

Atomic Barium Vapor Filter for Ultraviolet High Spectral Resolution Lidar

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This work presents a novel vapor notch filter functioning near the ultraviolet Nd:YAG third harmonic (355 nm) for use in High Spectral Resolution Lidar (HSRL) systems. This wavelength is benefitted by increased eye safety, decreased sunlight background, and increased scattering strength when compared to the commonly used higher wavelengths. The few existing HSRL systems functioning at 355 nm are currently restricted to etalon-based filtering approaches, which present alignment challenges. The proposed vapor filter functions by optically pumping a high temperature barium vapor to an excited and metastable electronic state, $6s5d\ ^3D_2$, with a continuous wave infrared beam at 791 nm. From this energy level, backscattered light at 354.8 nm can be absorbed. Although barium's lower vapor pressure and rapid oxidation present engineering challenges, these have been overcome through a unique vacuum sealed filter design with multiple temperature control measures. A detailed theoretical and experimental study has been performed to characterize the light transmission of this filter and understand the complex kinetics involved in the optical pumping scheme. These results demonstrate a unique, highly tunable, cusped, non-Maxwellian absorption feature. With adjustments to the pump intensity and frequency, the filter function width, depth, and central frequency can all be rapidly modified.

This filtering technology could augment several established diagnostic techniques for ground-based aerodynamic testing. However, the rapid tunability, ease of alignment when compared to etalons, and near ultraviolet frequency are particularly advantageous for remote sensing systems. Preliminary lidar simulations employing this notch filter show promise for the enabling of higher precision and safer atmospheric profiling when compared to typical visible light based systems. To fully demonstrate the effectiveness of this filter, a ground based HSRL system is under development at Texas A&M University. Currently, the system is near functioning as a 355 nm backscatter lidar. However, the filter is in the process of being implemented into a controlled, table-top filtered Rayleigh scattering temperature measurement, which will serve as a calibration for initial lidar testing. We hope to present these results and a set of preliminary separated molecular and aerosol lidar returns.

Preliminarily, we are interested in the use of this filter for HSRL based temperature measurements. Two temperature measurement methodologies are under consideration: 1) a Rotational Raman and molecular scattering ratio based measurement and 2) a more traditional dual filter HSRL temperature measurement. These techniques will be explored further in the extended abstract and at the conference.