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Coupling of a velocity-map imaging spectrometer with an electron cyclotron resonance ion source

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Synopsis A velocity-map imaging spectrometer has been coupled with an electron cyclotron resonance ion source for the first time. This new set-up aims at the study of the photodetachment of benchmark molecular anions, especially thermionic emission. First measurements have been taken on SF₆⁻.

Electron cyclotron resonance (ECR) ion source can deliver intense current of atomic and molecular anions. Photoelectron imaging carried out with a velocity-map imaging (VMI) spectrometer requires relatively high ion current. As a consequence coupling these two devices is of particular interest.

A continuous beam of SF₆⁻ is produced by an ECR Nanogan ion source [1] and is mass selected by a magnet. A beam chopper is used to make ion bunches of 3-μs duration at 1-kHz repetition rate. The VMI spectrometer is mounted orthogonally to the ion drift tube [2]. The light pulses of nanosecond lasers operating at 1-kHz repetition rate are synchronized with the ion bunches. We have used diode pumped Nd:YAG and Nd:YLF lasers of 349-nm and 532-nm wavelength. The voltages applied to the position-sensitive detector (MCP and phosphor screen) are gated in order to reduce the background (and to allow accurate selection of the delayed thermionic signal of photoexcited anions). Photoelectron impacts are recorded by a CCD camera. Photoelectron images of the atomic anions S⁻ and F⁻ are used for the calibration of the VMI spectrometer.

Sulfur hexafluoride (SF₆) is widely used as a gaseous dielectric and in plasma etching. Electron

attachment to this molecule at low energy is characterized by a very high cross section. It proceeds by s-wave electron capture and forms mostly long-lived SF₆⁻ anions by non-dissociative attachment. Thermionic emission from SF₆⁻ is closely related to the electron attachment to SF₆ through the detailed-balance principle. SF₆⁻ lifetime has been investigated by the measurement of neutralization rates over times up to 100 ms in a cryogenic ion-beam trap [3].

With the new set-up presented here, we have measured electron kinetic energy release distributions (KERDs) for SF₆⁻ photoexcited at 349 nm and 532 nm. These results will be discussed at the conference with particular attention to the angular distributions. First measurements on thermionic emission of this benchmark anion will be presented and discussed.

References

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