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Intensity-dependent near-threshold ionization of Kr in the vacuum-uv

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Abstract. In this work, we present measurements of the intensity-dependent photoelectron spectrum of Kr irradiated by the FLASH FEL tuned to a photon energy of 25.8 eV. Intensity dependent photoelectron spectra were obtained with the aid of a Velocity Map Imaging (VMI) spectrometer. As the FEL photon energy is close to threshold, two photon sequential double ionization is favoured. The number of open channels is kept to a minimum and leading to a simple description of the process.

1. Introduction

Observation of the two-photon double ionization of atoms in the VUV to soft X-Ray spectral region became possible with the advent of free electron lasers (FELs)[1]. Evidence of two-photon absorption in FELs has been shown using electron TOF spectroscopy [2, 3] and ion spectroscopy [4, 5]. Ion spectroscopy experiments were first carried out at FLASH in 2007 to study the aforementioned process in the case of Neon [4]. However it was only recently that studies of the photoelectrons involved in the process were published for Ne, Ar and Kr [6]. Measurements were taken for five FLASH photon energies from 38 eV to 91 eV and the results for Kr were compared with the theoretical values provided by Fritzsche et al.[7]. In our study, the photon energy was set at 25.2 eV, slightly above the $4p$ ionization threshold for Kr^+ (24.36 eV [8]) making the photoionization process less complicated due to the small number of open channels as can be seen in the partial energy diagram below (see figure 1(a)). This is also experimentally



confirmed by the angle-averaged photoelectron spectrum shown in figure 1(b). It is important to notice that our resolution allows for identification of the different LS components. Thus we can study the relative contribution of each component for different intensities. The angular distribution of the emitted photoelectrons was also measured and the anisotropy β -parameters are being extracted, for different FEL pulse energies. Here we report results from the ongoing analysis and more specifically the intensity dependence.

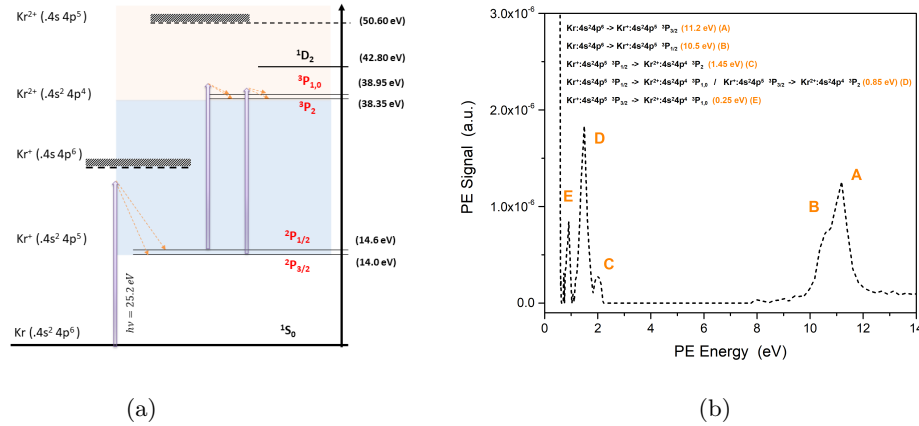


Figure 1. (a) Partial Grotrian diagram for neutral *Kr* and the singly and doubly charged ions, showing ionization pathways opened up by 25.2 eV FEL photons. (b) Angle-averaged photoelectron spectrum. The kinetic energies of the emitted photoelectrons are indicated in the figure labels.

2. Experiment

Our experimental campaign used the CFEL-ASG Multipurpose (CAMP)[9] chamber installed at BL1 FLASH1. The chamber houses a double-sided (electron and ion imaging) VMI spectrometer. The FEL pulse duration was estimated to be on the order of 80 fs with pulse to pulse fluctuation between 60 fs and 100 fs, due to the SASE related inherent fluctuation. The pulse energy at the focus varied between 3 μJ and 10 μJ . Assuming a maximum focal spot of 50 μm the intensities, present in our experiments varied between $2 \times 10^{12} W/cm^2$ and $5 \times 10^{12} W/cm^2$.

3. Preliminary results

In order to investigate the dependence of the several channels on the intensity, we divided the raw VMI images according to FEL pulse energy into 5 equal intervals ranging from the lowest 20 percent to the highest 20 percent. They refer to the highest intensity bin (80-100 band of the FEL intensities). Due to the high resolution of our spectrometer, spin-orbit components were resolved. Our preliminary analysis (summarized in figure 2) suggests that the relative contributions of the different channels depend on the FEL intensity. In order to form a plausible explanation of our findings, the theoretical treatment of the problem is currently carried out.

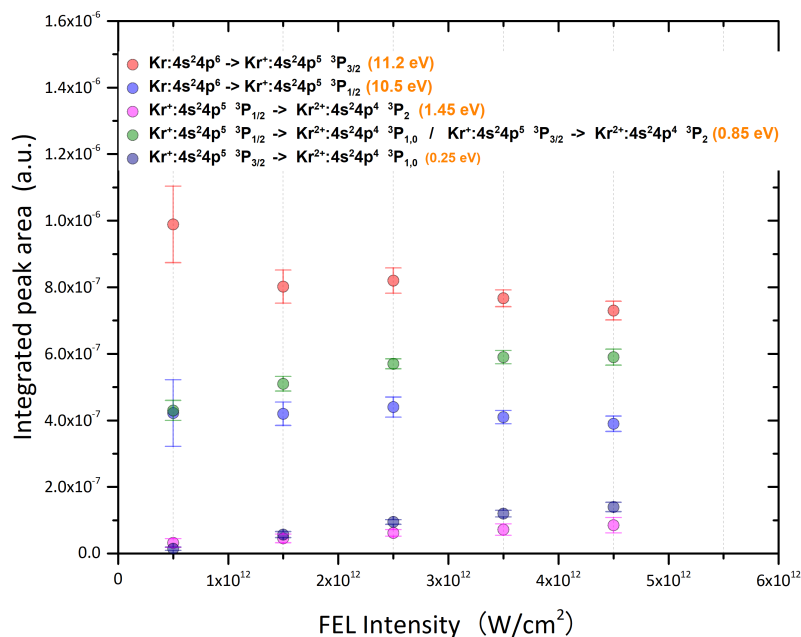


Figure 2. Intensity dependence of the different channels, present in our study. Spin-orbit components were resolved indicating the high resolution of our spectrometer.

4. Conclusion

In conclusion, we studied the sequential two-photon double ionization of Kr atoms induced by FEL photons in the VUV spectral region. As a part of our preliminary analysis, intensity dependent photoelectron spectra are reported for all the ionization pathways, open in our experiment.

5. Acknowledgments

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