x, y] := (Gx, y)$ (for simplicity let G^{-1} exist) if for each sequence $(x_n) \subset$ space with $||x_n|| = 1$, $(A - \lambda)\, x_n \to 0$ $(n \to \infty)$

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we have $\underline{lim}\ [x_n, x_n] \geq \delta > 0$.
The positive spectrum has a number of interesting properties. Corresponding invariant spectral subspaces are uniformly positive with respect to $[\cdot,\cdot]$. Points of positive type dont't become accumulation points for nonreal spectrum of compact G-s.a. perturbation.
The talk is based on joint results with H. Langer and A. Markus.

R. MENNICKEN

On the essential spectrum of some operator matrices

Let X_1, X_2 be Banach spaces and consider the operator matrix

$$\mathbb{L}_0 = \begin{pmatrix} A & B \\ C & D \end{pmatrix},$$

acting in the product space $X_1 \times X_2$. The entries A, B, C and D are linear, not necessarily bounded operators in/between the spaces X_1, X_2. Typical examples of such operator matrices are defined by systems of differential operators of mixed order which frequently occur in quantum mechanics, hydrodynamics and magnetohydrodynamics.
Sufficient conditions for the closability of the operator $\mathbb{L}_0$ are stated. Further, a characterization of the essential spectrum of the closure $\mathbb{L} := \overline{\mathbb{L}_0}$ in terms of the Schur complement $D - C\,(A-\mu)^{-1}B$ is presented. Applications to spectral problems from magnetohydrodynamics illustrate the effectiveness of the operator theoretical methods. Further aspects of the theory of operator matrices are treated by H. Langer in his presentation.
(Joint work with F.V. Atkinson, H. Langer and A.A. Shkalikov)

P. MEYER-NIEBERG

Vector valued Strassen disintegration theorems

The scalar valued disintegration theorem due to Strassen can be formulated as follows:
THEOREM (STRASSEN): *Let X be a real vector space, (Ω, μ) a positive measure space, $\phi : X \to \mathbb{R}$ linear and $\vartheta : X \to L^1(\mu)$ sublinear such that $\phi\,(x) \leq \int \vartheta(x)d\mu$ for all $x \in X$. There exists a linear operator $T : X \to L^1(\mu)$ satisfying $Tx \leq \vartheta\,(x)$ for all $x \in X$.*
A first vector valued version was given by Neumann, where the scalars are replaced by a Dedekind complete ordered Banach space with the Radon Nikodym property. In the Riesz space situation more general versions are presented:
THEOREM: *Let X be a real vector space, E and F Dedekind complete Riesz spaces such that $E_n^\sim$ separates the points of E and $F_n^\sim$ separates the points of F. Let $S : E \to F$ be positive linear satisfying $S^\sim F_n^\sim \subset E_n^\sim$, such that $S \mid_{F_n^\sim}$ is a lattice homomorphism. If $\vartheta : X \to E$ is sublinear, $T : X \to F$ is linear satisfying*

$Tx \leq S\ (\vartheta\ (x))$ *for all* $x \in X$*, then there exists* $T_0 : X \to E$ *linear such that* $Tx = ST_0x$ *and* $T_0x \leq \vartheta\ (x)$ *for all* $x \in X$.
COROLLARY: *If* $\vartheta : X \to L^1(\mu \times \nu)$ *is sublinear,* $T : X \to L^1(\mu)$ *is linear satisfying* $Tx \leq \int \vartheta\ (x)\ d\nu$ *for all* $x \in X$*, then there exists* $T_0 : X \to L^1(\mu \times \nu)$ *linear satisfying* $T_0x \leq \vartheta\ (x)$ *and* $Tx = \int T_0x d\nu$ *for all* $x \in X$.

N. NIKOLSKI

Quantitative characteristics of invisible spectrum

Let A be a unital Banach algebra continuously imbedded into the space $C(X)$, X stands for a topological space. The spectrum (maximal ideal space) of A, say $M(A)$, is said to be $\delta - n$-visible (from X), if there exists a constant $c(\delta, n)$ such that for every n-tuple $f = (f_1, \ldots, f_n) \in A^n = A \times \ldots \times A$ such that $\delta \leq |f(x)| = (\sum_{i=1}^n |f_i(x)|^2)^{1/2} \leq ||f|| = (\sum_{i=1}^n ||f_i||^2)^{1/2} \leq 1$, $x \in X$, there exists an n-tuple $g \in A^n$ solving the Bezout equation $\sum_{i=1}^n f_i g_i = e$ and satisfying $||g|| \leq c(\delta, n)$. We call the spectrum $n-$visible if for every $f \in A^n$ with $\inf_{x \in X} |f(x)| > 0$ there exists a solution $g \in A^n, \sum_{i=1}^n f_i g_i = e$.

