GR 3: Classical GR-2

Time: Tuesday 14:00–16:00 Location: H6

GR 3.1 Tue 14:00 H6

Geometrically thick tori around compact objects with a quadrupole moment — •Jan-Menno Memmen and Volker Perlick — Znetrum für angewandte Raumfahrttechnologien und Mikrogravitation, Bremen, Deutschland

We study geometrically thick perfect-fluid tori with constant specific angular momentum, so-called "Polish doughnuts", orbiting deformed compact objects with a quadrupole moment. More specifically, we consider two different asymptotically flat, static and axisymmetric vacuum solutions to Einstein's field equation with a non-zero quadrupole moment, the q-metric and the Erez-Rosen spacetime. It is our main goal to find features of Polish doughnuts in these two spacetimes which qualitatively distinguish them from Polish doughnuts in the Schwarzschild spacetime. As a main result we find that, for both metrics, there is a range of positive (Geroch-Hansen) quadrupole moments which allows for the existence of double tori. If these double tori fill their Roche lobes completely, their meridional cross-section has the shape of a fish, with the body of the fish corresponding to the outer torus and the fish-tail corresponding to the inner torus. Such double tori do not exist in the Schwarzschild spacetime.

GR 3.2 Tue 14:15 H6

A wild doughnut chase: Polish doughnuts around boson stars and their peculiarities — •Matheus C. Teodoro[1], Lucas G. Collodel[2], and Jutta Kunz[1] — [1]Institute of Physics, University of Oldenburg 26111 Oldenburg, Germany — [2]Theoretical Astrophysics, University of Tübingen 72076 Tübingen, Germany

In this talk we shall investigate and analyse some examples of polish doughnuts with a uniform constant specific angular momentum distribution in the space-times of rotating boson stars. These thick tori can exhibit peculiar features not present in Kerr space-times, specially in the context of retrograde tori. They may be endowed with two centers connect or not by a cusp or even present static surfaces. Inside these surfaces the fluid moves in prograde direction, while outside in the retrograde direction. All these features and how they appear will be the topic of this talk.

GR 3.3 Tue 14:30 H6

Influence of the relativistic Frequency-Shift on Continuous Variable Quantum Key Distribution — •Roy Barzel and Claus Lämmerzahl — ZARM, Universität Bremen

Quantum-Key-Distribution (QKD) offers the possibility to exchange confidential information unconditionally secure between two or more parties, in the sense that the security of the protocol does not depend on the computational or material limitations of a potential adversary intending to break the key. Since the quantum repeater technology is still far from being applicable to intercontinental quantum communication in the short term satellite-based free-space links today look like the most promising solution to achieve long-distance QKD. Therefore space-qualified, robust optical components, that will allow for stable data flow of high performance are required. Only making use of approved standard telecommunication technology for state preparation and detection continuous variable quantum key distribution (CV-QKD) today is one of the most promissing ways of implementation of a globaly operating network of secure quantum communication. Apart from atmospheric distortion effects like absorbtion recent studies revealed the sensitivity of CV-QKD against relativistic effects like the relativistic Doppler-shift and the gravitational redshift. In this talk it is shown how to quantify the influence of relativistic effects on the performance of CV-QKD in a quantum field theoretical framework. Methods are shown how to derive analytic formulas for the secret key rates in CV-QKD protocolls between satellites and ground stations, which depend on the orbital parameters of the communicators.

GR 3.4 Tue 14:45 H6

Tidal g-mode resonances in coalescing binaries of neutron stars as triggers for precursor flares of short gamma-ray bursts — •Hao-Jui Kuan — University of Tübingen

In some short gamma-ray bursts, precursor flares occurring $\sim$ seconds prior to the main episode have been observed. These flares may then be associated with the last few cycles of the inspiral when the orbital frequency is a few hundred Hz. During these final cycles, tidal forces can resonantly excite quasi-normal modes in the inspiralling stars, leading to a rapid increase in their amplitude. It has been shown that these modes can exert sufficiently strong strains onto the neutron star crust to instigate yieldings. Due to the typical frequencies of g-modes being $\sim$ 100 Hz, their resonances with the orbital frequency match the precursor timings and warrant further investigation. Adopting realistic equations of state and solving the general-relativistic pulsation equations, we study g-mode resonances in coalescing quasi-circular binaries, where we consider various stellar rotation rates, degrees of stratification, and magnetic field structures. We show that for some combination of stellar parameters, the resonantly excited g_1- and g_2-modes may lead to crustal failure and trigger precursor flares.

