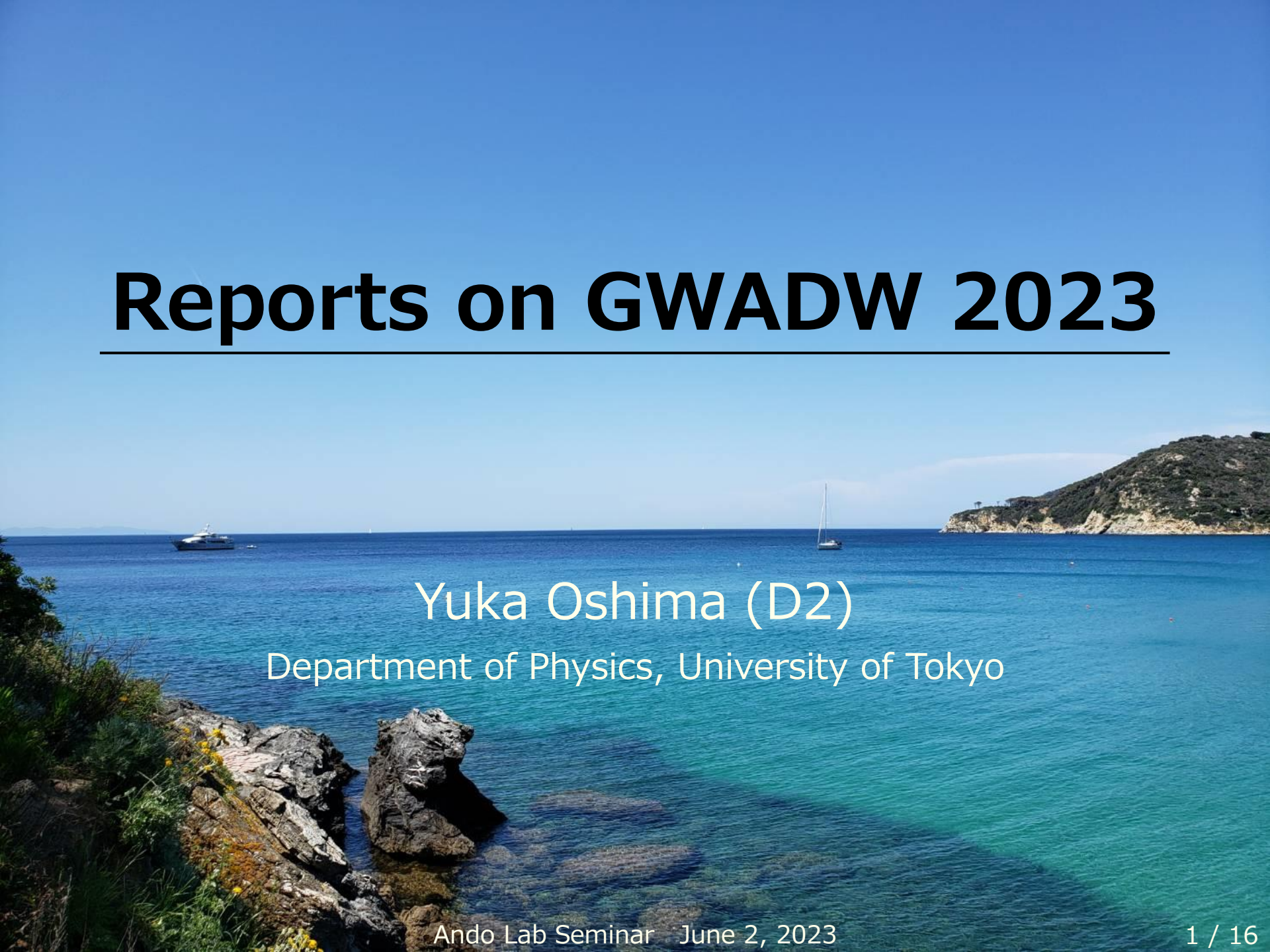
Reports on GWADW 2023



Yuka Oshima (D2)

Department of Physics, University of Tokyo

Meeting photographs

Contents

I will introduce 3 interesting talk/posters with 2/3 slides for each

- Progress towards a 6 DoF inertial sensor
  - Talk by Jiri Smetana from Univ. of Birmingham His slides

- Characterization of heterodyne phase locking for a Newtonian noise sensor
  - Poster by Avanish K. Ramamohan from Australian National Univ. His poster

- Mode matching sensing through RF Higher Order Modulation method
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6 DoF inertial sensor

- Motivation: to decouple troublesome cross-couplings and improve the sensitivity in low frequencies (introduced by Shimoda-san in Journal Club, 2018)

