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Spatial Adiabatic Passage of Ultracold Atoms in Optical Tweezers

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Precise and rapid control of quantum states is crucial in modern quantum technologies. Adiabatic following, such as adiabatic rapid passage (ARP) and stimulated Raman adiabatic passage (STIRAP), offers an effective method for gradually connecting initial and final states. Spatial adiabatic passage (SAP) is an intriguing extension of STIRAP that enables the transfer of a wave packet between non-directly coupled localized modes through an intermediate mode. Here, we present the first implementation of SAP to transfer massive particles between three micro-optical traps ('optical tweezers'). We prepare ultracold fermionic atoms in low vibrational eigenstates of one trap and manipulate the distance between the three traps to execute the SAP protocol. We observe a smooth transfer of atoms between the two outer traps, accompanied by a low population in the central trap. We validate our findings and underscore the significance of the counter-intuitive sequence by reversing the order of the pulse sequence. Additionally, we investigate the influence of the tunneling rate and the time delay between the motion of the two external tweezers on the fidelity of the process. Our results open up new possibilities for advanced control and manipulation schemes in optical tweezer array platforms.

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