MEDIUM POWER STABLE LASERS FOR HIGH PRECISION METROLOGY

by

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Abstract

Medium power (5-10W) single frequency lasers with low intensity and frequency noise, plus good beam quality are required for a range of high precision metrology applications. Examples of such applications include laser interferometric detection of gravitational waves and long range vibrometry. In this thesis I will describe the development of a compact and efficient, single frequency, injection-locked, 5 W Nd:YAG laser. The laser output is close to diffraction limited with M^2 values of 1.0 and 1.2 in the horizontal and vertical planes respectively.

The slave laser is a diode pumped slab laser based on the co-planar pumped folded zig-zag slab laser geometry. The slab is side pumped using a single twenty watt laser diode array.collimated by a Doric fibre lens. The slab is tranversely cooled using Peltier cells that are air cooled.

We use injection-locking to force single frequency operation and to transfer the frequency stability of the monolithic Non Planar Ring Oscillator (NPRO) master laser to the output of our slave laser. The inherrent stability of the slave laser allows injection-locking for periods of up to 30 s without the use of servo control. We achieve long term injection-locking by controlling the slave laser resonator using a Pound Drever Hall frequency control servo system.

A heterodyne technique is used to study the phase fidelity of our injection-locked laser compared to that of our master laser. We show that the slave laser contribution to the frequency noise of our injection-locked laser is negligible compared with the frequency noise of the free running master laser. This is in good agreement with theory.

The relative intensity noise of the injection-locked slave has also been measured and is less than 10^{-5} $/\sqrt{Hz}$ at low frequencies. Further intensity noise reduction, in excess of an order of magnitude at low frequencies, has been achieved by electronic feedback to the slave laser pump source (a high power multi-emitter diode linear array). The laser is shot-noise limited above 5 MHz for 6 mA of detected photo-current.

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