Cluster size distributions in statistical mechanics

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February 2, 2012

A classical geometric picture of the phase transition from gas to a condensed phase is that particles progressively aggregate into groups, "clusters" or "droplets". I will explain some rigorous results on cluster size distributions in classical equilibrium statistical mechanics, in the canonical ensemble (based on joint work with W. König and B. Metzger). The main result is an abstract large deviation principle for the cluster size distributions, and an exact bound on the difference between the exact rate function and the rate function of an ideal mixture of droplets. In the canonical ensemble, the idealized rate function resembles the Lyapunov function for the Becker-Döring equations of Ball, Carr and Penrose (1986); taking Legendre transforms in order to pass to the constant pressure ensemble, we obtain a rate function closer to the Lyapunov function derived by Dreyer and Duderstadt (2006). If time permits, I will also explain related results on Mayer and virial expansions.