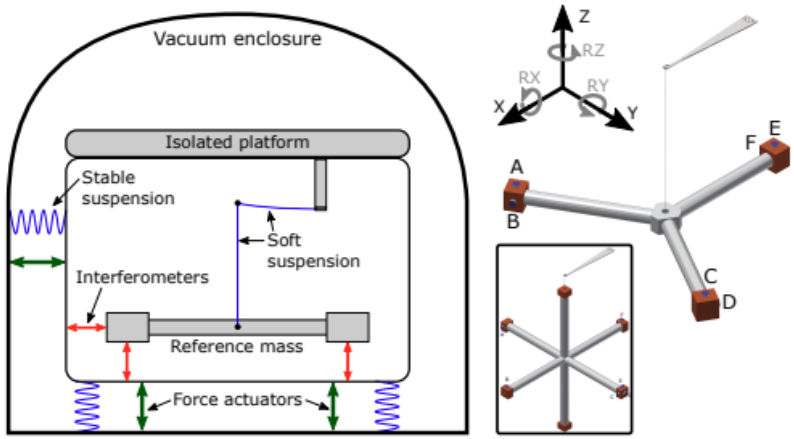


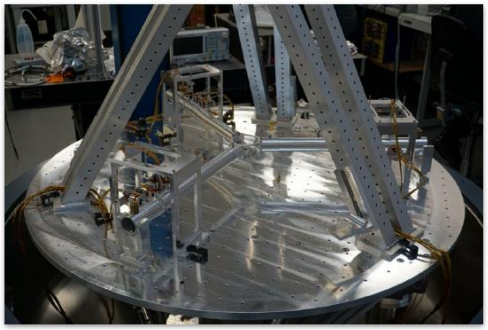
FIG. 1. A 2-d representation of the isolation architecture (left) and a design concept for the reference mass and suspension (right). Letters indicate interferometric sensing locations. Inset right: an alternative configuration with equal moments of inertia in the three principal axes that reduces Newtonian noise in RX and RY at the expense of size and complexity.

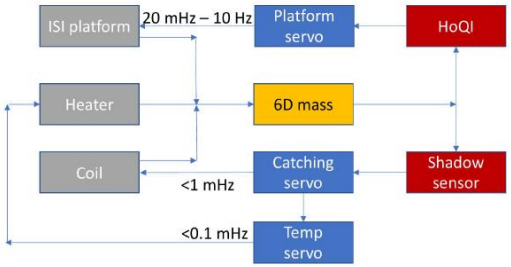
C. M. Mow-Lowry & D. Martynov, Class. Quantum Grav., **36**, 245006 (2019)

Current status of 6 DoF sensor

Conclusions - Controllability

- Developed multi-layered control scheme
- Need to stabilise mass relative to ISI as well as ISI itself





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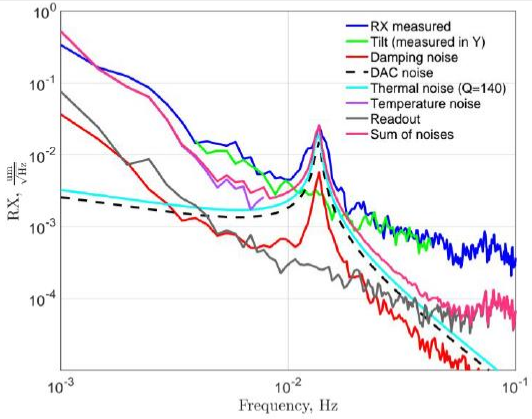
- Sensor and actuator: HoQI and BOSEM

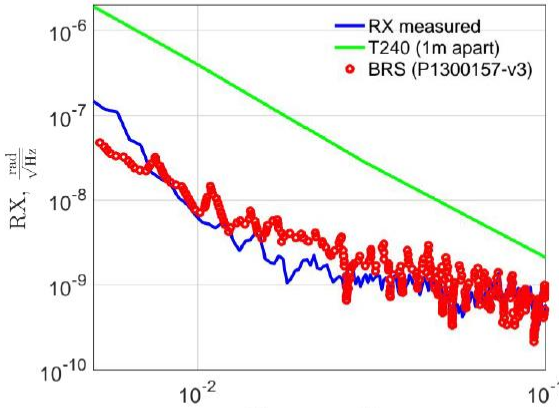
[My seminar slides on Nov. 4, 2022]

y

ctor upgrades

ant gains that could be made from adopting 6D





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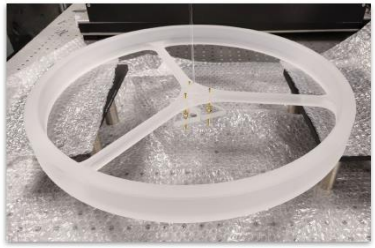
Progress in 6 DoF sensor