Some general sufficient conditions are given for the spectrum of an algebra to be $\delta - n$-visible. Several common algebras are tested: Wiener algebras of absolutely convergent Fourier series (both analytic and symmetric), algebras of measures, some Beurling algebras of sequences (both radical and semi-simple). Relations with the localization of the spectrum of an operator as well as some unsolved problems are discussed.

B. DE PAGTER

Lipschitz continuity of the absolute value map

In this talk we presented an extension to non-commutative L_p-spaces of a result of E.B. Davies concerning the Lipschitz continuity of the absolute value map and commutator estimates in the Schatten classes $\mathcal{C}_p$ $(1 < p < \infty)$. Let $\mathcal{M}$ be a von Neumann algebra on Hilbert space H, with semi-finite, normal faithful trace τ. By $\widetilde{\mathcal{M}}$ we denote the $*$-algebra of all τ-measurable operators, and by $L^p(\mathcal{M}, \tau)$, $1 \leq p \leq \infty$, we denote the corresponding non-commutative L^p-spaces. The main result is the follwing:
THEOREM: *Suppose* $1 < p < \infty$.

(1) *If* $S, T \in \widetilde{\mathcal{M}}$ *such that* $S - T \in L^p(\mathcal{M}, \tau)$*, then* $|S| - |T| \in L^p(\mathcal{M}, \tau)$ *and* $||\ |S| - |T|\ ||_p \leq K_p\ ||S - T||_p$;

(2) *If* $S^* = S \in \widetilde{\mathcal{M}}, T \in \widetilde{\mathcal{M}}$ *such that* $[S, T] \in L^p(\mathcal{M}, \tau)$*, then* $[|S|, T] \in L^p(\mathcal{M}, \tau)$ *and* $||\ [|S|, T]\ ||_p \leq K_p\ ||\ [S, T]\ ||_p$ *(the constant* K_p *only depends on p).*

This result has an extension to the Haagerup L^p-spaces for general von Neumann algebras. The results presented are joint work with P.G. Dodds, T. Dodds and F.

Sukochev.

A. PIETSCH

p-smooth and q-convex operators on Banach spaces

The concepts of p-smoothness and q-convexity are well-known for Banach spaces. Passing from spaces to operators, we give a new approach which has the advantage that there is an *isometric* duality.
An operator T acting from a Banach space X into a Banach space Y is called *p-smooth* $(1 < p \leq 2)$ and *q-convex* $(2 \leq q < \infty)$ if there is a constant $c \geq 0$ such that

$$\left(\frac{||Tx + y_0||^p + ||Tx - y_0||^p}{2} - ||y_0||^p \right)^{1/p} \leq c\,||x|| \text{ for } x \in X \text{ and } y_0 \in Y$$

and

$$||Tx|| \leq c \left(\frac{||x + x_0||^q + ||x - x_0||^q}{2} - ||x_0||^q \right)^{1/q} \text{ for } x, x_0 \in X,$$

respectively.

The class of all p-smooth operators is denoted by $\mathcal{S}_p$, and $\mathcal{C}_q$ stands for the class of all q-convex operators. Taking the infimum of all constants c as a norm, the classes $\mathcal{S}_p$ and $\mathcal{C}_q$ form a right-sided and left-sided Banach operator ideal, respectively. Both concepts are dual to each other:

$$\begin{aligned} T \in \mathcal{S}_{q'} \Longleftrightarrow T' \in \mathcal{C}_q \text{ and } ||T|\mathcal{S}_{q'}|| &= ||T'|\mathcal{C}_q||, \\ T \in \mathcal{C}_{p'} \Longleftrightarrow T' \in \mathcal{S}_p \text{ and } ||T|\mathcal{C}_{p'}|| &= ||T'|\mathcal{S}_p||. \end{aligned}$$

These results belong to a theory which connects orthonormal systems (in that case the Haar system) with the geometry of Banach spaces.

