Interference of Autoionizing Transitions into Different Final States?

Recently, Danjo and Koike reported[1] about quantum beats in autoionizing electron spectra. Oscillations in energy spectra of electrons from Na^+-Ne collisions were ascribed to an interference of autoionizing transitions from *one initial* Ne^{**} excited state to the *two final* Ne^+ states. This interpretation is at variance with basic principles of quantum mechanics.[2,3]

By measuring the electron energy, the unobserved system comprising the heavy-collision partners is prepared with a well-defined total energy. Dependent on the final Ne^+ state, either $^2P_{3/2}$ or $^2P_{1/2}$, this energy is divided into electronic and kinetic energy in two different ways. Therefore the final state of the system has to be written as a superposition of these states [Eq. (14-4) of Ref. 2]. However, at any time after the electron emission, a measurement of either the kinetic energy of the collision partners, or the final Ne^+ electronic state (e.g., using photoionization), can reveal which of the final states was chosen by the system (it cannot switch between these states after the electron has been emitted). In the words of Ref. 2 this means that the final states of Ne^+ may be regarded as "the pointer of the measuring apparatus," which, as a "macroscopic object," cannot occupy different positions at the same time. The superposition of final states therefore becomes a statistical mixture with no defined phase relation between the various components. This argumentation is the basis for the well-known rule that contributions to different final states have to be added incoherently, and interferences of the corresponding transitions do not occur. It may be pointed out that sometimes (e.g., in Ref. 4) the term "final-state coherence" is used in a misleading way, when final states of an excitation process are meant, which is followed by a spontaneous decay. These "final" states cannot be identified by a measurement when fluorescence beats of their decay are observed and therefore the term "intermediate-state coherence" is more appropriate.

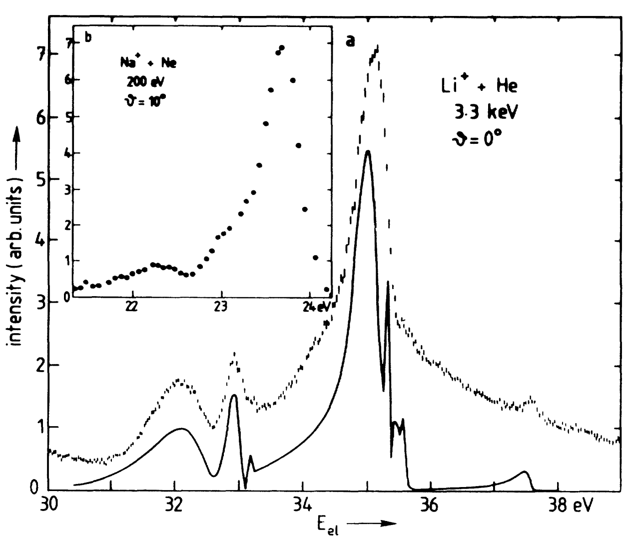

FIG. 1. Energy spectra of autoionization electrons (a) from He^{**} excited by Li^+ impact (Ref. 8), the solid line represents a calculation; (b) from Ne^{**} excited by Na^+ impact (part of the 10° spectrum of Ref. 1).

Also in case of the data of Danjo and Koike an interpretation of the oscillations is possible by the well-known[5-10] interference of contributions from different *intermediate* states. Figure 1 shows the similarity of features reported in Ref. 1 with those reported earlier.[8] In the latter and in all other cases of ion- or electron-atom collisions[5-10] intermediate states could be identified with the proper energies yielding the characteristic oscillations as observed in Fig. 1. In conclusion, there is no reason to question basic principles of quantum mechanics.

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