Next Step: Compact 6D

- Imminently starting next stage of 6D project
- Smaller mass made of fused silica: **Compact 6D**
  - Same sensitivity as metal prototype
  - Designed with LIGO BSC space constraints in mind
  - Better stability - thermal fluctuations affect angular DoF - suppressed by fused silica



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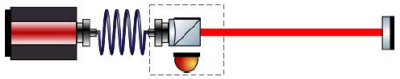
6

- Metal → fused silica
- HoQI → SmarAct
  (introduced by Takano-san in Journal Club, 2022)



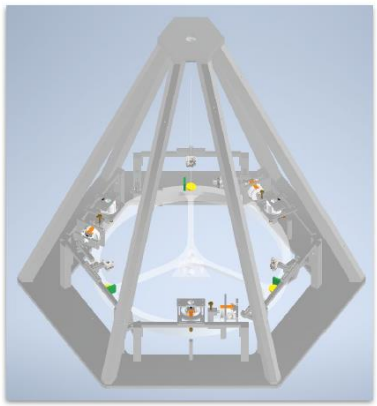
SmarAct

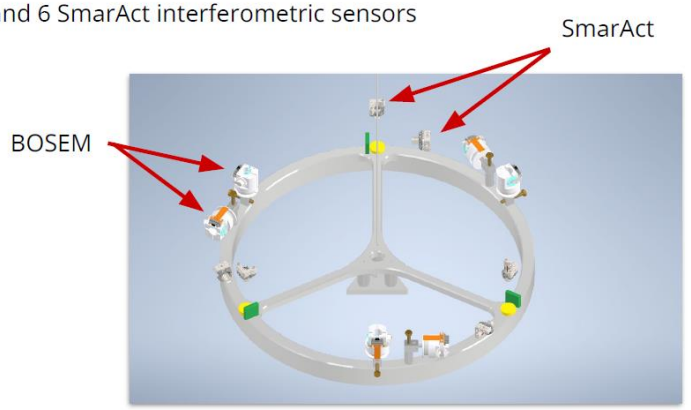
[J. Smetana+, Phys. Rev. Applied, **18**, 034040 (2022)]

…e and Sensor Design

…l being manufactured for local UoB ISI testing.

- Sensor suite of 6 BOSEMS and 6 SmarAct interferometric sensors





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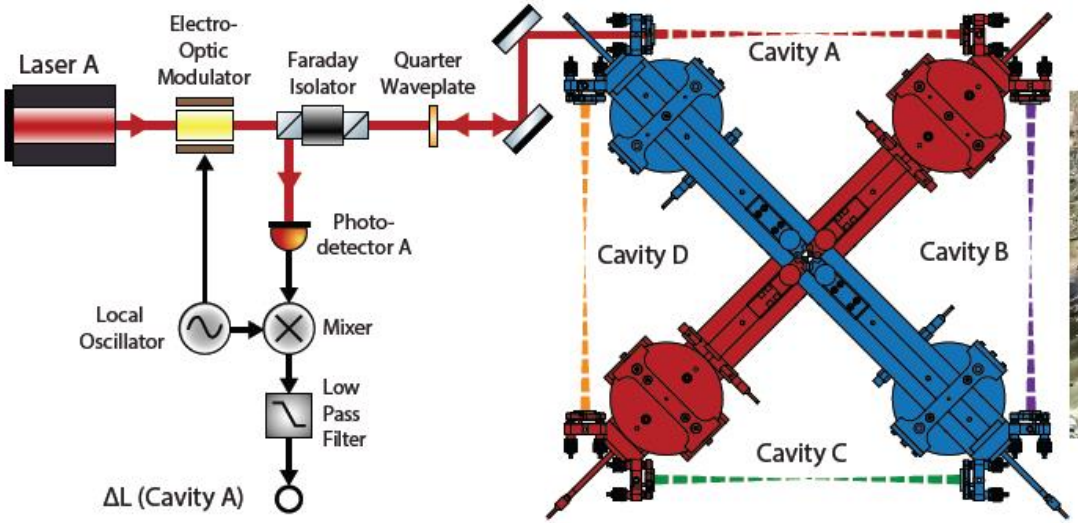
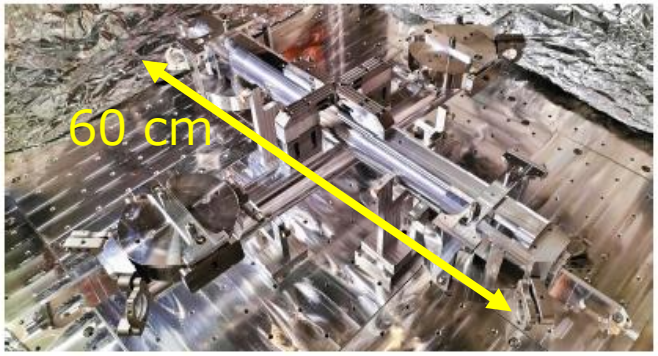
TorPeDO

