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Two-electron interference in angular resolved double photoionization of Mg

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Synopsis We observe a two-electron interference effect in the symmetrized amplitude of the resonant double photoionization of Mg which was predicted theoretically, but never before observed experimentally. This observation is based on our experimental study of angle-resolved double photoionization of Mg at the photon energy of 55.49 eV (2p →3d resonance) under equal and unequal energy sharing conditions.

Over the past 20 years, investigation of double photoionization (DPI) in He had challenged both experimentalists and theorists. It was established that correlated dynamics of the two-electron escape is strongly constrained by its own symmetry and the Coulomb repulsion. Alkaline-earth-metal atoms are "quasi two-electron" systems and represent the most suitable candidates for extending the investigation of DPI beyond He.

We have undertaken an investigation of DPI in Mg and measured the triply-differential cross-section (TDCS) at 55.49 eV (the excitation of the 2p →3d resonance) under both equal and unequal energy sharing conditions. Under the unequal energy sharing, the two complementary kinematics ($E_1 \leftrightarrow E_2$=10.4↔22.4 eV) have been investigated. The experiments have been performed with the multi-coincidence endstation of the Gas Phase beamline at Elettra. The results have been compared with theoretical calculations using the CCC formalism, where the effect of the resonant excitation was incorporated semi-empirically [1].

From the experimental TDCS, the gerade and ungerade amplitudes have been extracted [2] and compared with the theoretical predictions. The main result [1] is the observation of a gerade amplitude in the equal energy sharing case which deviates strongly from a Gaussian shape. The whole of the amplitude can be better described by the di-Gaussian parameterization proposed in [3] and associated with the shape in the coordinate space of the Mg^+ 3*s* orbital (Fig. 1). The two Gaussians are associated with two main areas in the target coordinate space. Conversely, the He^+ 1*s* radial orbital has only one area of charge localization and thus, the DPI amplitude is represented by a single Gaussian. This is the first observation of a strong modification of the angular correlation pattern in the DPI of a *ns*-orbital with respect to the one of He. The origin is in the structure of the initial state wavefunction and can be interpreted as a two-electron interference [3,1]. Similar to the electron ''two-slit'' experiments, where the wave functions of the electrons, ''emitted'' from different spatial positions, interfere, here the wave functions of two-electron pairs ''originated'' from two different regions of the charge density interfere.

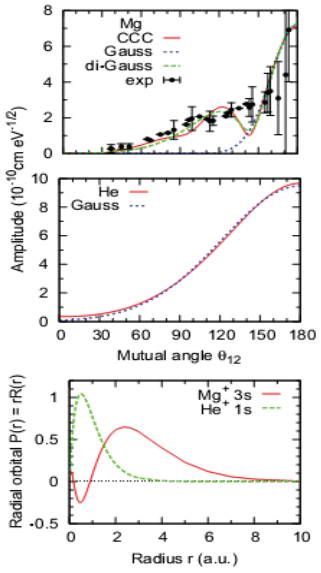

Figure 1. The gerade amplitudes of DPI of Mg (top) and He (middle) at $E_1 = E_2$ versus the mutual photoelectron angle θ_{12}. The CCC calculation (red solid line) is fitted with the Gaussian and di-Gaussian parameterization (blue and green dashed lines). The experimental amplitude is shown with error bars. Bottom: the radial orbitals for Mg^+ 3*s* and He^+ 1*s* (red solid and green dashed lines, respectively)

References

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