

# UCLA Physics Colloquium

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*February 6, 1997*

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Caltech/MIT/NSF

Laser Interferometer Gravitational Wave  
Observatory

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## Searching for Gravitational Waves With LIGO

Gary Sanders

California Institute of Technology

+ photos  
not included here



# LIGO Construction Status

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- ›› Construction of the \$296 million Project is 41% complete
- ›› Contracts in place commit \$215/\$292 of the Project
- ›› Hanford concrete work complete, buildings under construction
- ›› Livingston grading complete, building construction started last month
- ›› Beam tube fabrication in progress, ~200 of 800 sections fabricated
- ›› Beam tube installation in Hanford has begun
- ›› Vacuum equipment (tanks, gate valves, pumps,...) is ~50% complete
- ›› Detector laser and optics fabrication is underway
- ›› Detector controls fabrication is underway
- ›› Validating R&D on displacement sensitivity, phase sensitivity and configuration is in final stages

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Searching for Gravitational  
Waves With LIGO

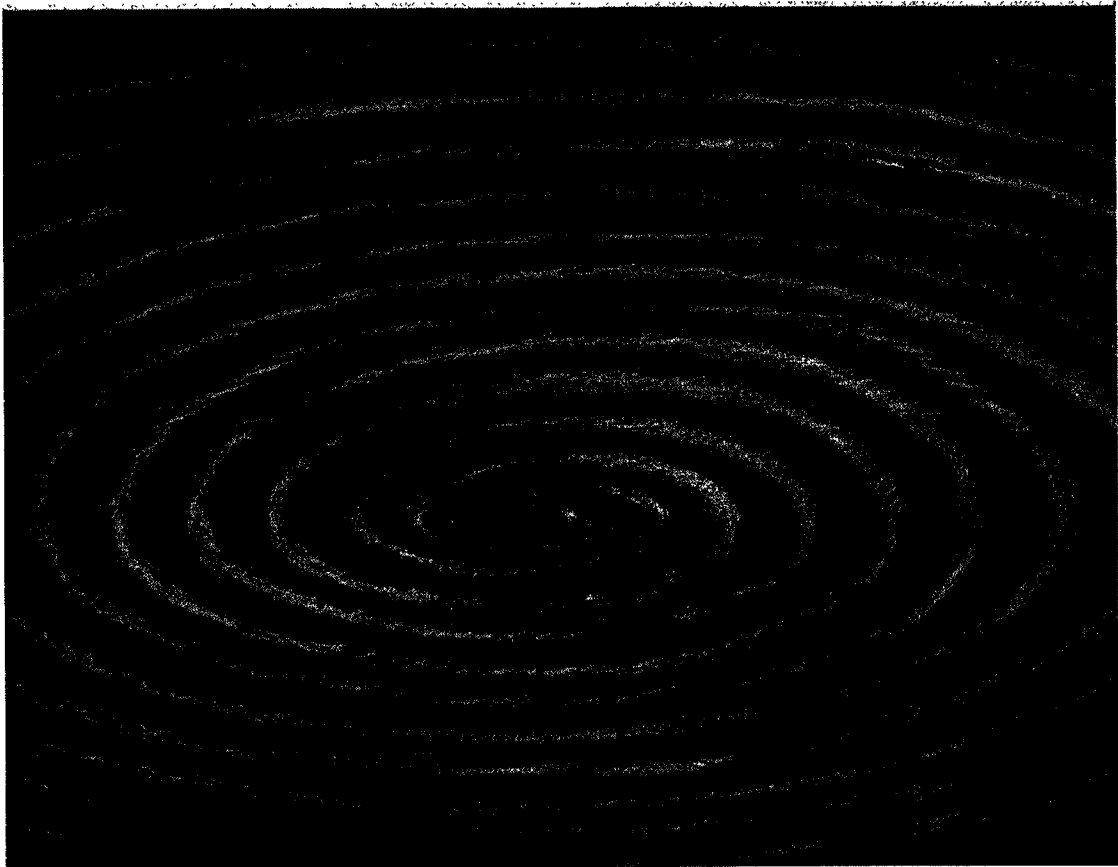
Gary Sanders

California Institute of Technology



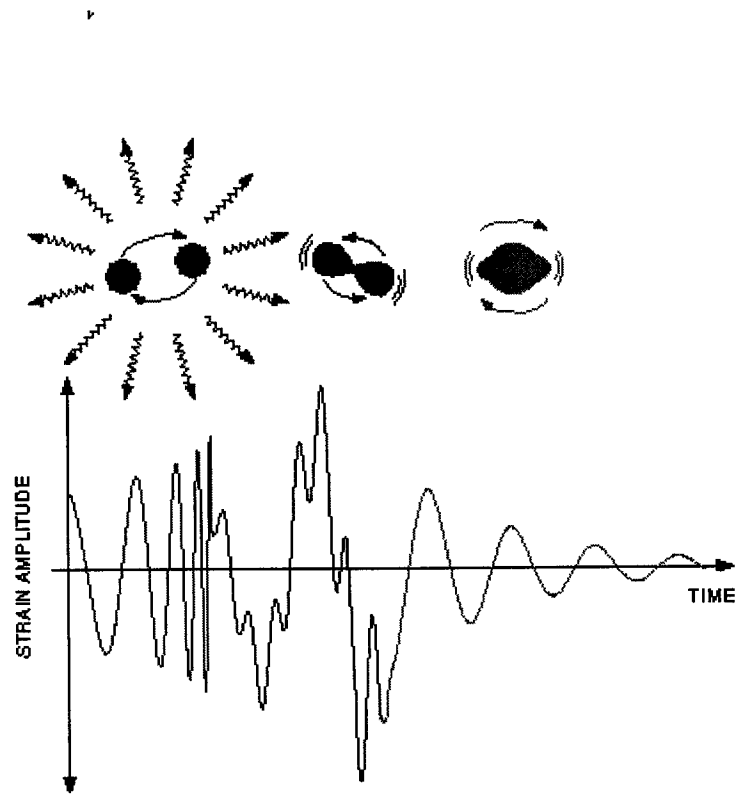
# Gravitational Radiation

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# A Gravitational Wave Signal