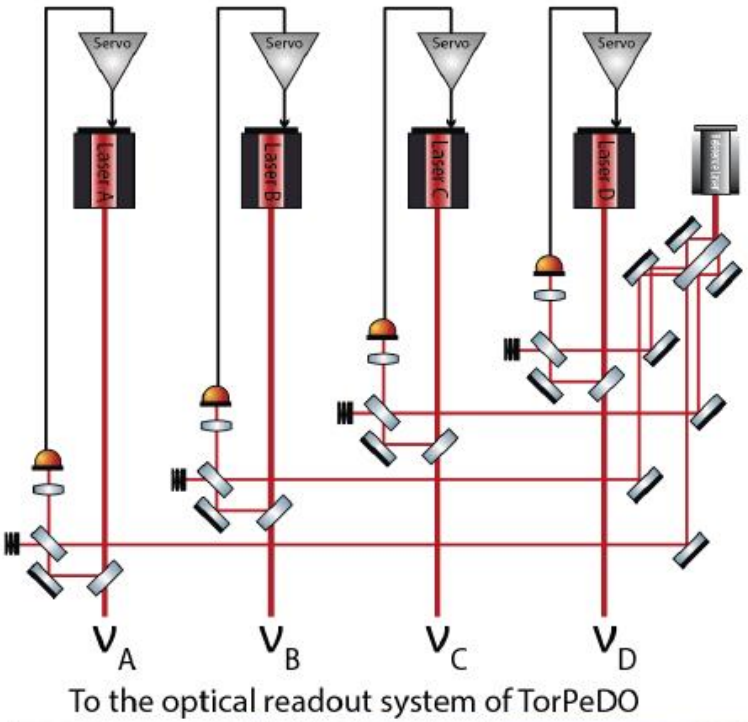
- TorPeDO: Torsion Pendulum Dual Oscillator
- Newtonian noise sensor developed by ANU
- About to suspend bars for third prototype

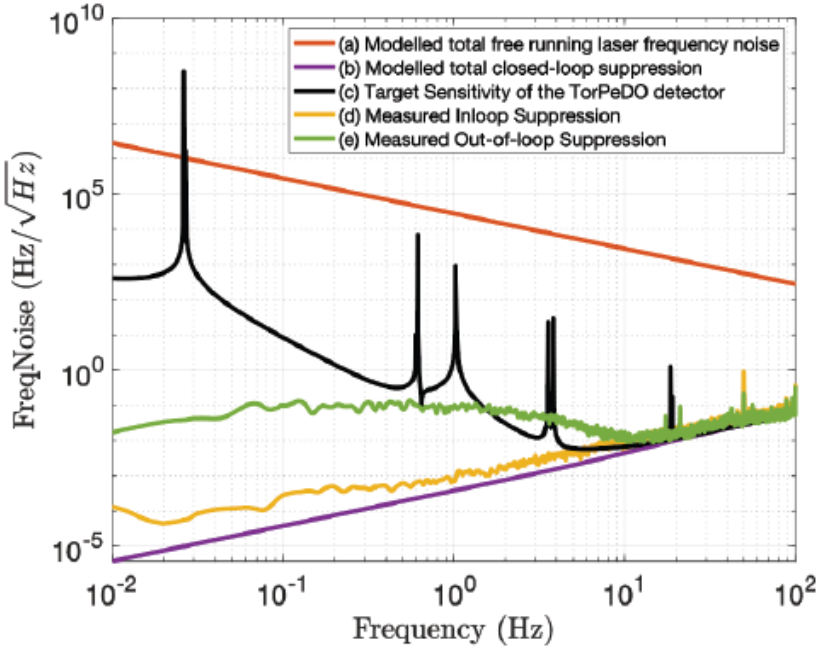




Aluminum bars are reused from the second (perhaps first) prototype

Heterodyne phase-locking





- Four readout lasers are phase-locked
  → They follow the same frequency noise as the reference laser

