ESI **The Erwin Schrödinger International Institute for Mathematical Physics**

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Preliminary schedule for the

Seminar on Mathematical Relativity

organized by: Robert Beig, Piotr Bizon, Piotr Chrusciel, Helmut Friedrich
January 27 - 29, 2011

Thursday, January 27

15:30 - 16:00 Joanna Jalmuzna (Krakow)
Focusing semilinear wave equations on the Schwarzschild spacetime
Abstract: We consider semilinear wave equations with a focusing power nonlinearity on the Schwarzschild background. We show that a static solution with one unstable mode acts as an intermediate attractor in the evolution of initial data lying at the threshold of blowup. We describe in detail the saddle-point dynamics near this attractor using linear perturbation analysis and numerical simulations.

16:10 - 16:40 Andrzej Rostworowski (Krakow)
Numerical investigation of a perturbed AdS spacetime
Abstract: We investigate numerically small perturbations of the AdS spacetime, hoping to get insight into the problem of nonlinear stability/instability of the AdS spacetime. This is work in progress so the purpose of the talk is mainly to present the project rather than give any firm results.

Friday, January 28

Chair: Helmut Friedrich
09:00 - 09:30: Marcus Ansorg (Jena)
The interior of axisymmetric and stationary black holes: Numerical and analytical studies
Abstract: We investigate the interior hyperbolic region of axisymmetric and stationary black holes surrounded by a matter distribution. In the first part of the talk we treat the corresponding initial value problem of the hyperbolic Einstein equations numerically in terms of a single-domain pseudo-spectral scheme. A rigorous mathematical approach is given in the second part, in which soliton methods are utilized to derive an explicit relation between the event horizon and an inner Cauchy horizon that arises as the boundary of the future domain of dependence of the event horizon. Both numerical and analytical studies prove the universal relation $A_{\mathrm{EH}}A_{\mathrm{CH}} = (8\pi J)2$ where A_{EH} and A_{CH} are the areas of event and inner Cauchy horizon respectively, and J denotes the black hole's angular momentum.

09:35 - 09:55: Norman Gurlebeck (Prag)
A Generalization to Chandrasekhar's & Elbert's 1-PN Dedekind ellipsoids
Abstract: A changing quadrupole moment leads to gravitational radiation in General Relativity. Does this imply that stationary but non-axisymmetric, isolated systems cannot exist? To learn something about the answer to this question, a PN approximation of the Newtonian triaxial and homogeneous Dedekind ellipsoids is investigated. We shall discuss a generalization of the ansatz used by Chandrasekhar and Elbert (1978), in particular its axisymmetric limit. Contrary to

Chandrasekhar & Elbert's ansatz this generalization permits an axially symmetric and rigidly rotating limit (PN Maclaurin spheroids). The additional freedom in the generalized solution can also be used to remove a singularity which occurs in their work. A limit where the Dedekind ellipsoids degenerate to a line mass distribution is also discussed.

09:55 - 10:30: Coffee Break

10:30 - 11:00: Walter Simon (Krakow)
Criteria for finite extent of stationary perfect fluids in Newtonian theory
Abstract: We consider stationary solutions of the Newton-Euler system for a gravitating perfect fluid with a barotropic equation of state, which may represent a star, a disk around a star, or a galaxy. From the virial theorem we derive simple conditions on the equation of state and on the velocity of the rotation (or on the centrifugal force) which guarantee that the fluid is confined to a compact region. Time permitting, we discuss the prospects of obtaining analogous results in relativity.

11:05 - 11:35: Gaston Avila (Golm)
Tensor decompositions with fast decay conditions at space-like infinity
Abstract: We present a quasilinear elliptic system of equations of which we expect that can be used to construct vacuum initial data which are asymptotically flat and time-reflection symmetric and asymptotic to static data up to a prescribed order at space-like infinity. We present an existence result which is valid when the order at which the solutions approach staticity is restricted to a given range.

11:50 - 12:20: Martin Scholtz (Praga)
On asymptotically flat solutions of Einstein's equations periodic in time
Abstract: By an argument similar to that of Gibbons and Stewart, but in a different coordinate system and less restrictive gauge, we show that any weakly-asymptotically-simple, analytic vacuum, or electrovacuum, or scalar field solutions of the Einstein equations which are periodic in time are necessarily stationary.

12:20 - 14:00: Lunch

Chair: Piotr Bizon
14:00 - 14:30: Reinhard Meinel (Jena)
On the black hole limit of rotating discs and rings
Abstract: Solutions to Einstein's field equations describing rotating fluid bodies in equilibrium permit parametric (i.e. quasi-stationary) transitions to the extreme Kerr solution (outside the horizon). This has been shown analytically for discs of dust and numerically for ring solutions with various equations of state. From the exterior point of view, this transition can be interpreted as a black hole limit. All gravitational multipole moments assume precisely the values of an extremal Kerr black hole in the limit. Moreover, it turns out that the exterior solution near the black hole limit is approximated very well by the (hyperextreme) Kerr solution with the same mass and angular momentum as the fluid body.

14:35 - 14:55: David Kofron (Prag)
The Newtonian limit of spacetimes for accelerated particles and black holes
Abstract: Solutions of vacuum Einstein's field equations describing uniformly accelerated particles or black holes belong to the class of boost-rotation symmetric spacetimes. They are the only

explicit solutions known which represent moving finite objects. Their Newtonian limit is analyzed using the Ehlers frame theory. Generic spacetimes with axial and boost symmetries are first studied from the Newtonian perspective. The results are then illustrated by specific examples such as C-metric, Bonnor-Swaminarayan solutions, self-accelerating "dipole particles", and generalized boost-rotation symmetric solutions describing freely falling particles in an external field. In contrast to some previous discussions, our results are physically plausible in the sense that the Newtonian limit corresponds to the fields of classical point masses accelerated uniformly in classical mechanics. This corroborates the physical significance of the boost-rotation symmetric spacetimes.

