P-17

Multifractals in Soliton Sea

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Systems exhibiting Bose-Einstein condensation are suitable for fabricating artificially designed structures, e.g., the bichromatic potentials have attracted much attention in recent years. More exotic structures also appear to be experimentally feasible in the optical imaging system with high resolution [1].
We consider one of exotic structures, Fibonacci potential, which is neither random nor periodic. On the Fibonacci potential without nonlinear interaction, it is known that the spectrum is singular continuous and all the eigenvectors are called a critical, in which multifractal states are included [2]. On the other hand, the physical properties of the Bose-Einstein condensates confined in a optical lattice can be described in terms of the Schrödinger equation with nonlinear term via particle-particle interactions. We numerically and mathematically investigated nonlinear Schrödinger equation on Fibonacci potential focusing on competition between nonlinear fluctuation and criticality [3]. The conclusion is that the critical states with the spectrum in the Cantor set retains their profile irrespective of the strength of the nonlinearity. The spectrum corresponding to the critical states is in a sea of "stationary solitons" which appear as a result of nonlinear effects.

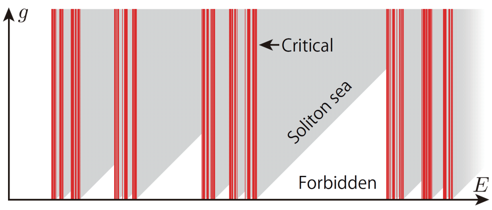

Fig. 1: The eigenenergy E v.s. the coupling g for chain length $N=377$ with Fibonacci sequence $\ell=13$.

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[2] M. Kohmoto, *et al.*, Phys. Rev. Lett. **50**, 1870 (1983).
[3] M. Takahashi, H. Katsura, M. Kohmoto, and T. Koma, arXiv: 1110.6328 (2011).