LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
- LIGO -
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Nd^{3+} Laser Target Specifications

Title

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NOTE: This version is a re-creation of E950081-05 due to loss of the original file. It has been checked for accuracy, but it is not the original document. D. Shoemaker

This is an internal working note
of the LIGO Project

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1 GENERAL

The following are target specifications for the Nd^{3+} lasers for LIGO. These specifications are subject to revision pursuant to agreements made at the conclusion of Phase 1, and as incorporated in the Final Nd^{3+} Laser/LIGO Design.

2 TYPE OF LASER

10 W, single frequency Nd^{3+} solid state laser.

3 PUMPING

The pumping will be based on diode lasers.

4 LASER LIGHT

4.1 General Properties

1. Wavelength: λ=1.064 μm, single frequency.
2. True CW.
3. Output power: >10 W in a circular TEM_{00} mode
4. Polarization: linear, within 1^o of vertical, extinction ratio >500:1

4.2 Stability

1. Warm-up time: <1 hour. The following stability specifications (2-7) refer to laser after warm-up.
2. Power: long term variation < 0.5% over 24 hours
3. Relative frequency drift $<10^{-6}$ per ^{o}C of ambient temperature change.
4. Frequency drift <100 MHz/hour at constant ambient temperature.
5. Pointing drift $<10^{-4}$ rad per ^{o}C of ambient temperature change.
6. Pointing drift $<10^{-4}$ rad at constant ambient temperature, over 24 hours.
7. Beam diameter stability: within 0.5% over 24 hours

4.3 Noise

1. Relative power fluctuations
   - Less than$10^{-5}/Hz^{1/2}$, between 100 Hz and 10 kHz
   - Less than$10^{-6}/Hz^{1/2}$, between 10 kHz and 3 MHz
   - Shot noise limited (at 10 mA photodetected current) above 10 Mhz
   - Relaxation oscillation: critically damped or overdamped
2. Frequency fluctuations: $<3x10^3$ Hz/$Hz^{1/2}$ at 100 Hz, $<3x10^2$ Hz/$Hz^{1/2}$ at 1 kHz

5 OUTPUT CONTROL

Frequency control:

1. Continuously tunable over >2 GHz range, within one hour
2. Continuously tunable over >10 MHz range, at rates up to 30 kHz

6 INTERFACES

6.1 Electrical

1. Mains: 110V-60Hz, single phase, maximum 1.5 kW/laser
2. Controls, outputs and inputs

The laser and associated components shall be designed such that the unit can be operated locally or remotely via a remote control interface. The following inputs and outputs shall be included:

1. Laser on/off and standby control and status monitor
2. Laser shutter control and status monitor
3. Local/Remote control switch and monitor. Local control shall be the default mode of operation.
4. Laser frequency control as specified in section 4.1 and 4.2
5. Laser output power control and monitor
6. Laser head temperature indicator
7. Laser pump diode current and voltage monitor

Acceptable types of remote interface signals include:

1. Analog Voltage levels for reference and feedback: 0-10V, ±5 V, ±10 V
2. Binary voltage levels for status and state control: TTL, 12-30 VDC
3. Contact closure for status and state control: rated 24 VDC, 1A min.
4. Other signals or types of interfaces shall be approved by LIGO prior to implementation

3. Connectors:
   All connectors shall be commercially available items that can be obtained from multiple sources. In the event that this is not possible or feasible, the vendor shall provide the connector and its mate with the unit.

6.2 Mechanical

1. The laser beam and the laser support points will be referenced to a rigid mechanical structure.
2. Support points for lifting and other handling will be provided.
3. If the laser subsystem is composed of more than one component (e.g., cooling unit/power supply/laser head), any cabling or other connections between the laser head and other components shall be at least 5m in length.

4. The laser head and any other components placed on the optics bench shall occupy an envelope no greater than 0.5m(W) x 1m(L) x 0.5m(H)

6.3 Cooling

1. Cooling capacity and type (air, water) to be determined by the vendor.
2. The laser cooling unit will be separate from the laser head.
3. The cooling unit will be self-contained and operated on 110 V power.

7 RELIABILITY AND MAINTENANCE

1. MTBF: >10,000 hours.
2. Minimum stretch of continuous operation, between required maintenance events: 500 hours.
3. Laser subsystems that need periodic maintenance will be designed as modules, kinematically attached to the frame whenever needed, and easy to access, remove and replace.
4. Design for easy maintainability, by technical personnel with average training level in operating and maintaining lasers.

8 SAFETY

1. The laser design shall incorporate the following additional safety features in compliance with ANSI Z136.1-1993:
    1. Protective housing
    2. Interlocks on protective housing
    3. Service access panel
    4. Key control
    5. Activation warning systems
    6. Labels

2. All control inputs shall be internally protected against overload damage.
3. Recommend optimum protective eyewear and provide information on other potential hazards of this laser design.
4. Provide instructions for safe operation of this laser system.

9 TRANSPORTABILITY

The laser should be transportable by commercial carrier without degradation in performance. Special shipping containers necessary to comply with this requirement as well as shipping and handling instructions shall be provided by the laser manufacturer.