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EXPERIMENTAL STUDIES OF SELF-SUPPRESSION OF VACUUM ULTRAVIOLET GENERARTION IN Xe*

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DISCLAIMER

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ABSTRACT

Vacuum ultraviolet light in the range 116 nm to 117 nm was produced by using a two-photon resonant four-wave mixing scheme in Xe. The buildup of coherent cancellation of the two-photon resonant transition employed in the generation of the vacuum ultraviolet, with resulting limitations imposed on the achievable vacuum ultraviolet intensity was investigated. Under certain predicted conditions, increases in the intensity of one of the pumping beams, ≈1500 nm infrared, or tuning this beam towards resonance with the $5p^57s(3/2)_1$ level of Xe led, not to increases, but decreases in the vacuum ultraviolet generated.

INTRODUCTION

Generation of vacuum ultraviolet (VUV) by four-wave mixing (FWM) in Xe has both practical and theoretical interest. For instance, this method has been used successfully[1] to produce tunable VUV for the selective excitation and subsequent ionization of Kr as part of a way to quantitatively detect small amounts of Kr isotopes in a gas sample. On the other hand, a careful theoretical analysis[2,3] of this process predicts some subtle effects whose importance we have only recently recognized. Under certain conditions, as the generated VUV propagates through the generation cell along with the 252.5 nm ultraviolet (UV) and the 1507 nm infrared (IR) pumping beams, a two-photon effect can become operative and cause cancellation of the two-photon resonant enhancement in the generation process. This comes about when the Xe level pumped by the two-photon UV transition is also two-photon pumped by the VUV and the second laser field, but out of phase. The theory predicts that, for certain predicted conditions, the generated VUV intensity will decrease rather than increase when the intensity of the IR is increased or when the IR is tuned closer towards resonance with the $5p7s(3/2)_1$ level of Xe. We undertook experiments to make checks on the theory's predictions. In the present study we present results that appear to verify some of these predictions.

RESULTS

Figure 1 shows the energy level diagram involved. The doubled frequency of a YAG laser pulsed at 10 Hz is split to pump two dye lasers. The output of one dye laser is mixed with a residual 1064 nm beam from the YAG to produce the 252.5 nm UV. It is kept tuned for an exact two-photon resonance with the $5p^56p[3/2]_2$ state of Xe. The output of the second dye laser is injected into a hydrogen filled Raman-shifter. By tuning this dye laser, the second stokes output (≈1507 nm) of the Raman shifter can be set at a desired energy $\hbar\delta$ above the $5p^57s[3/2]_1$ level of Xe. The theory predicts how the VUV intensity will depend on the laser bandwidths, laser intensities, amount of detuning, δ, Xe pressure, and distance into the VUV generation cell. The prediction, for one simplified example, is that at one point in the cell under certain conditions the relationship between the beam intensities and detuning δ is given by $I_{VUV} \propto \frac{I_{UV}^2 \delta^2}{I_{IR}}$.

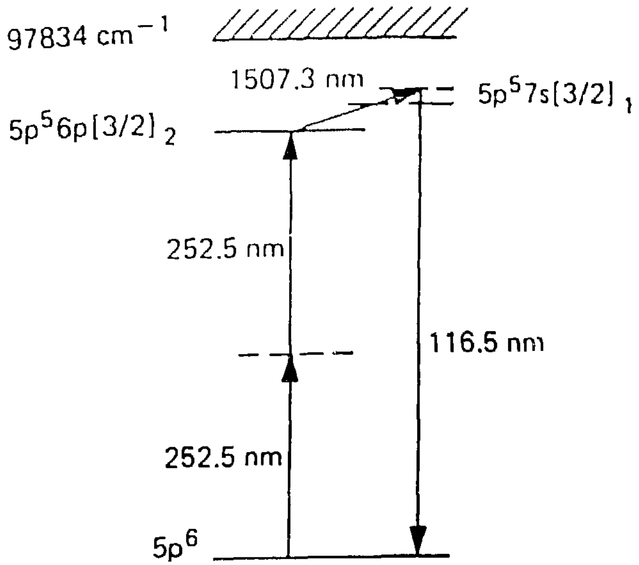

Figure 1. Two-photon resonant four-wave mixing scheme in xenon

Our experimental results shown in Figs. 2 and 3 are for a fixed δ of 0.048 nm on the high energy (negatively dispersive) side of the $7s[3/2]_1$ state with 8 torr of Xe in the VUV cell. Figure 2 shows the relative VUV intensity as a function of UV intensity. Figure 3 shows the relative VUV intensity as a function of IR pump intensity.

These results, in particular the location of the knee of the curve in Fig. 3, closely follow predictions of the theory which takes into account all the parameters previously mentioned. Our study of this cancellation process for different values of the parameters is continuing.

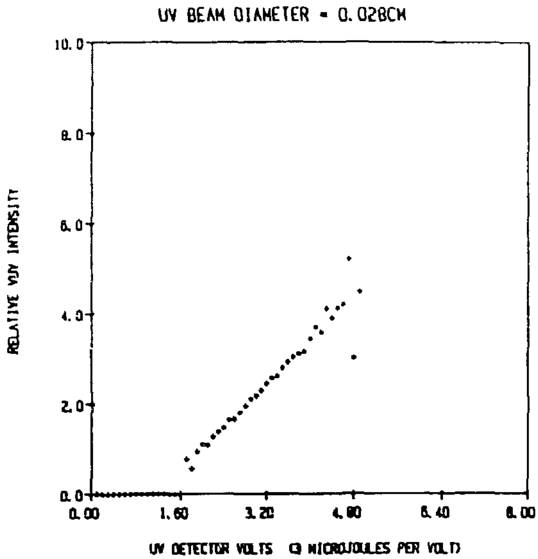

Figure 2. Relative VUV intensity as a function of UV intensity

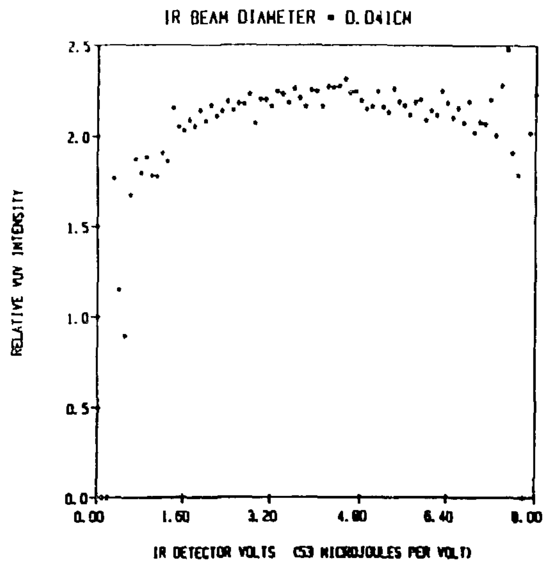

Figure 3. Relative VUV intensity as a function of IR intensity

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