

Juggling Interferometer

L-V meeting

Sep. 24, 2008 @ Amsterdam

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Motivation 1

- **Lower frequency gives higher GW signals.**
- **Suspension thermal noise and seismic noise are huge at low frequencies.**
- **What if we can remove suspension?**
- **Magnetic levitation is a kind of suspension.**
- **Free-fall experiment is just one shot.**

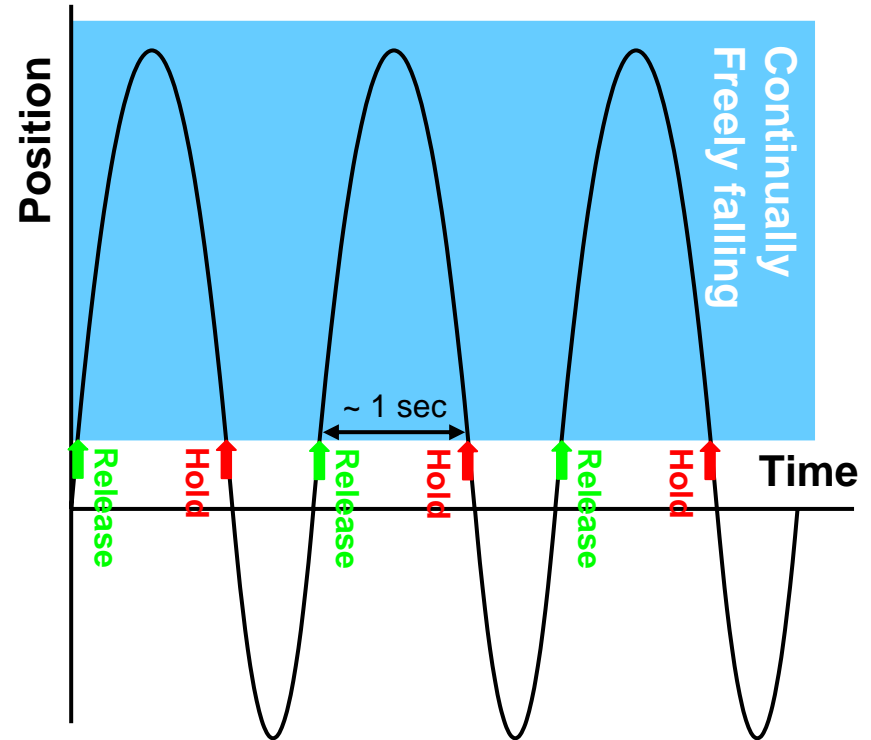
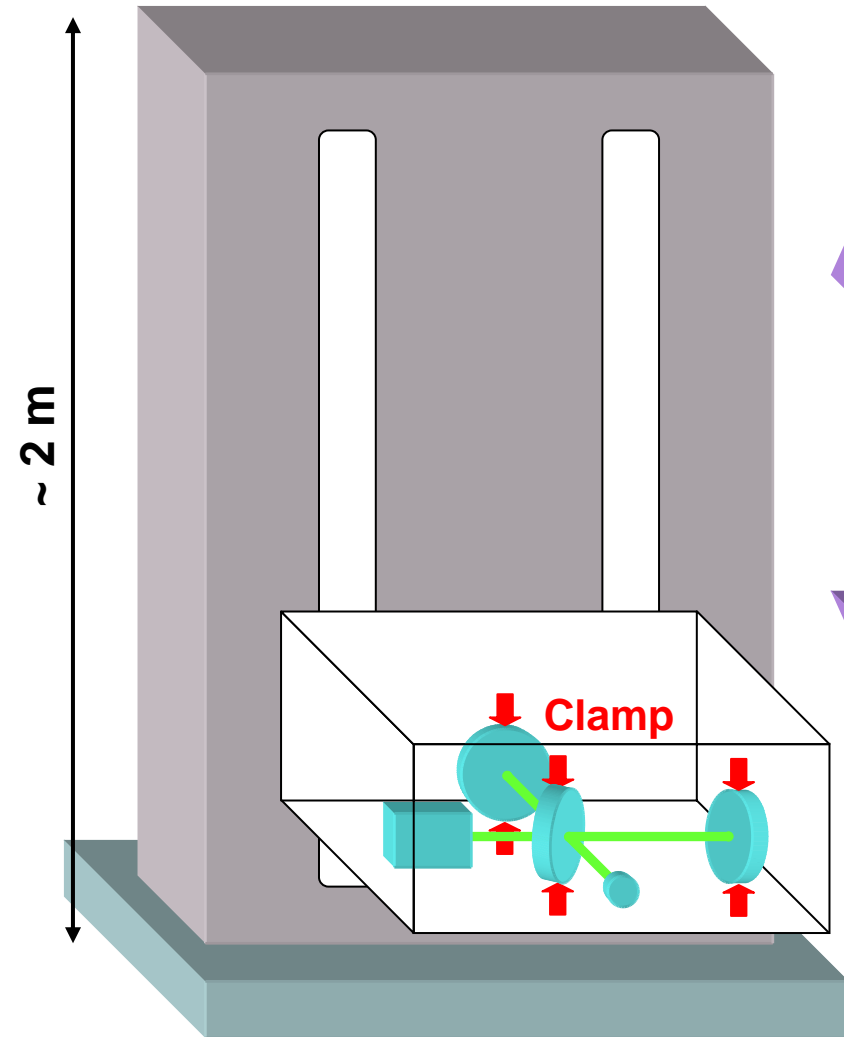
Motivation 2

