AGPhil 2: Quantum and Classical Gravity 2

Time: Monday 11:30–13:15 Location: PTB SR AvHB

Invited Talk AGPhil 2.1 Mon 11:30 PTB SR AvHB

The AdS/CFT correspondence: Status and new relations between information and geometry — •Johanna Erdmenger — Lehrstuhl für Theoretische Physik 3, Julius-Maximilians-Universität Würzburg

Based on string theory, the AdS/CFT correspondence conjectures a duality between a quantum gravity theory and a quantum field theory without gravity. A central conceptual element is the holographic principle, according to which a gravity theory in a given volume has the same amount of degrees of freedom as the theory on its boundary. This is reminiscent of the Bekenstein-Hawking formula, according to which the entropy of a black hole scales with its horizon area.

Within AdS/CFT, information-theoretic measures are mapped to geometry. Examples include entanglement entropy (mapped to a minimal surface by the Ryu-Takayanagi formula) and computational complexity. Recent developments allow for the evaluation of the Page curve describing the evolution of von Neumann entropy under black hole evaporation. Moreover, operator algebras of algebraic quantum field theory are used to address the 'factorization puzzle' of AdS/CFT.

I will give an overview over these recent developments, and briefly mention own work that uses the topological concept of geometric phases for characterizing the factorization properties of the operator algebra associated to the AdS eternal black hole [1].

[1] S. Banerjee, M. Dorband, J. Erdmenger, A.-L. Weigel, 'Geometric phases characterise operator algebras and missing information', JHEP 10 (2023) 026.

AGPhil 2.2 Mon 12:15 PTB SR AvHB

The quantum theory of gravitation, effective field theories, and strings: yesterday and today. — •Alessio Rocci[1] and Thomas Van Riet[2] — [1]Vrije Universiteit Brussel and Solvay Insitutes, Brussels, Belgium — [2]KU Leuven, Leuven, Belgium

This paper analyzes the effective field theory perspective on modern physics through the lens of the quantum theory of gravitational interaction. The historical part argues that the search for a theory of quantum gravity stimulated the change in outlook that characterizes the modern approach to the Standard Model of particle physics and General Relativity. We present some landmarks covering a long period, i.e., from the beginning of the 1930s until 1994, when, according to Steven Weinberg, the modern bottom-up approach to General Relativity began. Starting from the first attempt to apply the quantum field theory techniques to quantize Einstein's theory perturbatively, we explore its developments and interaction with the top-down approach encoded by String Theory. In the last part of the paper, we focus on this last approach to describe the relationship between our modern understanding of String Theory and Effective Field Theory in today's panorama. To this end, we briefly describe the modern concepts of moduli stabilization and Swampland to understand another change in focus that explains the present framework where some string theorists move.

AGPhil 2.3 Mon 12:45 PTB SR AvHB

The Cosmological Quantum Measurement Problem — •Charlotte Erika Zito — University of Geneva, Switzerland

Despite being enormously successful on the practical level, quantum mechanics (QM) still faces a lot of conceptual challenges. One of these is represented by the quantum measurement problem (QMP), that has as many formulations as solutions in the dedicated literature. Arguably though, the QMP has echoes beyond the framework of non-relativistic QM. There exists indeed a precise analogue of the QMP in the early universe cosmology: while geometric properties of large scales appear determinate, the more fundamental levels, and particularly those closer to the initial singularity, appear to be fully quantum.

Different cosmological models based on QG, from loop quantum cosmology to string cosmology, have been developed. Yet, the cosmological version of the QMP is rarely mentioned in the literature and even more rarely discussed. In this talk I will start to fill this gap by addressing the issue that concerns the formulation of the QMP in cosmology, which arguably will not focus on the role of an external observer. Rather, I will argue that the cosmological QMP coincides with the problem of spacetime emergence, that affects theories of QG, and discuss the challenges that the main interpretations of QM face in this context, paying particular attention to Everettian solutions.