LOGICAL FOUNDATION AND INTRODUCTION FOR RELATIVITY THEORY AND FOR RELATIVISTIC COMPUTING

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The purpose of our talk is foundation for relativistic computing, in particular for hypercomputing, and gentle introduction to relativity theory. No prerequisites are assumed from physics. This talk is designed to serve as an introduction to the 2-hour talk of the same authors in the Hypercomputing Workshop. In particular, the talk provides a foundation for relativistic hypercomputing designed especially for an audience of logicians and/or computer scientists. The length of this talk is 3 hours and discussion.

In the talk, we build up relativity theories (special, general, cosmological) as theories in the sense of mathematical logic. We intend to provide an easily understandable, logic based introduction to special, general and cosmological theories of relativity, and also we intend to give insight (for the logically minded) to the most exotic and recent developments related to the theory ranging from the recently discovered acceleration of the expanding universe (e.g., exotic matter) through wormholes, timewarps and observational evidence for huge rotating black holes. Special attention will be paid to new developments in black hole physics (and BH astronomy) including exotic black holes such as Kerr-Newman, Reissner-Nordström, Reissner-Nordström-de Sitter spacetimes. The latter is interpreted as a charged black hole embedded into an ever expanding universe with cosmological constant Λ. All the above is relevant to relativistic hypercomputing.

We build up relativity theories (including special SR, general GR, and cosmological) as theories of pure first-order logic. We make efforts to keep the axioms for our theories as simple and transparent as possible, and as small in number as possible. One of the aims is to prove all predictions of "usual" relativity from a few natural axioms. While the axioms should be simple, logically transparent, intuitively convincing and easy to comprehend, the surprising or unusual predictions of relativity theory should be provable as theorems of the theory and not assumed as axioms. For example, the prediction "no observer can move faster than light" is a theorem in our approach. First-order logic will be used as a device for forcing us to make all tacit assumptions explicit.

We will be careful to build up our theories in a "bottom up" way, starting from simple observation oriented axioms with tangible meanings in a step by step manner, in each step assuming only what is needed. In particular, we will avoid assuming, say, the whole of ZFC set theory as part of our axiomatization.

A novelty is that we will try to keep the transition to general relativity (GR) from special relativity (SR) logically transparent and illuminating. We will introduce Einstein's Principle of Equivalence (EP) and will “derive” GR from SR+EP in a logical way. In more detail, we will build up SR as a purely first-order logic theory. Then, by using EP, we build GR on top of SR as a strictly logical extension. Both GR and SR will be streamlined, easy to understand theories. We will also provide a logical analysis of the SR – GR transition, making the logical counterpart of GR streamlined and transparent.

In elaborating our logic based theories, we will put an emphasis on the spacetime aspects of relativity. At the same time, we will indicate how the theory extends to the direction of covering relativistic dynamics, too, including Einstein’s famous $E=mc^2$.

One of the aims is to clarify the logical structure of relativity theories (SR, GR, …). Some of the questions we address are: what is believed and why?, which assumptions are needed to support these beliefs?, what happens if we discard some of our axioms?, can we change the axioms and at what price?. Among others, this logical analysis makes relativity theory modular: if we do not like some axiom, we can replace it with another, and our logical machinery ensures that we can continue working in this modified theory. This modularity might come handy, e.g., if/when we want to extend our GR to a unified theory of quantum gravity.

The above is an application of logic to relativity. We can view relativistic hypercomputation as an application in the reverse direction: general relativity theory can be applied to logic and even to the famous Hilbert Programme in the foundation of mathematics via the relativistic hypercomputation. For this, see the 2-hour talk of the same authors in the Hypercomputing Workshop.

Bibliography

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