Walkshop on Mathematical Physics

organised by

Paul Beckermann, Erik Heidrich, Amru Hussein, Dominik Spyrka

Kassel, June 25–26, 2026

Venue: The lectures will be held in the seminar room **0173** , located at the Institute of Mathematics of the University of Kassel, Heinrich-Plett-Straße 40. Coffee breaks will take place in a room next door.

Programme

Thursday, June 25, 2026		
10:00 – 11:00	*Coffee available on arrival*	
11:00 – 11:10	*Opening*	
11:10 – 11:40	Guendalina Palmirotta	Wigner meets Ruelle: a walk through resonances
11:50 – 12:20	Albert Werner	Exponential suppression of transport in electric quantum walks
12:30 – 13:10	*lunch break*	
13:10 – 13:40	Werner Varnhorn	Local in time regularity region for general weak solutions of the Navier-Stokes equations
13:50 – 14:20	Tobias Werner	(S)PDEs on domains with corners and edges: an operator theoretic perspective
14:30 – 15:00	*Coffee break*	
15:00 – 19:00	*Walk to the Bergpark Kassel*	
19:00	*Dinner*	
	More on the walk and the dinner at the end of this file	

Friday, June 26, 2026		
9:30 – 10:00	Konstatin Pankrashkin	Essential spectrum in finite boxes: An example with Dirac operators
10:10 – 10:40	Noah Körner	Eigenvalue Asymptotics of the Schrödinger Operator with a strong delta-interaction on curves with corners
10:50 – 11:20	*Coffee break*	
11:20 – 11:50	Kiyan Naderi	Conformal eigenvalues on metric graphs
12:00 – 12:30	Gilles Jordan Pedieu Tcheuha	Non-Existence of stationary equilibrium configurations of three aligned rotating black-holes
12:40 – 13:20	*Lunch break*	
13:20 – 13:50	Vladislav Rykhlov	Semiclassical Spectral Series for the Dirac Operator for Graphene in Magnetic Field
14:00 – 14:30	Denis Périce	Ground state of the Bose-Hubbard model with large coordination number
14:40–15:10	*Closing, and then Coffee for free discussion and take away*	

Abstracts

Guendalina Palmirotta (University of Paderborn, Germany)

Thursday, 11:10–11:40

Title: **Wigner meets Ruelle: a walk through resonances**

Abstract: We present a guided tour through the relationship between quantum phase-space distributions and resonances on Schottky surfaces. In particular, we discuss how Wigner distributions associated with Laplace eigenfunctions relate to Patterson–Sullivan distributions arising from hyperbolic dynamics, providing a bridge between quantum and classical chaos in the semiclassical regime. We further explain how this correspondence is linked to Ruelle resonances via dynamical zeta function and enables their numerical computation on Schottky surfaces.

Albert Werner (University of Copenhagen, Denmark)

Thursday, 11:50–12:20

Title: **Exponential suppression of transport in electric quantum walks**

Abstract: Quantum walks subject to homogeneous electric fields provide a natural setting in which spectral theory, arithmetic effects, and long-time dynamics interact. In this talk I will discuss one-dimensional translation-invariant quantum walks driven by periodic electric fields. The main result gives sharp asymptotics for the maximal group velocity and shows that transport is exponentially suppressed as the field period grows, throughout the full parameter regime. The analysis also yields explicit revival relations and a characterization of the absolutely continuous spectrum, with consequences for the spectral theory of generalized CMV matrices. I will discuss the mechanism behind this suppression phenomenon and its relation to the broader picture of ballistic motion, revivals, and localization in electric quantum walks.

Werner Varnhorn (University of Kassel, Germany)

Thursday, 13:10–13:40

Title: **Local in time regularity region for general weak solutions of the Navier-Stokes equations**

Abstract: In this joint work with Reinhard Farwig let $\Omega \subseteq \mathbb{R}^3$ be a bounded domain with $\partial\Omega \in C^\infty$, and let $0 < T \leq \infty$. In $[0,T) \times \Omega$ we consider a general weak solution of the Navier-Stokes equations

$$u_t - \Delta u + u \cdot \nabla u + \nabla p = f, \qquad u = 0, \qquad u|_{\partial\Omega} = 0, \qquad u|_{t=0} = u_0,$$

where $u_0 \in W^{1,2}_{0,\sigma}(\Omega)$ and $f = \operatorname{div} F$, $F \in C^\infty_0([0,T); C^\infty(\overline{\Omega}))$, are given data. Our main result concerns Leray's structure theorem, see [2, p.244]. In particular, for the special case $F = 0$, $T = \infty$, and u satisfying the strong energy inequality

