PRAMANA
—journal of
physics

Vol. 50, No. 6,
June 1998
pp. 501–514

The power and beauty of $(\gamma, 2e)$ experiments

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Abstract. The power and beauty of energy- and angle-resolved two-electron emission in the double photoionization of atoms is demonstrated, concentrating on the particular shapes of the angular correlation patterns of the triple differential cross section. The cases selected are direct double photoionization in helium and neon as well as sequential double photoionization in xenon, both for equal and unequal energies of the emitted electrons.

Keywords. $(\gamma, 2e)$; double photoionization; triple differential cross sections.

PACS No. 32.80

1. Introduction

In double photoionization one photon interacts with an atom leading to the emission of two electrons, $(\gamma, 2e)$. Contrary to the well established related $(e, 2e)$ experiments, energy- and angle-resolved $(\gamma, 2e)$ experiments became feasible only in the last few years [1–3], mainly for two reasons; for double photoionization the cross section is extremely low, and one needs monochromatized synchrotron radiation which is limited in its availability.

Selecting specific examples, the power and beauty of energy- and angle-resolved $(\gamma, 2e)$ experiments will be demonstrated. The power comes from the fact that such measurements provide (except for a spin analysis of the emitted electrons) complete information on photon-induced double ionization. This enables detailed studies of aspects as (i) the break-up of three particles which are subject to their mutual Coulomb interactions, (ii) parametrizations which completely describe the process, (iii) dependences of the observables on atomic structure, energies and directions of the emitted electrons under different light polarizations, and (iv) different mechanisms leading to double ionization: the direct process with the simultaneous emission of two photoelectrons, the two-step process with photoelectron and subsequent Auger electron emission, or the resonance-affected double photoionization which lies between these two limiting cases.

The beauty of the experiments lies in the stimulating interplay between state-of-the-art experiments and theoretical formulations, and in the attractive presentation of the results. Essential points in this context are the simplicity and the study of a cross section which is highly differential. The simplicity comes from the initial channel which consists of a ground-state atom and a single photon with known interaction operator. The cross section is a triple differential cross section (TDCS), being differential with respect to the solid angles $d\Omega_1$ and $d\Omega_2$ into which electron emission occurs and in the energy interval dE for the energies E_1 and E_2 of the electrons which are connected by energy conservation ($E_1 + E_2 = E_{exc}$, with the excess energy E_{exc} given by the photon energy $h\nu$ minus the