New Folder Name Initial Design Tasks

LIGO PROJECT

CALIFORNIA INSTITUTE OF TECHNOLOGY

TO Science Team

FROM Interferometer Design Team

SUBJECT Initial Design Tasks

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The interferometer conceptual design team has identified three LIGO design issues that require immediate work, to be divided among three subteams, as listed below. The work of each subteam should begin with an assessment of techniques and implementations tested in the 40-m and fixed-mass prototype interferometers; initial designs should be based directly on the prototypes. Departures from tested designs should be minimized and noted explicitly.

The schedules for the design work will evolve as the work proceeds. At the next Review Meeting, 21 February, each team should present a rough outline of planned work, a preliminary estimate of time and effort required, and any early results.

1. Optical topology and modulation

Description of task

The arrangement and operation of optical components and modulators is the most critical and least developed of the identified design tasks. Several schemes have been proposed, but none tested in a suspended interferometer.

Assumptions

- "Initial interferometer" configuration, with a single argon ion laser, monolithic test masses, recombination.
- Sensitivity comparable to the projection on page 56 of the December 1989 proposal. This is a rough guide to required performance, not a requirement.
- Broadband ("power") recycling, included from the start or left as an option.

Deliverables

1. A diagram with a level of detail similar to the one on page 47 of the December 1989 proposal. (The proposal design is not to be taken as the starting point.)
2. An explanation of operation, more complete and clearer than the one in the proposal.
3. Explicit details of the following:
    1. Number of modulators, frequencies, locations
    2. Explanation of modulation scheme
    3. Position control of critical optical elements
    4. Critical servo loop operation including interactions

Principals

The work will be given to two subteams, working in parallel and independently.

- R. Weiss, full-time, and D. Shoemaker, part-time.
- R. Drever, full-time, and R. Spero, part-time.

2. Test mass and beamsplitter control

Description of task

The design should include the following interrelated subsystems:

- "Suspension system", starting from the quiet end of seismic isolation stack and ending with the suspended component.
- Sensing and control of angular orientation of test masses, beamsplitter, and other critical optical components.
- Sensing and control of longitudinal position of mirrors and other components, including test masses, that must be controlled relative to the optical phase of beams.
- Sensing and control of position transverse to incident beams.
- A system for acquiring optical resonance and positioning phase-critical components, starting cold ("lock acquisition").

Assumptions

- There are two or more levels of precision required, depending on the function of the controlled component. The design task includes the most critical components, but the designs may be adapted to other, less critical, components.
- For critical degrees of freedom, there may be two or more sensors to meet requirements of dynamic range and accuracy.
- If necessary, the design will include test mass orientation control based on the resonant light ("automatic alignment").

Deliverables

1. Specification of which degrees of freedom are controlled, and a description of how the sensing and control are accomplished. Include details of the geometry of wire suspensions. If drift-compensating motors are included in the design, describe their operation.

2. Description of reaction mass forcers, if used.

3. Description of electrostatic, magnetic, or combination force transducers.

4. Details of application of forces at the test mass and near the suspension point (upper mass of "double pendulum"), and how the two types of feedback interact, if used together.

5. An analysis of the required precision and range of the control system, and an estimate of the as-designed performance.

6. A description of automatic alignment systems, if any.

7. A description of lock acquisition.

Principals

S. Kawamura, L. Sievers, M. Zucker.

3. Input optics

Description of task

The design should include the laser, reference cavity, and input mode cleaning cavity.

Assumptions

- The laser system will be similar to that in use in the 40-meter prototype.
- At least one mode cleaner will be built from suspended mirrors, perhaps similar to one of the 40-m arms in the prototype.
- The input mode cleaning and reference cavities provide a beam stabilized in frequency and spatial properties.
- The number of cavities, their arrangement, and geometrical parameters, is determined by required filtering, power handling capabilities, and modulation scheme.
- Optical fibers may be used to provide spatial filtering.

Deliverables

1. Number, location, and function of cavities.

2. Geometry, including length, mirror curvature, and number of mirrors.

3. Cavity bandwidth and any special considerations relating to modulation.

4. Performance, including spatial, amplitude, and frequency filtering properties.
5. Power handling capabilities.
6. Optical isolation requirements.
7. Mirror position requirements, and method of control.

Principals

A. Abramovici, F. Raab.

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