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Nd:GLASS-RAMAN LASER FOR WATER VAPOR DIAL

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In this paper we describe a tunable solid-state Raman shifted laser which we use in a water vapor DIAL system at 9400 Å. The DIAL transmitter is based on a tunable glass laser operating at 1.06 μm, a hydrogen Raman cell to shift the radiation to 1.88 μm, and a frequency doubling crystal. We report the results of measurements which characterize the output of the laser with respect to optimization of optical configuration and of Raman parameters. We also describe the DIAL system and show preliminary atmospheric returns.

These experiments are a part of an ongoing DIAL research program at RCA Astro-Electronics to develop and demonstrate techniques for measuring atmospheric water vapor, pressure, and temperature profiles which will lead to the development of spaceborne sensors. The space environment requirements (i.e. long lifetime and high electrical efficiency) led us to choose the Nd:glass-Raman gas cell configuration. The Nd:glass laser is a tunable solid state laser with a long research history and since its absorption band occurs at 8000 Å (which coincides with the emission band of the AlGaAs diode), it has the potential to be pumped by 2D diode arrays. The diode array pump has two strong advantages over flashlamps — much greater operational lifetimes, and efficiencies of up to ten percent. Furthermore, since hydrogen is the candidate gas for achieving 9400 Å radiation, we benefit by using the gas which exhibits the largest efficiency ($\lesssim$80%) of all Raman gases. Second harmonic generation is a mature technology with which efficiencies of 40 to 50 percent can be achieved. Thus, with diode pumping, Nd:glass - H_2 Raman lasers can achieve overall efficiencies of ~2%.

Since 2D diode arrays are not yet available, we are using flashlamps to demonstrate the water vapor DIAL technique. A block diagram of the flashlamp pumped DIAL system laser transmitter is shown in Fig. 1. The oscillator contains a birefringent filter (BRF), and two etalons, 0.1 cm and 1.0 cm thick. These three components are used for wavelength selection. Tuning is achieved by tilting the 1.0 cm etalon. The other etalon is tilted and the BRF is rotated to maintain the laser cavity at the center of the respective modes. The cavity is Q-switched with a Pockels cell. The Q-switched output of the cavity is 50 mJ with a pulse duration of 60 nsec and a linewidth of <0.04 cm^{-1}. This output is then passed through Nd:glass amplifiers, which include up to three flashlamp pumped Nd:glass rods, one of which may be, if necessary, double passed. We maintain the amplifier gain to obtain ~1 Joule pulses.

The output of the amplifiers is Raman shifted in hydrogen gas. To achieve a high conversion efficiency of the Raman shift, we use a Raman oscillator-amplifier configuration. Here, a pump beam is divided into two beams. A low energy tightly focused beam enters the Raman oscillator to provide a low energy Stokes beam to seed the Raman amplifier. In the Raman amplifier, the main part of the pump beam is spatially and temporally overlapped with the seed and amplification occurs, with consequent depletion of the pump. The Raman shifted radiation (1.88 μm) is passed into a frequency doubling crystal ($LiIO_3$) where 9400 Å radiation then emerges.

The receiver of the DIAL system is a f/4.5, 45 cm Newtonian telescope. A field stop (1 to 10 mm) is placed at the focal plane of the telescope, a lens images the field stop on a RCA C30950E Silicon Avalanche Photodiode detector. In a preliminary test of the system a 1 to 2 mJ per pulse, 9400 Å beam was transmitted vertically on a clear evening and aerosol backscatter was observed up to 3.5 km.

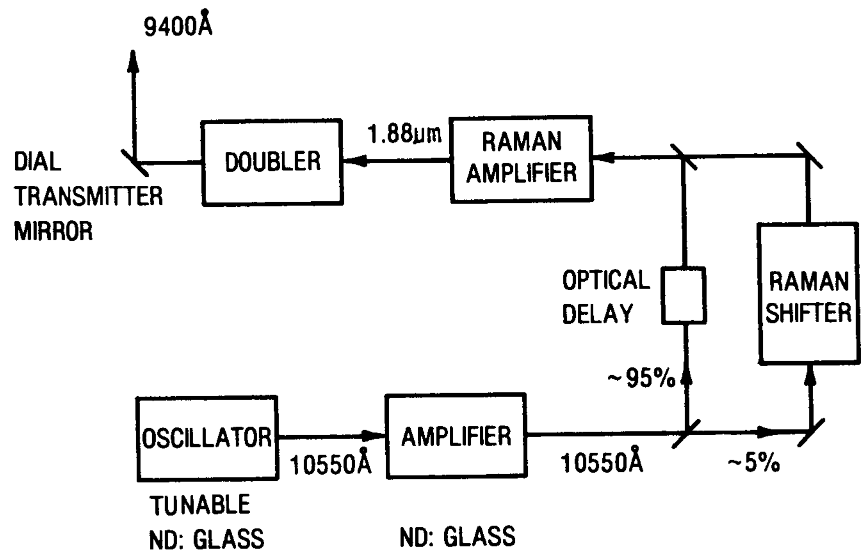

FIG. 1. BLOCK DIAGRAM OF ND: GLASS-RAMAN LASER