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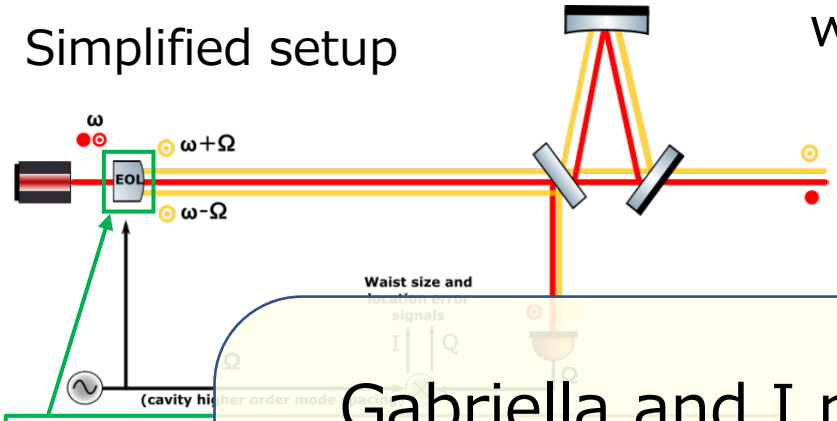
Mode matching sensing with PDH-like method

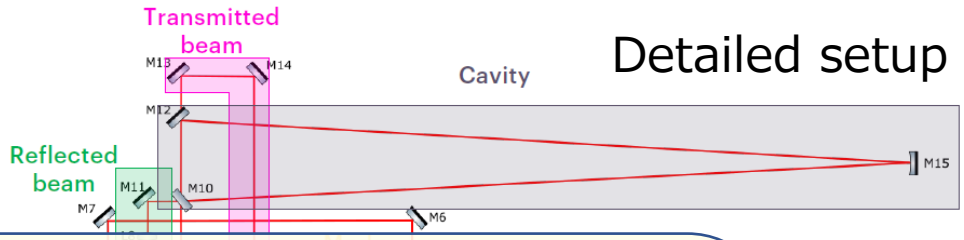
by Gabriella Chiarini from Univ. of Padova

Detect the beating between the LG10 sideband and LG10 carrier with the same RFPD for PDH method

Simplified setup

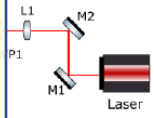


Detailed setup



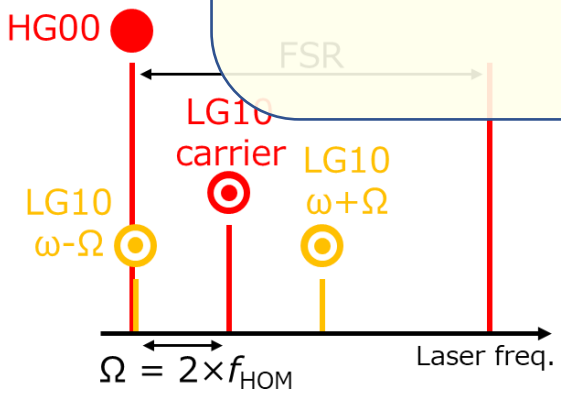
EOL (electro-optic lens): generating LG10 sidebands

Break sideband symmetry (= amplitude + phase modulation)



Gabriella and I met in Padova last year and we remembered each other

She told me about her experiment in detail, so I introduced again

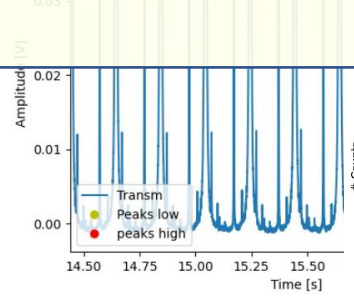


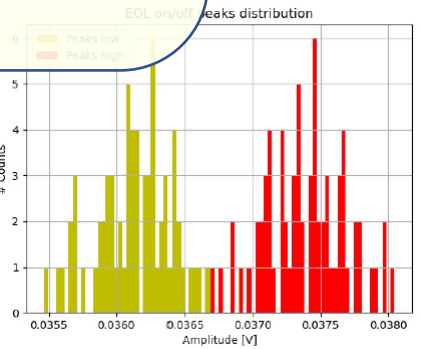
I/Q demodulation:

$$Q = I_0(\gamma m_G + \beta m_B)$$

$$I = I_0(\beta m_G - \gamma m_B)$$

m_B, m_G: modulation depth
β: waist size mismatch
γ: waist position mismatch

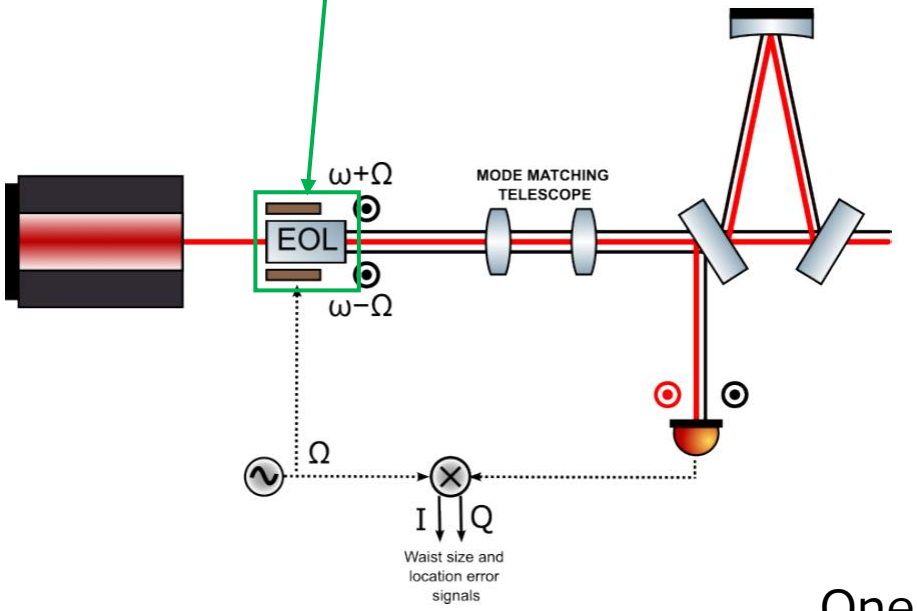


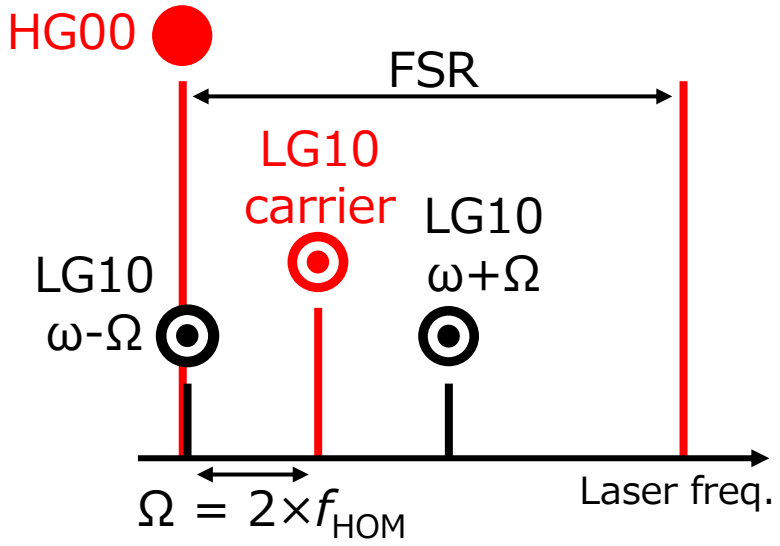


Mode matching sensing with RF modulation

- Motivation: to improve freq. dependent squeezing level in Virgo
- Goal of exp.: online sensing for mode mismatch
- Method: detect the beatnote between the LG10 sideband and LG10 carrier with the same RFPD for PDH method

Electro-optic lens (EOL):
to generate LG10 sidebands (next page)

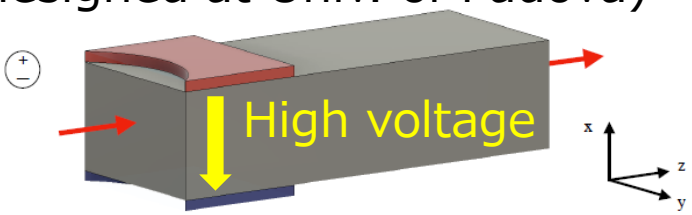




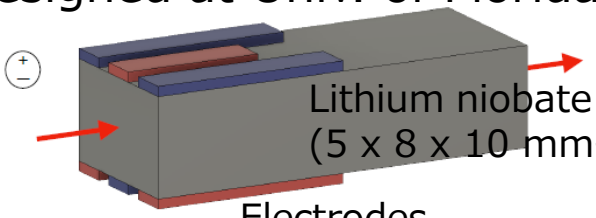
One sideband resonant in the cavity
→ break the sideband symmetry and amplitude modulation is generated

Electro-optic lens (EOL)

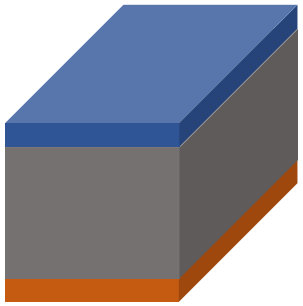
EOL_{pd}
(designed at Univ. of Padova)