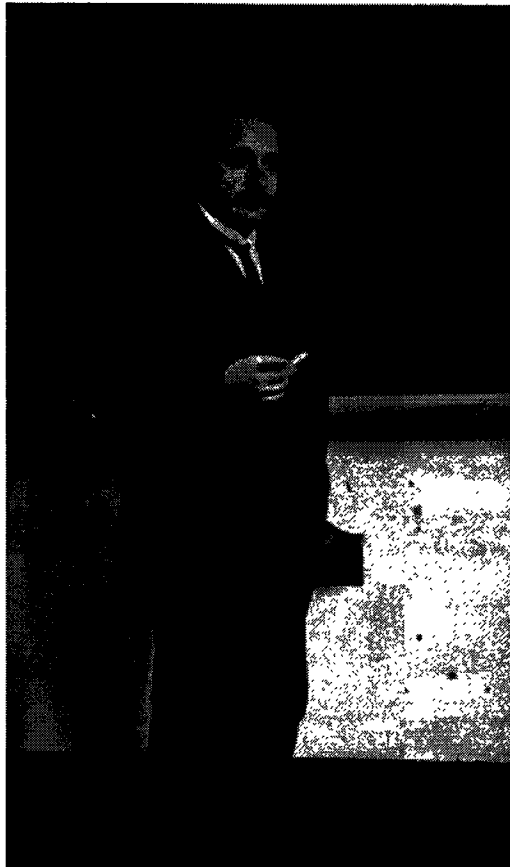
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Signal from a neutron star - neutron star binary inspiral and coalescence

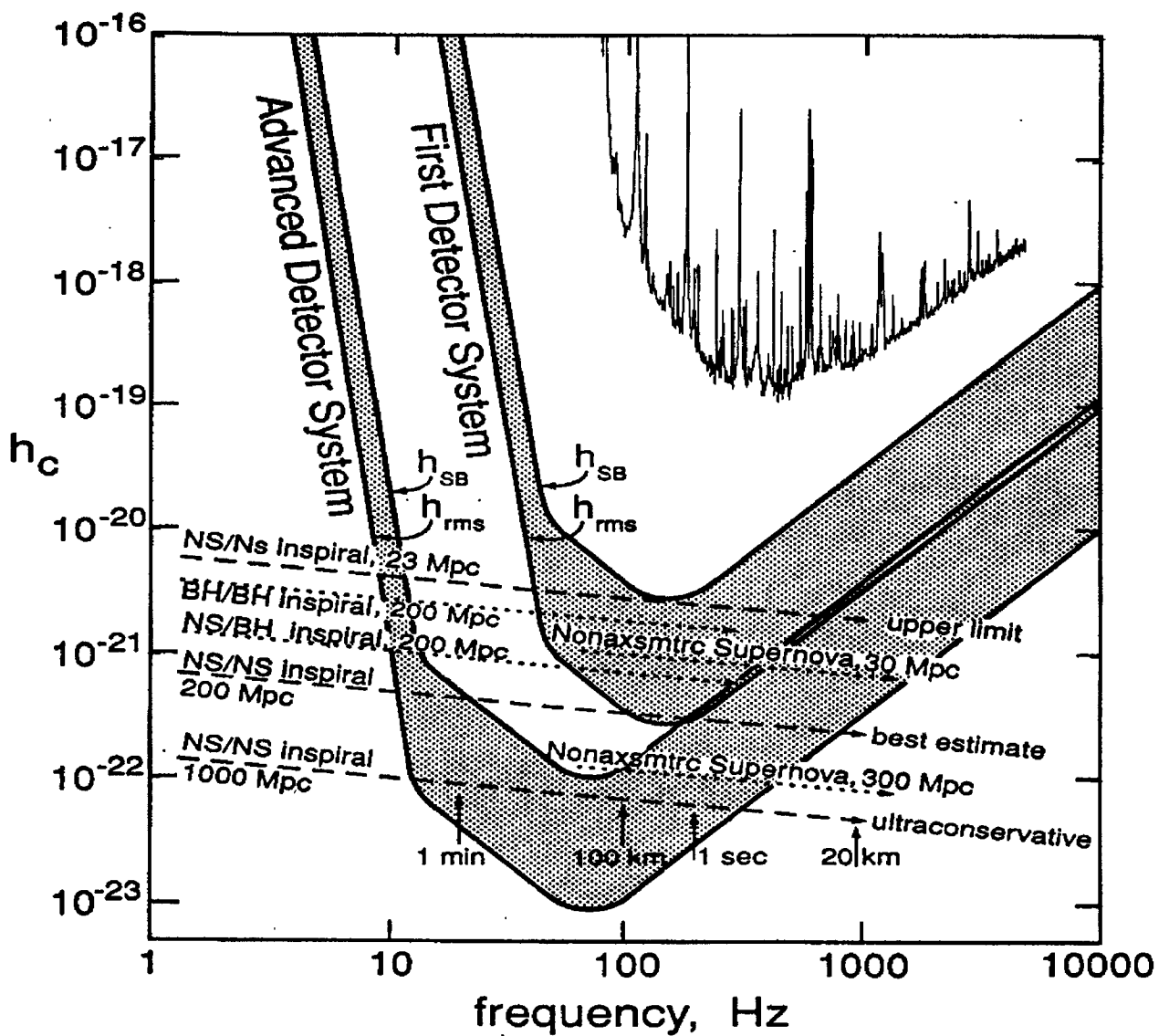
# Einstein

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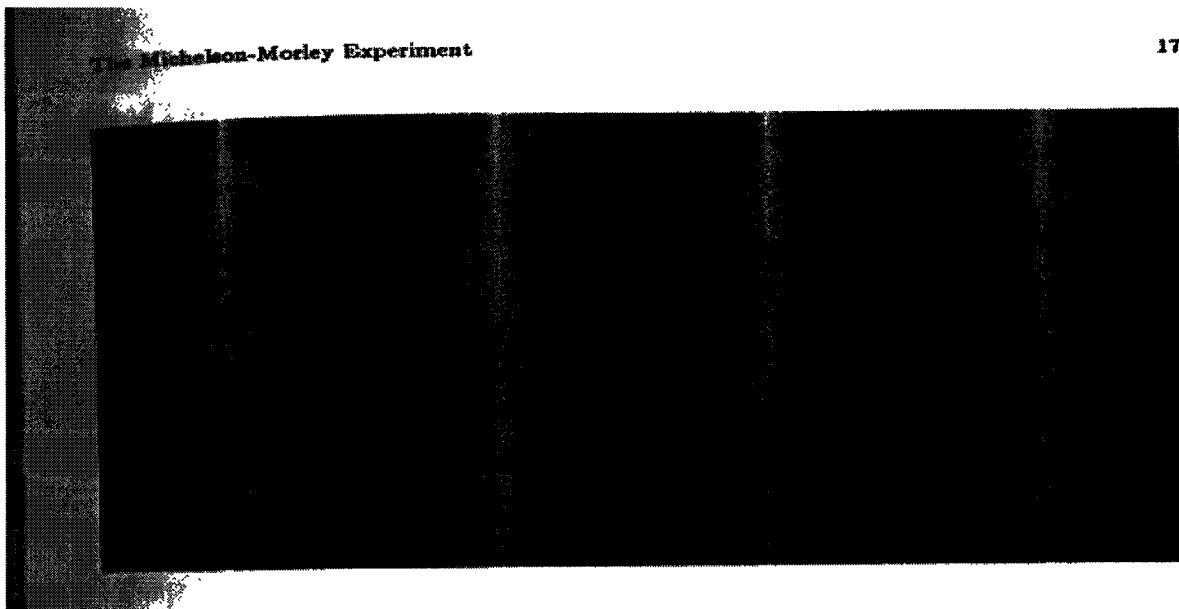
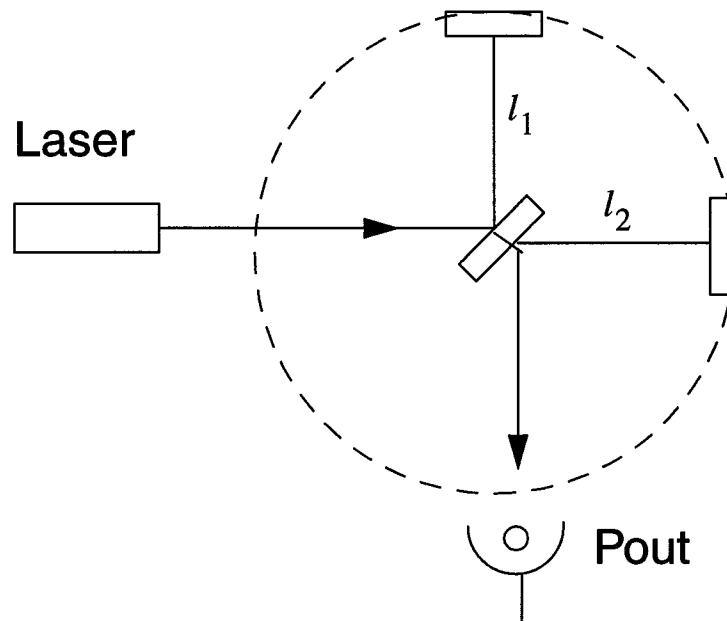
- ››gravitational radiation
- ››photons as quanta
- ››thermal physics - Brownian motion
- ››even “Big Science”