S. PRÖSSDORF

Pseudodifferential operators and wavelets

The lecture starts with a short introduction to periodic pseudodifferential equations and multiscale analysis. The main topic are generalized Galerkin-Petrov schemes for elliptic pseudodifferential equations in $\mathbb{R}^n$ covering classical Galerkin methods, collocation methods, and others, using wavelet bases as trial functions and test funtionals. Necessary and sufficient stability conditions are given in terms of the ellipticity of the "numerical symbol". The key to our analysis is a local principle and a discrete commutator property of the wavelet projections.
These results together with well known estimates for the Schwarz kernels of the operators and vanishing moment conditions for the wavelets establish important prerequisities for developing and analyzing methods for the fast solution of the resulting

linear systems. These methods are based on compressing the stiffness matrices relative to wavelet bases for the given multiscale analysis. The order of the overall computational work which is needed to realize a certain accuracy is $O\ (N log^b N)$, where N is the number of unknowns and $b \geq 0$ is some real number. The theoretical results are confirmed by numerical performances concerning the exterior Dirichlet problem for the Helmholtz equation.
The talk is based on joint work with W. Dahmen and R. Schneider.

M. PUTINAR

Quadrature domains and hyponormal operators

A natural equivalence is established between bounded quadrature domains in the complex plane and a class of hyponormal operators with rank-one self-commutator. Several questions in spectral theory are translated in this way into function theoretic facts. Problems of interpolation theory, two-variable moments of bounded functions and rational approximation techniques appear also naturally in this framework.

F. RÄBIGER

Spectrum and asymptotic behaviour of dominated operators

For operators $0 \leq S \leq T$ on a Banach lattice E we investigate the following questions:
1) Which asymptotic properties of T are inherited by S?
2) If $r(T) = 1$, what is the relation between $\sigma(S) \cap \Gamma$ and $\sigma(T) \cap \Gamma$?
Recall that T is Abel bounded if $\overline{\lim}_{\lambda \downarrow 1} ||(\lambda - 1)\ (\lambda - T)^{-1}|| < \infty$. For operators $0 \leq S \leq T$ on a Banach lattice E we have the following results:
THEOREM 1: *If T is Abel bounded, then $\sigma(S) \cap \Gamma \subseteq \sigma(T) \cap \Gamma$.*
THEOREM 2: *If αT is ergodic for all $\alpha \in \Gamma$, then $P\sigma(S) \cap \Gamma \subseteq P\sigma(T) \cap \Gamma$.*
THEOREM 3: *If T is Abel bounded and E is a KB-space, then $P\sigma(S) \cap \Gamma \subseteq P\sigma(T) \cap \Gamma$.*
THEOREM 4: *If $P_T x := \lim_n T^n x$ exists for all $x \in E$, E has order continuous norm and either $\sigma(T) \cap \Gamma \neq \Gamma$ or rank $P_T < \infty$, then $\lim_n S^n x$ exists for all $x \in E$.*
The talk is based on joint work with M. Wolff.

L. SAKHNOVICH

Spectral theory of canonical differential systems

Let us consider the canonical differential system

$$\frac{dy}{dx} = iz\mathcal{J}\mathcal{H}(x)Y, \quad 0 \leq x \leq \ell \leq \infty \tag{1}$$

where

$$\mathcal{J} = \begin{bmatrix} 0 & E_m \\ E_{-\{m\}} & 0 \end{bmatrix}, \ \mathcal{H}(x) \geq 0,\ Y(x) = col\ [Y_1(x),\ Y_2(x)].$$

We add the following boundary condition

$$D_2 Y_1(0) + D_1 Y_2(0) = 0, \tag{2}$$

where D_1, D_2 are matrices of $m \times m$ order and

$$D_1 D_2^* + D_2 D_1^* = 0, \ D_1 D_1^* + D_2 D_2^* = E_m \tag{3}$$

For system (1), (2) we introduced the definition of spectral matrix-function and described the set of corresponding spectral functions. The inverse spectral problem is also solved. In this case we divided the class of canonical systems on subclasses and found the solution of inverse spectral problem in the fixed subclass.

