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The Euclidean Φ_2^4 Theory as the Limit of an Interacting Bose Gas

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Gibbs measures of nonlinear Schrödinger equations are a fundamental object used to study low-regularity solutions with random initial data. In the dispersive PDE community, this point of view was pioneered by Bourgain in the 1990s. On the other hand, the nonlinear Schrödinger equation can be viewed a classical limit of many-body quantum theory. We are interested in the problem of the derivation of Gibbs measures as mean-field limits of Gibbs states in many-body quantum mechanics.

The particular case we consider is when the dimension $d = 2$ and when the interaction potential is the delta function, which corresponds to the Euclidean Φ_2^4 theory. The limit that we consider corresponds to taking the density to be large and the range of the interaction to be small in a controlled way. Our proof is based on two main ingredients:

An infinite-dimensional stationary phase argument, based on a functional integral representation.
A Nelson-type estimate for a nonlocal field theory in two dimensions.

This is joint work with J. Fröhlich, A. Knowles, and B. Schlein.

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