Contribution ID: **315** Type: **Parallel**

Cluster-size scaling in O(N) non-linear sigma models

Tuesday 18 June 2019 16:30 (20 minutes)

In O(N) models, the multi-cluster algorithm generates spins clusters, which are usually considered as purely algorithmic objects. We show that the histograms of their sizes scale towards a continuum limit, with a fractal dimension D, which suggests that these clusters do have a physical meaning.
We demonstrate this property for the quantum rotor in separate topological sectors (where D=1), for the 2d XY model in the massive and in the massless phase (where D<2, and where we also define a cluster vorticity), and in the 3d O(4) model (where we relate D to the critical exponents).
The latter represents an effective theory for 2-flavor QCD in the chiral limit, at high temperature, where the topological charge corresponds to the baryon number.
For a suitable lattice actions, it can be traced back to the topological charge assigned to the clusters.
Clusters are therefore the physical carriers of topology and vorticity, beyond semi-classical approximations.

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Session Classification: Theoretical Developments

Track Classification: Theoretical Developments