Echoes in Single Quantum Systems

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Echoes in physics can be defined as spontaneous delayed responses following a series of pulsed excitations. Perhaps the most famous example is the spin echo [1]. Echoes are typically observed in inhomogeneously broadened ensembles of many particles evolving at different frequencies. Here, we describe a different class of echoes induced in the single isolated non-linear quantum systems, quantum-optical [2] and molecular ones [3]. The latter echoes have been observed by us in the vibrational motion of a single isolated Ar_2^+ ion. In our experiments, a short laser pulse is used to impulsively excite a vibrational wave packet in the anharmonic ionic potential. The wave packet then oscillates and eventually disperses with time. A second delayed pulsed excitation is applied, giving rise to an echo – a partial recovery of the initial coherent oscillations. The vibrational dynamics of single molecules are visualized by a time-delayed probe pulse dissociating them one at a time. Quantum echoes may lead to the development of new tools for probing ultrafast processes in molecules and systems related to quantum information processing.

References

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