LIGO-T960174-00-D

FAX COVER PAGE

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DATE:	
TIME:	

FROM:	P. Fritschel
ORGANIZATION:	
FAX NUMBER:	
VOICE NUMBER:	
REFER TO:	
SUBJECT:	Eddy current damping

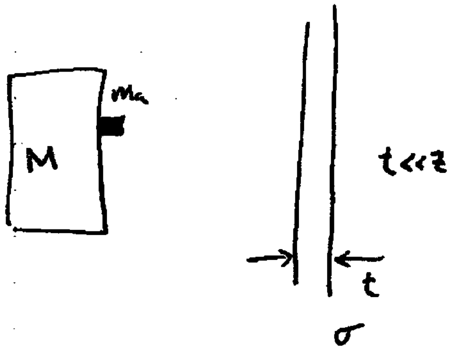
NUMBER OF PAGES FAXED INCLUDING THIS COVER SHEET:	

NOTES: Dennis - Here are my scribbles, Rai's scribbles, + a summary of the eddy current damping experiment.

— Peter

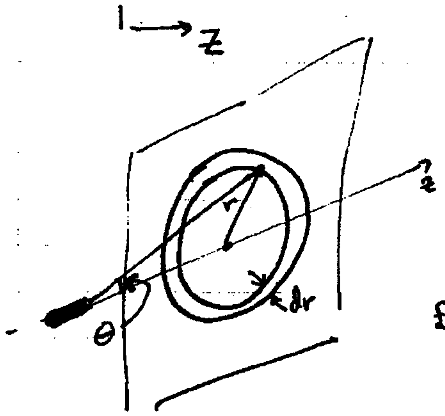
Laser Interferometer Gravitational-Wave Observatory

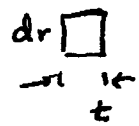
PF
June 94



$$B_r = \frac{\mu_0 m_a}{4\pi z^3}\left(2\cos^2\theta - \sin^2\theta\right)$$

$$B_t = \frac{\mu_0 m_a}{4\pi z^3}\, 3\cos\theta \sin\theta$$





$$dI = t\sigma E\, dr$$

$$= \frac{t\sigma r}{2}\frac{dB}{dt}\, r$$

$$\mathcal{E}(r) = \frac{r}{2}\frac{dB}{dt}$$

$$EMF = \frac{d\phi_m}{dt} = \pi r^2 \frac{dB}{dt}$$

Simplification: consider small $\theta \rightarrow$ use only axial component

$$B(t) = \frac{\mu_0 m_a}{2\pi z^3(t)} \qquad z(t) = z_0 + \Delta z \sin\omega t$$

$$\frac{dB}{dt} = \frac{3\mu_0 m_a}{2\pi z_0^4}\,\Delta z\,\omega \cos\omega t \qquad E_{pend} = \frac{1}{2} M \Delta z^2 \omega^2$$

Avg. Power dissipated in a disk of radius a:

$$\overline{W} = \int_0^a (\mathcal{E}_{mf})(dI) = \frac{9}{64\pi}\,\frac{m_a^2 \mu_0^2 \Delta z^2 \omega^2 a^4 \sigma t}{z_0^8}$$

$$Q = \frac{\omega_p E_{pend}}{\overline{W}} = \frac{32\pi}{9}\,\frac{M \omega_p z_0^8}{\mu_0^2 m_a^2 a^4 \sigma t}$$

Eg. $M = 10\,kg$; $f_p = 1\,Hz$; $z_0 = 2\,cm$
$M_a = 30\,ma \cdot m^2$; $a = 1\,cm$; $t = 5\,mm$
$\sigma_{ss} = 10^6/\Omega\text{-}m$
$Q = 3 \cdot 10^8$

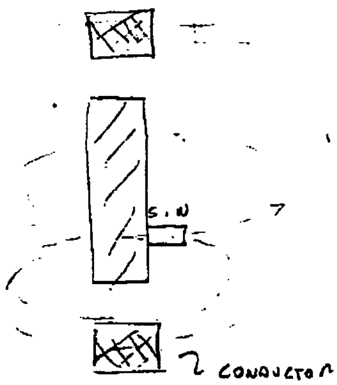
6/27/94

EDDY CURRENT DAMPING AND SEISMIC COUPLING

ORDER OF MAGNITUDE ESTIMATES

LOSSES

(USE RECIPROCITY MOVING SOURCE OF FIELD ⇒ TO MOVING THE DISSIPATIVE CONDUCTOR;



$$\mu = \frac{B_o}{4\pi} V = \frac{iA}{c}$$

V = Volume of magnet $\simeq 4\times10^{-2}$

B_o = B field at magnet surface $\simeq$ 1kg

$$B_\theta(r) \simeq \frac{\mu}{2 r^3}$$

μ = 3ma meter^2 ⇒ 3 cgs

$$B \simeq \frac{20 \text{ gauss}}{r^3 (\text{cm})}$$

$$\text{Power loss/volume} = \vec{E}\cdot\vec{J} = \sigma E^2 \simeq \sigma B^2 \frac{v^2}{c^2}$$

v = Relative velocity

$$\text{Force/volume} = \frac{\sigma B^2 v}{c^2}$$

$\sigma(\text{al}) \simeq 5\times10^{17}$ sec^{-1}

$\sigma(\text{S.S}) \simeq 1.2\times10^{16}$ sec^{-1}

Volume of Conductor $2 \times 2\pi\times6$ (THICK) $\times 2$ (WIDE) $= 150$cc

Peter
2 cm typical to Radius Conductor
6 cm
2 cm Thickness of conductor
1 Hz Pendulum
$Q \sim 3000$

