GEO 600 Slave Laser Prototype II

I. Zawischa*, O.S. Brozek†, V. Quetschke‡, C. Fallnich*, B. Willke‡, K. Danzmann†‡ and H. Welling*

* *Laser Zentrum Hannover, Hollerithallee 8, D-30419 Hannover*
† *Max-Planck-Institut für Quantenoptik, Außenstelle Hannover, Callinstraße 38, D-30169 Hannover*
‡ *Universität Hannover, Institut für Atom- und Molekülphysik, Callinstraße 38, D-30169Hannover*

Abstract. Key-points of the design of the quasi-monolithic, longitudinally diode-pumped 13W Nd:YAG ring-laser that serves as slave in the GEO 600 injection locked laser source are reported. Performance data of the 2nd stage prototype are given as well as a short outlook to the next steps.

The light source for the GEO 600 gravitational wave detector will be an injection locked laser system. A diode pumped, monolithic non-planar ring oscillator (NPRO) is taken as master oscillator. It is pre-stabilized to a vacuum suspended ULE reference resonator. Intensity fluctuations are reduced by a feedback to the pump diode current. In order to increase the output power from about 800 mW to the GEO requirement of about 10 W a power oscillator is injection locked to the NPRO emission. The slave laser cavity is kept within the locking range to the NPRO emission by the Pound-Drever-Hall technique. Further information about the whole laser system can be found in reference 1.

The GEO slave laser is designed as a longitudinally, mode selectively pumped two rod bow tie ring resonator (fig. 1). This design was chosen because its high efficiency minimizes energy supply requirements as well as waste heat removal requirements. The latter affords high passive stability of the resonator where as the first promises good passive stability and active control properties in the power supply.

In the 2nd stage prototype two fused silica Brewster plates compensate for the astigmatism of the resonator and the hot laser crystals and enforce p-polarized emission. Together with the depolarizing effects in outer radii of the rods the plates also efficiently suppress higher transverse modes.

As a special feature in active resonators the laser employs a quasi-monolithic resonator design, i.e. three of four mirrors are pressed and glued directly to the rigid aluminum spacer. The fourth, piezo mounted mirror is glued into a special jig and once again fixed in proper position to the spacer without any later alignment and self-misalignment possibilities. Thus a very rugged, disturbance insensitive, and potentially long-term stable laser could be realized.

At 34 W pump power the laser system emits radiation at 1064 nm in excess of 13W in a 99% p-polarized TEM_{00} mode. With spherical lenses 94.5 % of the externally attenuated beam could be coupled through a ring mode cleaner cavity of finesse 200 (fig. 2 left). As the attenuation polarizers are believed to cause some mode distortion,

CP523, *Gravitational Waves: Third Edoardo Amaldi Conference*, edited by S. Meshkov

and residual ellipticity is not corrected even better values are expected in the final setup.

In order to estimate the short term stability of the slave resonator the piezo actuator signal within the locking servo bandwidth was recorded and converted to the corresponding free-running frequency correction (fig.2 right). During this measurement the master laser was kept locked to its reference cavity. The frequency correction signal is almost identical to the frequency fluctuation of a free running NPRO. Though being a very good result, the coincidence requires further investigation and renders the data preliminary.

As future steps the resonator spacer will be cut in Ni36Fe64 alloy reducing the sensitivity to thermal fluctuations of the environment. Furtheron focus will be put on an intensity noise reduction by both passive pump diode current filtering and active feedback from an optical power monitor. Applicability of pump current modulation as part of the frequency servo (as it works well with the NPRO) will be considered.

The authors wish to thank I. Freitag, S. Knoke, for their support during the development of the laser.

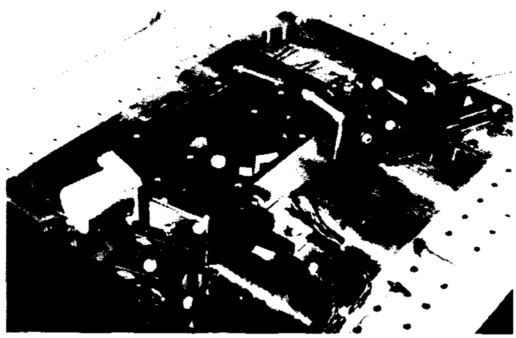

FIGURE 1. Photograph of the GEO 600 Slave Laser Prototype II.

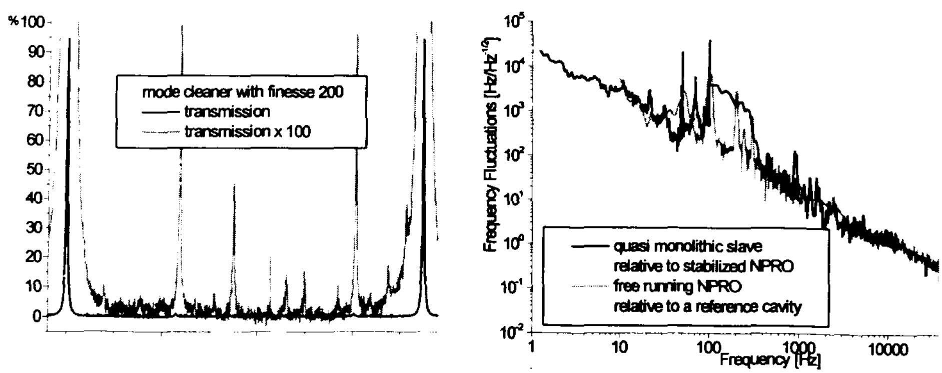

FIGURE 2. Performance of the GEO 600 Slave Laser Prototype II.

1. B. Willke et. al., The GEO600 Stabilized Laser System and the Current-Lock Technique, this proceedings