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Integrability and weak diffraction in a one-dimensional two-particle Bose-Hubbard model

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We study the one dimensional two-particle Bose-Hubbard model with a defect site. The continuum case of the model was claimed by McGuire to be nonintegrable fifty years ago, but now it is shown that the odd parity sector is integrable. More precisely, the odd-parity eigenstates are all in the Bethe-form.

Interestingly, this model offers a long-sought kind of exotic bound state: Bound state in the continuum. This kind of state was shown by von Neumann and Wigner eighty years ago to exist, but for the first time, we have found such a state with simple wave function and in a simple, realistic model.

We also show explicitly that the even-parity eigenstates are not in the Bethe form. However, some of them are close to the Bethe form and can be considered weakly diffractive. As a by-product, we bring up a method based on the Prony algorithm to check whether a numerically obtained wave function is in the Bethe form or not, and if so, to extract parameters from it. This algorithm is applicable to many other Bethe ansatz relevant models.

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