H. H. SCHAEFER
On theorems of Carathéodory and Dixmier

Supplementing a theorem of J. Dixmier (1951), it is shown that a bounded linear functional on $C(K)$ (K compact) is sequentially order continuous iff the corresponding regular Borel measure vanishes on meagre Baire subsets of K. Next it is shown that if K is an F-space (i.e., disjoint open F_σ-sets have disjoint closures) it is quasi-Stonian (i.e., every open F_σ-set has open closure) iff for every closed Baire subset $A \subseteq K$, the interior $\mathring{A}$ is Baire. Finally, the relation between countably additive measures in the Boolean resp. set theoretical sense and the Carathéodory extension theorem is studied and classified.

F. VAN SCHAGEN
Wiener Hopf factorizations for operator polynomials

For an operator polynomial $L(\lambda)$ on the Banach space $\mathcal{Y}$ we consider Wiener-Hopf factorizations $L(\lambda) = E_-(\lambda)\,(\sum_{i=1}^r \lambda^{\nu_i} P_i)\, E_+(\lambda)$ with respect to a closed rectifiable Jordan curve Γ in the complex plane. The existence of such a Wiener-Hopf factorization is characterized in terms of a Γ-null pair (A, B) of $L(\lambda)$. The projections P_i and the numbers ν_i are identified as the characteristics under block similarity of an operator block associated with the pair (A, B).
The talk reports on joint work with I. Gohberg and M.A. Kaashoek.

E. SCHROHE
Boundary value problems on manifolds with conical singularities

(In joint work with B.-W. Schulze)
We develop a Mellin pseudodifferential calculus for boundary value problems on manifolds with finitely many conical singularities.
Outside the singular set our space is a smooth manifold, and we use Boutet de Monvel's calculus in its standard form. Near a singularity, it is diffeomorphic to a cone

whose cross-section X is a smooth compact manifold with boundary. We blow up the singularity and work on the cylinder $X \times \mathbb{R}_+$ using Mellin type operators on $\mathbb{R}_+$ with values in Boutet de Monvel's algebra on X.
As a first step, we provide a parameter-dependent version of Boutet de Monvel's calculus based on operator-valued symbols and wedge Sobolev spaces. Even in the case without parameters this yields a much faster presentation of Boutet de Monvel's algebra.
Next, we introduce the Green operators, the residual operators in the calculus. They are defined in terms of their mapping properties and form an ideal in the final algebra. A slightly larger ideal is given by the smoothing Mellin operators with asymptotics, a class of operators which are regularizing, but in general non-compact. We then construct the cone algebra without asymptotics. It provides a framework in which all the relevant operations can be performed; it is, however, too coarse a tool for a Fredholm theory. To this end we finally develop the full cone calculus for boundary value problems between Mellin Sobolev spaces with asymptotics. The operators in this calculus are sums of (i) a Mellin operator with a holomorphic (Boutet de Monvel algebra-valued) Mellin symbol supported close to the singular set, (ii) an operator in Boutet de Monvel's calculus supported away from the singularities, and (iii) a smoothing Mellin operator.
We introduce a notion of ellipticity in terms of an interior pseudodifferential and a conormal Mellin symbol that implies the Fredholm property of the operators. Moreover, we obtain results on regularity and asymptotics of solutions via a parametrix construction.

B.-W. SCHULZE

Algebras of pseudo-differential operators on singular spaces

The program of the analysis of pseudo-differential operators on spaces with singularities (in particular, conical, edge, corner ones) contains the following points. Start with the typical differential operators that allow a notion of ellipticity, perform algebras of pseudo-differential operators that allow to express the parametrices (or the inverse operators), study the adequate scales of (weighted) Sobolev spaces and subspaces with asymptotics, establish the index theory.
For a closed C^∞ manifold X the answer is the algebra of standard pseudo-differential operators $L^\mu(X)$, in the case of a manifold X with C^∞ boundary one has Boutet de Monvel's algebra $\mathcal{B}^{\mu,d}(X)$, for conical singularities the cone algebra $C^\mu(\mathbf{B}, g)$, for manifolds with edges the edge algebra $\mathcal{Y}^\mu(\mathbf{W}, g)$ and so on. Boundary value problems may be understood in the framework of edge pseudo-differential operators.
In contrast to the elliptic regularity of solutions of boundary value problems with the transmission property the solutions $u(t,x,y)$ of edge problems have (roughly speaking) asymptotics for $t \to 0$ of the form

$$u(t,x,y) \sim \sum_{j=0}^{\infty} \sum_{k=0}^{m_j} c_{jk}(x,y) t^{-p_j} log^k t$$

with coefficients c_{jk} that are C^∞ in $x \in X$, where X is the base of the model cone of the wedge, t the cone axis variable, y the edge variable, $p_j \in \mathbb{C}$, $\mathrm{Re} p_j \to -\infty$ as $j \to \infty$, $m_j \in \mathbb{N}$. In general, we have $p_j = p_j(y)$, $m_j = m_j(y)$, which causes a very complicated behaviour of the asymptotics under varying y along the edge. This phenomenon can be described in terms of the continuous asymptotics with C^∞ families in y of analytic vector-valued analytic functionals in the complex Mellin plane.

