LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
- LIGO -
CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

2022/06/07

# OLD SURF PROPOSAL

Jennifer Hritz

**California Institute of Technology**
**LIGO Project, MS 18-34**
**Pasadena, CA 91125**
Phone (626) 395-2129
Fax (626) 304-9834
E-mail: info@ligo.caltech.edu

**Massachusetts Institute of Technology**
**LIGO Project, Room NW22-295**
**Cambridge, MA 02139**
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

**LIGO Hanford Observatory**
**Route 10, Mile Marker 2**
**Richland, WA 99352**
Phone (509) 372-8106
Fax (509) 372-8137
E-mail: info@ligo.caltech.edu

**LIGO Livingston Observatory**
**19100 LIGO Lane**
**Livingston, LA 70754**
Phone (225) 686-3100
Fax (225) 686-7189
E-mail: info@ligo.caltech.edu

http://www.ligo.caltech.edu/

# Methods of Improving Optical Contacting

Jennifer Hritz, Caltech

Mentor: Professor Rana Adhikari, Caltech

**Abstract**

This project will attempt to improve optical contacting between silicon objects. There will be a focus on the use of heat and pressure to increase the strength of the bond. The eventual goal is to make optical contacting strong enough to be a viable method for conjoining pieces of high precision equipment in space, specifically for the LIGO Voyager.

## 1 Background

Optical contacting is the phenomenon of bonding very flat, highly polished surfaces together using molecular forces instead of adhesives. Van der Waals dispersion forces are believed to be the main cause of this adhesion. These forces are weak between single atoms and molecules at large distances, but bring many atoms and molecules very close together and it makes for an incredibly strong bond. Any contamination or deviation from flatness will result in fewer, weaker bonds, hence polishing and cleaning are an imperative step in optically contacting two plates.[1]

When performed properly, the bond between the two surfaces is strong enough to effectively turn them into one plate. The applied force is concentrated at the edge, so while pulling apart the two plates is difficult, it can be broken by wedging the plates apart at an edge or corner.[2] The only way to destroy this adhesion is through thermal stress, where unequal heating causes thermal expansion to break the closeness of the surfaces.[3] The efficacy of the bond can be tested by determining the tensile strength or measuring heat flow.[1][4]

Heat and pressure were shown to be important in creating a good bond.[4] Optical contacting could theoretically occur between any two surfaces, but it is typically performed with silicon or silicon-containing molecules due to its weight and thermal properties.

## 2 Motivation

Optical contacting is a fairly unexplored field but has big uses in space, where strong, light bonds are a necessity. Furthermore, the near perfect bond allows two pieces to effectively be turned into one without the use of adhesives which risk failing due to having different chemical and thermal properties. Silicon's small thermal expansion coefficient makes it particularly useful for high sensitivity probes[1] including gravitational wave detectors such as LISA and the LIGO Voyager.

However, before optical contacting can be of use, it needs to be studied further. The aim of my research to explore methods of optimizing optical contacting to produce a consistently

strong bond. This includes refining previous work which indicated that heat and pressure were instrumental in good bonds. If I can produce sufficiently strong bonds, I will proceed to working on their application in the LIGO Voyager.

# 3 Approach

I will create a smooth silicon surface then optically bond it in a sterile environment. Once a bond has been achieved, I will test the strength then repeat the process based on the gained insights.

# 4 Proposed Work

Week 1 – 2: Training and familiarization with fabrication and preparation of silicon surfaces.

Week 3 – 4: Attempting to achieve optical contact.

Week 5 – 6: Testing different bond methods, including controlling heat and pressure.

Week 7 – 10: Measuring the success of bonds and further refining methods to improve their strength.

# 5 Summary

Through optical contacting, silicon surfaces can be adhered into a single object which, if optimized, could prove useful for the LIGO Voyager.

# References


[1] Wright, J. J. Zissa, *D. E. OPTICAL CONTACTING FOR GRAVITY PROBE STAR TRACKER*. 14 (1984).

[2] Rayleigh, Lord, *Optical Contact*. Nature 139, 781–783 (1937).

[3] Ferme, J.-J., *Optical contacting*. in (eds. Geyl, R., Rimmer, D. Wang, L.) 26 (2004).

[4] Zawada, A., *Final Report: In-Vacuum Heat Switch*. 14.