Introduction

- The Center for Applied Physics Studies (CAPS) located at Louisiana Tech University has commenced a research program in gravitational physics at the LIGO Livingston Observatory in Livingston Parish, Louisiana.
- The CAPS group has assumed responsibility for the installation and operation of seismic measuring devices for the purpose of measuring and characterizing
  - the low frequency noise spectrum centered around the microseismic peak which impacts the servo-control of the LIGO interferometer, and
  - the gravity-gradient noise which is anticipated as a limiting background for advanced LIGO design work.

Introduction (continued)

- Residual gases are detrimental to light transmission because of scattering and because the gases tend to contaminate the core optics.
- CAPS will initiate a program of residual gas studies using surface analysis techniques.
- Surface analysis technology available at the Louisiana Tech Institute for Micromanufaturing of which CAPS is a member.
- New surface decontamination techniques will be explored.

Seismic Study I: Microseismic Noise

- Apparently driven by local ocean activity and therefore site-dependent
- The maximum noise for which the servo-control feedback system must compensate.
- Study seasonal variation of microseismic noise at LLO

Benefits of Seismic Study I

- Further assurance of servo-control set-point based on limited data set by A. Rohay.
- important for Advanced LIGO design
  - microseism will likely determine the time the detector is "on", in integrated time and in length of continuous stretches
  - advanced knowledge of microseism will likely determine future directions in seismic isolation and servo topology

Seismic Study II: Gravity-gradient noise

- Occurs when ambient seismic waves pass near and under an interferometric gravitational wave detector inducing density perturbations in the earth producing fluctuating gravitational forces on the test masses.
- Mimic stochastic background of gravitational waves and thus constitute a noise source.
- Since gravity-gradient noise is the limiting source of noise for the Advanced LIGO interferometer, a major goal of this work is to adequately characterize this noise in order for it to be subtracted from the data.

Seismic I LSC Coordination

- We will be coordinating the microseism measurements with members of the LSC Stochastic Forces-Isolation and Suspension Systems group, (chiefly D.Shoemaker at MIT and G. Gonzalez at PSU) and with M. Coles and the LLO staff
- In discussion over a role CAPS might play in incorporating seismology effort in actuator control design (Co-PI Alley Butler).

Seismic II LSC Coordination

- Characterization of gravity gradient noise will be performed by teams from Louisiana Tech (CAPS) and the University of Oregon.
- Work will be coordinated for the LSC Stochastic Forces-Isolation and Suspension Systems group (see the 1998 LSC White Paper on Detector Research and Development section on Isolation) by PSU and with Kip Thorne's group at Caltech.

Residual Gases

- In LIGO Document T960124-00, R. Weiss describes problems of and states limits for residual gases in the beam tubes and baffles. The allowed residual gas pressure in the beam tubes is set by the anticipated sensitivity of the detectors in LIGO.
- Contamination on mirrors : from outgassing by the beam tube and baffles
- Mirror heating associated with this absorption will require recollimation of the input beam and could, if excessively large destroy the coatings.
- The offending adsorbed layers are most likely hydrocarbons which are activated by the laser intensity to absorb the laser light.

Residual Gas Studies at IfM by CAPS

- CAPS will analyze the surface properties of materials in the LIGO vacuum system.
- K. Johnston, Director of CAPS, and J. Maxwell, Director of the Institute for Micromanufacturing (IfM), have a collaborative agreement between the two Centers for shared use of the facilities in both Centers.
- The IfM
  - has several surface analysis techniques: such as XPS and Auger Spectroscopy
  - State-of-the-art metrology laboratory with capabilities in AFM/STM, SEM, interferometric microscopy, etc. for surface roughness studies.

Residual Gas Studies (continued)

- IfM institute a fleet of surface studies to identify the exact contaminant and the surface structure.
- CAPS has a high vacuum, liquid He refrigerator that can cool samples in a vacuum which can be used to study the temperature effects of the core optics cryogenic mirrors that may be needed for LIGO III.

Coordination of RGA work with LSC

- K. Johnston and J. Maxwell will coordinate their CAPS and IfM Residual Gas study with
  - R. Weiss
  - the bakeout crews
  - M. Coles and the LLO staff

FUTURE

DIRECTIONS

- Decontamination Techniques
- Applications of micro-technology

Decontamination Techniques

- Remove the core optics and clean which will entail considerable down time and expense assuming feasibility without damge.
- Active removal of contaminants in situ, i.e. attached to the isolation system and in a vacuum. At Tulane University , Laser Assisted Particle Removal (LAPR) under development. LAPR removes particles from surfaces using a laser and a medium to transfer energy from the laser beam to kinetic energy in the particles. Disadvantage: a medium must be flowed across the surface thus destroying your vacuum.
- Radiation pressure technique: a tightly focused laser beam used to push the particles off surfaces. Advantage:can do in situ in LIGO vacuum perhaps continuously or periodically with minor down times to clean the mirrors.

IfM

The Raptor Project

The Institute for Micromanufacturing

Louisiana Tech University

Freeform Growth of Amorphous Carbon Coils: Resolution