A YOUNG-TYPE EXPERIMENT USING A SINGLE ELECTRON SOURCE AND AN INDEPENDENT ATOMIC-SIZE TWO-CENTER INTERFEROMETER

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Recently, we performed an experiment to show that one *single* electron can interfere with itself, providing a clear illustration of the quantum nature of matter [1]. We considered the autoionization of doubly excited $2\ell n\ell'$ ($n \geq 2$) states of He atoms in slow $He^{2+} + H_2 \rightarrow He + 2\ H^+$ collisions. When the electron is emitted in the backward direction, it scatters on the two H^+ centers, which play the role of an atomic-size double-slit apparatus. Many experiments were devoted to the observation of electron interference effects by aiming an electron beam towards a macroscopic interferometer [2-4]. However, the present experiment is original in the sense that *(i)* the interferometer is a Young-like two-slit system of atomic size, and *(ii)* the He^{**} atom acts as a *single* electron source, so that only one electron passes through the interferometer at a time. It also difers from a recent molecule ionization experiment [5] in that *(iii)* the electron source is independent from the two-center scatterer.

The present experiment was performed at GANIL (Caen, France). A $^3He^{2+}$ ion beam with a kinetic energy of 30 keV, collided with a gas jet of H_2 molecules leading to a uniform H_2 pressure in the collision region. An electrostatic parallel-plate analyzer was used to detect the emitted electrons as a function of their energy and emission angle. Two distinct contributions were observed: *(i)* a monotonically decreasing part originating from the direct ionization of the target molecule and, *(ii)* a group of peaks in the range ~30 – 40 eV, due to the autoionization of $2\ell n\ell'$ ($n \geq 2$) doubly excited He states. The statistical uncertainties were found to be less than 3%. The direct ionization part was fitted with a polynomial function and subtracted from the experimental data. To obtain the angular dependence of the ionization and autoionization processes, the resulting spectra were integrated over the emitted electron energy.

The resulting cross section is presented in Fig.1, as a function of the observation angle. In contrast with the direct ionization part (Fig. 1a), the autoionization cross section (Fig. 2b) reveals well defined oscillations with pronounced maxima and minima, providing clear evidence for the interference pattern. The period of ~17° for the oscillations is in good agreement with the theoretical predictions [6].

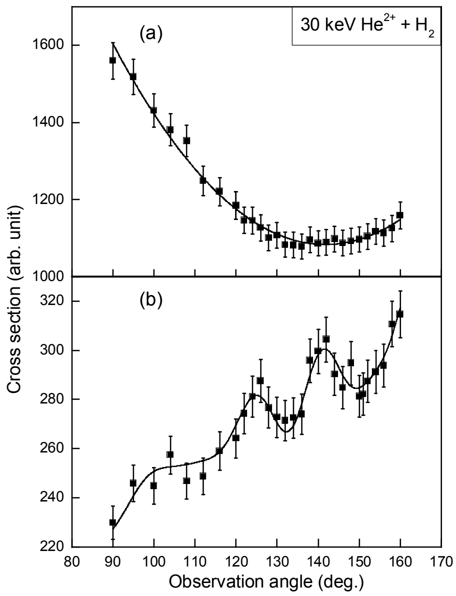

Fig. 1 Cross section for direct ionization (a) and autoionization (b) following double electron capture in 30 keV $He^{2+} + H_2$ collisions, as a function of the observation angle with respect to the beam direction.

References

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