GR 2: Classical GR-1

Time: Tuesday 11:00–12:30 Location: H6

Invited Talk GR 2.1 Tue 11:00 H6

The Sagnac effect in General Relativity — •Jörg Frauendiener — University of Otago, Dunedin, New Zealand

The Sagnac effect can be described as the difference in travel time between two photons traveling along the same path in opposite directions. In this talk we explore the consequences of this characterisation in the context of General Relativity. We derive a general expression for this time difference in an arbitrary space-time for arbitrary paths. In general, this formula is not very useful since it involves solving a differential equation along the path. However, we also present special cases where a closed form expression for the time difference can be given. We discuss the effect in a small neighbourhood of an arbitrarily moving observer in their arbitrarily rotating reference frame. Time permitting we may also discuss the special case of stationary space-times and point out the relationship between the Sagnac effect and Fizeau's "aether-drag" experiment.

GR 2.2 Tue 11:45 H6

Gravitational Properties of Light — •Dennis Rätzel — Humboldt Universität zu Berlin, Institut für Physik, Newtonstraße 15, 12489 Berlin, Germany

The properties of light are premises in the foundations of modern physics: they were used to derive special and general relativity and are the basis of the concept of time and causality in many alternative models. Therefore, it is worthwhile to study the gravitational field of light with its rich phenomenology, even though the effects are in general very weak. In this talk, an overview is given of the gravitational properties of light, in particular, of laser pulses and focused laser beams with well-defined angular momentum. The time-dependence in the case of a laser pulse enables the investigation of the formation of the gravitational field of light. The stationary case of the gravitational field of a focused laser beam shows effects of the fundamental wave properties of light. I will also present results on the effect of angular momentum of light: frame dragging, the gravitational Faraday effect and gravitational spin-spin coupling of light.

GR 2.3 Tue 12:00 H6

General Relativistic Geodesy — •Claus Lämmerzahl and Volker Perlick — ZARM, University of Bremen

Geodesy in a Newtonian framework is based on the Newtonian potential. The general relativistic gravitational field, however, possesses more degrees of freedom. Accordingly, the full gravitational field of a stationary source can be decomposed into two scalar potentials and a tensorial spatial metric, which together serve as basis of a general relativistic geodesy. One of the scalar potentials is a generalization of the Newtonian potential while the second is related to the rotational degree of freedom of gravitating masses for which no non-relativistic counterpart exists. The operational realizations of these two potentials are discussed, as well as of the spatial metric. For analytically given space-times the two potentials are exemplified and their relevance for practical geodesy on Earth are discussed.

GR 2.4 Tue 12:15 H6

Chronometric Height: a genuine general relativistic definition of height in geodesy — •Dennis Philipp — ZARM, Universität Bremen

The Newtonian gravity potential is one of the main objects for conventional geodesy and employed for basic concepts, such as the definition of heights. A modern height definition in terms of geopotential numbers can offer a variety of advantages. Moreover, from the theoretical point of view, such a definition is considered more fundamental. We know, however, that relativistic gravity (General Relativity) requires to reformulate basic geodetic notions and to develop a consistent theoretical framework, relativistic geodesy, to yield an undoubtedly correct interpretation of contemporary and future (high-precision) measurement results. The new framework of chronometric geodesy that builds on the comparison of clocks at different positions in the gravitational field offers fundamental insight into the spacetime geometry if a solid theoretical formulation of observables is underlying all observations. For chronometry, high-performance clock networks, i.e., optical clocks connected by dedicated frequency transfer techniques, are capable to observe the mutual redshift with incredible accuracy. Here we approach a genuine relativistic definition of the concept of height. Based on the relativistic generalization of geopotential numbers, a definition of chronometric height is suggested, which reduces to the well-known notions in the weak-field limit. This height measure is conceptually based on the so-called time-independent redshift potential, which describes the gravitoelectric degree of freedom in General Relativity.