GR 1: Black Holes

Time: Monday 11:00–12:30 Location: H2

GR 1.1 Mon 11:00 H2

Microlensing in terms of an exact lens map — •Volker Perlick — ZARM, University of Bremen, Germany

In spherically symmetric and static spacetimes, gravitational lensing can be formulated in terms of an exact lens map, in close analogy to the weak-field formalism of lensing. Whereas in the latter case the lens map is a map from a lens plane to a source plane, the exact lens map is a map from the celestial sphere of the observer to a sphere where the light sources are thought to be situated. It is demonstrated that, with the help of the exact lens map, microlensing light curves can be calculated exactly. Several examples are presented, including microlensing by a Barriola-Vilenkin monople and by a Schwarzschild black hole.

GR 1.2 Mon 11:15 H2

Gravitational Lensing by Charged Accelerating Black Holes — •Torben Frost — ZARM, Universität Bremen, Bremen, Germany — ITP, Leibniz Universität Hannover, Hannover, Germany

Current astrophysical observations show that on large scale the Universe is electrically neutral. However, locally this may be quite different. Black holes enveloped by a plasma in the presence of a strong magnetic field may have acquired a significant electric charge. We can also expect that some of these charged black holes are moving. Consequently to describe them we need spacetime metrics describing moving black holes. In general relativity such a solution is given by the charged C-de Sitter-metric. In this talk we will assume that it can be used to describe moving charged black holes. We will investigate how to observe the electric charge using gravitational lensing. First we will use elliptic integrals and functions to solve the geodesic equations. Then we will derive lens equation, travel time and redshift. We will discuss the impact of the electric charge on these observables and potential limitations for its observation.

GR 1.3 Mon 11:30 H2

Photon region and shadow in a spacetime with a quadrupole moment — •Jan Hackstein and Volker Perlick — ZARM, University of Bremen, Germany

A black hole's shadow is expected to deform under the influence of an external gravitational field caused by matter present in its vicinity. This talk aims to characterise the distortion of a Schwarzschild black hole shadow due to a non-zero quadrupole moment c_2 by qualitatively investigating the behaviour of light rays close to the black hole horizon. In particular, the numerical investigation in the meridional plane for $1 \gg c_2 > 0$ finds four non-circular closed geodesics and their neighbouring geodesics exhibit chaotic behaviour that is not present in the undistorted Schwarzschild spacetime. The black hole shadow is therefore approximated by restricting the observational setup accordingly. In that case, the black hole shadow's eccentricity indicates a prolate deformation for static observers. The photon sphere in the Schwarzschild spacetime deforms into a photon region with a crescent-shaped projection on the meridional plane. Furthermore, the resulting boundary curve of the black hole shadow is visualised.

GR 1.4 Mon 11:45 H2

Application of the Gauss-Bonnet theorem to lensing in the NUT metric — •Mourad Halla and Volker Perlick — ZARM, Universität Bremen

We show with the help of Fermat's principle that every lightlike geodesic in the NUT metric projects to a geodesic of a two-dimensional Riemannian metric which we call the optical metric. The optical metric is defined on a (coordinate) cone whose opening angle is determined by the impact parameter of the lightlike geodesic. We show that, surprisingly, the optical metrics on cones with different opening angles are locally (but not globally) isometric. With the help of the Gauss-Bonnet theorem we demonstrate that the deflection angle of a lightlike geodesic is determined by an area integral over the Gaussian curvature of the optical metric. A similar result is known to be true for static and spherically symmetric spacetimes. The generalisation to the NUT spacetime, which is neither static nor spherically symmetric (at least not in the usual sense), is rather non-trivial.

GR 1.5 Mon 12:00 H2

Spin-Induced Scalarized Black Holes — Emanuele Berti[1], Lucas Collodel[2], Burkhard Kleihaus[3], and •Jutta Kunz[3] — [1]Johns Hopkins University Baltimore — [2]University of Tübingen — [3]University of Oldenburg

When General Relativity is supplemented with a Gauss-Bonnet term coupled to a scalar field, scalarized black holes arise. For appropriately chosen coupling functions Kerr black holes remain solutions of the field equations, but undergo a tachyonic instability, where curvature induced scalarized black holes arise. For slow rotation, these scalarized rotating black holes are connected to the static black holes. However, for fast rotation a second set of scalarized black holes arises, which exist only above the value of the Kerr rotation parameter $a = 0.5\,M$. In this talk such even and odd parity black hole solutions with spin-induced scalarization are presented, and their properties are discussed.

GR 1.6 Mon 12:15 H2

Quasinormal modes of hot, cold and bald Einstein-Maxwell-scalar black holes — Jose Luis Blázquez-Salcedo[1], Carlos A. R. Herdeiro[2], •Sarah Kahlen[3], Jutta Kunz[3], Alexandre M. Pombo[2], and Eugen Radu[2] — [1]Universidad Complutense de Madrid, Spain — [2]Universidade de Aveiro, Portugal — [3]Universität Oldenburg, Germany

In Einstein-Maxwell-scalar (EMs) theory, gravity is coupled to a Maxwell field and a scalar field ϕ, with some function f coupling the two fields. The choice of that function strongly influences the properties of the resulting black hole solutions. In the talk, static spherically symmetric EMs black hole solutions with coupling function $f(\phi) = 1 + \alpha\phi^4$ are dealt with. For fixed coupling constant α, there are two branches of solutions. The quasinormal modes, the eigenvalues of the linearly perturbed field equations, that can be categorized into axial and polar modes, are presented for both these branches. This allows for statements about their stability, and it is furthermore demonstrated how the presence of the scalar field influences different types of modes and breaks the isospectrality between polar and axial modes, which e.g. holds for Reissner-Nordström black holes in Einstein-Maxwell theory and for Schwarzschild black holes.