- **Space GW antenna is the way to go eventually.**
- **We want an intermediate step on ground, which we can play with, before we go into space.**

Motivation 3

- **Space GW antenna requires launch lock system and very low force noise**
- **We need a test bed, where we can try launch lock system and measure force noise.**

Juggling interferometer prototype



km-class juggling interferometer

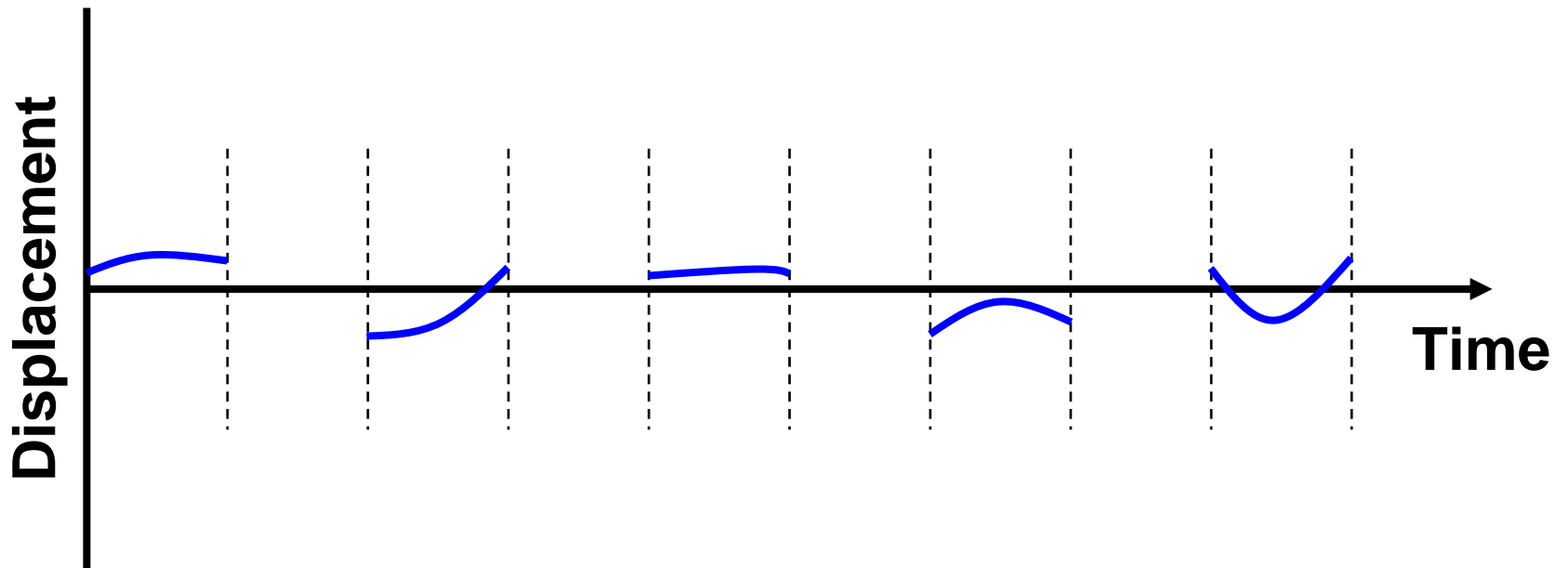
- **Extend the arm length to km**
- **Oval beam tube required**

Interferometer

- **Simple Michelson interferometer**
 - FP cavity is not necessary because the sensitivity is limited by displacement noise at low frequencies anyway
- **S&AS PD outputs with no fringe lock**
 - Fringe lock is not necessary because intensity noise can be suppressed and no power recycling is necessary
- **Phase modulation necessary?**

Data processing 1

- Produce displacement signal (x) from the two PD outputs



Noise caused by juggling

- **x:**
 - Longitudinal position on release fluctuates
- **dx/dt:**
 - Longitudinal velocity on release fluctuates
 - Angular velocity on release fluctuates, which couples with beam off-centering
- **d²x/dt²:**
 - Above two effects couple with each other
- **x, dx/dt, d²x/dt² are constant in each segment**

Data processing 2

- In each segment, calculate $\langle x \rangle$, $\langle dx/dt \rangle$, $\langle d^2x/dt^2 \rangle$
- Remove them from the data

Loss of GW signal

- A part of GW signal especially below 1 Hz is lost during the data processing 2.
- So is a part of any noise.
- **S/N remains the same.**
- Except the digitization noise

Digitization noise

- Depends on $\langle x \rangle$, $\langle dx/dt \rangle$, $\langle d^2x/dt^2 \rangle$
- Depends on the number of bits
- To be calculated soon

Other noise

- **1 Hz noise (gravity gradient, EM environmental)**
- **Outskirts of 1Hz noise ?**
- **To be estimated**

Many things to do

- **Mechanism for moving the box**
- **Noise estimate**
- **Fiber or laser in the box**
- **Person force**
- **Money**

Application for budget

- **This year I will apply for basic-research budget with a juggling interferometer**
- **Up to \$500k for 3-5 years**
- **20-30% adoption ratio**

Summary

- **Juggling interferometer is the potential 3rd generation detector.**
- **It can be used as a test bed for space antenna.**
- **We will start building the prototype soon, I hope.**