AGPhil 6: Semi-Classical Gravity 2

Time: Tuesday 11:30–13:00 Location: PTB SR AvHB

AGPhil 6.1 Tue 11:30 PTB SR AvHB

Essential Idealization in Hawking Radiation: A New Paradox for Semi-Classical Black Holes — •Dominic Ryder — London School of Economics, London, UK

In this paper, I argue that three mainstream derivations of Hawking radiation contain an essential idealization. They are Hawking's original derivation, Fredenhagen and Haag's mathematically "watertight" derivation, and the algebraic derivation of the Unruh vacuum. These derivations are carried out in a spacetime which does not model black hole evaporation, whereas, given the existence of Hawking radiation, black holes are expected to evaporate. Given the assumption of non-evaporation is unphysical, one should be able to de-idealize by removing it. However, I show that assumptions essential for the derivations breakdown in evaporation spacetimes. The idealization of non-evaporation is essential for these derivations.

First, I introduce the paradox that arises for each derivation because of this essential idealization. The paradox is distinct from standard issues of idealization in physics: usually, the soundness of physical assumptions is challenged, but here the problem is an invalid argument. Second, I discuss possible resolutions to the paradox. Hawking himself recognized the troublesome idealization and proposed an approximation regime to resolve the issue. I argue that Hawking's proposal fails and canvas alternative resolutions. Rejecting the claim that quantum gravity can resolve the issue, I propose a resolution which relies upon weakening the premises of Hawking's derivation.

AGPhil 6.2 Tue 12:00 PTB SR AvHB

The Holographic Dual of Black Hole Thermodynamics — •Manus Visser — DAMTP, University of Cambridge, UK

Black hole thermodynamics contains important clues for quantum gravity. Often black hole entropy is viewed as a low-energy constraint that every quantum theory of gravity has to satisfy. However, black hole thermodynamics itself poses conceptual puzzles, since it contains certain features that are seemingly different from those in standard textbook thermodynamics. For instance, black hole entropy scales with the horizon area, unlike the entropy of usual thermal systems that is proportional to the volume. Another puzzle is that the first law of black hole mechanics does not seem to contain a work term. These and other disanalogies between black hole thermodynamics and standard thermodynamics have led philosophers to argue that black holes are not really thermodynamic. In this talk I will explain how holography or gauge/gravity duality resolves these puzzles in an interesting way. In such a framework black holes in the 'bulk' geometry are dual to thermal states in the 'boundary' field theory. Crucially, these thermal states satisfy the usual laws of thermodynamics, for instance their entropy is extensive. I will develop a holographic 'dictionary' that relates the nonstandard laws of black hole thermodynamics to the standard laws of the dual field theory thermodynamics.

AGPhil 6.3 Tue 12:30 PTB SR AvHB

Black boxes in black hole imaging — •Juliusz Doboszewski[1,2] and Elder Jamee[3,2] — [1]Lichtenberg Group for History and Philosophy of Physics, University of Bonn — [2]Black Hole Initiative, Harvard University — [3]Tufts University

Machine learning methods are increasingly adapted to various problems in black hole imaging. Examples include the 2023 M87* image based on PRIMO (a dictionary-learning algorithm), alpha-DPI (a deep learning framework for, among others, posterior estimation of black hole parameters), and machine learning-based denoisers (suggested as a plug-in component within more conventional imaging algorithms). As a result, issues related to the notion of epistemic opacity also become relevant to black hole imaging. In this talk, I will first argue that at least one problematic form of opacity is already present in black hole imaging: GRMHD simulations of some (e.g. SgrA*; but not all, e.g. M87*) sources are opaque to some extent. This form of opacity signals limitations of the current understanding of the source*s models. However, there are also forms of opacity (including opacity resulting from the use of a deep neural network) which can remain entirely unproblematic when seen as a part of a broader inferential framework. I will propose six conditions under which that can plausibly the case, and discuss how opaque methods can be useful in the context of the next generation Event Horizon Telescope.