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Black Hole Thermodynamics from Entanglement Mechanics

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Since its inception, the Bekenstein-Hawking area relation for black-hole entropy has been the primary testing ground for various theories of quantum gravity. However, a key challenge to such theories is identifying the microscopic structures and explaining the exponential growth of microstates, providing a fundamental understanding of thermodynamic quantities. Since entropy is a single number, we explore other quantities to provide complete information about the black-hole microstates. We establish a one-to-one correspondence between entanglement energy, entropy, and temperature (quantum entanglement mechanics) and the Komar energy, Bekenstein-Hawking entropy, and Hawking temperature of the horizon (black-hole thermodynamics), respectively. We also show that this correspondence leads to the Komar relation and Smarr formula for generic 4-D spherically symmetric space-times. While offering an independent derivation of black-hole thermodynamics from field observables, the universality of results suggests that quantum entanglement is a fundamental building block of space-time. DOI : https://doi.org/10.1103/PhysRevD.102.125025

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