GR 1: Black Holes

Time: Monday 16:30–18:10 Location: ZEU/0260

GR 1.1 Mon 16:30 ZEU/0260

Light propagation in a plasma on an axially symmetric and stationary spacetime: Separability of the Hamilton-Jacobi equation and shadow — Barbora Bezděková[1], •Volker Perlick[2], and Jiří Bičák[3] — [1]KIPAC, Stanford University, Stanford, CA 94305, USA — [2]ZARM, University of Bremen, Germany — [3]Institute of Physics, Charles University, Prague, Cech Republic

We study the effects of a non-magnetised, pressure-less plasma on light rays under the assumption of stationarity and axisymmetry. The necessary and sufficient conditions on the metric and on the plasma frequency are formulated, such that the rays can be analytically determined from a fully separated Hamilton-Jacobi equation. We demonstrate how these results allow to analytically calculate the photon region and the shadow, if they exist. As a special example, a rotating wormhole is considered. - For more details see J. Math. Phys. 63, 092501 (2022).

GR 1.2 Mon 16:50 ZEU/0260

Black holes at the Planck scale — •Piero Nicolini — Universität Triest, Triest, Italien — FIAS, Frankfurt am Main, Deutschland — Johann Wolfgang Goethe-Universiät Frankfurt am Main, Frankfurt am Main, Deutschland

Despite the difficulty in formulating a quantum theory of gravity, the good news is that the existing quantum gravity proposals seem to converge towards a unique scenario for the physics of black holes. In this talk, I will present an overview about the phenomenology of Planckian black holes and the possibility of detecting some effects in present and near future experiments. As a conclusion, I will comment about some of the existing open questions and future directions of investigation.

GR 1.3 Mon 17:10 ZEU/0260

Formulation Improvements for Critical Collapse Simulations — •Daniela Cors[1], Sarah Renkhoff[1], Hannes Rüter[2], David Hilditch[3], and Bernd Brügmann[1] — [1]Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena — [2]CFisUC, Department of Physics, University of Coimbra — [3]CENTRA, Instituto Superior Técnico, University of Lisbon

We use our adapted pseudospectral code bamps, with its new hp adaptive mesh refinement, to tune close to the barrier between gravitational collapse and dispersed fields, in order to study the critical phenomena that emerges near that threshold. To achieve that goal and improve our previous results, we introduce adjustments to the generalised harmonic gauge formulation of General Relativity adapting it to the specific case of near collapse simulations. In particular, we adjust the constraint violations damping scheme, taking into account the collapse of the lapse that occurs in extreme spacetimes. We also prevent coordinate singularities by carefully choosing the gauge source function for collapsing spacetimes. As a result of these changes, we manage to improve our threshold estimation results. In spherical symmetry, we show critical phenomena of a massless scalar field minimally coupled to the Einstein field equations. In axisymmetry, we study gravitational waves in vacuum, revisiting our previous results.

GR 1.4 Mon 17:30 ZEU/0260

Wave optical image formation of exact scalar wave scattering in Kerr-de Sitter spacetime — •Felix Willenborg[1], Dennis Phillip[1,2], and Claus Lämmerzahl[1,2] — [1]Zentrum für angewandte Raumfahrt und Mikrogravitation (ZARM), University of Bremen, 28359 Bremen, Germany — [2]Gauss-Olbers Center, c/o ZARM, University of Bremen, 28359 Bremen, Germany

Linear perturbations of black holes have been discussed widely in many contexts. Of interest are properties such as differential cross-sections, quasi-normal modes, scattering or the intereference. A useful tool in this respect is the Newman-Penrose formalism and the resulting Teukolsky equations, giving seperated angular and radial differential equations. These were mostly evaluated by numerical means. However, the introduction of a cosmological constant allows the problem to be solved in an exact analytical manner by transforming the differential equations into the Heun differential equation, the most general second-order differential equation with four regular singularities.

We show for the Kerr-de Sitter spacetime that scattering of waves from a point source needs an additational discussion around the so-called Heuns function, which enables a then possible normalization of the angular solution, similarly to the case of spherical harmonics. We assume in the discussion and analysis a scalar source star of fixed frequency and solve the scattering problem by a partial wave sum. The observed wave optical image formation by means of Kirchhoff-Fresnel diffraction and the resulting shadow will be compared to the geodesic black hole shadow.

GR 1.5 Mon 17:50 ZEU/0260

Gravitational Lensing of Massive Particles in the NUT Spacetime — •Torben Frost — ZARM, University of Bremen, Bremen, Germany

Gravitational lensing of light is already a well-investigated question. Gravitational lensing of massive particles on the other hand did not receive much attention so far. This has mainly two reasons. First, appropriate particles, currently only neutrinos, are rare, hard to detect and their emission events short-lived. Second, particle detectors capable of detecting them only have a low angular resolution. However, considered in the framework of a multimessenger approach gravitational lensing of massive particles may provide us with supplementary information to gain a better understanding about their source and the lens. Therefore, in this talk we will discuss the potential of gravitational lensing of massive particles using the example of a NUT black hole acting as lens. We will first discuss and solve the equations of motion for timelike geodesics using elementary as well as elliptic functions and integrals. Then we will introduce latitude-longitude coordinates on the celestial sphere of an observer in the domain of outer communication and relate them to the constants of motion. Finally, we will derive the angular radius of the particle shadow, write down a lens equation, and calculate the travel time of the particles. We will also discuss differences with respect to lightlike geodesics.