New Folder Name Autoalignment Experiments at MIT

LIGO PROJECT

LIGO-T910003-00-R

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

TO Science team — DATE 20 May, 1991

FROM D. Shoemaker — E-MAIL dhs

SUBJECT Proposal for suspended cavity research — FILE ~ dhs/labwork/hang1.tex

Proposal for autoalignment experiments at MIT

Relevance and scope Resonant cavities will certainly be part of the LIGO interferometer; however, alignment acquisition (getting the beam down the tube and onto the mirror), pointing, and in particular auto-alignment of these cavities have only been given limited attention. The systems on the 40 m grew in an organic fashion, and it is clear that a more systematic approach is now necessary. While some tests can be performed on rigid cavities, many of the important tests concerning low frequencies, modulation, and servo-systems require a hanging system. To properly investigate these questions involves a start-up time to produce a number of hanging masses and control systems. This is an advantageous time to start that process.

Caltech (FJR) will be starting at about this same time a program to study mode cleaners. Because of the need to try a hanging mode cleaner on the 40 m prototype, the effort there will concentrate on the pressing questions relevant to preparing a mode cleaner for that purpose. Three-mirror mode cleaners are of renewed interest, and so the plan at Caltech is to produce and test a three-mirror mode cleaner.

At MIT, interest is concentrated on the general problem of acquiring alignment and then auto-alignment of cavities (especially the 4 km arm cavities, but also for mode-cleaning cavities). These can be studied for two-mirror cavities, and if desired can be later extended to three-mirror cavities, depending on the results from the Caltech effort. Should it become desirable, some of the characterization of cavities as mode cleaners could also be performed at MIT.

The initial common MIT-Caltech effort will be the adoption of a standard hung mass design, resembling that used in the beasmplitter suspension of the 40 m prototype. This standard design will be duplicated to serve both research projects. In addition, we will be using common electronics for damping and (OSEMS).

Plan The program can be broken into two stages: (1) Initial studies on paper and with a rigid cavity. In parallel will be the development and production of the standard hanging mass suspension. This is done in coordination with the Caltech effort and with the LIGO engineering team. (2) The suspended cavity alignment research. Very rough, but conservative, estimates of the time required are 4 to 6 months for the first stage and 8 to 12 months for the second stage. A more detailed breakdown is attached.

Manpower DHS will be half-time until a new scientist is found for the MIT group, when a full scientist's time will be available to the project. One full-time graduate student is available (for whom the undertaking will form part of the PhD thesis material) and some part time from a second. Undergraduates will play a minor role.

Cost The proposed research fits in the current 1991 MIT budget, at 58 k$, along with the other MIT projects. These are continued rigid interferometry (30 k$), continued stack development (30 k$), and thermal noise research (30 k$). These fiugeres include new laboratory equipment as well as parts and construction costs. This leaves 18 k$ uncommitted for reserve. A more detailed breakdown of the suspended cavity research cost is attached.

Experimental tools The basic arrangement will consist of a pair of hanging, OSEM-damped mirrors on a 5 m baseline in vacuum. The light delivery system will be similar to the current rigid interferometer arrangement, except that the fiber output, mode matching, optical isolation, and RF modulation will sit on a suspended platform in the vacuum system. The light source will be an existing Spectra-Physics 165 Argon laser, which will be stabilized using the same established system as currently used with the rigid interferometer. To frequency analyze and mode-analyze the light transmitted by the cavity under test, a rigid scanning Fabry-Perot cavity will be suspended after it.

We have started studies on the requirements for the alignment precision and autoalignment bandwidth needed. Because this has shown that a significant misalignment involves a considerable beam motion (on the order of a mm), we will initially attempt to design a system which simply uses the position of the beams as the alignment error signal. Other, more complicated systems will be studied and implemented if this is not sufficient. Possibilities include the Ward reflection RF phase sensing, Anderson's higher-mode excitation technique, and mechanical mirror angle modulation.

Certainly CCD cameras will play the role which is currently performed by sending someone down to look at the far mirror; a more sophisticated application may prove worthwhile. Variants of the present 40 m pointing system may be employed.

Deliverables The deliverable from the reasearch plan will be a practical alignment acquisition and autoalignment design for LIGO, and an implementation appropriate to the prototypes.

Experimental plan and time frame

Develop and start production of suspensions,	
Develop detailed experimental plan	1-2 months
Prepare experimental tools,	
Study alignment schemes on rigid cavity	2-3 months
Install hanging cavity, light injection block, rigid analysis cavity	1-2 months
Initial tests (locking, pointing, alignment, debugging)	2-3 months
Detailed study of alignment error signals and servo control	4-6 months

Costs for suspended mode cleaner research **58k**

Stabilization of existing SP165 Argon laser		**18k**
optics		11k
Pockels cells (2)	5k	
replacement laser tube	4k	
piezo mounts for mirrors	1k	
reference cavity	1k	
electronics		7k
HV amplifier	3k	
RF amplifier	2k	
shop electronics, photodetector	2k	

Optics, electronics, mechanical		**40k**
suspensions (total for 5)		17k
electronics (CIT)	1k	
mechanical (shop and commercial)	2.4k	
price per mass subtotal	3.4k	
locking electronics (CIT)		2k
optics		8.5k
pockels cell (1)	2.5k	
misc. mirrors, $\lambda/2$, $\lambda/4$, pol. BS	5k	
diode lasers, couplers (for pointing)	1k	
electronics		12.5k
shop electronics (rf mod/demod, etc)	5k	
X-Y scanning galvonometers	1.5k	
CCD camera and frame grabber	6k	

Cindy

From dhs@tristan.mit.edu Mon May 20 10:31:40 1991
To: betty@ligo.caltech.edu
Subject: Re: Appointment with Robbie

Betty, 3pm Wed sounds good.

I am printing a slightly different version of the document that I sent out this morning (addressed to the Science team in stead of R. Vogt). Could you please have this duplicated and distributed to the science team, with a copy to WEA? Thanks! (Stan too, of course; is he part of the science team????) David

+ RV

I did copies for RV, SW, WA.
B