14:55 - 15:15: Coffee Break

15:15 - 15:35: Michal Eckstein (Krakow)
The Black Saturn solution
Abstract: The Black Saturn is a 5-dimensional vacuum solution of Einstein equations, whose event horizon consists of two disjoint regions with topology R x S3 and R x S1 x S2. The seminar will include the presentation of the solution found by Elvang and Figueras as well as some of its properties revealed by P.T. Chrusciel, S. Szybka and myself.

15:40 - 16:00: Sebastian Szybka (Krakow)
Stable causality of the Pomeransky-Senkov black holes
Abstract: We show stable causality of the Pomeransky-Senkov black holes.

Saturday, January 29

Chair: Robert Beig
09:00 - 09:30: Laszlo B. Szabados (Budapest)
On quasi-local charges and Newman-Penrose type quantities in Yang-Mills theories
Abstract: We generalize the notion of quasi-local charges (introduced by Paul Tod for Yang-Mills fields with unitary groups) to non-Abelian gauge theories with arbitrary gauge groups, and calculate its small sphere and large sphere limits both at spatial and null infinities. We show that for semisimple gauge groups *no* reasonable definition yield conserved total charges at null infinity in generic, radiative configurations. We also investigated the Newman-Penrose type quantities and proved similar results. The conditions of their conservation, both in terms of the field configurations and the structure of the gauge group, are clarified.

09:35 - 10:00: Jerzy Kijowski (Warszawa)
Quasi-local character of gravitational energy
Abstract: It is shown that the very nature of Einstein equations implies the quasi-local character of gravitational energy. A simple framework which covers different definitions of the energy (e.g. Hawking, Brown-York, Liu-Yau, etc.) is proposed. The framework is universal and does not depend upon particular variational formulation of the theory.

10:00 - 10:30: Coffee Break

10:30 - 10:50: Nadbor Drozd (Warszawa)
Evolution of gravitational field as an infinite dimensional Hamiltonian system
Abstract: Evolution of gravitational field can be viewed as an infinite dimensional Hamiltonian system. Main features of this system are: 1) gauge invariance with respect to spacetime diffeo-

morphisms and 2) the quasi-local nature of energy and momentum. I will present an idea how to discretize (spatially) Einstein equations (i.e. to replace it by a finite-dimensional Hamiltonian system) in such a way that the above properties remain valid.

10:55 - 11:15: Steffen Aksteiner (Hannover)
Linearized gravity on type D backgrounds
Abstract: In this talk I present joint work with Lars Andersson about the field equations of linearized gravity on a Petrov type D background, which includes Kerr spacetime. The Geroch Held Penrose (GHP) formalism is used to derive decoupled equations for all linearized Weyl scalars. The identification of gauge source functions leads to a generalized Regge-Wheeler equation. On Schwarzschild, a derivation of the gauge invariant Regge-Wheeler and Zerilli equation directly from the equation for the spin 0 scalar will be presented.

11:20 - 11:40: Adam Szereszewski (Warszawa)
D-dimensional metrics with D-3 symmetries
Abstract: Hidden symmetry transformations of D-dimensional vacuum metrics with D-3 commuting Killing vectors are studied. We solve directly the Einstein equations in the Maison formulation under additional assumptions. We relate the 4-dimensional Reissner-Nordstrom solution to a particular case of the 5-dimensional Gross-Perry metric.

11:40 - 13:30: Lunch

Chair: Piotr Chrusciel
13:30 - 13:50: Istvan Racz (Budapest)
On the topology of strictly stable codimension two surfaces
Abstract: It is shown that in $n \geq 4$ dimensional spacetimes strictly stable codimension two surfaces do possess exactly the same topological properties as strictly stable MOTS. Issues related to the existence of strictly stable codimension two surfaces will also be addressed.

13:55 - 14:15: James Grant (Vienna)
Monotonicity theorems for null cones
Abstract: We discuss comparison and monotonicity properties of areas and volumes of subsets of the null cone of a point in a Lorentzian manifold. Motivated by isoperimetric considerations, we define some geometrical quantities on null cones, and discuss their monotonicity properties.

14:20 - 14:40: Patryk Mach (Krakow)
From ultrarelativistic jets to a hydrodynamical Riemann problem
Abstract: Solutions of the Riemann problem in relativistic hydrodynamics in which the fluid moves with a non-zero velocity tangent to the initial discontinuity were recently obtained both numerically and analytically. Remarkably, they can be applied in astrophysics, e.g. in the modeling of astrophysical jets. In this talk corrugation instabilities of such solutions will be discussed. I will show results of 3+1 dimensional simulations performed both for ultrarelativistic and perfect gas equations of state. It turns out that the instabilities that develop are only restricted to a region around a contact discontinuity. Both shock and rarefaction waves appear to be stable.

14:45 - 15:05: Merse E. Gaspar (Budapest)
On the dynamics of relativistic multi-layer spherical shell systems
Abstract: Relativistic time evolution of multi-layer spherically symmetric shell systems, consisting infinitely thin shells with arbitrary equation of state, is examined. Whenever two shells collide the

evolution is continued with the assumtion that the collision is either totally transparent or totally inelastic. The framework is suitable for studying the dynamics of the so called shell crossing singulariy, or investigate phenomenon such as mass inflationïnside the black hole region.

All lectures will take place in the ESI Boltzmann Lecture Hall.