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Near-saddle-point-energy single- and two-photon Stark spectra of Sr

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Synopsis We present single-photon ionization Stark spectra of Sr as a function of static electric field strength and just above the saddle-point-energy. The spectra exhibit a significant number of avoided crossings between Stark resonances, superimposed on an ionization background due to the continuum excitation. The latter may be avoided by employing single- and two-photon ionization in conjunction with phase sensitive coherent control techniques. This scheme will lead to the isolation of the resonances in differential ionization cross section measurements.

When an atom is placed in a uniform static electric field of strength F, its ionization threshold is lowered from its zero-field value E=0, to the so-called saddle point energy, classically given by E_{sp}=–2$F^{1/2}$ a.u. Within the E_{sp}≤E≤0 energy range quasi-bound Stark states (resonances) are degenerate with the continuum ones. In non-hydrogenic atoms these states are coupled and the resonance-continuum coupling leads to autoionization [1]. Resonance-resonance coupling is more interesting and leads to avoided crossings of the resonance energies as a function of F [1]. In the vicinity of an avoided crossing one of the participating resonances is partially decoupled from the degenerate continua and its spectral width exhibits a minimum. Then, the outgoing photoelectron escapes to infinity solely via tunneling. This fact is very attractive for Photoionization Microscopy (PM) studies, the term denoting the measurement of the probability density of slow (meV) photoionized electrons in the presence of F [2]. It turns out that the image of the probability density is proportional to the squared modulus of the electronic wave function. Decoupled PM images have been recorded so far only for He atom [2]. As a first step towards the extension of similar observations to heavier atoms, we recorded (using a typical atomic beam/time-of flight ion spectrometer setup) Stark spectra of strontium for a number of field strengths and just above the respective saddle point energies.

Figure 1(a) shows a number of recorded spectra where several avoided crossings between pairs of resonances may be identified. Figure 1(b) shows the aforementioned spectral width narrowing as a function of F observed for the specific resonance indicated in Fig. 1(a). We have also employed two-photon excitation and the corresponding spectra are generally found to be similar to the spectra of Fig. 1 but with a worse spectral resolution.

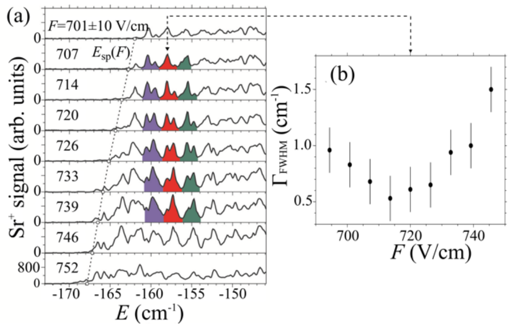

Figure 1. (a) Single-photon Stark spectra of Sr out of its ground state for several field values. The open circles mark the respective saddle point energies which are connected with a dashed line. Three avoided crossings between pairs of resonances are shown with three different colours. (b) Measured spectral width of the resonance indicated by an arrow in (a) as a function of F.

Finally, we have performed simultaneous single- and two-photon ionization studies in conjunction with phase sensitive coherent control techniques [3] and the latter techniques are currently applied to PM.

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