A.A. Shkalikov

Dissipative operator pencils and related operator equations.

Let $A(\lambda) = A_0 + \lambda A_1 + \ldots + \lambda^{2n} A_{2n}$ be an operator polynomial in finite dimensional space H satisfying the dissipativity condition

$$Im(A(\lambda)x, x) \geq 0 \quad \text{for all } x \in H,\ \lambda \in \mathbb{R}.$$

Then $A(\lambda)$ admits a factorization $A(\lambda) = K_2(\lambda)K_1(\lambda)$, where $K_j(\lambda)$, $j = 1,2$, are operator polynomials of degree n, and the spectrum of $K_1(\lambda)$ lies in the upper half plane. Moreover, the real spectrum of $K_1(\lambda)$ can be explicitly described. Our main result gives the generalization of this theorem for infinite dimensional space H with unbounded operator coefficients. We connect the problem on factorization with the solvability of the following problem

$$A(-i\,\frac{d}{dz})\,u(z) = 0, \qquad u^{(j)}(0) = \varphi_j,\ j = 0, 1, \ldots, n-1,\ u(\infty) = 0.$$

B. Silbermann

Asymptotic Moore-Penrose invertibility of Toeplitz operators

Let $T(a)$ be a Toeplitz operator on ℓ^2 generated by some L^∞-function a. Form the finite sections $A_n := P_n T(a) P_n$ where P_n is the projection defined by $P_n\{x_0, x_1, \ldots, x_n, x_{n+1}, \ldots\} = \{x_0, \ldots, x_n, 0, \ldots\}$ and consider the following problem: find all strongly converging sequences of $(n+1) \times (n+1)$ matrices B_n such that

$$||A_n B_n A_n - A_n|| \to 0,\ ||B_n A_n B_n - B_n|| \to 0,$$
$$||(A_n B_n)^* - (A_n B_n)|| \to 0,\ ||(B_n A_n)^* - (B_n A_n)|| \to 0.$$

It will be demonstrated that for Fredholm Toeplitz operators $T(a)$ with $a \in PC$ that problem admits solutions, and all solutions can be described.

M. Solomyak

The product and tensor product of spectral measures

(The talk is based on a joint work with M. Birman)

Let E_1 and E_2 be spectral measures, defined on measurable spaces $(Y_1, \mathcal{A}_1)$ and $(Y_1, \mathcal{A}_2)$, and acting in a Hilbert space $\mathcal{H}$. If E_1 and E_2 commute, then their product

$$E(\delta) = E_1(\delta_1)\, E_2(\delta_2), \quad \delta = \delta_1 \times \delta_2 \in \mathcal{A}_1 \times \mathcal{A}_2,$$

is an additive projection-valued function. However, E may fail to be countably additive. The corresponding example was constructed in 1979 by M. Birman, A. Vershik and the author. Such a pathology can not happen, if Y_1 and Y_2 are locally compact topological spaces and spectral measures E_1 and E_2 are compatible with the corresponding topologies.

Another way to multiply spectral measures is to take their tensor product:

$$\mathcal{E}(\delta) = E_1(\delta_1) \otimes E_2(\delta_2), \quad \delta = \delta_1 \times \delta_2 \in \mathcal{A}_1 \times \mathcal{A}_2.$$

This is a projection-valued function in $\mathcal{H} \otimes \mathcal{H}$. The commutativity of E_1 and E_2 is not needed here. What is more, $\mathcal{E}(\delta)$ is always countably additive, in contrast with the above function E; this does not depend on topological and other properties of Y_1 and Y_2.

The last result, and some of its generalizations, has useful applications in the theory of double and multiple operator integrals.

