HIGH-RESOLUTION VUV SPECTROSCOPY OF XENON USING A NEW ALL-SOLID-STATE VUV LASER SYSTEM PRODUCING FOURIER-TRANSFORM-LIMITED PULSES OF ARBITRARY SHAPE AND DURATION

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A new, all-solid-state laser system has been developed which enables the generation of Fourier-transform-limited pulses of programmable shape and duration. The laser system is based on the pulse-amplification of the single-frequency near-infrared (NIR) radiation delivered by a commercial Ti:sapphire ring laser. The pulses are obtained from the continuous wave (cw) NIR ring laser output using the pulsed first order diffraction sideband of a freely programmable acousto-optic modulator and are pulse-amplified in Ti:sapphire crystals pumped by the 532 nm output of a Nd:YAG laser in a multipass arrangement. Pulse energies of up to 15 mJ, 1 mJ, 100 μJ and 1 nJ are generated in the NIR, visible, UV and VUV (vacuum ultraviolet) ranges, respectively. The tunable range of this pulsed laser can be extended from the NIR (720 - 825 nm) to the visible (360 - 412 nm) and the UV (240 - 275 nm) by frequency doubling and tripling in nonlinear crystals. The tunable range has also been extended to several regions of the VUV range between 66200 and 94000 cm^{-1} by resonance-enhanced sum- and difference-frequency mixing in xenon using the $(5p)^5 6p[1/2]_0 \leftarrow (5p)^6\ ^1S_0$ two-photon resonance at 80118.96 cm^{-1}. The characterization of the system, including the determination of frequency chirps and shifts, of pulse shapes in the various frequency ranges and of the bandwidth will be presented. The operation characteristics in the VUV will be demonstrated by measurements of the $(5p)^5 7d[3/2]_1 \leftarrow (5p)^6\ ^1S_0$ transition of xenon by 1+1' resonance-enhanced two-photon ionization. In these experiments a bandwidth of 120 MHz (corresponding to a resolving power $\frac{\nu}{\Delta\nu} = 3 \cdot 10^7$ at 93000 cm^{-1}, the best obtained so far in the VUV) has been achieved as measured by the FWHM of spectral lines. At this resolution the hyperfine structure in the spectra of ^{129}Xe and ^{131}Xe could be resolved.