# Titles and abstracts of invited talks

Thomas Bäckdahl:

*Linear perturbations of special spacetimes*

In this talk I will review recent results on the structure of the linearized gravity equations, in particular on the Kerr spacetime. Gauge issues, hyperbolicity, symmetries and conservation laws will be discussed. The key ingredient used in all constructions will be a valence (2,0) Killing spinor. Such Killings spinors are present in all vacuum spacetimes of Petrov type D, including the Kerr spacetime

Lydia Bieri:

*Gravitational radiation in asymptotically flat and cosmological spacetimes*

The most interesting spacetimes emerging from the Einstein equations exhibit gravitational radiation. In 2015 LIGO produced a major breakthrough of General Relativity (GR) with its first detection of gravitational waves. The mathematical structures to describe the latter are connected with the very basic concepts of energy, mass and momenta in GR. Whereas there has been a good understanding of many aspects in the asymptotically-at set- ting, the cosmological case bears further challenges. Yet, some of the most powerful sources of gravitational waves are at cosmological distances. In this talk, we investigate the geometric-analytic properties of various spacetimes with gravitational radiation, in particular of cosmological spacetimes. We will present our results on how gravitational radiation and its memory effect in cosmological spacetimes get inuenced by a factor containing redshift and gravitational lensing. The latest part is joint work with D. Garnkle and N. Yunes.

Carla Cederbaum:

*On geometric foliations related to the center of mass in general relativity*

We will discuss new developments in the analysis of asymptotic foliations by prescribed curvature in relativistic initial data sets with prescribed asymptotic decay, generalizing results by Huisken and Yau. We will relate these foliations to the definition of the center of mass of the initial data sets under consideration. The results presented are joint work with Cortier–Sakovich and with Nerz.

David Fajman:

*Nonvacuum stability of the Milne universe*

The Milne model is the only cosmological vacuum solution to Einstein's equations (with vanishing cosmological constant) that is known to be nonlinearly (future-) stable due to the work of Andersson-Moncrief. We present a first generalisation of this result to the nonvacuum case, namely to the Einstein-Vlasov system. In particular, we introduce a new idea to combine earlier approaches to control massive collisionless matter in cosmological spacetimes with a physically motivated estimate that is necessary to establish sufficient decay properties of the matter field. This is joint work with Lars Andersson (Golm).

José Figuera O'Farrill:

*Killing superalgebras for Lorentzian manifolds*

Killing superalgebras are Lie superalgebras generated by distinguished spinor fields on lorentzian spin manifolds. By "distinguished" one typically means spinor fields satisfying some geometric PDEs. One natural question is then which PDEs can one impose so that the corresponding spinor fields generate a Lie superalgebra. One answer to this question is provided by supergravity theories, but this is not the general answer. After reviewing the necessary concepts, I will report on joint work with Andrea Santi and Paul de Medeiros which given general answers (under some hypothesis) to this question in dimensions 4 and 6. (No previous knowledge of supergravity is required.)

Mihalis Dafermos:

TBA

Anne Franzen:

*Strong cosmic censorship analysed on the level of scalar waves in Kerr interiors*

We consider solutions of the massless scalar wave equation $\Box_g \psi = 0$, without symmetry, on fixed subextremal Kerr backgrounds $(\mathcal{M}, g)$. It follows from previous analyses in the Kerr exterior that for solutions $\psi$ arising from sufficiently regular data on a two ended Cauchy hypersurface, the solution and its derivatives decay suitably fast along the event horizon $\mathcal{H}^+$. Using the derived decay rate, we show here, that $\psi$ is in fact uniformly bounded, $|\psi| \leq C$, in the black hole interior up to and including the bifurcate Cauchy horizon $\mathcal{CH}^+$, to which $\psi$ in fact extends continuously. In analogy to our previous paper on boundedness of solutions to the massless scalar wave equation on fixed subextremal Reissner-Nordström backgrounds, the analysis depends on weighted energy estimates, commutation of angular momentum operators and application of Sobolev embedding. In contrast to the Reissner-Nordström case the commutation leads to additional error terms that have to be controlled.