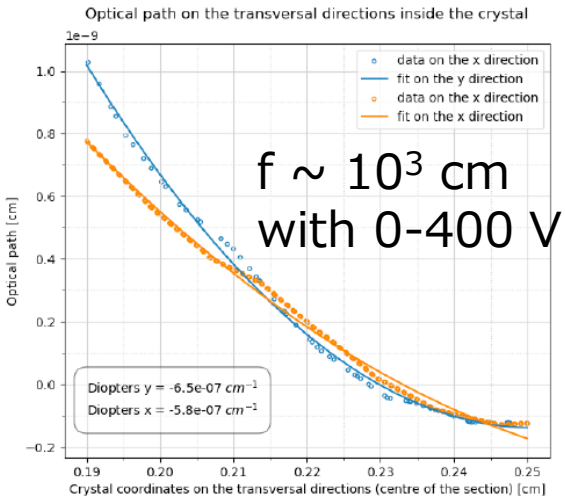


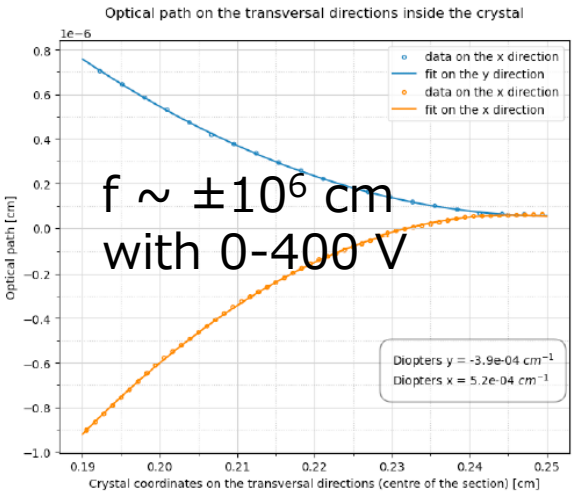
EOL_{fl}
(designed at Univ. of Florida)



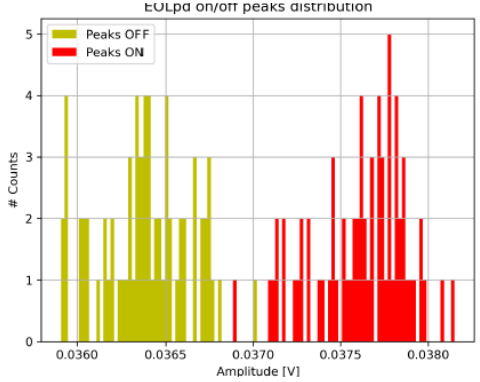
cf.) nominal EOM

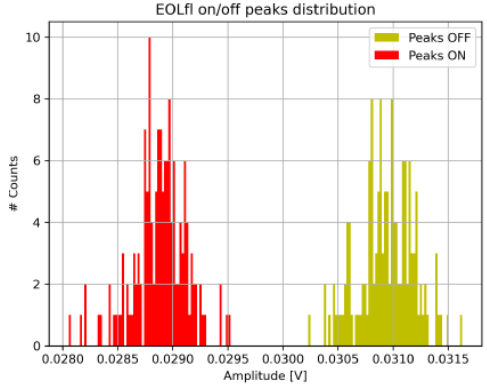


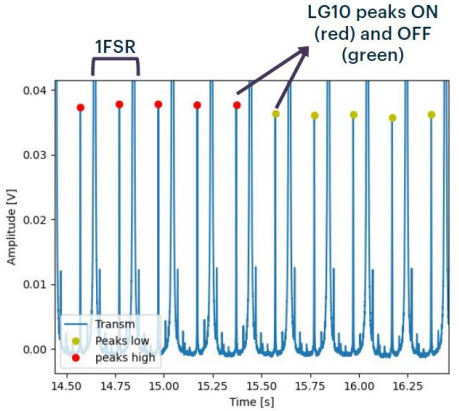




They decided to use EOL_{fl} due to its stronger effect





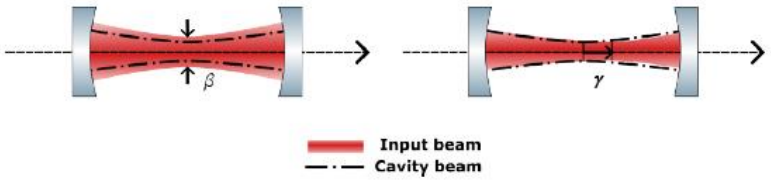


Results

$$LG_{00}(w_0+\delta w, z_0+\delta z) = LG^C_{00}(w_0,z_0) - \left(\frac{\delta w}{w_0} - i\frac{\delta z}{2z_R}\right) LG^C_{10}(w_0,z_0)$$

