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heuristic compactness maximization algorithm for two-dimensional single-atoms traps rearrangement

Construction of defect-free or zero-entropy arrays of single atoms is the basis towards synthesizing a fully controlled and scalable quantum system in term of the interaction and a number of interacting systems, which is crucial in some applications such as quantum information processing, quantum simulation, and quantum error correction. By starting with cooled atomic cloud from the technique called magneto optical traps(MOT), single-atoms are typically loaded into optical tweezers. In this process, the loading efficiency of singles atoms is limited to have 50 percents probability of successful single-atom loading, due to the collisional pair loss induced by cooling light. This undoubtedly creates some vacancies in an initial loaded single-atom array. In order to obtain a defect-free array, one of various approaches is to rearrange those filled single-atom trap to eliminate vacancies by overlapping the filled trap with a deeper potential trapping beam called moving tweezers and translating the moving tweezers to the target vacancy using 2D-AOD. From here, an efficient rearranging algorithm is required since the rearranging has to be fast comparing to the trapping lifetime. Here we establish an algorithm and computational results based on a heuristic rearranging approach constructing a defect-free compact shape array. In this approach, the vacancies are filled from the inner layer defined by the distance from the center of the loading site by selecting the filling atoms that would minimize a system' s compactness and the algorithm is set to iterate until the compactness is at its local minimum. From the results in 10x10 initial loaded array condition, it is manifested that a compactness of the system increases approaching to the minimum compactness along with increasing algorithm iterations.

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