The four laws of black hole mechanics in its 50th anniversary

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Abstract

The four laws of black hole mechanics were formulated by Bardeen, Carter, and Hawking during their stay in the Les Houches Summer School on Black Holes, held in August 1972. The corresponding paper was sent to Communications of Mathematical Physics in January 1973 and published just after. The paper contains a proof of the zeroth and first law of black hole mechanics, while the second law was restated from Hawking's work of 1970, and the third law was conjectured. These laws established general properties of stationary black holes within general relativity. Since then, some of these laws and their proofs have been refined and even challenged. There is of course a great intrinsic geometric value in these laws; however, the most important contribution in the publication was ultimately the birth of black hole thermodynamics. Indeed, the four laws of black hole mechanics strike an astonishing resemblance to the four laws of thermodynamics. Nevertheless, initially the authors were reluctant to assume equivalence. With the further contributions of Bekenstein and Hawking, an equivalence between black hole mechanics and thermodynamics was conjectured and then shown. In this talk, I review the four laws of black hole mechanics and its context in this fiftieth anniversary. I then present the influence of this seminal work on black hole thermodynamics during these 50 years, and also show some developments related to my own work.

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