Dietrich Häfner:

*Scattering for Dirac and Klein-Gordon fields on the (De Sitter) Kerr metric and the Hawking effect*

We consider Dirac and Klein-Gordon fields on the (De Sitter) Kerr metric which describes rotating black holes. Whereas there exists a conserved $L^2$ norm for the Dirac field, no positive conserved quantity exists for the Klein-Gordon field, which makes the analysis more difficult for the latter. We obtain asymptotic completeness results for the Dirac field on the Kerr and for the Klein-Gordon field on the De Sitter Kerr metric. We then present a rigorous result about the Hawking effect for fermions in the setting of a collapse of a rotating charged star. This effect predicts the creation of particles by black holes.

Gustav Holzegel:

*The black hole stability problem*

I will discuss recent work with Dafermos and Rodnianski proving the linear stability of the Schwarzschild spacetime under gravitational perturbations. Two key elements of the proof are 1) a complete understanding of so-called "pure gauge solutions" and 2) decay estimates for solutions to the Teukolsky equation on Schwarzschild. The latter are obtained through a physical space transformation theory going back to Chandrasekhar and generalise to slowly rotating Kerr spacetimes. Time permitting I will also discuss recent progress on the non-linear problem.

Jérémie Joudioux:

*The stability of Minkowski space as a solution to the Einstein-Vlasov system*

Joint work with David Fajman (Vienna) and Jacques Smulevici (Orsay)
(arXiv:1707.06141). We discuss in this talk the proof of the stability of Minkowski space as a solution to the Einstein-Vlasov system. This proof is based on the construction of appropriate commutators with the transport operator. This method is known as the modified vector-field method, and was developed in earlier works by the same authors for the massive Vlasov-Nordström system. It is based on the approach by Klainerman for the wave equation. We work in the wave gauge and a hyperboloidal foliation similar to the work of LeFloch-Ma on the stability of Minkowski spacetime as a solution to the Einstein-Klein-Gordon system. In this talk, we focus on the commutation properties of the transport equation, and discuss in detail the structure of the commutation formula leading to the necessary decay estimates for the Vlasov field and their consequences for the analysis of the Einstein-Vlasov system.

Philippe G. LeFloch:

*Nonlinear stability of self-gravitating massive fields*

I will discuss the global evolution problem for self-gravitating massive matter in the context of Einstein's theory and, more generally, for the f(R)-modified theory of gravity. In collaboration with Yue Ma (Xi'an Jiaotong), by analyzing the Einstein equations in wave gauge coupled to Klein-Gordon equations, I have established that Minkowski spacetime is globally nonlinearly stable in presence of massive fields. This extends a fundamental work by Christodoulou and Klainerman in 1993, later revised by Lindblad and Rodnianski, who were concerned with the stability of vacuum spacetimes and massless fields.

Thomas Mohaupt:

*Solutions to $N = 2$ supergravity with vector multiplets: From Nernst branes to S-branes*

We review the structure of the field equations of theories of $N = 2$ vector multiplets coupled to supergravity. The bosonic sectors of these theories, which appear as compactifications of string theory, generalize Einstein-Maxwell-Dilaton-Axion theories, and contain several Abelian vector fields and scalar fields, with field dependend couplings encoded by special Kaehler geometry, and possibly a scalar potential. Assuming the existence of a time-like or space-like Killing vector, they can be reduced to three-dimensional sigma models coupled to gravity, with a target space that is quaterionic Kaehler or para-quaternionic Kähler. Using a suitable parametrization of the scalar manifold, several classes of non-supersymmetric, non-extremal solutions can be found by elementary integration. We illustrate this using a class of solutions with planar horizons, which contains Nernst branes (solutions that have zero entropy density in the extremal limit) and S-branes (cosmological solutions).

Tomás Ortín:

*Non-Abelian gauge fields in superstring theory and gauged supergravity*

I will review recent work on supersymmetric solutions of gauged supergravity theories containing non-trivial non-Abelian gauge fields and their embedding in superstring theory. I will focus in tow particular cases:

1. 5-dimensional supersymmetric non-Abelian black holes, their embedding in Heterotic Superstring Theory and the computation of their alpha prime corrections. I will present a class of 10-dimensional solutions of the Heterotic Superstring Theory of which the 5-dimensional black holes are particular example, for which the alpha prime corrections can be computed explicitly due to a series of fortunate "coincidences" that relate the corrections associated to selfdual Yang-Mills fields, 5-branes and selfdual gravitational instantons.

