The Laser System For The LISA Technology Demonstrator

O.S. Brozek[1], M. Peterseim[1,2], K. Danzmann[1],
I. Freitag[3], C. Fallnich[2], H. Welling[2]

1) Max-Planck-Institut für Quantenoptik, Callinstrasse 38, D-30167 Hannover
2) Laser Zentrum Hannover, Hollerithallee 8, D-30419 Hannover
3) Innolight GmbH, Vahrenwalder Strasse 7, D-30165 Hannover

Abstract. Future space science missions rely on qualified interferometric position and length measurement technology. Laser metrology is one of the key issues. We describe the laser system for the LISA technology demonstrator. This laser system consists of a laser-diode pumped monolithic non-planar Nd:YAG ring laser with a design optimised to withstand the severe space environment.

1. INTRODUCTION

Key technologies for the laser interferometer space antenna - LISA [1] - are drag free control, micro-Newton thrusters and laser metrology with highly stabilised lasers in the detection frequency-band between 1 mHz and 1 Hz [2,3]. It is of great importance to validate these technologies in space. The aim of the LISA technology demonstrator, currently studied by both ESA and NASA, is to prove these techniques in space in a GTO, geosynchronous or other suitable orbit. The laser metrology shall be demonstrated with a measurement accuracy of better than 10 pm/$\sqrt{\text{Hz}}$.

2. THE LASER SYSTEM

Due to their compactness and high efficiency laser-diode pumped monolithic non-planar Nd:YAG ring lasers (NPRO) [4,5] show excellent frequency and power noise performances and are therefore best suited for this mission. The laser (Fig.1) is fabricated in a way that the laser resonator and the active medium are made of one monolithic piece of Nd:YAG. The resonator geometry is enforced by total internal reflections and the dual band coated front surface. The laser is pumped by two laser diodes at 808 nm, which are operated at 50 % of their nominal output

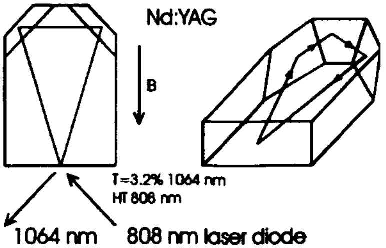

FIGURE 1: *Ray traces in the monolithic Nd:YAG ring laser.*

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

power to achieve a redundant pump scheme in case of the failure of one of the diodes. An optical output power of 1 W is required for LISA, but a few mW are sufficient for the technology demonstrator. Active power stabilisation and frequency stabilisation to a Fabry-Perot ring cavity will be used to achieve $5\times10^{-4}/\sqrt{\mathrm{Hz}}$ of relative power noise and 1.5×10^{3} $\mathrm{Hz}/\sqrt{\mathrm{Hz}}$ of frequency noise in the frequency-band between 1 mHz and 1 Hz [2]. A compact laser head (Fig.2) has been designed that fulfils the power and mass constraints and withstands thermal and mechanical stresses as encountered, e.g., during launch. All components are included in a quasi-monolithic design with no movable parts and are contacted to a massive mono-block made of fused silica. The light from the NPRO is matched into a polarisation preserving single-mode fibre. The fibre directs the laser light to the optical bench of the main experiment, where it is used to verify the performance of the drag free control system [1,2].

The selection, space qualification and mechanical design studies of the individual components of the laser head are under progress.

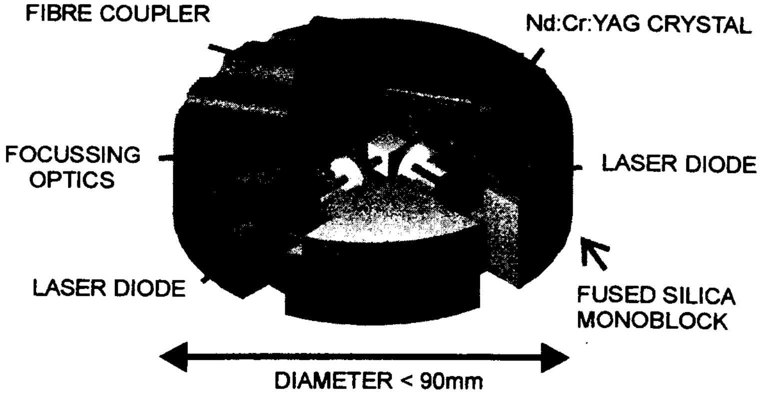

FIGURE 2: *Schematic layout of the quasi-monolithic laser head.*

ACKNOWLEDGMENTS

This work was supported by a grant of the Wernher von Braun Stiftung zur Förderung der Weltraumwissenschaften.

REFERENCES

1. K. Danzmann et al., *LISA: Pre-Phase A Report*, 2nd Edition, MPQ **233**, 1998.
2. M. Peterseim et al., *Advances in LISA technology*, these proceedings.
3. M. Peterseim, O.S. Brozek, A. Tünnermann and K. Danzmann, *Earthbound and deep space testing of laser metrology*, AIP Conference Proceedings **456**, 391-395 (1998).
4. T. Kane and R.L. Byer, *Monolithic, unidirectional single-mode Nd:YAG ring laser*, Opt. Lett. **10,** 65-67 (1985).
5. I. Freitag, A. Tünnermann and H. Welling, *Power scaling of diode-pumped monolithic Nd:YAG lasers to output powers of several watts*, Opt. Comm. **115,** 511-515 (1995).