H. Upmeier

Toeplitz operators and geometric quantization

We study Hilbert spaces of holomorphic functions on a complex symmetric domain, realized as representation spaces (discrete series) of its semi-simple symmetry group G. These Hilbert state spaces have reproducing kernels which can be used to define Toeplitz operators using Berezin quantization. The main results presented concern the Berezin transform (expressed in terms of higher G-invariant Laplacians) and the structure of C^*-algebras (representations, index theory) generated by Toeplitz operators.

F.-H. Vasilescu

On the structure of commuting contractions

Let $\mathcal{H}$ be a complex Hilbert space and let $T = (T_1, T_2)$ be a pair of commuting contractions on $\mathcal{H}$. Assume also that

$$(*) \qquad 1 - T_1^* T_1 - T_2^* T_2 + T_1^* T_2^*\, T_1 T_2 \geq 0,$$

which is precisely Brehmer's condition (for $n = 2$). Then there are Hilbert spaces $\mathcal{G}_k$ and commuting pairs of contractions $R^k = (R_1^k, R_2^k)$ on $\mathcal{G}_k$ $(k = 0, 1, 2, 3)$ with the following properties:

(i) R_1^0, R_2^0 satisfy $(*)$ and are of class $C_{0\bullet}$ (i.e. their iterates tend strongly to zero);

(ii) R_1^1 is an isometry and R_2^1 if of class $C_{0\bullet}$;

(iii) R_1^2 is of class $C_{0\bullet}$ and R_2^2 is an isometry;

(iv) R_1^3, R_2^3 are isometries;

(v) T is unitarily equivalent to pair $R^0 \oplus R^1 \oplus R^2 \oplus R^3$ | Invariant subspace.

This result, which is a structure theorem for pairs of commuting contractions, can be extended to commuting multioperators that satisfy some positivity conditions.

S. M. VERDUYN-LUNEL

New results in completeness of eigenvectors and generalized eigenvectors for unbounded operators

We consider the question of completeness of the system of eigenvectors and generalized eigenvectors for unbounded operators. There is a rich and interesting literature about the completeness question. However, the operators that we consider are very nonselfadjoint and do not fit into the classes of operators that have intensively studied.

The operators we study arise either as generators of semigroups or as period maps for periodic evolutionary systems and have compact resolvent or are compact. The question of completeness is closely connected with the interesting problem whether the evolutionary system has small solutions, i.e. solutions that decay faster than any exponential. In fact, for the classes of operators we consider noncompleteness of the generator or the period map is equivalent to the existence of nontrivial small solutions.

As an example consider the equation $\dot{x}(t) = b(t)\, x(t-1)$, $b(t+1) = b(t)$, the period map $U : C[-1,0] \to C[-1,0]$ is given by

$$(U\varphi)(\theta) = \varphi(0) + \int_{-1}^{\theta} b(s)\, \varphi(s)\, ds.$$

We have the following result.

THEOREM: *If b is continuous and has isolated zeros, then U has a complete system of eigenvectors and generalized eigenvectors if and only if b has no sign change if and only if $\dot{x}(t) = b(t)\, x(t-1)$ has no nontrivial small solutions.*

M. WOLFF

Asymptotic dominance of operators and its spectral relevance

Let E be a complex Banach lattice. The positive operator T dominates $S \in \mathcal{L}(E)$ if $|Sx| \leq T|x|$ holds for all $x \in E$.

THEOREM 1: *Let T dominate S, and assume that the spectral radius $r(T)$ is a Riesz point of $\sigma(T)$. Then the essential spectral radius $r_{ess}(S)$ of $\sigma_{ess}(S)$ is strictly less then $r(T)$.*

THEOREM 2: *Let $(S_n) \subset \mathcal{L}(E)$ be a sequence converging strongly to the positive operator T. Asume in addition that T dominates (S_n) asymptotically, i.e. $\lim_{n\to\infty}(sup\ \{\|(T|x| - |S_n x|)^-\| : \|x\| = 1\}) = 0$. If $r(T)$ is a Riesz point of $\sigma(T)$ then the following holds:*

(1) *There exists a sequence (λ_n) with $\lambda_n \in \sigma(S_n)$ and $\lim_n \lambda_n = r(T)$.*

(2) $\exists \delta > 0\ \exists n_0\ \forall n \geq n_0\ :\ [r_{ess}(S_n) < r(T) - \delta]$.

A similar result holds in the case of discrete convergence. The talk is based on joint work with F. Räbiger.

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