Studies of nonlinear optical processes with ultraviolet excimer lasers

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The development of ultrahigh spectral brightness rare gas halogen excimer sources[1] is enabling the detailed study of many nonlinear processes in the ultraviolet region. These include high resolution multiquantum spectroscopy of high lying atomic and molecular states[2], state selective collisional processes[3], isotopically selective mechanisms involving excited molecular electronic levels, and frequency conversion[5] to the XUV.

Figure (1) illustrates a KrF* (248 nm) source[1] which exhibits performance parameters which closely approach the fundamental limits governing spectral width, beam divergence, and absolute wavelength control. This instrument combines the property of continuous tunability over the full gain profile with the following experimentally established output pulse characteristics: pulse energy $\sim$60 mJ, pulse duration $\sim$10 nsec, spectral width 150 $\pm$ 30 MHz, absolute frequency control to within 300 MHz, and beam divergence $\sim$50 μrad.

Frequency conversion in the range from 82.8 nm to 83.3 nm has been achieved with this source by third harmonic generation[5] in xenon using the configuration shown in Figure [2]. In order to demonstrate the spectroscopic utility and linewidth of the XUV radiation, 100 mtorr of H_2 was introduced into the intermediate chamber. At a wavelength λ=82.926 nm, a strong absorption was observed due to the Q (3) line of the $D^1\Pi_u \leftarrow X^1\Sigma_g$ (4,0) band. The linewidth of the absorption was measured to be 36 ± 6 GHz, a value which corresponds to the Doppler width of the transition.

It is evident from these measurements that a considerable variety of atomic and molecular processes can be readily examined at high resolution in the XUV range. This presentation will emphasize the current research being conducted in that area.

References

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用紫外准分子激光器研究非线性光学过程

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超高光谱亮度的稀有气体卤素准分子激光源的发展使人们可以对紫外波段的许多非线性光学过程进行详尽的研究。这包括原子和分子高激发态的高分辨率多量子光谱学，态选择碰撞过程，受激分子电子能级的同位素选择机理及向 XUV 波段的频率转换。

图 1 示出了一个 KrF* (248 毫微米) 激光源，它的光束参数都十分接近于控制光谱宽度、光束发散角及绝对波长的基本极限。本仪器把整个增益曲线内的连续可调谐性与由实验确定的如下输出脉冲特性结合起来：脉冲能量～60 毫焦耳，脉冲宽度～10 毫微秒，光谱宽度为 150±30 兆赫，绝对频率控制在 300 兆赫以内，光束发散角～50 微弧度。

用图 2 所示的装置由氙的三次谐波得到了向 82.8 毫微米到 83.3 毫微米范围内的频率转换。为了论证 XUV 辐射的光谱学实用性和线宽，在中间气室充入 100 毫托的 H_2。在 $\lambda=82.926$ 毫微米处观察到强吸收，这来自于 $D^1\Pi_u \longleftarrow X^1\Sigma_g$ (4, 0) 带的 Q(3) 线。测得吸收线宽为 36±6 千兆赫，这相当于此跃迁的多普勒宽度。

这些测量证实，许多不同的原子和分子过程是容易在 XUV 波段内进行高分辨率检测的，本文将把重点放在这个领域中目前正在进行的研究上。