GR 3.5 Tue 15:00 H6

On the properties of metastable hypermassive hybrid stars — •Matthias Hanauske[1,2], Horst Stöcker[1,2], and Luciano Rezzolla[1,2] — [1]Institut für Theoretische Physik, Max-von-Laue-Straße 1, 60438 Frankfurt, Germany — [2]Frankfurt Institute for Advanced Studies, Ruth-Moufang-Straße 1, 60438 Frankfurt, Germany

Hypermassive hybrid stars (HMHS) are extreme astrophysical objects that could be produced in the merger of a binary system of two neutron stars. In contrast to their purely hadronic counterparts, hypermassive neutron stars (HMNS), these highly differentially rotating objects contain deconfined strange quark matter in their slowly rotating inner region. HMHS and HMNS are both metastable configurations and can survive only shortly after the merger before collapsing to rotating black holes. The properties of a HMHS/HMNS (e.g. rotational property, density and temperature distribution) and the space-time distortion it causes, have been computed by fully general-relativistic hydrodynamic simulations and the complicated dynamics of the collapse from a HMNS to a more compact HMHS have been analysed in detail. The interplay between the density and temperature distributions and the differential rotational profiles in the interior of the HMHS, produces a clear gravitational wave signature of the production of quark matter, if the hadron-quark phase transition is strong enough. During the collapse of the HMHS to a Kerr Black the color degrees of freedom of the pure strange quark matter core gets macroscopically confined by the formation of the event horizon.

GR 3.6 Tue 15:15 H6

Consistent solution of Einstein-Cartan equations with torsion outside matter — •Klaus Morawetz — Münster University of Applied Sciences,Stegerwaldstrasse 39, 48565 Steinfurt, Germany — International Institute of Physics- UFRN,Campus Universitário Lagoa nova,59078-970 Natal, Brazil

The Einstein-Cartan equations in first-order action of torsion are considered. From Belinfante-Rosenfeld equation special consistence conditions are derived for the torsion parameters relating them to the metric. Inside matter the torsion is given by the spin which leads to an extended Oppenhaimer-Volkov equation. Outside matter a second solution is found besides the torsion-free Schwarzschild one with the torsion completely determined by the metric and vice-versa. This solution is shown to be of non-spherical origin and its uniqueness with respect to the consistence is demonstrated. Unusual properties are discussed in different coordinate systems where the cosmological constant assumes the role of the Friedman parameter in Friedman-Lamaître-Robertson-Walker cosmoses. Parameters are specified where wormholes are possible. Transformations are presented to explore and map regions of expanding and contracting universes to the form of static metrics. The autoparallel equations are solved exactly and compared with geodesic motion. The Weyl tensor reveals that the here found solution is of Petrov-D type. [arXiv:2010.01393]

GR 3.7 Tue 15:30 H6

The gravitating kinetic gas - Lifting the Einstein Vlasov system to the tangent bundle — •Christian Pfeifer — ZARM, University of Bremen, Bremen, Germany

In this talk I will present a new model for the description of a gravitating kinetic gas, by coupling the 1-particle distribution function (1PDF) of the gas directly to the gravitational field, described directly by the geometry of the tangent bundle of spacetime. This procedure takes the influence of the velocity distribution of the kinetic gas particles on

their gravitational field fully into account, instead of only on average, as it is the case for the Einstein-Vlasov system.

By using Finsler spacetime geometry I construct an action for the kinetic gas on the tangent bundle, which is added as matter action to a canonical Finslerian generalisation of the Einstein-Hilbert action. The invariance of the kinetic gas action under coordinate changes gives rise to a new notion of energy-momentum conservation of a kinetic gas in terms of an energy-momentum distribution tensor. The variation of the total action with respect to the spacetime geometry defining Finsler Lagrangian yields the gravitational field equation, which determines the geometry of spacetime directly from the full non-averaged 1PDF.

GR 3.8 Tue 15:45 H6

Teleparallel Newton–Cartan gravity — •Philip K Schwartz — Institute for Theoretical Physics, Leibniz University Hannover, Appelstraße 2, 30167 Hannover, Germany

We discuss a teleparallel version of Newton–Cartan gravity. This theory arises as a formal large-speed-of-light limit of the teleparallel equivalent of general relativity (TEGR). Thus, it provides a geometric formulation of the Newtonian limit of TEGR, similar to standard Newton–Cartan gravity being the Newtonian limit of general relativity. We show how by a certain gauge-fixing the standard formulation of Newtonian gravity can be recovered.