FREQUENCY AGILE Tm,Ho:YLF LOCAL OSCILLATOR FOR A SCANNING DOPPLER WIND LIDAR IN EARTH ORBIT

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ABSTRACT

A compact cw Tm,Ho:YLF laser with single-mode tunability over +/- 4 GHz has been developed into a modular unit containing an isolator and photomixer for offset tuning of the LO from a master oscillator which controls the frequency of a Doppler lidar transmitter. This and an alternative diode laser LO will be described,

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During the past year several advances have been made in the design and fabrication of a compact, modular cw Tm,Ho: YLF laser which is designed for both short-term (time scale of a few ms) frequency stability and continuous single-mode tunability over a range of frequencies which would be encountered with an Earth-orbiting coherent Doppler lidar using a conical scan and nadir angle in the neighborhood of 30°. The laser is to be used as a local oscillator (LO) in a testbed 2-pm Doppler lidar. It is pumped by nominal 1-W diode array at 792 nm, which is located remotely and coupled into the LO unit via optical fiber.

A frequency-agile local oscillator is an important element in an Earth-orbiting coherent Doppler lidar. The capability to tune the LO in synchronism with the conical scan azimuth angle, tracking the Doppler shift imposed on the signal backscattered from the atmosphere due to spacecraft motion, obviates the need for a photomixer-preamplifier combination which provides near quantum-noise limited performance throughout a 4-5 GHz bandwidth. At 350 km altitude the spacecraft velocity is approximately 7700 m S-l. If the nadir angle of the conical scan is 30°, the Doppler shift at the extrema (fore and aft pointing) positions are nearly +/- 4 GHz. In addition the earth's rotational velocity (465 m s^{-1} at the equator) introduces a frequency shift which is latitude dependent as well as azimuth scan angle dependent.

A schematic of the LO is shown in Figure 1, Although the basic cavity design is similar to that of the single-mode laser described previously [1,2], the cavity is much shorter, the output coupler is much smaller with reduced reflectance, and the optomechanical structure has been completely redesigned, The optical elements are in miniature mounts mechanically constrained by a set of four small Invar rods and include a Faraday isolator in addition to the pump conditioning optics the crystal, and the cavity elements. The cavity length is 13 mm. The cavity design is a compromise in an attempt to maximize the longitudinal mode spacing, the single mode output power, and the resistance to off-axis mode or secondary longitudinal mode oscillation, while limiting the effects of acoustical and thermal fluctuations on the frequency stability. The laser crystal is attached to a thermoelectric (TE) cooler plate and is temperature stabilized with a compact controller designed at JPL. The laser environment is flushed with dry nitrogen and maintained with a low water vapor partial pressure. The laser crystal temperature is maintained near 0° C, Efficient heat rejection is an important issue due to the small mode dimensions and the compact structure, In fact the optimum pump power at present is closer to 500 mW than the full power capability of the diode array.

As shown in the schematic the Laser Head includes not only the LO but also a pair of beam splitters and a photomixer for provision of offset frequency locking or tuning with respect to an external laser which injection seeds the lidar transmitter. The injection laser, or master oscillator, would be independently stabilized to e.g., a reference cavity. For our studies of LO performance a two-laser configuration is used, the second laser mimicking the injection laser, stabilized to an external etalon. Outputs from the two lasers are mixed on a 1.5 GHz bandwidth iridium gallium arsenide photomixer. The photomixer output signal is very useful for frequency stability studies, as mentioned previously [2]. Offset tuning beyond the photomixer bandwidth is observed with a 150 MHz free spectral range (FSR) etalon, while additional etalons with FSR'S ranging up to 150 GHz (corresponding to a 2 nm wavelength spacing at 2 μm) are used to study the mode structure during offset tuning. The spectral width of the lasing transition in the crystal is rather large, extending over a range of about 15 nm. Since the gain medium is not completely homogeneously broadened, and more importantly for laser design, since spatial hole burnign effects exist, simultaneous oscillation can occur on modes spaced by a few nm. The intracavity etalon reduces this possibility; however if the gain is high enough, secondary modes can appear. The use of the various etalons is essential to gain the necessary understanding of the parameter space for single mode operation with a particular laser cavity, pumping level, and crystal temperature.

In conclusion, with the use of the dual laser configuration it has been demonstrated that +/- 4 GHz of continuous single-mode tunability can be obtained with a compact Tm,Ho:$YLiF_4$ laser suitable for use as a frequency agile local oscillator. A unit will be used at the NASA Marshall Space Flight Center in a testbed Doppler lidar.

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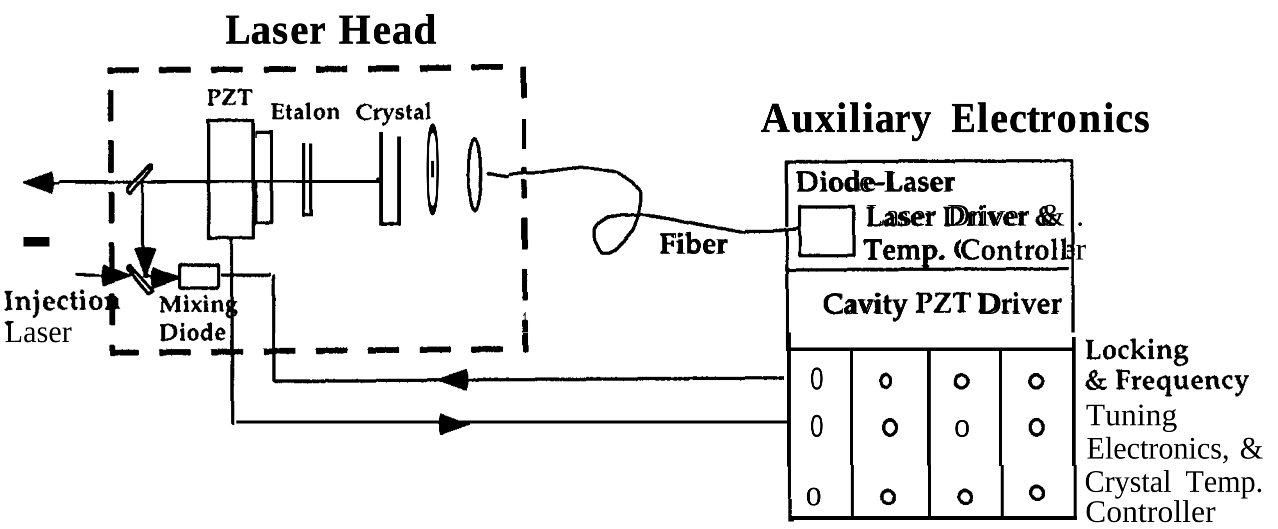

Laser Head Volume: < 10 cm x 14 cm x 28 cm

Figure ***1. Schematic of the Frequency Agile Local Oscillator Laser***