Slowing of AlF molecules using a low cost, robust deep ultraviolet laser system

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Lasers in the deep-ultraviolet (DUV) have many applications to cutting edge research such as spectroscopy [1], the creation of optical clocks that are insensitive to blackbody effects [2], and the laser cooling and trapping of atoms and molecules [3, 4]. Aluminium monofluoride (AlF) molecules are a promising candidate for laser cooling to ultracold temperatures, featuring a large scattering photon rate and favourable Franck-Condon factors, and the main $A^1\Pi(v = 0) \rightarrow X^1\Sigma(v = 0)$ transition being at 227.5 nm providing a large optical force, allowing for rapid slowing of a molecular beam.

With the recent success in producing a magneto-optical trap (MOT) of AlF molecules [4], the next stages of the AlF experiments will rely on further development of these high power DUV lasers, and the ability to rapidly switch large magnetic field gradients of ~1000 G/cm in order to investigate sub-Doppler cooling, and loading of the molecules into an optical dipole trap.

Using laser systems based on Vertical External Cavity Surface Emitting Lasers (VECSELs), frequency doubled twice to the DUV, we produce narrow linewidth, high power (<350 mW) beams of 227.5 nm and 231.5 nm light. We demonstrate the frequency and intensity stability of the laser systems and their application to laser slowing of a beam of AlF molecules with comparisons to simulations. We also present the upgraded experimental apparatus that will allow for the sub-Doppler cooling of AlF molecules and the push towards loading molecules into an optical dipole trap.

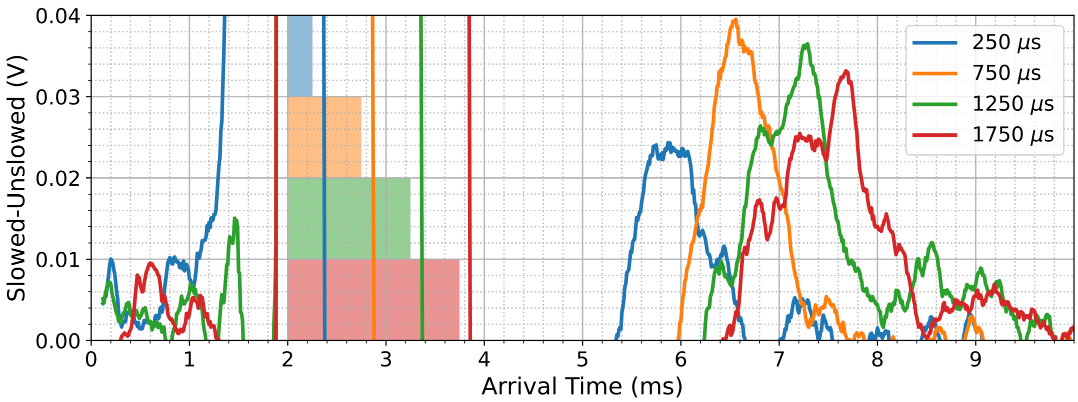

Figure 1: Arrival times of slowed molecules detected with a PMT for various lengths of a slowing pulse. Longer duration pulses show a clear delay in arrival time of the molecules. The slowing pulse is detuned to be resonant with molecules moving with v=200 m/s.

References

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