GR 9: Black Holes II

Time: Wednesday 13:45–15:15 Location: KH 02.012

GR 9.1 Wed 13:45 KH 02.012

Gravitational lensing in a warm plasma — Barbora Bezdekova[1] and •Volker Perlick[2] — [1]Department of Physics, Faculty of Natural Sciences, University of Haifa, Haifa 3498838, Israel — [2]Faculty 1, Universität Bremen, 28359 Bremen, Germany

We consider gravitational kensing in a warm, non-magnetized electron-ion plasma, thereby extending the rather extensive literature on lensing in a cold plasma. After discussing the general equations for light rays in such a medium on a general-relativistic spacetime, we specify to the axially symmetric and stationary case which includes the spherically symmetric and static case. In particular, we calculate the influence of a warm plasma on the bending angle. In the spherically symmetric and static case, we also calculate the shadow in a warm plasma. We illustrate the general results with a static (respectively corotating) and an infalling warm plasma on Schwarzschild and Kerr spacetimes. A preprint of this work is available at arXiv:2512.09341 .

GR 9.2 Wed 14:00 KH 02.012

Rényi second laws for Charged AdS Black Hole — Alice Bernamonti[1], Federico Galli[1], and •Emiliano Rizza[2] — [1]Università degli Studi di Firenze, Florence, Italy — [2]Jagiellonian University, Krakow, Poland

Hawking's black hole area theorem offers a geometric interpretation of the second law of thermodynamics, imposing fundamental constraints on gravitational dynamics. By examining entropic inequalities following from the monotonicity of Rényi entropies, it is shown that these constraints often set stricter bounds than those imposed by the area theorem in asymptotically AdS space.

This work aims to explore in detail the case of charged AdS black holes, which exhibit rich thermodynamic phase structures in the canonical ensemble. In particular, we study the coalescence of charged black holes in AdS, establishing a lower bound on the mass of the final state and an efficiency bound on the amount of gravitational radiation.

GR 9.3 Wed 14:15 KH 02.012

Bound States of the Schwarzschild Black Hole — •Sebastian H. Völkel — Max Planck Institute for Gravitational Physics (Albert Einstein Institute), D-14476 Potsdam, Germany

Understanding the physical significance and spectral stability of black hole quasinormal modes is fundamental to high-precision spectroscopy with future gravitational wave detectors. Inspired by Mashhoon's idea of relating quasinormal modes of black holes with their equivalent bound states in an inverted potential, we investigate, for the first time, energy levels and eigenfunctions of the Schwarzschild black hole quantitatively. While quasinormal modes describe the characteristic damped oscillations of a black hole, the bound states of the inverted potential are qualitatively more similar to those of the hydrogen atom. Although the physical interpretation of these states may initially be of more academic interest, it furthers our understanding of open problems related to quasinormal modes in a similar spirit to Maggiore's interpretation of the Schwarzschild quasinormal mode spectrum. One surprising insight from the explicit calculation of bound states is that eigenfunctions corresponding to quasinormal mode overtones become rapidly delocalized and extremely loosely bound. This observation raises immediate questions about the common interpretation of quasinormal modes as excitations of the lightring region. Closely related, as a second application, we also explore the spectral stability of bound states and demonstrate that they can provide complementary insights into the quasinormal mode spectrum.
Völkel, Phys. Rev. Lett. 134, 241401, 2025

GR 9.4 Wed 14:30 KH 02.012

Astrophysical Quantum Matter: Black-Hole and Cosmological Particle Production — •Michael Florian Wondrak — Anton Pannekoek Institute for Astronomy/GRAPPA, University of Amsterdam, The Netherlands

Energy extraction from black holes is—at first sight—a counter-intuitive concept. However, black holes are known to lose mass by classical and quantum processes. In recent work, the formal analogy with particle production by electric fields (Schwinger effect) was elaborated.

Building upon this analogy, we will use independent techniques, from canonical to path-integral quantization, to predict quantum particle production in astrophysical settings, from black holes to cosmology. We will present a novel class of time profiles allowing an analytic treatment and allowing an exact prediction of particles produced. We will put the findings into context and comment on the impact of backreaction.

GR 9.5 Wed 14:45 KH 02.012

Forecasting Ground Motion with Large Sequence Models: Implications for the Einstein Telescope — •Waleed Esmail[1], Alexander Kappes[1], Stuart Russell[2], and Christine Thomas[2] — [1]Institut für Kernphysik, Universität Münster, Wilhelm-Klemm-Straße 9, 48149, Münster — [2]Institut für Geophysik, Universität Münster, Wilhelm-Klemm-Straße 9, 48149, Münster

Seismic forecasting is entering a new phase in which data-driven sequence models can learn the complex temporal structure of ground motion directly from waveform records. In this talk, I will discuss a transformer-based approach that treats seismic waveforms as a generative sequence prediction problem, allowing short-horizon forecasting. A key motivation comes from the Einstein Telescope, where seismic noise, especially at low frequencies, can limit detector sensitivity. Accurate, low-latency forecasting enables active noise cancellation, where the detector can anticipate incoming noise and suppress it before it couples into the interferometer. I will show how transformer-based models can support this vision and why a seismic foundation model may become a core component of the next generation of gravitational-wave observatories.

GR 9.6 Wed 15:00 KH 02.012

Relativistic hydrogen spectrum of the Bopp-Podolsky electrostatic potential — •Altin Shala[1] and Volker Perlick[2] — [1]ZARM, Bremen, Germany — [2]Faculty 1 University of Bremen, Bremen, Germany

We investigate the relativistic hydrogen spectrum given by the Dirac equation when the electrostatic potential of the nucleus is described by the potential given by Bopp-Landé-Thomas-Podolsky theory of electrodynamics. Employing numerical and analytical methods, we take advantage of known measurement uncertainties in the hydrogen spectrum in order to place new constraints on the introduced parameter.