GR 13: Grundlegende Probleme und allgemeiner Formalismus

Zeit: Donnerstag 14:00–15:55 Raum: SFG 0140

Hauptvortrag GR 13.1 Do 14:00 SFG 0140

Quantum matter determines the underlying gravity theory — •Frederic P. Schuller — Department of Physics, Friedrich-Alexander University Erlangen-Nuremberg, Staudtstr. 7, 91058 Erlangen

How much choice does one have in postulating gravitational dynamics? Virtually none, if one has already decided on quantizable equations of motion for all matter fields that populate the spacetime.

The mechanism is quite simple. Geometry and matter must share the same initial data surfaces, in order to allow for a common evolution. But this inevitably injects the principal polynomial of the matter dynamics into the constraint algebra of viable dynamics for the geometry. And since the constraint algebra can then be written as a linear functional differential equation for the gravitational Lagrangian, the latter can be determined constructively. In fact, the gravitational Lagrangian is uniquely determined, up to constants of integration.

Finding the gravitational dynamics that support given matter field equations thus amounts to no more, and no less, than solving a linear system of differential equations. The technicalities behind this assertion are subtle, but utterly physical. Interestingly, there is no theoretical constraint whatsoever that restricts one to a metric background, which opens up unexpected avenues for the construction of modified matter theories on refined background geometries.

We will close by demonstrating how the mechanism works in practice and point out a type of physical questions that was previously inaccessible, but can now be addressed and answered.

GR 13.2 Do 14:40 SFG 0140

Tonti diagrams for the teleparallelism theory of gravity (TG) and for the Poincaré gauge theory (PG) — •Friedrich W. Hehl[1] and Enzo Tonti[2] — [1]Universität zu Köln and University of Missouri, Columbia — [2]Università degli Studi di Trieste

One of us, over the past decades, developed a general classification program for classical and relativistic theories in physics, such as, e.g., for particle dynamics, electromagnetism, the mechanics of deformable media, fluid mechanics, thermodynamics etc. [1]. Here we will display for the first time the corresponding diagrams (i) for the teleparallelism theory of gravity, see [2], as well as (ii) for the Poincaré gauge theory, see [3]. Interrelationships between both diagrams of (i) and (ii) are discussed. [1] E. Tonti, *The Mathematical Structure of Classical and Relativistic Physics,* A general classification diagram (Birkhäuser-Springer, New York, 2013). [2] Y. Itin, Yu. N. Obukhov, J. Boos, and F. W. Hehl, Local and linear premetric teleparallel theory of gravity: Tonti diagram, constitutive tensor, gravitational waves, in preparation (2016/17). [3] M. Blagojević and F. W. Hehl (eds.), *Gauge Theories of Gravitation: A Reader with Commentaries* (Imperial College Press,London, 2013).

GR 13.3 Do 14:55 SFG 0140

(A)dS at low and high velocity — •Lukas Brunkhorst — ZARM, Universität Bremen

From the standpoint of the Relativity postulate, Minkowski spacetime has two limiting cases: the Galilean and the Carrollian one. These arise if one is concerned with phenomena whose dynamics are either slow when compared with the speed of light or closely approaching it, respectively, and are geometrically represented by a degenerating of the metric and its inverse. It is of conceptual as well as practical interest to introduce gravity into these mathematically peculiar, though physically meaningful situations, which has been done for the Galilean case in terms of Newton-Cartan theory. We discuss the constant curvature spaces, with emphasis on the Carrollian case, by viewing them as the limits of de Sitter and Anti de Sitter spacetime.

GR 13.4 Do 15:10 SFG 0140

Treating the Einstein-Hilbert action as a higher derivative theory: what can be learnt from this? — •Branislav Nikolic — Institute for Theoretical Physics, Cologne, Germany

The Einstein-Hilbert action is a first order theory — by an appropriate partial integration, it can be put into a form exhibiting up to first time derivatives of the metric in the canonical formulation. Here, we investigate some of the consequences that arise if the action is treated as a second order theory. It is shown, in particular, that information about a broken conformal symmetry can be exhibited if we introduce extrinsic curvature as an independent variable — a procedure usual for genuine second order theories; in the original formulation, this is not easily obtainable. We also discuss implications and further examples.

GR 13.5 Do 15:25 SFG 0140

Some results of canonical gauge theory of gravity — •Johannes Münch[1,2], Jürgen Struckmeier[1,3], Matthias Hanauske[1], Johannes Kirsch[2], David Vasak[2], and Horst Stöcker[1,2,3] — [1]Goethe Universität, Frankfurt am Main, Deutschland — [2]Frankfurt Institute for Advanced Studies (FIAS), Frankfurt am Main, Deutschland — [3]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Deutschland

In analogy to SU(N)-gauge theories, the goal was set to also derive gravity as a gauge theory. This presentation shows how to deduce a gauge theory - in particular the relevant coupling terms - in the extended Hamiltonian formalism of field theory. The gauge group is formed by diffeomorphisms. The corresponding gauge transformations are formulated as canonical transformations in the Hamiltonian theory. It remains freedom in choosing a dynamic term, which represents the free theory of gravity. Thus, a special dynamic term is being discussed. The term refers to a linear combination of a quadratic and a linear term in the canonical momentum corresponding to the gauge field. In this way a modification to Einstein's equations occurs. Conformities and deviations of the solutions compared to Einstein's theory are being discussed.

GR 13.6 Do 15:40 SFG 0140

Matter Ordered by Quantum Phase Fields: Emergent Gravity in a Dynamic Universe — •Ingo Steinbach — Ruhr-University Bochum

The question of quantum gravity is approached from a new point of view. The phase field concept, which is successfully applied in certain condensed matter problems [Steinbach & Pezzolla, Physica D, 1999], will be generalized to a quantum phase field concept. It is applicable to matter in general, formulated in terms of a variational principle. The new concept [I. Steinbach, Z. Naturforschung A, to be published] has energy as the only fundamental substance. Different states of energy are ordered by a discrete set of quantum phase fields. The dual elements of matter, mass and space, are described as volume- and gradient-energy contributions of the set of fields, respectively. Time and space are formulated as background-independent dynamic variables. The evolution equations of the fields and the wave-function of the universe are derived in quasi-static approximation. Gravitational interaction emerges from quantum fluctuations in finite space. Application to a large number of fields predicts scale separation in space and repulsive action of masses distant beyond a marginal distance. The predicted marginal distance is compared to the size of the voids in the observable universe.