Length Distributions in Loop Soups

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Abstract:

We consider statistical ensembles of loops, such as the vortex lines of a smooth random two-component field in three space dimensions. These systems typically have phases in which the lengths of the longest loops are extensive. In such phases it is natural to ask about the distribution of loop lengths. Remarkably, the joint probability distribution of the lengths of the macroscopic loops can be calculated exactly. The distribution has a form that is known in the statistics literature as Poisson-Dirichlet, and depends on a single parameter, which is fixed by the loop fugacity and by symmetries of the ensemble.
We show how to derive these results using CP(n−1) or RP(n−1) and O(n) σ models together with replica techniques.

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