Vacuum Black Hole Mass Formula Is a Vanishing Noether Charge

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Abstract: The Noether current and its variation relation with respect to diffeomorphism invariance of gravitational theories have been derived from the horizontal variation and vertical-horizontal bi-variation of the Lagrangian, respectively. For Einstein's GR in the stationary, axisymmetric black holes, the mass formula in vacuum can be derived from this Noether current although it definitely vanishes. This indicates that the mass formula of black holes is a vanishing Noether charge in this case. The first law of black hole thermodynamics can also be derived from the variation relation of this vanishing Noether current.

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