# LIGO Detector Spectral Noise Density



# Michelson Interferometer

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# Fabry-Perot Interferometer

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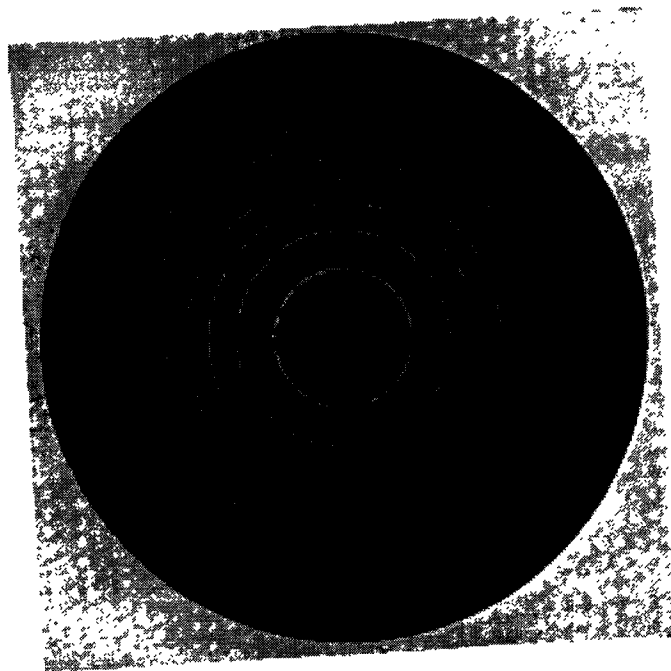
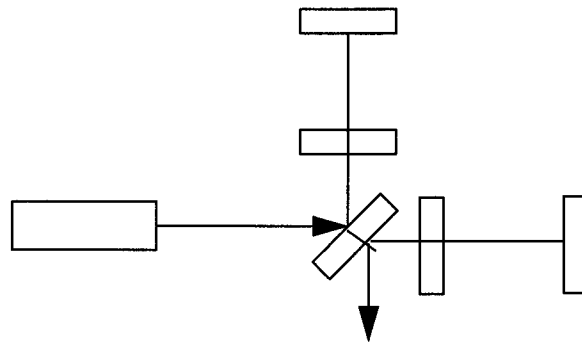
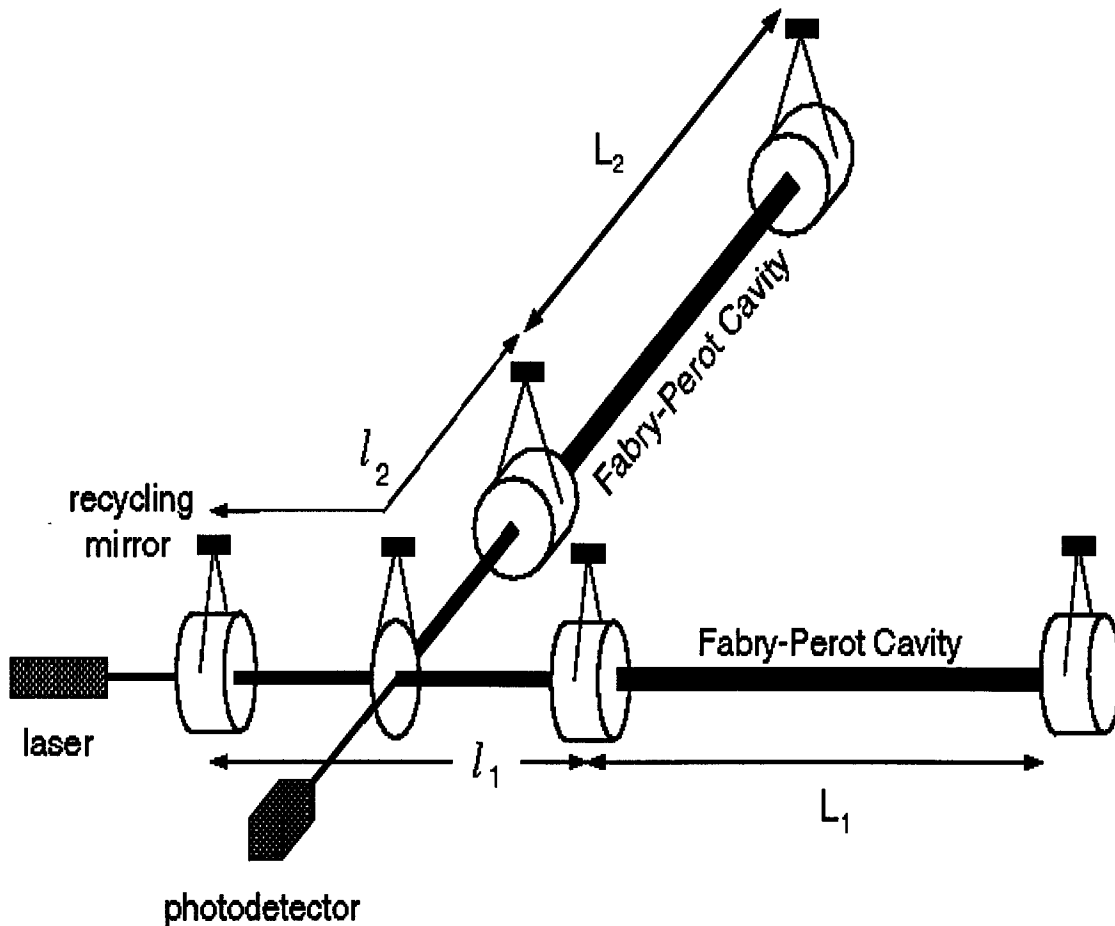


Fig. 7.50. FABRY-PEROT fringes.

