High-Resolution, Mass-Selective Spectroscopy in a Supersonic Jet Between 1-14 Terahertz: Rydberg Spectroscopy of Xe Atom

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An experimental apparatus has been developed that allows for high-resolution (down to 3 MHz) spectroscopic investigations in supersonic beams between 0.1-14 terahertz (THz) with an absolute frequency accuracy of 2.8 MHz. The THz radiation source which is based on the Fourier-transform-limited, coherent, pulsed source of tunable THz radiation reported in [1] was combined with mass-selective detection. To illustrate the properties of this new apparatus, we present Rydberg spectra of Xe in the region of 1-14 THz. Rydberg states of principal quantum number in the range n = 14 - 30 were prepared by irradiation of a supersonic beam of Xe with vacuum ultraviolet (VUV) radiation. The narrow-band, pulsed THz source was then used to record spectra of transitions from these Rydberg states to higher-lying Rydberg states. By varying the length of the THz pulses, the spectral resolution could be adjusted between ~3 MHz and ~100 MHz. The transitions were detected by selective field ionization and recording either the electrons or the ions, the latter offering the advantage of mass selection. The spectra provide information on the structure and dynamics of Xe Rydberg states and on the hyperfine structure of Xe^+ as well as on the energy-dependence of the eigenchannel quantum defects of Xe.

References:
[1] J. Liu and F. Merkt, Appl. Phys. Lett. **93**, 131105 (2008).