

**LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
- LIGO -**

**CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY**

LIGO-E970055-01-D	6/13/97
Target Specifications	
LIGO 10-W Laser	

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1 PERFORMANCE SPECIFICATIONS

<i>Parameter</i>	<i>Specification</i>
1. Power in circular TEM ₀₀ mode	> 10 W
2. Total power in all non-TEM ₀₀ modes	< 1 W ($M_{\text{horizontal}} \times M_{\text{vertical}} < 1.1$)
3. Relative spot size fluctuations, $\delta w/w$	< 2% peak-to-peak
Relative Power Fluctuations, $\delta P(f)/P$:	
4. Drift over 24 hours	< 1% peak-to-peak
5. Drift over 500 hours	< 3% peak-to-peak
6. 1-100 Hz	< [-100 + 40 log(100 Hz / f)] dB / Hz
7. 100 Hz - 10 kHz	< -100 dB / Hz
8. 10 kHz - 3 MHz	< -120 dB / Hz
9. 10 MHz	< -163 dB / Hz (within 2 dB of the shot noise limit for 10 mA photodetected current)
Relative Power Fluctuations, $\delta P(f)/P$, at 60 Hz Line Frequency and Harmonics:	
10. 60 Hz and 120 Hz	< 1×10^{-5} rms
11. Between 150 Hz and 10 kHz	< 1×10^{-5} rms
12. Between 10 kHz and 3 MHz	< 2.4×10^{-6} rms
13. Relative power fluctuations, $\delta P(f)/P$, at Model 126 power supply switching frequency (~80 kHz)	< 2×10^{-5} rms
Frequency Fluctuations:	
14. Between 40 Hz and 100 Hz	< [54 + 50 log(100 Hz/f)] dB Hz ² / Hz
15. Between 100 Hz and 10 kHz	< [54 + 20 log(100 Hz/f)] dB Hz ² / Hz

<i>Parameter</i>	<i>Specification</i>
<p>Frequency Drift:</p> <p>16. At constant ambient temperature</p> <p>17. At constant ambient temperature</p> <p>18. Per degree ambient temperature change</p>	<p>< 50 MHz / hour</p> <p>< 1 GHz / month</p> <p>< 30 MHz</p>
<p>Frequency-to-Intensity Conversion:</p> <p>19. Fractional power change (W/W) per Hz of frequency change</p>	<p>< 2×10^{-10}</p>
<p>Relative Pointing Angle Fluctuations, $\delta\theta/(\theta_d/2)$, (divergence half angle, $\theta_d/2 = \lambda/(\pi \times w_0)$):</p> <p>20. Drift over 24 hours</p> <p>21. 40 Hz to 150 Hz</p> <p>22. > 150 Hz</p>	<p>< 2.5×10^{-2} peak-to-peak</p> <p>< $[-110 + 40 \log(150 \text{ Hz} / f)] \text{ dB} / \text{Hz}$</p> <p>< -110 dB / Hz</p>
<p>Relative Transverse Position Fluctuations, $\delta x/w$, (w is the spot size):</p> <p>23. Drift over 24 hours</p> <p>24. 40 Hz to 150 Hz</p> <p>25. > 150 Hz</p>	<p>< 2.5×10^{-2} peak-to-peak</p> <p>< $[-110 + 40 \log(150 \text{ Hz} / f)] \text{ dB} / \text{Hz}$</p> <p>< -110 dB / Hz</p>
<p>26. Polarization extinction ratio</p>	<p>> 300:1</p>
<p>27. Electromagnetic interference (EMI) emissions</p>	<p>In compliance with CE mark, EN 55011 Class A</p>
<p>Reliability:</p> <p>28. Mean time between failure (MTBF)</p> <p>29. Minimum time between required beam alignment adjustments</p>	<p>> 10,000 hours</p> <p>> 2,500 hours</p>

2 CONFIGURATION SPECIFICATIONS

<i>Parameter</i>	<i>Specification</i>
30. Type of laser	Nd ³⁺ :YAG
31. Wavelength	1064 nm
32. Optical scheme	Master Oscillator Power Amplifier, double-pass
33. Amplifier pumping	8 x 20-W diode bar, direct-coupled, side-pumped
Frequency Control:	
34. Thermal tuning range, continuous	10 GHz
35. Thermal tuning range, total	30 GHz
36. Thermal tuning rate	1 GHz/sec
37. Piezo tuning range, ± 15 V	30 MHz
38. Piezo response bandwidth, small-signal	> 30 kHz
39. Warm-up time	< 1 hour
Laser head, mechanical:	
40. Support structure	2 ft. x 2 ft., 1/4 in.-20 tapped holes on 1 in. square grid
41. Modules/components	a. Model 126-1064-700 master oscillator b. Power amplifier, sealed c. Coupling and beam control optics
42. Beam height above support structure	TBD ± 0.05 in.
43. Cover	Removable dust protective cover, metal
44. Total laser height	< 1 ft.
45. Distance from laser head to power supplies	Up to 50 ft.

<i>Parameter</i>	<i>Specification</i>
Laser head, optical:	
46. Output beam waist spot size, w_0	0.25 mm TBD ± 0.1 mm
47. Output beam waist location	TBD ± 50 mm from output aperture
Laser chiller:	
48. Type	Low-temperature, bath circulator
49. Manufacturer, Model	Neslab, RTE-140M
50. Cooling capacity	600 W at 10 °C, at ambient temp. of 20 °C
51. Pumping capacity	0.9 gpm through 100 ft. length of 3/8 in. ID hose
52. Dimensions (h x w x d)	66.0 cm x 31.4 cm x 48.3 cm (> 12 in. clearance at front and rear for ventilation)
53. Distance from laser head to chiller	Up to 50 ft.
54. Distance from chiller microprocessor controller to chiller	Up to 50 ft.
55. Laser safety	In compliance with federal register 21 CFR 1040.10 & 1040.11 laser safety standard
56. Transportability	Transportable by commercial carrier without performance degradation

3 ELECTRONICS SPECIFICATIONS

Refer to *Specification for LIGO 10W Laser Amplifier Electronics*, Lightwave Electronics document number D-0226X2.DOC, attached.