# LIGO Interferometer Configuration



# LIGO Sites

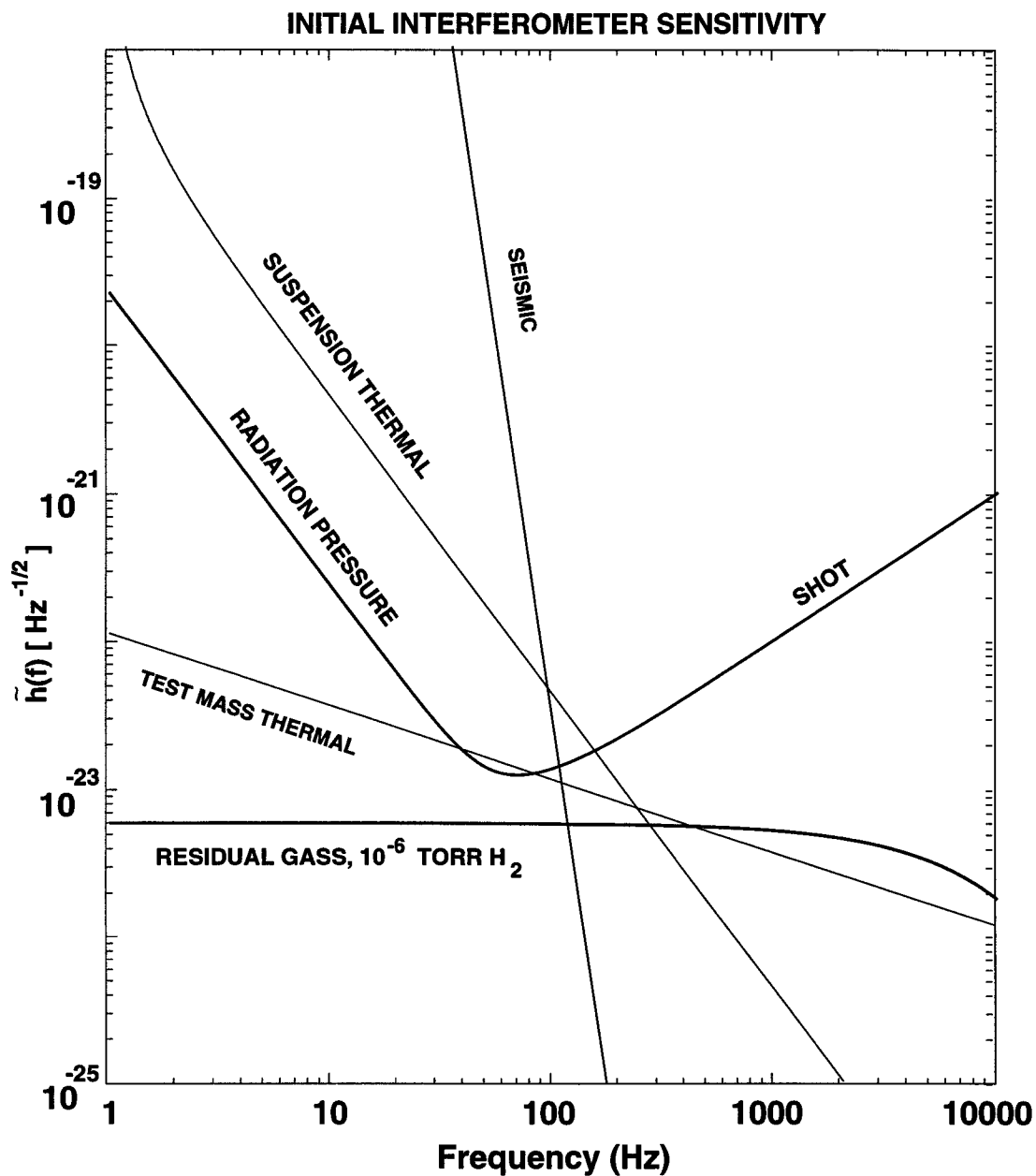
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**HANFORD,  
WASHINGTON**



