

# Superconducting Gravity Gradiometers

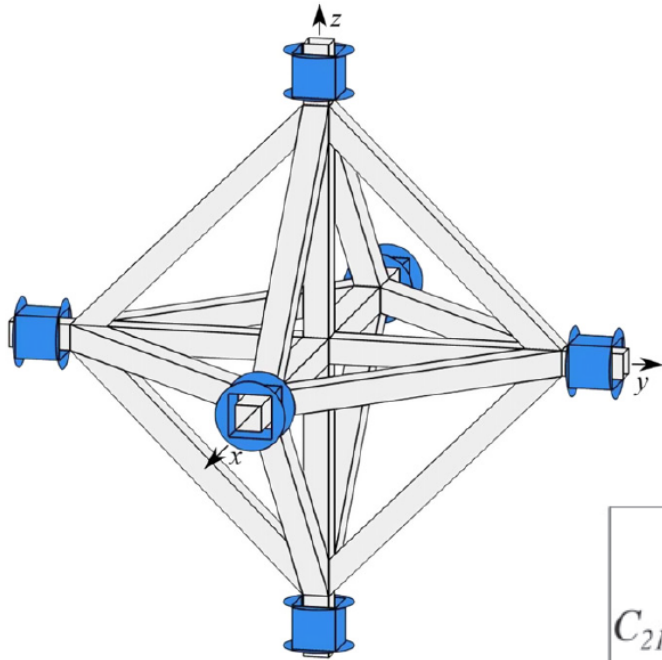
1

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E-GRAAL 2016

# Basic Measurement Scheme

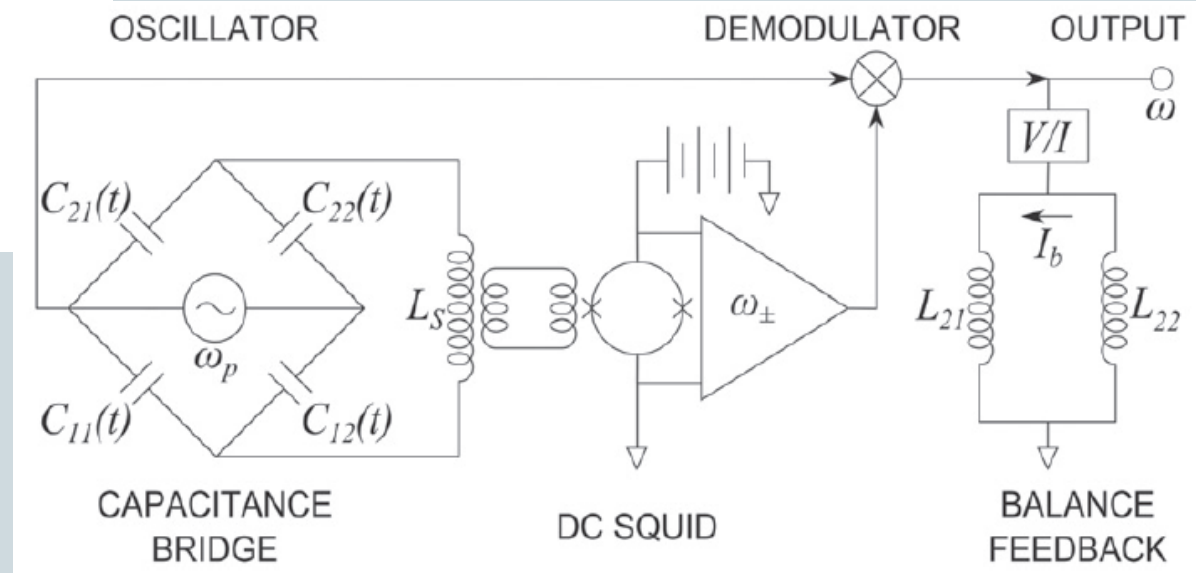
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## Full-tensor configuration

