AN ALL SOLID STATE LASER FOR THE MEASUREMENT OF THE TEMPERATURE OF MESOSPHERIC SODIUM LAYER

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ABSTRACT

We present here an all solid-state laser used in a LIDAR to measure the density and temperature distribution of the mesospheric sodium layer situated in the height range from 75 to 105 km. The laser consists of two seeded Nd:YAG lasers, one at 1064 nm. and the other at 1319 nm. The outputs of these lasers are then mixed to generate a narrow bandwidth pulse of approximately 20 nsec. in the region of 589.158 nm.

1. INTRODUCTION

The laser system normally used in a temperature-winds lidar consists of a narrow width cw dye laser to generate the three or four closely spaced wavelengths needed to measure the required parameters of the Doppler broadened D2 line of sodium which are used to determine the temperature and wind profiles. The output of this laser is then sent to a pulsed dye amplifier to generate the light pulse that is used to sound the atmosphere (see ref. [1]). More recently the cw laser has been substituted by a system of two cw seeder lasers at 1064 and 1319 nm. whose output is mixed in a crystal to generate the narrow bandwidth lines which are then amplified. The first all solid state laser for sodium temperature measurements was described in [2]. This laser was quite innovative because the 1064 and 1319 nm. wavelengths were co-lased in the same rod.

2. LASER DESCRIPTION

The 1064 nm. laser is shown at the bottom left of fig. 1. The laser consists of only an oscillator in an unstable cavity design with a Gaussian dot output coupler. It uses a very long cavity in order to better match its pulse length to that of the 1319 nm. laser in order to maximize the available 589.158 nm. pulse energy. A 1064 nm. seeder is used to get single longitudinal mode operation.

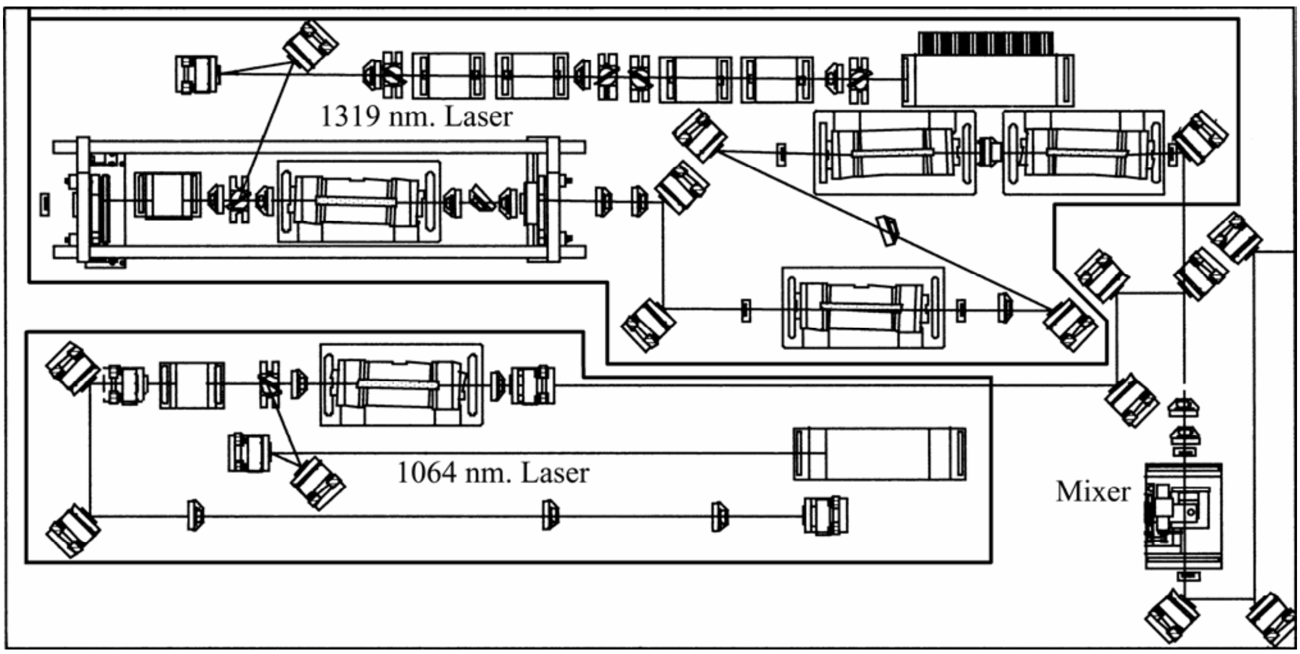

Figure 1. General layout of the laser showing the two lasers (1064 and 1319 nm.) as well as the mixing section.

The 1319 nm. oscillator runs in TEM_{00} mode with an inter cavity pinhole. The cavity is kept as short as possible in order to generate the shortest pulse possible. The output then passes through a pre-amplifier and a two stage amplifier. A 1319 nm. seeder is used for single mode operation. It has two stages of Faraday isolators to eliminate feedback.

The 1064 and 1319 nm. beams are combined using a dichroic mirror. Time synchronization of the pulses is achieved by adjusting the 1064 nm. Q-switch pulse timing with respect to that of the 1319 laser. The two wavelengths are then mixed in a KTP crystal to generate the 589.158 nm. output pulses. The output pulse is about 100 mJ. with a pulse repetition rate of 10 Hz. and a duration of about 20 nsec.

3. Discussion

In testing the laser we have taken scans through the sodium line using our sodium scattering cell as the detector. The scans have shown normal sodium scattering cross-section wavelength dependence. These scans do not have sufficient accuracy in locating the $D2_a$ hyperfine feature so we will have to use pulsed Doppler-free saturation fluorescence spectroscopy (ref. [3]) to get a precise tuning of the laser to the $D2_a$ peak and the crossover feature needed for temperature determination. Since we have not yet tried pulsed Doppler-free spectroscopy we do not know if we will have sufficient tuning accuracy to be able to make accurate wind measurements with this laser.

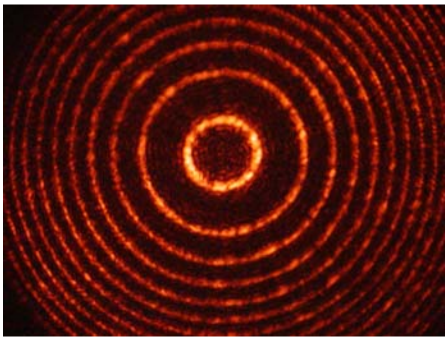

Figure 2. Pattern from a 1.97 pm. free spectral Fabry-Perot showing the line from the laser.

Fig 2 shows the pattern from a Fabry-Perot analyzing the emitted 589.158 laser line. A simple analysis (comparing the full width at half maximum of the center ring to the known free spectral range of the Fabry-Perot) gives a upper limit for the bandwidth as 0.28 pm. FWHM.

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