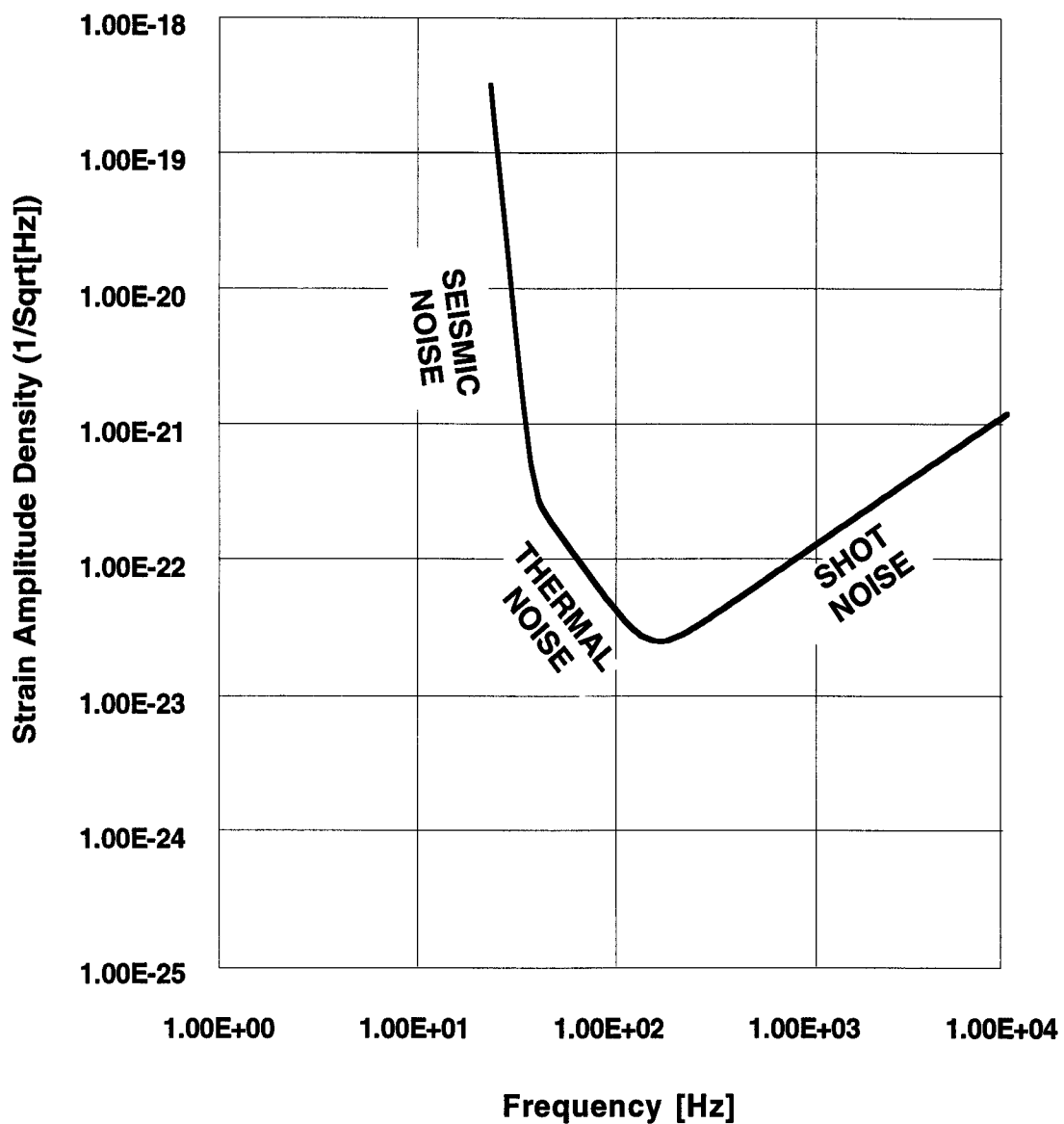
**LIVINGSTON, LOUISIANA**

# Initial Design Performance Goal



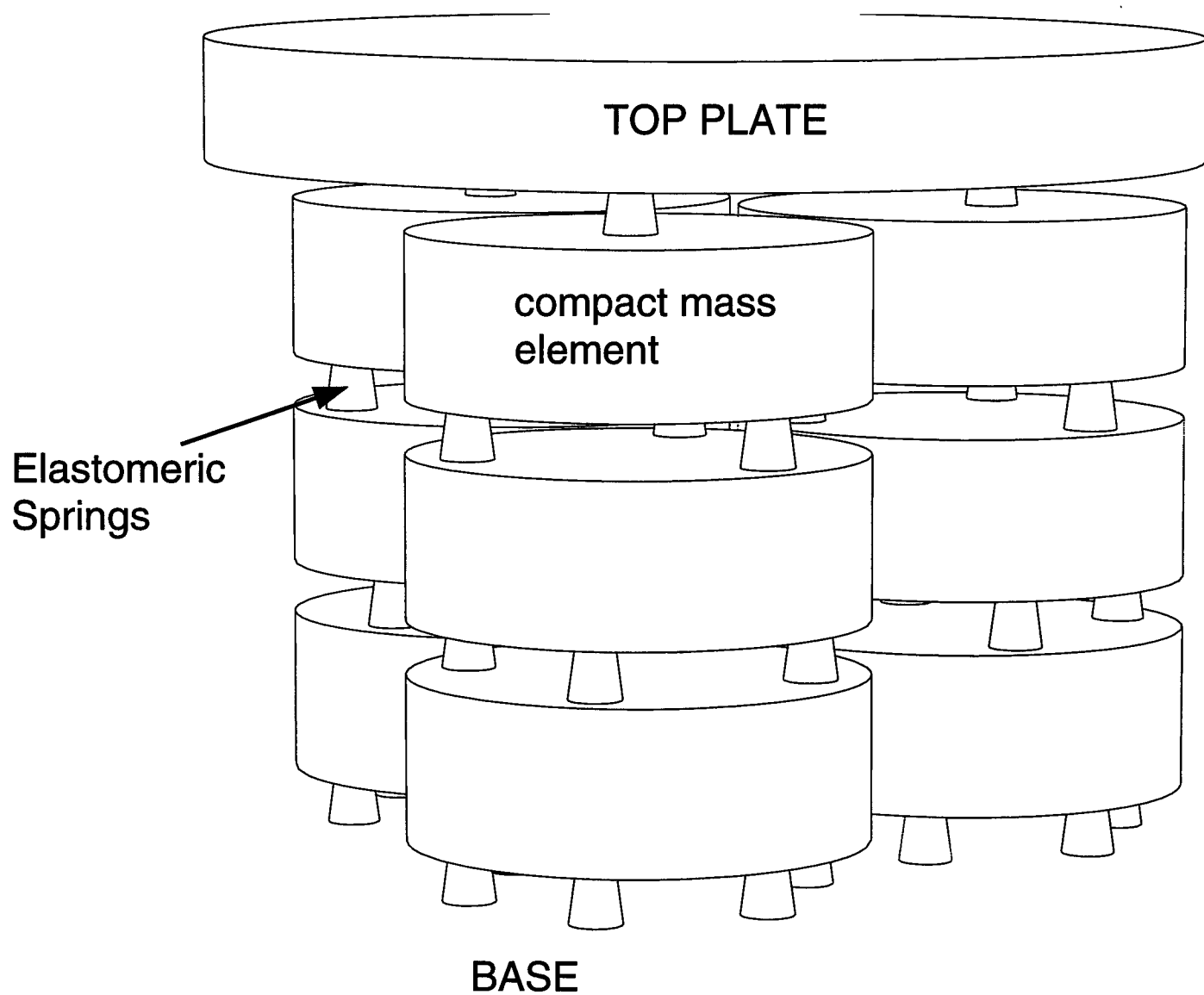
# Initial Design Performance Goal

LIGO Initial Interferometer Noise Equivalent Strain

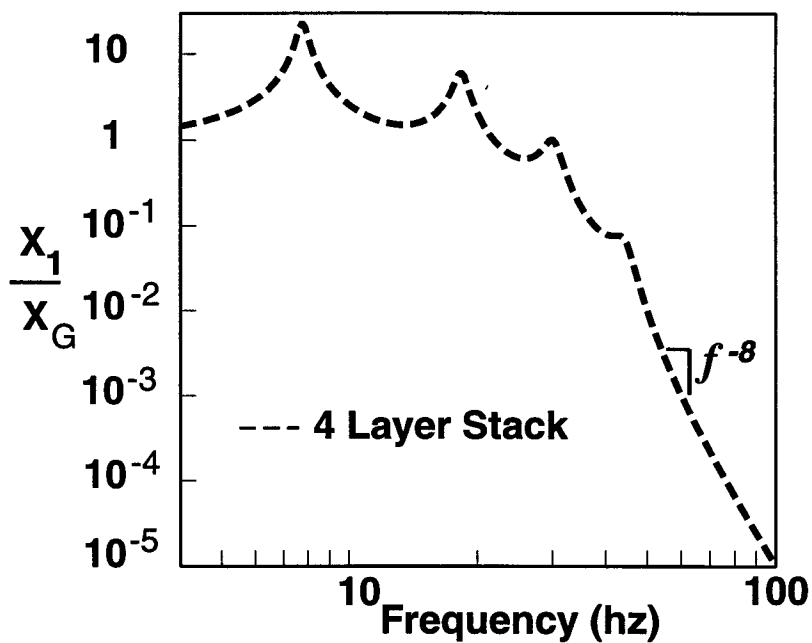