MIRROR MASS; $\rho = 2.2$

thickness = 1" = 2.54 cm

diameter = 3" = 7.6 cm

M = 254 gm

TYPICAL DISTANCE TO CONDUCTOR 6 cm

$$F(\text{dynes})_{al} = \frac{5\times10^{17}\times(20)^2\ 150}{6^6\ (3\times10^{10})^2}\ v$$

$$= 7\times10^{-4}\ v \text{ dynes}$$

$\rho(\text{SS}) = 1.02\times10^{-4}$

$\rho(\text{al}) = 2.5\times10^{-6}$

Magnets 3mm dia
6mm length

$$\ddot{x} + \frac{\alpha}{m}\dot{x} + \omega_o^2 x = 0$$

$$\frac{\alpha}{m} = \frac{\omega_o}{Q} \qquad Q = \frac{\omega_o m}{\alpha}$$

$$= \frac{2\pi\ 254}{7\times10^{-4}} \simeq 2\times10^6$$

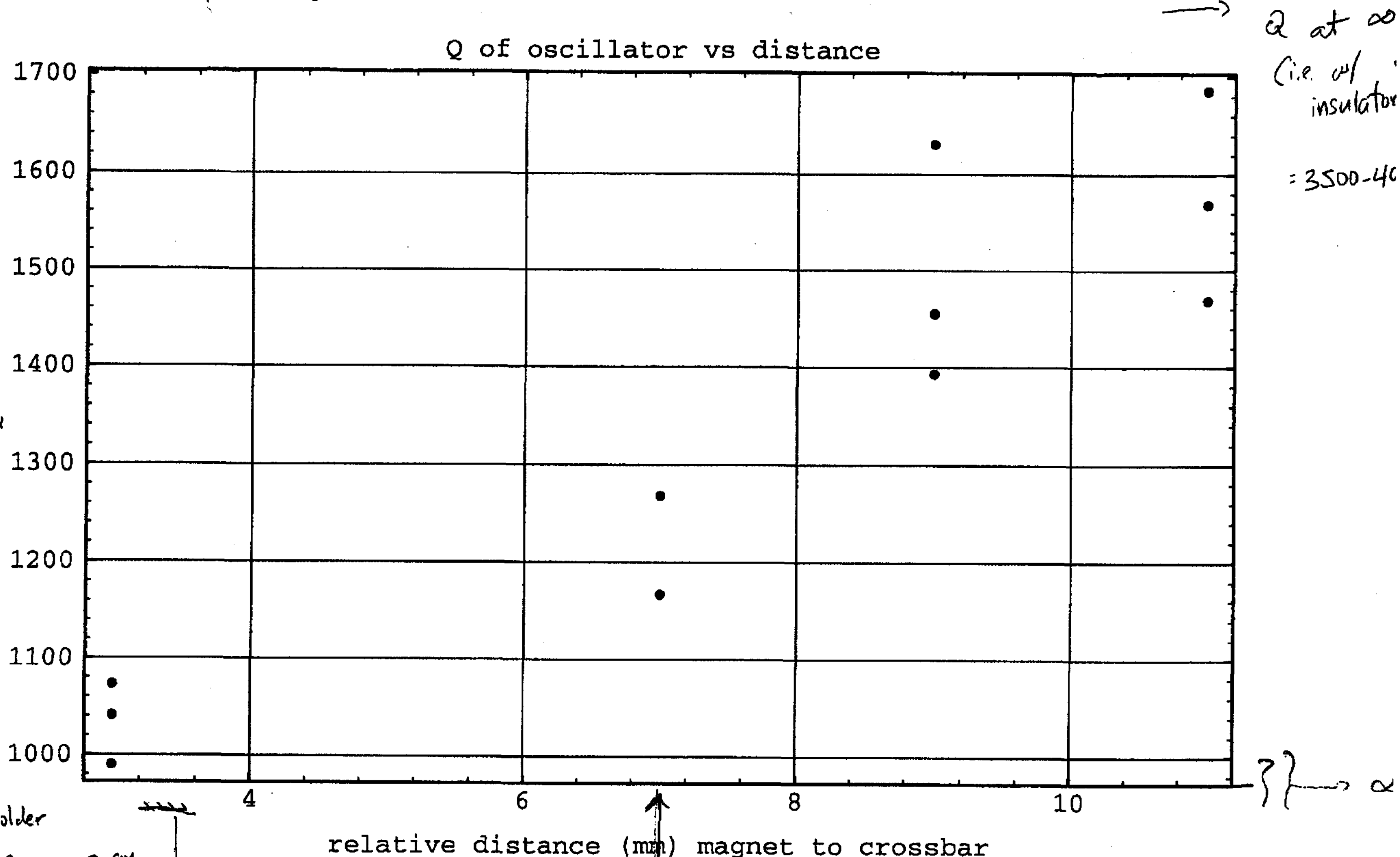
$$Q = \frac{4\omega_o\, m_{mir}\, r^6}{\sigma \mu^2 V_c}$$

