GR 3: Alternative theories of gravity and general formalism

Zeit: Dienstag 16:30–19:10 Raum: NW-Bau - HS3

GR 3.1 Di 16:30 NW-Bau - HS3

Effective action model of dynamically scalarizing binary neutron stars — Noah Sennett, Lijing Shao, and •Jan Steinhoff — Albert Einstein Institute Potsdam

Gravitational waves can be used to test general relativity (GR) in the highly dynamical strong-field regime. Scalar-tensor theories of gravity are natural alternatives to GR that can manifest nonperturbative phenomena in neutron stars (NSs). One such phenomenon, known as dynamical scalarization, occurs in coalescing binary NS systems. Ground-based gravitational-wave detectors may be sensitive to this effect, and thus could potentially further constrain scalar-tensor theories. This type of analysis requires waveform models of dynamically scalarizing systems; in this work we devise an analytic model of dynamical scalarization using an effective action approach. For the first time, we compute the Newtonian-order Hamiltonian describing the dynamics of a dynamically scalarizing binary in a self-consistent manner. Despite only working to leading order, the model accurately predicts the frequency at which dynamical scalarization occurs. In conjunction with Landau theory, our model allows one to definitively establish dynamical scalarization as a second-order phase transition. We also connect dynamical scalarization to the related phenomena of spontaneous scalarization and induced scalarization; these phenomena are naturally encompassed into our effective action approach.

GR 3.2 Di 16:50 NW-Bau - HS3

Generalized scalar-torsion theories of gravity — •Manuel Hohmann — Universität Tartu, Tartu, Estland

Teleparallel gravity theories, which attribute gravity to the torsion of spacetime instead of curvature, have gained growing attention in the last years, in particular due to their recently developed Lorentz covariant formulation. The fundamental fields of these theories are a tetrad and a flat spin connection. A straightforward extension to teleparallel gravity, which provides for possible explanations for the observed accelerating phases in cosmology, is obtained by coupling one or several scalar fields to torsion. Here we discuss the properties of a general class of such scalar-torsion theories. We show how local Lorentz invariance is naturally achieved through their covariant formulation, and study a class of theories which is invariant under conformal transformations of the tetrad field. We also discuss the resulting cosmological dynamics.

GR 3.3 Di 17:10 NW-Bau - HS3

Teleparallel theories of gravity in analogy to (non-linear) theories of electrodynamics — Manuel Hohmann, Laur Järv, Martin Krssak, and •Christian Pfeifer — Laboratory for theortical physics, University of Tartu, Tartu, Estonia

The teleparallel formulation of gravity theories reveals close structural analogies to electrodynamics, which are more hidden in their usual formulation in terms of the curvature of spacetime. In this talk I will demonstrate how every locally Lorentz invariant teleparallel theory of gravity with second order field equations can be understood as built from a gravitational field strength and excitation tensor which are related to each other by a gravitational constitutive relation. This construction is analogous to the axiomatic formulation of theories of electrodynamics, where different theories are distingusihed by an electromagnetic constitutive relation which expresses the electromagnetic excitation in terms of the electromagnetic field strength. The advantage of this approach to gravity is that the field equations for different models all take the same compact form and general results can be obtained.

To demonstrate the strength of our approach I will present the general teleparalel gravitational field equations in this language and display constitutive laws for previously studied teleparallel theories of gravity, including the teleparallel equivalent of general relativity and so called f(T)-models.

GR 3.4 Di 17:30 NW-Bau - HS3

Spontaneous Scalarization of Rotating Ellis Wormholes — •Xiao Yan Chew, Burkhard Kleihaus, and Jutta Kunz — Institut of Physics, University of Oldenburg, Carl-von-Ossietzky-Straße 9-11, 26129 Oldenburg

Scalar–tensor theory is one of the alternative theories of gravity. We consider the spinning generalization of the Ellis wormhole in this theory. Similar to other compact objects such as neutron stars and boson stars, these spinning wormholes also exhibit the phenomenon of spontaneous scalarization. The domain of existence of these scalarized wormholes is determined and their properties are investigated.

GR 3.5 Di 17:50 NW-Bau - HS3

Friedmann equations for gravity underlying birefringent electrodynamics — •Maximilian Düll and Nils Fischer — Universität Heidelberg

In recent years, it has become clear how quantizable matter fields determine the gravitational theory of the spacetime on which those matter fields live. This procedure - the gravitational closure of matter field equations - in the end boils down to finding the gravitational action as a solution of a set of partial differential equations that have been constructed from the prescribed matter dynamics. In this talk, we will show how appropriate symmetry assumptions - namely spatial homogeneity and isotropy - greatly simplify this problem of finding the appropriate gravitational action. We will illustrate the procedure with two explicit examples - the standard case of Friedmann-Robertson-Walker cosmology for a metric spacetime and cosmology for a spacetime with possible birefringence in vacuum.

GR 3.6 Di 18:10 NW-Bau - HS3

Gravitational field equations following from a bi-metric matter theory — •Udo Beier — Friedrich-Alexander Universität Erlangen-Nürnberg, Erlangen, Deutschland

Given any quantizable matter action, it is possible to determine the gravitational Lagrangian for the underlying geometry. This procedure is called gravitational closure and is equivalent to solving a set of partial differential equations, the so-called gravitational closure equations.

I will present how one performs the procedure of gravitational closure for a simple bi-metric matter theory, namely two Klein-Gordon fields that couple to two separate metric fields.

Using the deceptively simple matter model as input, I will show how one practically solves the ensuing gravitational closure equations perturbatively. The resulting action and linearized gravitational field equations will then be interpreted and compared to previous proposals in the literature.

GR 3.7 Di 18:30 NW-Bau - HS3

Pre-metric two-form gravity — •Florian Wolz — Friedrich-Alexander-Universität, Erlangen, Deutschland

Within the constructive gravity program it was shown that predictive and quantizable matter field theories pose such strong conditions on the underlying geometry that its Lagrangian is completely determined. Building on this program efforts have been made to derive the Lagrangian of pre-metric geometry.

After both, the weak field limit and the symmetry reduced case of birefringent cosmology, were successfully derived, in this talk we now employ a first order formulation of pre-metric geometry constructed with 2-forms in order to obtain an exact solution of the pertinent gravitational closure equations.

GR 3.8 Di 18:50 NW-Bau - HS3

Supermassive objects (black holes) calculated using the Tolman Oppenheimer Volkoff (TOV) equation — •Jürgen Brandes — Karlsruhe, Germany

Lorentz interpretation of general relativity (LI of GRT) predicts supermassive objects without event horizon and therefore different from black holes of classical GRT [1], [2]. These differences should become observable by the Event Horizon Telescope and Black Hole Cam projects during 2018. To assist the evaluation of the observational results, supermassive objects are calculated using the TOV equation regarding the different arguments of classical GRT and LI of GRT.

Classical GRT and LI of GRT use the same formulas and make (nearly) the same experimental predictions. So, gravitational waves and all the other well-known relativistic experiments are predicted in the same manner [1], [2] but the one important exception are black holes with and supermassive objects without event horizon.

[1] J. Brandes, J. Czerniawski: *Spezielle und Allgemeine Relativitätstheorie für Physiker und Philosophen - Einstein- und Lorentz-Interpretation, Paradoxien, Raum und Zeit, Experimente*, 4. Aufl. 2010, [2] Website www.grt-li.de.