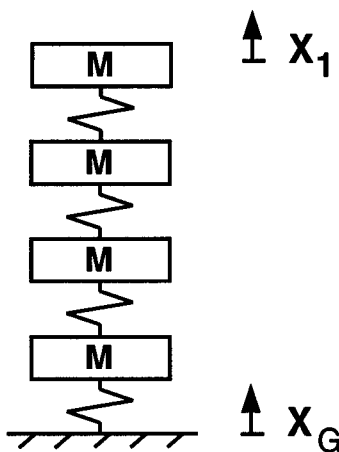
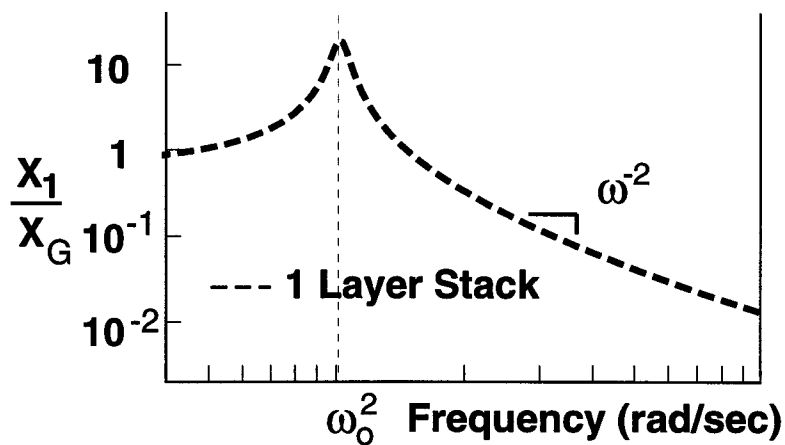
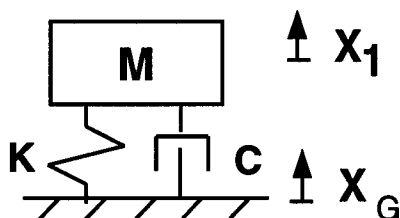


# Seismic Isolation

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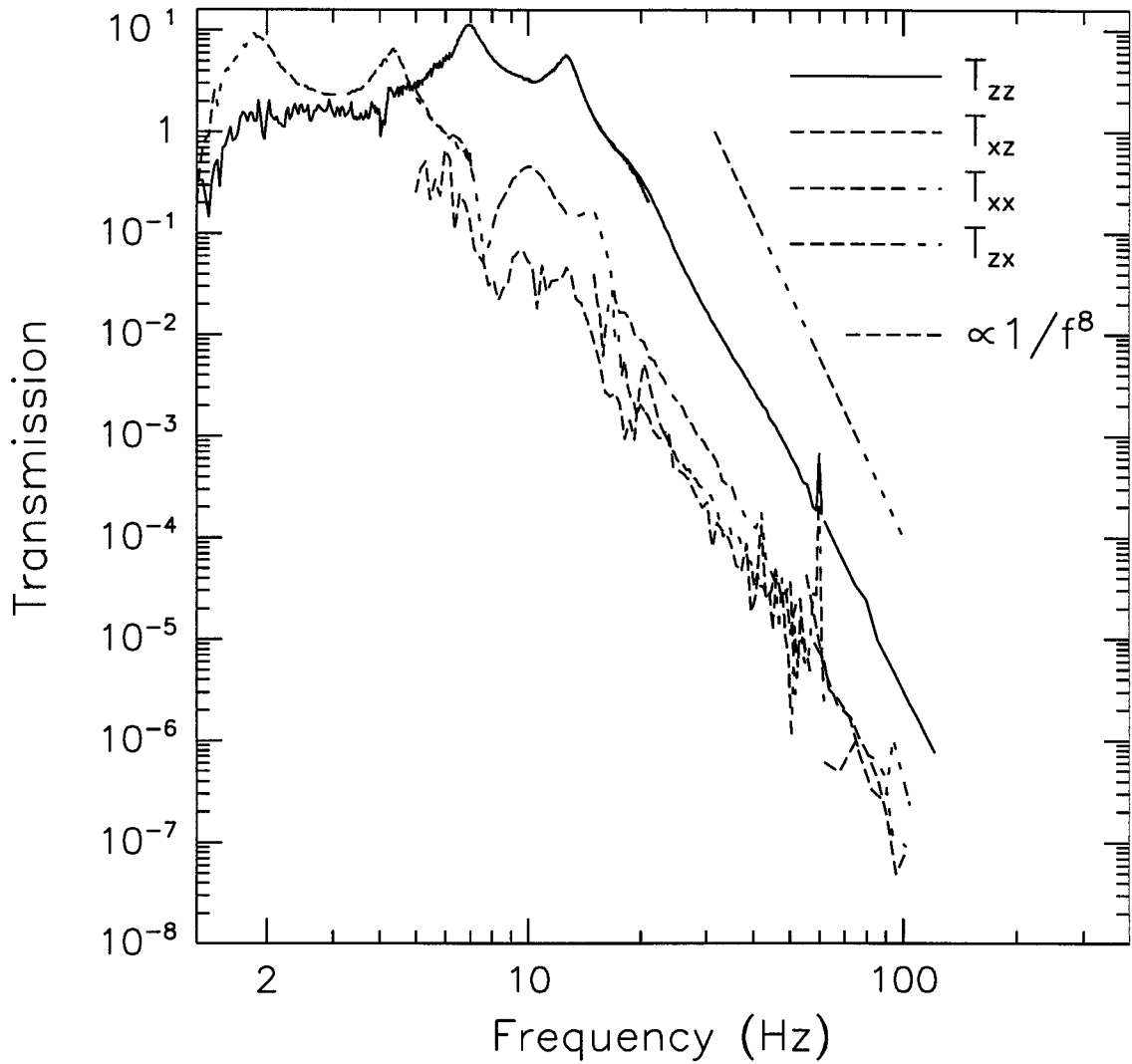


# Seismic Isolation



Simple Model of Mark 2 Stack Isolation (vertical)