$$MM = \frac{LG_{10}}{LG_{00}} = \gamma^2 + \beta^2$$

$\beta + i\gamma$



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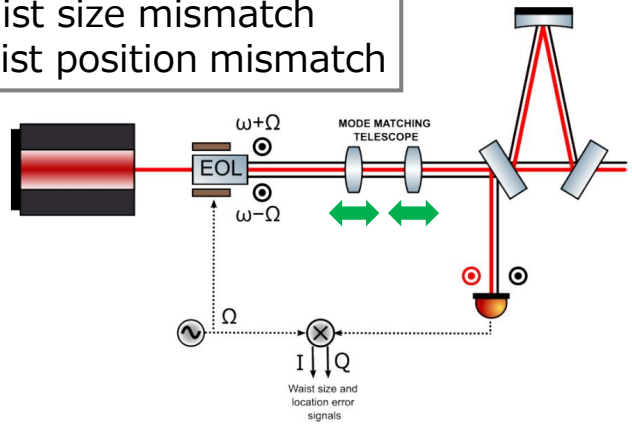

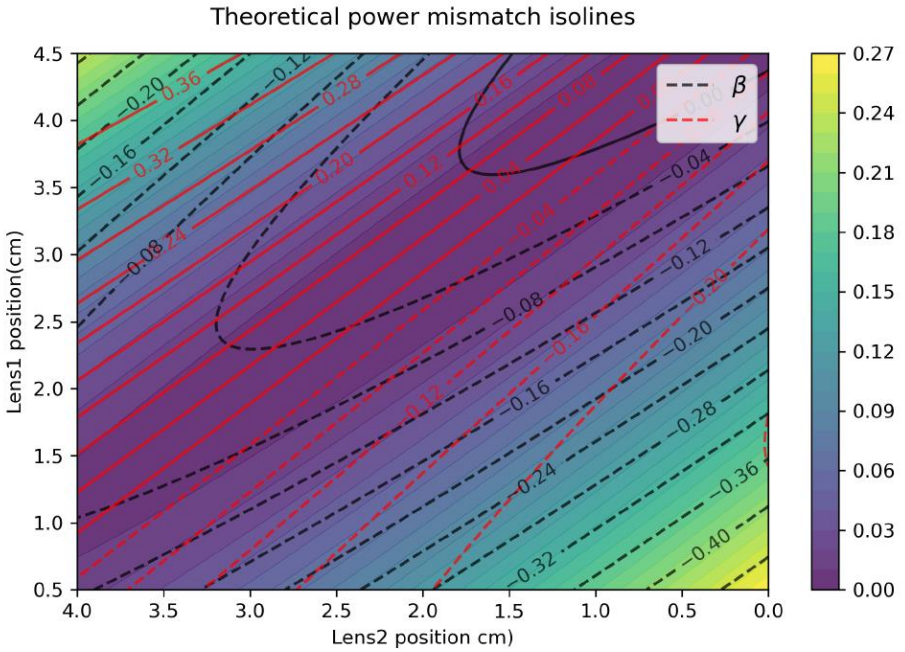

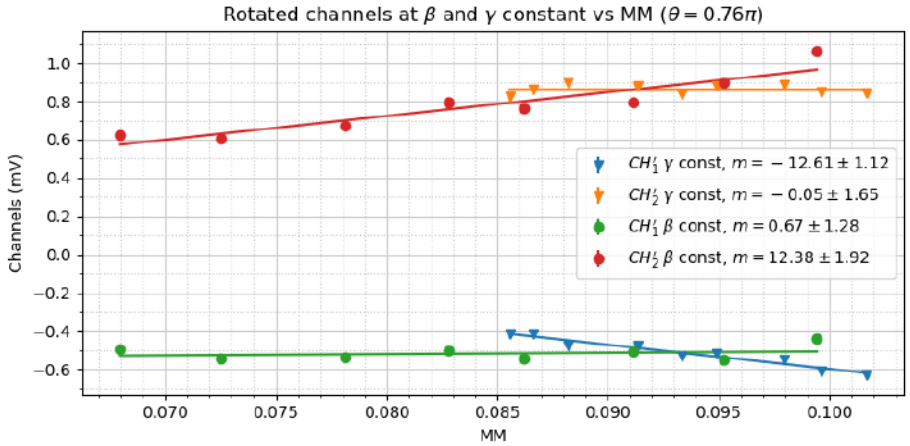

- She plans to come to Japan as a postdoc (NAOJ?) next year

Summary & my impressions

- GWADW is the most interesting conference because all participants and talks are related to GW experiments
- I was excited to meet many researchers of the papers I have been reading
- Elba and Hotel Hermitage is a nice place !!