First Congress of Greek Mathematicians
Special Session in Mathematical Physics
June 29, 2018

Organizers

Spyros Alexakis – Stefanos Aretakis – Grigorios Fournodavlos

Time Schedule of Talks

	Friday, June 29
09:00 – 09:20	Agathos
09:20 – 09:40	Moschidis
09:40 – 09:50	*break*
09:50 – 10:10	Pappas
10:10 – 10:30	Porfyriadis
10:30 – 10:50	Melas
17:00 – 17:20	Ampatzoglou
17:20 – 17:40	Fikioris
17:40 – 17:50	*break*
17:50 – 18:10	Fikioris
18:10 – 18:30	Hitzazis

Speakers

Michalis Agathos (Cambridge University)
Gravitational waves

The direct detection of gravitational waves (GWs) by Advanced LIGO heralded the beginning of a new era in experimental gravity. By analysing signals of GWs emitted by coalescing black hole binaries we can test general relativity (GR) in its relativistic, strong-field regime and study effects of its non-linear dynamics that were so far inaccessible to us. In this talk, I will briefly present the methods that were employed in order to test GR with the first two GW detections, GW150914 and GW151226. I will also attempt to summarize the prospects of probing the nature of gravity with current and upcoming GW detectors and will mildly speculate on what nature may have in store for such explorations in the long term.

Ioakeim Ampatzoglou (University of Texas at Austin)
A rigorous derivation of a Boltzmann-type cubic equation for a classical system of particles

In this talk we will present a rigorous derivation of a Boltzmann-type cubic equation describing the motion of a classical system of particles. The equation serves as a a kinetic model for a dense gas in non-equilibrium, and is for the first time derived from laws of three particle interactions, preserving momentum and energy. We first define the appropriate phase space of triple interactions and prove there is a well-defined dynamics for almost all initial configurations. We then introduce BBGKY-type and Boltzmann-type hierarchies and prove local well-posedness in exponentially energy weighted L^∞-spaces. The equation derived provides solution of the Boltzmann-type hierarchy for chaotic initial data, showing chaos is propagated in time. The Boltzmann-type hierarchy is proved to be the limit in observables of the BBGKY-type hierarchies, occurring from laws of classical

mechanics, as the number of particles goes to infinity and their diameter goes to zero in the appropriate scaling. Extensions of the method for derivation of higher order equations is also discussed.

Joint work with Nataša Pavlović.

George Fikioris (National Technical University of Athens)

Convergence and Divergence in the Method of Auxiliary Sources

A very simple scattering electromagnetic (or acoustic) scattering problem is considered, together with its solution obtained via the Method of Auxiliary Sources (MAS). We show that it is possible to concurrently have divergence of the auxiliary currents together with convergence of the scattered field generated by these divergent currents. The divergence manifests itself as rapid, unphysical oscillations in the auxiliary currents. It is stressed that the oscillations are not due to effects such as roundoff, matrix ill-conditioning, or to the well-studied phenomenon of internal resonances. We arrive at our conclusions using a number of means including asymptotic methods and a thorough discussion of the singularities of the analytic continuation of the scattered field. We discuss connections of our results to well-known phenomena pertaining to Fredholm integral equations of the first kind. We make a detailed comparison to corresponding discretizations of the Extended Integral Equation (EIE), in which similar phenomena do not occur. Finally, we point out connections to the well-known phenomenon of antenna superdirectivity.

Joint work with Nikolaos L. Tsitsas.

George Fikioris (National Technical University of Athens)

Unphysical Galerkin Solutions of an Approximate Integral Equation of Electrostatics

The electrostatic charge distribution on a conducting cylindrical wire exactly satisfies a certain integral equation. Many antenna and electromagnetics textbooks discuss an approximate form of this equation and solve it using Galerkin methods. The first work to follow this approach was probably a 1978 article by Tsai and Smith, published in the IEEE Transactions on Education. We show that the aforementioned approximate electrostatics equation is not as innocent as it might appear because it admits Galerkin solutions that are unphysical. We explain why such solutions occur and propose several remedies. We include a theorem pertinent to the solvability of the equation in the Lebesgue space of integral funstions. Our approach has parallels in recent works on Hallén's equation; this is a well-known first-kind Fredholm integral equation satisfied by the steady-state current distribution on a center-fed linear antenna. In particular, we use a detailed analytical study of the wire of infinite length as a means of deducing information about the actual (finite-length) wire.