2. The attempt to construct asymptotically-AdS5 supersymmetric solutions with non-trivial Yang-Mills fields in 5-dimensional gauged supergravity. We face the problem of constructing self-dual Yang-Mills instantons in Kaehler spaces with one holomorphic isometry and we find a generic way to do it generalizing Kronheimer's results. Using this result, we construct solutions whose metric is a 1-parameter deformation of AdS5.

George Papadopoulos:

*Geometry and classification of string AdS backgrounds*

I shall review on the progress that has been made so far to understand the global and local aspects of the geometry of the internal spaces of warped AdS backgrounds in 10- and 11- dimensional supergravity theories. I shall also report on the classification of these backgrounds that preserve more that half of supersymmetry.

Miguel Sánchez:

*Ehlers-Kundt conjecture and the initial value problem for gravitational waves*

Ehlers-Kundt conjecture asserts that all geodesically complete gravitational pp-waves must be plane waves. Physically, the conjecture is related to the lack of global hyperbolicity of plane waves as well as its idealized role as a relativistic model. Mathematically, it becomes equivalent to a problem in Classical Mechanics with a surprisingly simple formulation: given a (non-necessarily autonomous) potential $V(z, u)$ harmonic in $z = (x, y)$ on all the Euclidean plane $R^2$, the trajectories of the associated dynamical system are complete if and only if $V(z, u)$ is a polynomial in $z$ of degree at most 2 for each $u$. Along the talk, the conjecture will be discussed and solved in the significative case that $V(z, u)$ is bounded polynomially in the variable $z$. Based in joint work with J.L. Flores (U. Malaga), arxiv: 1706.03855.

Stefan Suhr:

*Temporal functions for Lorentzian metrics of low regularity*

Time - or temporal functions are basic to the characterization of causality conditions in Lorentzian geometry such as stable causality and global hyperbolicity, the later being important to the evolutionary aspect of Einstein equations. I will introduce an approach to the existence of temporal functions originating in the theory of dynamical systems which allows to treat the problem for a class of Lorentzian metrics which includes certain noncontinuous ones.

Shadi Tahvildar-Zadeh:

*On the quantum mechanics of a single photon*

I will present my recent work with Michael Kiessling, where we show that a Dirac-type equation for a rank-two bi-spinor field on Minkowski configuration spacetime furnishes a Lorentz-covariant quantum-mechanical wave equation in position-space representation for a single free photon. Our formulation yields conserved non-negative Born-rule-type quantum probabilities for the photon, with a probability current density vector that transforms properly under Lorentz transformations. As an application of this new apporach, I will also report on our work-in-progress with Matthias Lienert on interacting photon-electron systems.

## Titles and abstracts of contributed talks

Florian Hanisch:

*Nonlinear systems with anticommuting fields*

Nonlinear classical supersymmetric sigma models, defined on curved spacetimes, give rise to nonlinear systems of PDEs for bosonic and fermionic fields. In physics literature, the fermionic fields are often considered to be "anticommuting", reflecting the fact that in quantum theory, fermionic quantities satisfy anticommutation relations. It then seems reasonable to study nonlinear systems of pde, taking into account the additional feature. It turns out that this does not only change the geometric description of PDEs and their solutions but also their analytical behaviour as certain nonlinearities appear to be better behaved than in the original situation. We will present a geometric framework (derived from supergeometry) that takes into account the aforementioned features and illustrate the new features of the equations by means of an example obtained from the Dirac-wave-map system.

Oliver Lindblad Petersen:

*Wave equations with initial data on compact Cauchy horizons*

We will present new energy estimates for wave equations close to compact non-degenerate Cauchy horizons. The estimates allow us to conclude several existence and uniqueness results for wave equations with initial data on the horizon. We do neither assume symmetry of the spacetime nor closeness of the generators.

Maximilian Thaller:

*On static solutions of the Einstein-Vlasov system with charged particles*

The Einstein-Vlasov system describes the motion of an ensemble of collisionless particles in the framework of General Relativity. First the Vlasov matter model and the geometric set-up for describing self-gravitating collisionless matter in General Relativity is introduced. Second the static Einstein-Vlasov system is discussed in spherical symmetry: the system of equations is presented and an overview over known results and properties of static solutions is given. Finally a perturbation technique is explained which can be used to prove the existence of static solutions with charged particles in spherical symmetry. Some of the mentioned results are a collaboration with H. Andréasson (Chalmers Univ. of Technology) and D. Fajman (Univ. of Vienna).