$$\frac{1}{2}\|u(t)\|_2^2 + \int_{t_0}^t \|\nabla u\|_2^2 \tau \leq \frac{1}{2}\|u(t_0)\|_2^2$$

for almost all $t_0 \in [0,T)$ and all $t \in [t_0,T)$, Galdi [1, Theorem 6.3, pp. 57] has proved the existence of an open local in time regularity region $R \subseteq (0,T)$ such that $u \in C^\infty(R; C^\infty(\overline{\Omega}))$. Our main theorem in extends Galdi's result to several directions: Instead of $F = 0$, $T = \infty$ we allow $F \neq 0$, $0 < T \leq \infty$ as above, and we admit a general weak solution u in $[0,T) \times \Omega$ in the usual sense, without assuming the strong energy inequality. Our local in time regularity region $R \subseteq (0,T)$ for u is given by $R := \{t_0 \in (0,T); u(t_0) \in W^{1,2}_{0,\sigma}(\Omega), \exists\, 0 < T_0 = T_0(t_0) < T$ with $u \in L^s(t_0, t_0 + T_0; L^q(\Omega))\}$, where $2 < s < \infty$, $3 < q \leq 6$ with $\frac{2}{s} + \frac{3}{q} = 1$ are Serrin exponents. The region R satisfies the regularity condition $u \in C^\infty(R; C^\infty(\overline{\Omega}))$ and can be characterized by the following local in time (s,q)-Serrin condition: $t \in R \Longleftrightarrow \exists\, \varepsilon > 0$ with $u \in L^s(t-\varepsilon, t+\varepsilon; L^q(\Omega))$. Correspondingly, we obtain the singularity region $\Sigma := (0,T) - R$ of u characterized by $t \in \Sigma \Longleftrightarrow \nexists\, \varepsilon > 0$ with $u \in L^s(t-\varepsilon, t+\varepsilon; L^q(\Omega))$. So the complete local in time regularity region $R \subset (0,T)$ for u is obtained without assuming the strong energy inequality as above.

References

[1] G. P. Galdi, An Introduction to the Navier-Stokes Initial-Boundary Value Problem, Birkhäuser Verlag 2000.

[2] J. Leray, Sur le Mouvement d'un Liquide Visqueux Emplissant l'Espace, Acta Math. 63 (1934), 103.

Tobias Werner (University of Kassel, Germany)

Thursday, 13:50–14:20

Title: **(S)PDEs on domains with corners and edges: an operator theoretic perspective**

Abstract: It is well known that (stochastic) maximal L^p-regularity follows from a sufficiently strong bounded H^∞-calculus of the leading operator. While this property has been established for a broad class of differential operators on sufficiently smooth domains, much less is known in the case of non-smooth domains. In this talk, I will present recent results showing that the Dirichlet and Neumann Laplacian on cones, wedges, polygons, polyhedra and related geometries admits a bounded H^∞-calculus of angle zero in suitably weighted L^q-spaces. These spaces are designed to capture singular behavior arising from geometric irregularities, the incompatibility of noise with Dirichlet boundary conditions, and their interplay. This entails new regularity results for the stochastic heat equation on the above mentioned domains. If time permits, I will give some insights on how to deal with nonlinear equations in these settings. The talk is based on joint work with Petru A. Cioica-Licht and Emiel Lorist in [1].

References

[1] Petru A. Cioica-Licht and Emiel Lorist and P. Tobias Werner, *H^∞-calculus for the Dirichlet Laplacian on conical domains*. arXiv: 2509.09519.

Konstantin Pankrashkin (University of Oldenburg, Germany)

Friday, 9:30–10:00

Title: **Essential spectrum in finite boxes: An example with Dirac operators**

Abstract: We discuss the appearance of geometry-induced intervals of essential spectrum for differential operators in bounded domains using a special construction of Dirac operators with suitable chosen transmission conditions. Based on joint work with Jussi Behrndt, Badreddine Benhellal and Markus Holzmann..

Noah Körner (University of Oldenburg, Germany)

Friday, 10:10–10:40

Title: **Eigenvalue Asymptotics of the Schrödinger Operator with a strong delta-interaction on curves with corners**

Abstract: Let $\Gamma \subset \mathbb{R}^2$ be a piecewise smooth closed curve with corners. We discuss the asymptotic behavior of the individual eigenvalues of the two-dimensional Schrödinger operator $-\Delta - \alpha\delta_\Gamma$ for $\alpha \to \infty$, where δ_Γ is the Dirac δ-distribution supported by Γ. It is shown that the asymptotics of several first eigenvalues is determined by the corner openings only, while the main term in the asymptotic expansion for the other eigenvalues is the same as for smooth curves. Under an additional assumption on the corners of Γ (which is satisfied, in particular, if Γ has no acute corners), a more detailed eigenvalue asymptotics is established in terms of a one-dimensional effective operator on the boundary.

