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Cold hybrid electrical-optical ion trap

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Abstract Advances in research such as quantum information and quantum chemistry require subtle methods for trapping particles (including ions, neutral atoms, molecules, etc.). Here we propose a hybrid ion trapping method by combining a Paul trap with optical tweezers. The trap combines the advances of the deep-potential feature for the Paul trap and the micromotion-free feature for the optical dipole trap. By modulating the optical-dipole trap synchronously with the radio frequency voltage to counteract the alternating electrical potential in the trap center, the micromotion temperature of a cold trapped ion can reach the order of nK while the trap depth is beyond 300K. These features will support a stable cold collision process between an ion and an atom in the S-wave scattering regime and trap the reacted ion molecule in the cold hybrid system, which will facilitate cold ion molecule and cold quantum chemistry research. Additionally, this will enable the investigation of new reaction pathways and reaction products in the cold regime, which are important for the study of cold chemistry. It will also provide a unique platform for probing the interactions between the ions and the surrounding neutral particles.

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