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Stochastic nature induced by laser noise in narrow transitions[1]
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We use a probability-theory approach to study the laser noise's effects on laser-atom interactions. We consider the case where the atom is described by a two-level system without spontaneous emission and the laser has both intensity and frequency noises. A stochastic differential equation is established based on the Schrödinger equation of the laser-atom interaction in the semiclassical picture. We then analyze the equation using the path-integral technique to the first order of a perturbation approach. Because of the presence of laser noises, the atom wave function at a given time is a random variable. Therefore we construct a stochastic process charactering its time evolution. We also provide the theoretical description for the experimental realization of measuring the laser line width by driving a narrow atomic transition, and establish the connection between the laser noise's roles in the laser-atom interaction and laser line width measurement by beat signal.

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