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New phases of N=4 SYM at finite chemical potential

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We do a systematic search of supergravity solutions that, via the AdS5/CFT4 correspondence, are dual to thermal states in N=4 SYM at finite chemical potential. These solutions dominate the microcanonical ensemble and are required to ultimately reproduce the microscopic entropy of AdS black holes. Using a mix of analytical and numerical methods, we construct and study static charged hairy solitonic and black hole solutions with global AdS5 asymptotics. They are constructed in two distinct consistent truncations of five dimensional gauged supergravity (and can thus be uplifted to asymptotically AdS5 x S5 solutions of type IIB supergravity). In the single charge" truncation which consists of one charged scalar field, hairy black holes exist above a critical charge and merge with the known Cvetic-Lu-Pope (CLP) black holes along a curve determined by the onset of superradiance in the latter family. The lowest mass hairy black hole is a singular zero entropy soliton. In thetwo charge" truncation which consists of a two equal charged scalar fields, hairy black holes exist for all charges and merge with the known CLP black holes along their superradiant onset curve. The lowest mass hairy black hole is a smooth supersymmetric zero entropy soliton. Together with the known phases of the truncation with three equal charges, our findings permit a good understanding of the full phase space of SYM thermal states with three arbitrary chemical potentials.

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