Kiyan Naderi (University of Innsbruck, Austria)

Friday, 11:20–11:50

Title: **Conformal eigenvalues on metric graphs**

Abstract: A metric graph G is a metric space consisting of vertices and intervals connecting the vertices. If we now consider a measure on this space, we obtain a corresponding first-order Sobolev space, with the energy form as its inner product. For every measure we obtain a self-adjoint Laplace operator generated by the energy. We investigate lower bounds for the k-th eigenvalue of all these Laplacians. More precisely, we define the so-called k-th optimal eigenvalue as the infimum of all k-th eigenvalues of Laplace operators generated by Borel measures. First properties of these new graph invariants are investigated: On the one hand, the first optimal eigenvalue is closely related to the resistance metric for graphs, random walks, and spectral graph partitioning. On the other hand, we have studied the asymptotic behavior of the higher optimal eigenvalues and proved a Weyl law.

Gilles Jordan Pedieu Tcheuha (University of Münster, Germany)

Friday, 12:00–12:30

Title: **Non-Existence of stationary equilibrium configurations of three aligned rotating black-holes**

Abstract: Following the foundational studies of Hennig and Neugebauer on the balance of binary black holes, this work addresses the long-standing question of whether a third body can stabilize a stationary configuration. By constructing the explicit Triple-Kerr-NUT solution and employing a generalized regularity criterion based on sub-extremality inequalities, we provide a rigorous proof for the non-existence of equilibrium. Our results confirm that spin-spin repulsion remains insufficient to counter non-linear gravitational attraction in the three-body case, suggesting a universal constraint within the theory.

Vladislav Rykhlov (Lomonosov Moscow State University, Russia)

Friday, 13:20–13:50

Title: **Semiclassical Spectral Series for the Dirac Operator for Graphene in Magnetic Field**

Abstract: We consider the spectral problem for the operator $\widehat{\mathcal{L}}_{\mathrm{TW}} = \mathcal{L}_{\mathrm{TW}}(\widehat{p}, x)$:

$$\widehat{\mathcal{L}}_{\mathrm{TW}}\Psi = \mathcal{E}\Psi,$$

where the symbol has the form

$$\mathcal{L}_{\mathrm{TW}}(p,x) = \begin{pmatrix} U(x,h)+M(x,h) & \mathbf{p}_1 - i\mathbf{p}_2 \\ \mathbf{p}_1 + i\mathbf{p}_2 & U(x,h)-M(x,h) \end{pmatrix} + \mu \begin{pmatrix} 0 & (\mathbf{p}_1+i\mathbf{p}_2)^2 \\ (\mathbf{p}_1-i\mathbf{p}_2)^2 & 0 \end{pmatrix}.$$

This equation describes charge carriers in graphene with impurity mass M, placed in an electric potential U and a constant magnetic field. Here, $\mathbf{p}_j = p_j + A_j(x)$, $\widehat{\mathbf{p}}_j = \widehat{p}_j + A_j(x)$, where $A_1 = Bx_2/2$, $A_2 = -Bx_1/2$, $\widehat{p}_j = -ih\partial/\partial x_j$, $\mu = O(h)$, and $h \to 0$.

By scalarizing the problem, we construct spectral series $(\mathcal{E}, \Psi)$, with Ψ expressed in terms of Airy functions, assuming that U and M are such that the principal symbols of the scalar Hamiltonians are integrable.

Denis Périce (Constructor University Bremen, Germany)

Friday, 14:00–14:30

Title: **Ground state of the Bose-Hubbard model with large coordination number**

Abstract: We consider the ground state energy of the Bose-Hubbard model on a graph with large and homogeneous coordination number. In the limit of infinite coordination number, we prove convergence of the ground state energy to the minimizer of a mean-field energy functional. This functional is obtained by averaging the hopping term over the large number of connected sites, while the interaction energy is not averaged. Hence, the resulting mean-field description is in the strong coupling regime, and is expected to provide a qualitatively correct picture of the phase diagram of the Bose-Hubbard model for large enough coordination number. For our proof, we develop a new version of a de Finetti type theorem, which we call a polaron-type quantum de Finetti theorem, and which we expect to be a more broadly useful extension of existing quantum de Finetti results. Our theorem covers the case where the Hilbert space is a tensor product of some Hilbert space with a Bosonic Fock space. This theorem is applied to the convergence of the ground state energy of the Bose-Hubbard model after reducing it to a polaron-type model.