

## 9th Shivalik HEPCATS (High Energy Physics, Cosmology, Astronomy: Theory and Simulations)



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# Analytic three-dimensional primary hair charged black holes and thermodynamics

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We present and discuss new families of primary hair charged black hole solutions in asymptotically anti-de Sitter space in three dimensions. The coupled Einstein-Maxwell-scalar gravity system, that carries the coupling  $f()$  between the scalar and Maxwell fields is solved, and exact hairy black hole solutions are obtained analytically. The hairy solutions are obtained for three different profiles of the coupling function: (i)  $f() = 1$ , corresponding to no direct coupling between the scalar and Maxwell fields, (ii)  $f(\phi) = e^{-\phi}$ , and (iii)  $f() = e^{-2/2}$ ; corresponding to non-minimal coupling between them. For all these couplings the scalar field and curvature scalars are regular everywhere outside the horizon. We analyze the thermodynamics of the hairy black hole and find drastic changes in its thermodynamic structure due to the scalar field. For  $f() = 1$ , there exists a critical value of the hairy parameter above which the charged hairy black hole exhibits the Hawking/Page phase transition. In contrast, no such phase transition occurs below this critical value. Similarly, for  $f() = e^{-}$  and  $f() = e^{-2/2}$ , the hairy solution exhibits a small/large black hole phase transition for the above critical values of the hairy parameter. Interestingly, for these couplings, the thermodynamic phase diagram of three-dimensional hairy charged black holes resembles that of a higher-dimensional RN-AdS black hole, albeit with two second-order critical points.

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