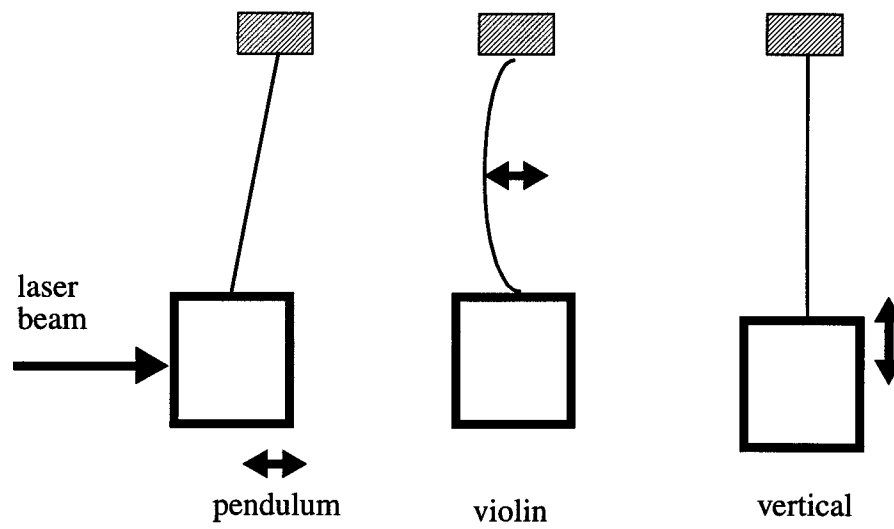
# Seismic Isolation





# Suspension Thermal Noise

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# “Excess” Suspension Thermal Noise (Braginsky, Moscow)

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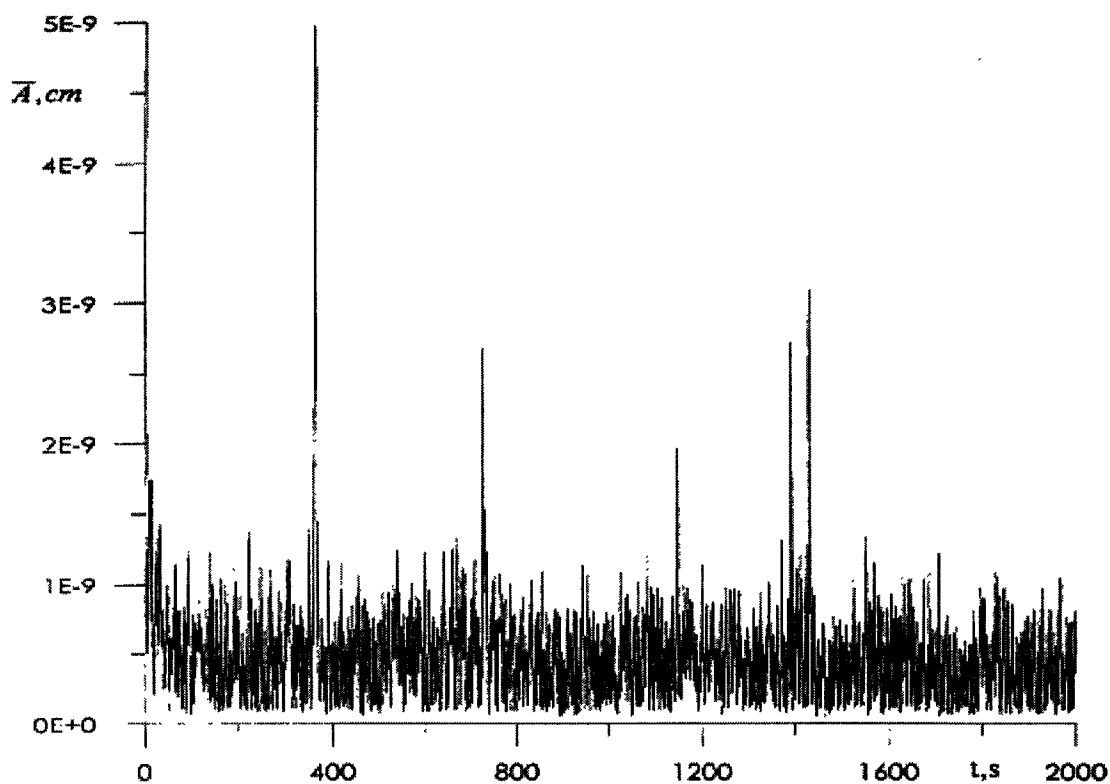
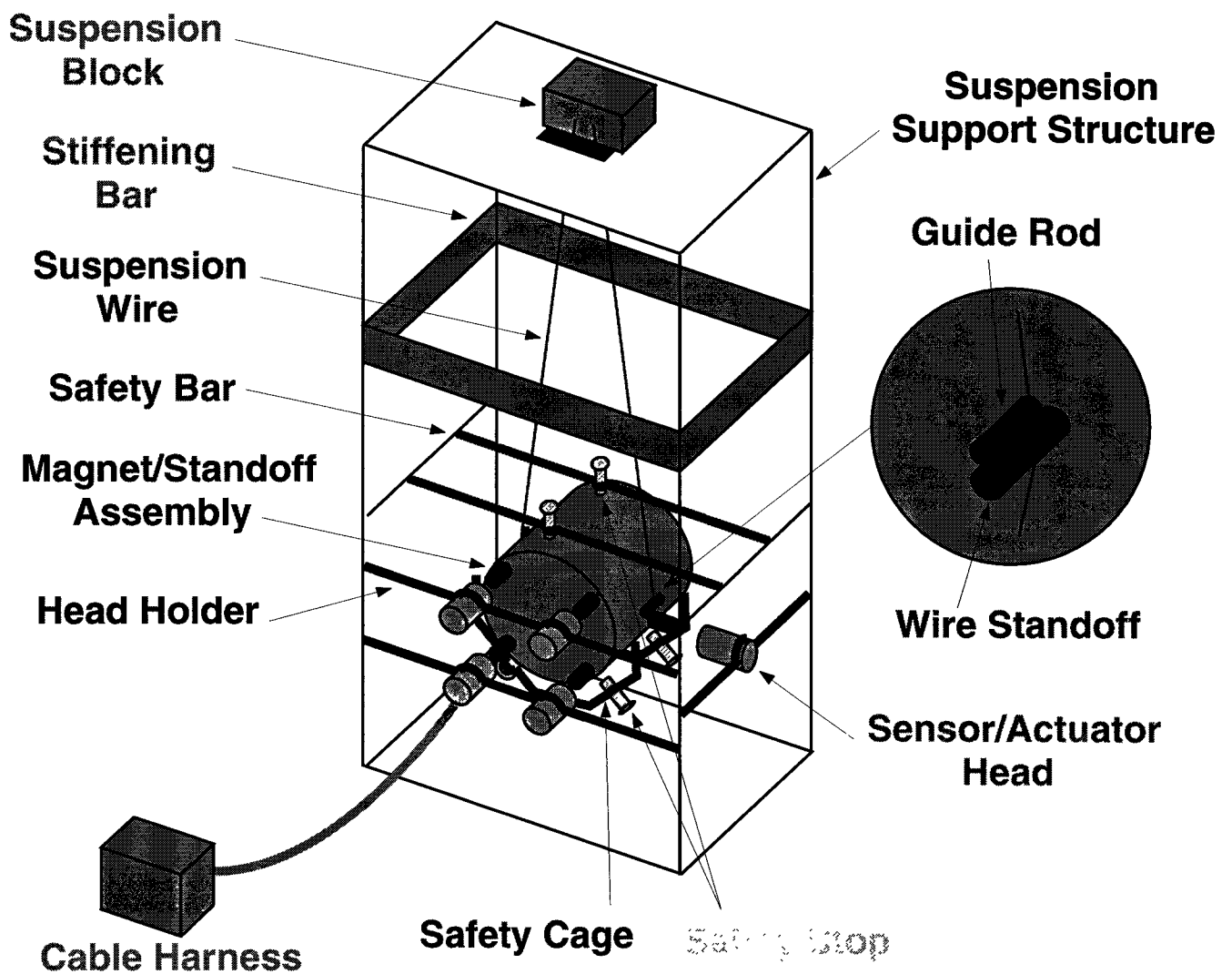