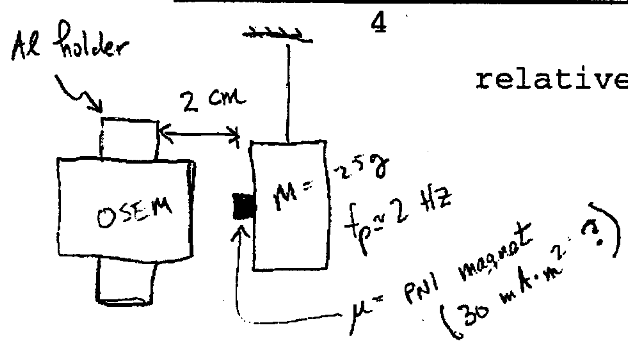
for $X(f) \sim 4\times10^{-16}$ cm/Hz$^{1/2}$

⇒ 1×10^{-10} rad/Hz$^{1/2}$

Require $Q > 2\times10^5$

M=25g


Q of oscillator vs distance
1700
1600
1500
1400
1300
1200
1100
1000
Q
4
6
8
10
relative distance (mm) magnet to crossbar
Q at ∞ (i.e. w/ insulator)
=3500-40
α
nominal position


Al holder
2 cm
OSEM
M=25g
f_p≈2 Hz
μ= PNI magnet (30 mA·m² ?)

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

SOW	**LIGO-T960175-02 -**	**R**	Nov. 5, 96

Statement of Work: Installation of the New 40m BS suspension

Seiji Kawamura and Janeen Hazel

This is an internal working note
of the LIGO Project.

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1 OBJECTIVES/SCOPE

Install the new 40m Beam Splitter (BS) suspension system into the Beam Splitter chamber of Mark II and characterize the system for input to the LIGO suspension final design. This work is a sub-task of Installation of Side Chamber and Reconfiguration of Associated Optics at the 40m (LIGO-M960115-00-R).

2 PROCEDURE

1. Supply and check of the suspension parts (- Nov. 20)
2. Disassembly of the existing BS mount (Nov 19 - 20)
3. Preparation of the suspension parts (Nov. 21 - Dec. 3))
4. Preparation of BS (Dec. 4 - 6)
5. Assembly of the new BS suspension (Dec. 9 - 18)
6. Installation of the new BS suspension (Jan. 3 - 6)
7. Characterization of the new BS suspension (Feb. 3, 97 - Feb. 7)

2.1. Supply and check of the Suspension Parts (2 weeks except for the feedthrough)

1. Supply the following items:
    - Magnet standoffs
    - Guide rods
    - Kapton vacuum cables
    - Brackets for mounting cables on stacks
    - Ceramaseal 50 pin D vacuum feedthrough mounted on conflat flange (5 weeks)
2. Check damping with the Kapton cables.

2.2. Disassembly of the Existing BS Suspension (2 days)

1. Adjust and maintain the global/local optical levers.
2. Vent and open the tank.
3. Mark the position of the BS.
4. Disassemble the BS suspension.

2.3. Preparation of the Suspension Parts (7 days)

1. Clean and Bake the suspension parts.
2. Glue the magnets to the standoffs. (1 day)

2.4. Preparation of BS (3 days)

1. Clean the BS.
2. Glue the magnet/standoffs to the BS.
3. Glue the guide rods to the BS.

2.5. Assembly of the new BS suspension (8 days)

1. Hang and balance the BS.
2. Bake the BS.
3. Clean the BS.
4. Re-hang the BS.

2.6. Installation of the new BS suspension (2 days)

1. Clamp the BS using the safety stops.
2. Transfer the assembly into the BS chamber.
3. Install the cable and the electronics.
4. Check damping
5. Close and pump down the tank.

2.7. Characterization of the new BS suspension (5 days)

- Optimize the electronics parameters.
- Check saturation.

Measure:

- Pendulum, pitch, and yaw resonance frequency
- Wire vertical resonance frequency
- Loop gain
- Sensor noise
- Driver noise
- Q of the wire violin mode
- Q of the BS internal mode

3 HOMO SAPIENS POWER

- Task leader ....Seiji Kawamura
- Co-leader...........................Jennifer Logan
- Mechanical........................Janeen Hazel
- Electronic ....Jay Heefner
- Key worker........................Brent Ware
- Support..............................Malik Rakmanov
- Support..............................Shinji Miyoki
- Scientific ....Robert Spero
- Lab ....Denise Durance
- Vacuum ....Steve Vass
- Baking...............................Yehuda Kommemi
- Optics ....Doug Jungwirth