- 6 test masses
- Readout along all 3 displacement directions

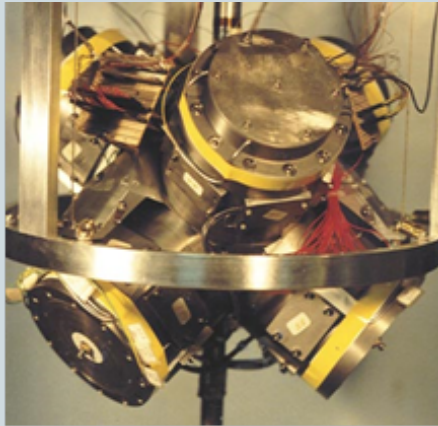
## Capacitor-bridge transducer



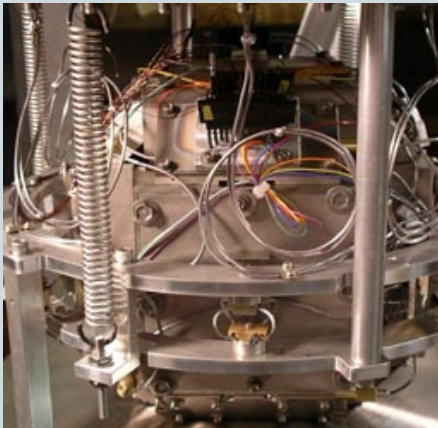
# Past Achievements

3

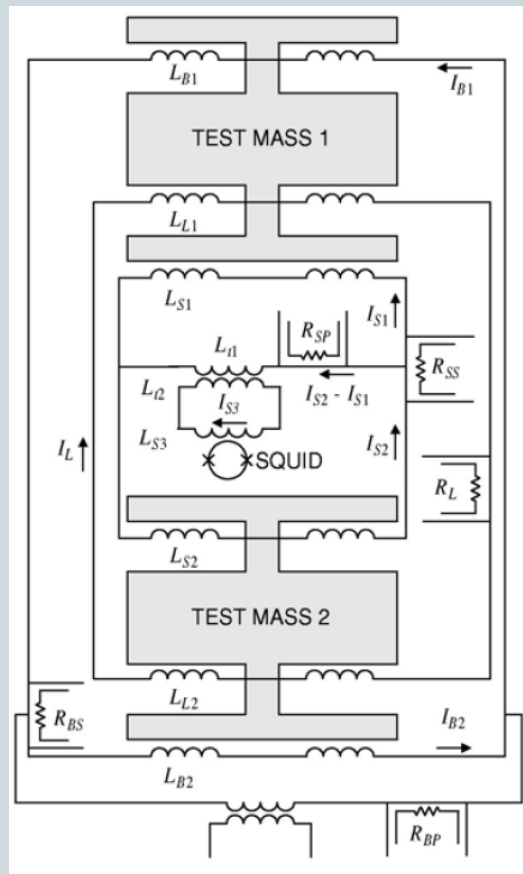
Diagonal



Off-Diagonal

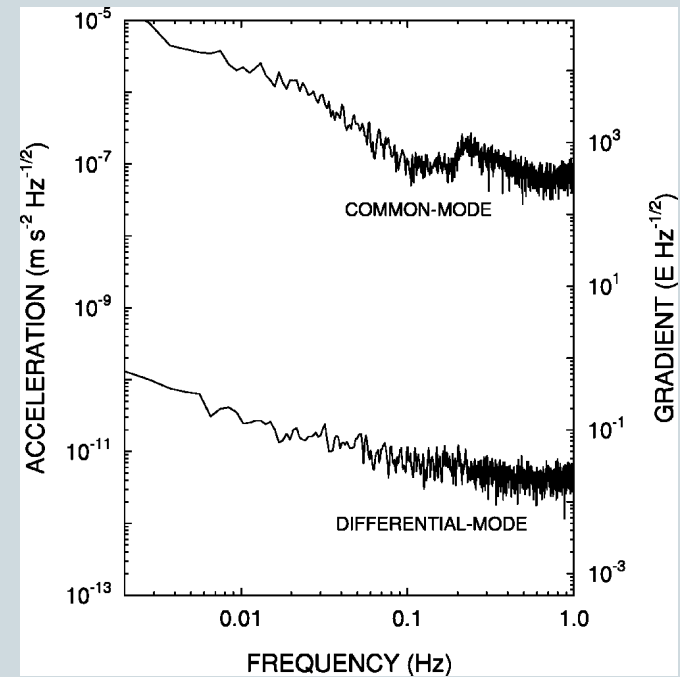


«Seesaw» levitation for the vertical



Moody, Paik, Canavan (2002)

Common-mode suppression of seismic noise



# Fundamental Noise

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**SQUID noise** (parameterized by an effective noise temperature)  
+ **thermal noise** of the test mass:

$$S_h(f) = \frac{16}{ML^2\omega^4} \left[ \frac{k_B T \omega_D}{Q_D} + \frac{|\omega^2 - \omega_D^2|}{2\omega_p} \left( 1 + \frac{1}{\beta^2} \right)^{1/2} k_B T_N \right]$$

To achieve  $10^{-15}$ /rtHz strain noise, one needs 9 orders of magnitude suppression of **seismic noise** (mostly by common-mode suppression).

To achieve  $10^{-15}$ /rtHz strain noise, cancellation of **terrestrial gravity noise** by about a factor 10 may be required depending on the site

# Comparison with other Concepts

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	<b>SGG</b>	<b>TOBA</b>	<b>ATOM</b>
Main seismic isolation mechanism	Common-mode suppression (mechanical)	Passive filtering	Common-mode suppression (laser phase noise)
Gravity noise	Common to all		
Other important instrumental noise	Thermal noise, SQUID	Thermal noise, quantum noise	Quantum noise, wavefront aberrations
Estimated size (for $10^{-15}/\text{rtHz}$ , and given near-future technology)	O(1m)	O(1m)	O(100m)