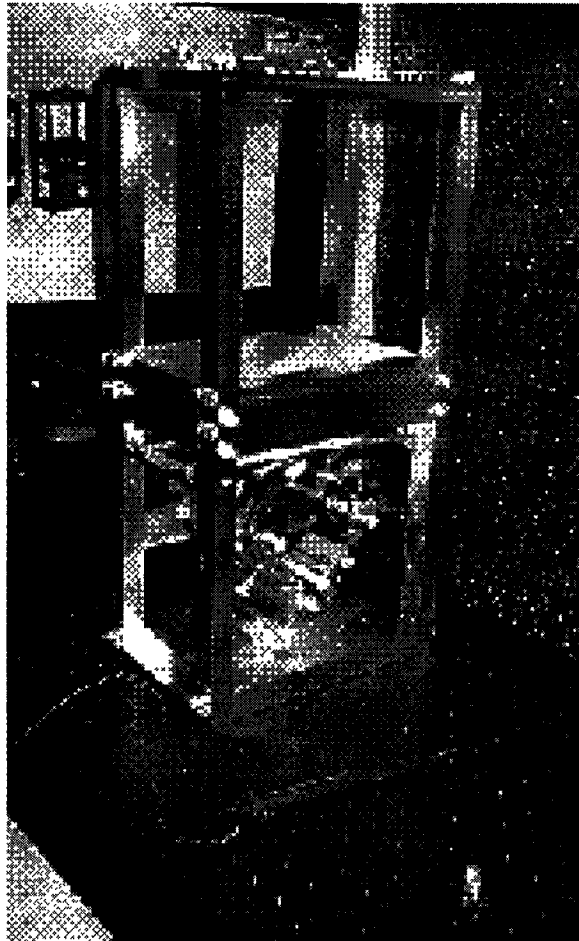
Fig. 5. Fragment of the record of noise oscillation of tungsten wire

# Test Mass Suspension

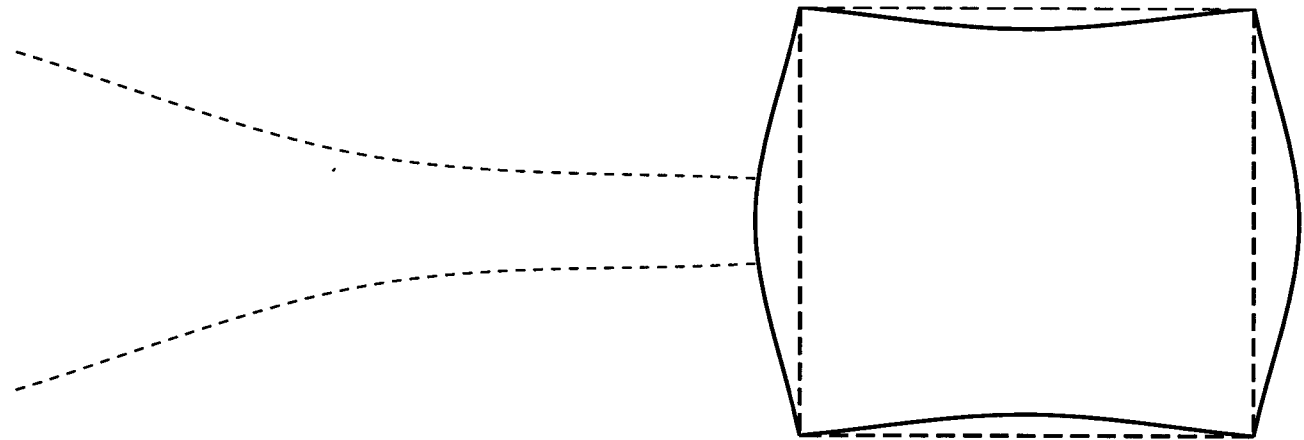


# New Single Loop Suspension

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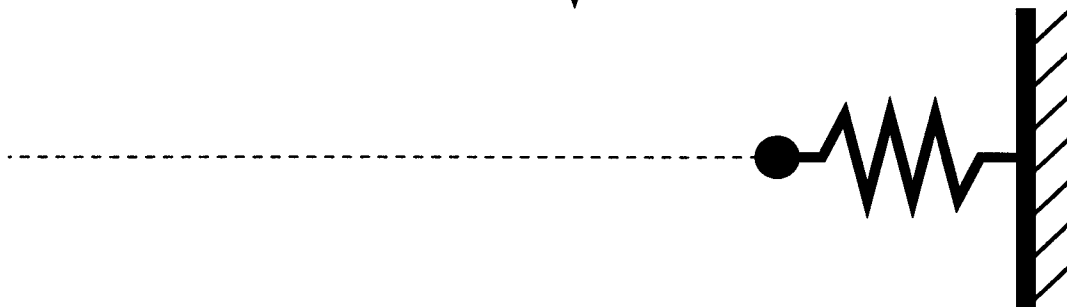


# Test Mass Internal Thermal Noise



optical mode:  $\psi(\rho, \theta, z)$   
wave vector:  $\vec{k}$

mirror mode:  $\vec{u}(\rho, \theta, z)$   
frequency:  $\omega_n$



one-dimensional  
laser beam  
wave vector:  $\vec{k}$

point mass on spring  
mass:  $\alpha_n m$   
frequency:  $\omega_n$

# Test Mass Internal Thermal Noise

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