Joint work with Ioannis Tastsoglou, Georgios D. Kolezas, and Telemachos Hatziafratis.

Iasonas Hitzazis (Cambridge University)

A Generalized Extension Principle for an Einstein-Yang-Mills Spacetime

A fundamental open problem in general relativity concerns the structure of singularities formed by the gravitational collapse of self-gravitating bodies. Two well-known conjectures related to this problem are the so-called weak and strong cosmic censorship conjectures. In a recent work of J. Kommemi, a framework is laid out which provides tools necessary to tackle these very difficult problems in the future. The system considered therein was the case of spherically symmetric, asymptotically flat (with one end) Einstein-Maxwell-Klein-Gordon spacetimes. The main difficulty was to establish an appropriate characterization of "first singularities", which is called a "generalized extension principle", and which motivates a notion of "strongly tame" systems. In the present work

we demonstrate that for an Einstein-Yang-Mills system a generalized extension principle holds as well. Therefore, this system can also be characterized as strongly tame, a necessary framework for studying the cosmic censorship conjectures for such spacetimes in the future.

Evangelos Melas (National and Kapodistrian University of Athens, Department of Economics)

Representations of the Bondi-Metzner-Sachs group in three space-time dimensions

The original Bondi-Metzner-Sachs group B is the common asymptotic symmetry group of all asymptotically flat Lorentzian 4-dim space-times. As such, B is the best candidate for the universal symmetry group of General Relativity (G.R.). In 1973, with this motivation, P. J. McCarthy classified all relativistic B-invariant systems in terms of strongly continuous irreducible unitary representations (IRS) of B. Here, we construct the IRS of B(2,1), the analogue of B, in 3 space-time dimensions. The IRS are induced from little groups which are compact. The finite little groups are cyclic groups of even order. The inducing construction is exhaustive notwithstanding the fact that B(2,1) is not locally compact in the employed Hilbert topology.

Georgios Moschidis (Princeton University)

Instability of the Anti-de Sitter spacetime for the Einstein-massless Vlasov system

The AdS instability conjecture is a conjecture about the initial value problem for Einstein vacuum equations with a negative cosmological constant. Proposed by Dafermos and Holzegel in 2006, the conjecture states that there exist arbitrarily small perturbations to the initial data of the AdS spacetime which, under evolution by the vacuum Einstein equations with reflecting boundary conditions on conformal infinity, lead to the formation of black holes. Following the work of Bizon and Rostworowski in 2011, a vast amount of numerical and heuristic works have been dedicated to the study of this conjecture, focusing mainly on the simpler setting of the spherically symmetric Einstein–scalar field system. In this talk, we will provide a rigorous proof of the instability of AdS for the Einstein–massless Vlasov system. We will also discuss how the main ideas can be extended to more general matter fields.

George Pappas (Sapienza University of Rome)

Stationary solutions in theories beyond GR

When studying theories that extend general relativity (GR), a necessary part of the process is finding solutions in these theories in order to better understand the theories themselves, but also to be able to compare their predictions against those of GR. Even if we didn't think that going beyond GR is necessary, having such solution is an important tool for performing tests of GR. In this talk we will discuss how we can produce such solutions both in specific theories and in more generic frameworks. The ultimate goal is in this era of multi-messenger astronomy to perform the most thorough tests of our theories of gravity.

Achilleas Porfyriadis (University of California, Santa Barbara)

Scattering of gravito-electromagnetic perturbations off $AdS_2 \times S^2$ in extreme Reissner-Nordström

The direct products of a two-sphere with AdS_2 or near-AdS_2 are exact solutions of four-dimensional Einstein-Maxwell theory without a cosmological constant. I will present the analytic solutions to the coupled gravitational and electromagnetic perturbation equations of $AdS_2 \times S_2$ and near-$AdS_2 \times S_2$ in this theory. While AdS_2 and near-AdS_2 are

locally diffeomorphic, the corresponding solutions to the perturbation equations give rise to distinct answers for the so-called connection problem. This is the problem of extending anti-de Sitter solutions away from the near-horizon region of (near-)extreme black holes and connecting them with solutions in the far asymptotically flat region. I will present analytic solutions to the connection problems for perturbations of $AdS_2 \times S_2$ and near-$AdS_2 \times S_2$ in the extreme and near-extreme Reissner-Nordström black hole, respectively.