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A Bayesian approach to network modularity JAKE HOFMAN, Columbia University, Department of Physics, CHRIS WIGGINS, Columbia University, Department of Applied Mathematics and Applied Physics — We present an efficient, principled, and interpretable technique for inferring module assignments and identifying the optimal number of modules in a given network. Our approach is based on a probabilistic network model equivalent to an infinite-range spin-glass Potts model on the irregular lattice defined by a given network; the problem of identifying modules is then tantamount to inferring distributions over both the module assignments (i.e. spin states) and the model parameters (i.e. coupling constants) while also identifying the number of modules (i.e. number of occupied spin states) in the network. Using a variational approximation we derive a mean-field free energy, the minimization of which provides controlled approximations to the distributions of interest. We show how several existing methods for finding modules can be described as variant, special, or limiting cases of our work, and how related methods for complexity control – identification of the true number of modules – are outperformed. We apply the technique to synthetic and real networks and outline how the method naturally allows selection among competing network models.

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