Contribution ID: **83** Type: **keynote talk**

Lessons for quantum cosmology from anti-de Sitter black holes

Saturday 26 September 2020 14:30 (45 minutes)

Gravitational physics is arguably better understood in the presence of a negative cosmological constant than a positive one, yet there exist strong technical similarities between the two settings. These similarities can be exploited to enhance our understanding of the more speculative realm of quantum cosmology, building on robust results regarding anti-de Sitter black holes describing the thermodynamics of holographic quantum field theories. To this end, we study 4-dimensional gravitational path integrals in the presence of a negative cosmological constant, and with minisuperspace metrics. We put a special emphasis on boundary conditions and integration contours. The Hawking-Page transition is recovered and we find that below the minimum temperature required for the existence of black holes the corresponding saddle points become complex. When the asymptotic anti-de Sitter space is cut off at a finite distance, additional saddle points contribute to the partition function, albeit in a very suppressed manner. These findings have direct consequences for the no-boundary proposal in cosmology, because the anti-de Sitter calculation can be brought into one-to-one correspondence with a path integral for de Sitter space with Neumann conditions imposed at the nucleation of the universe. Our results lend support to recent implementations of the no-boundary proposal focusing on momentum conditions at the "big bang".

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Session Classification: Beyond General Relativity