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Three-dimensional gravity with a conformally coupled scalar field: Chern-Simons-like formulation and black hole thermodynamics

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We present a Chern-Simons-like description of three-dimensional gravity with negative cosmological constant, where the matter source is a conformally coupled real scalar field. This description is based on a first-order action that provides a set of field equations equivalent to that derived from the usual second-order action. The system admits a rotating hairy black hole solution, which is accordingly expressed in terms of the first-order fields. The mass, angular momentum and entropy are obtained from the Chern-Simons-like Euclidean action in the grand canonical ensemble. Regularity conditions at the horizon are provided when the holonomies along the thermal cycle are computed. This procedure establishes the relations between the integration constants that characterizes the hairy black hole and the fixed chemical potentials.

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