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Title:	Eisenbud–Wigner–Smith time delay in atom–laser interactions
Authors:	Mandal, A (/jspui/browse?type=author&value=Mandal%2C+A)
Keywords:	Eisenbud–Wigner–Smith atom–laser interactions time delay
Issue Date:	2021
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Citation:	European Physical Journal: Special Topics, 230(23), 4151–4164.
Abstract:	Recent development of ultrafast measurement techniques on the sub-femtosecond time scale has enabled us to see the atom–laser interaction in real time. One of the important observables to study the temporally resolved dynamics is the various time delay in the process. Time delays is an experimentally measurable quantity, where the time is not. Time delays in quantum collisions and in photoionization/photodetachment of atomic and molecular systems is reviewed. The formalisms of time delay in the context of quantum collisions by Eisenbud and Wigner that by Smith and their equivalence is discussed. The time-reversal symmetry between solutions with outgoing and ingoing wave boundary conditions allow us to interpret photoionization/photodetachment as half-scattering. Subsequently, the formalism of Eisenbud–Wigner–Smith time delay is extended in photoionization/photodetachment from collisions. We discuss that the time delay can be written as a self-adjoint quantum operator which depicts its measurability. On the experimental side, the measurement protocols are reviewed for attosecond streaking and RABBIT. Along with the EWS time delay, the measurement introduces an additional (which is negative) time delay. From the measurement of total delay and an analytical/numerical estimate of the measurement induced part, one gets the EWS time delay in the process. A few illustrative examples of studies on time delay are given to get a flavour of the outstanding advances made in this field in the last two decades.
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