Report on Visits to Durham and Singapore

Yuta Michimura

Department of Physics, University of Tokyo

My Travels Since Last Seminar

- September 9-13: TAUP2019 @ Toyama
- September 17-20: JPS meeting 2019 Fall @ Yamagata U
- October 9-10: Soda Lab Seminar @ Kobe U
- October 14-17: GWPAW2019 @ RESCEU
- October 21-24: 4M-COCOS @ Fukuoka U
- November 8-10: 量子エレクトロニクス研究会 @ 山中寮
- December 16-17: EU-USA-JAPAN International Symposium on Quantum Technology @ Kyoto U
- December 20-21: 2019年度第1回CRC将来計画タウンミーティング @ グランキューブ大阪
- December 25-27: 第32回 理論懇シンポジウム @ 天文台
- January 6-10: QSFP School 2020 @ Durham U
- January 14-17: GYSS2020 @ Singapore

2020 Global Young Scientists Summit

GYSS2020

- 280 young scientists (less than 35 years old, mostly students and postdocs) around the world

- Award winning invited speakers

- Plenary lectures in the morning, small group discussions in the afternoon

- Hotel & Food provided

GYSS@one-north
GLOBAL YOUNG SCIENTISTS SUMMIT
SINGAPORE

Aaron Ciechanover
Nobel Prize in Chemistry
2004

Ada Yonath
Nobel Prize in Chemistry
2009

Ben Feringa
Nobel Prize in Chemistry
2016

Kurt Wüthrich
Nobel Prize in Chemistry
2002

Klaus von Klitzing
Nobel Prize in Physics
1985

Sir Konstantin Novoselov
Nobel Prize in Physics
2010

Sir Tim Hunt
Nobel Prize in Physiology or Medicine
2001

Efim Zelmanov
Fields Medal
1994

Ngô Bảo Châu
Fields Medal
2010

Wendelin Werner
Fields Medal
2006

Michael Grätzel
Millennium Technology Prize
2010

John Hopcroft
Turing Award
1986

Leslie Lamport
Turing Award
2013

Leslie Valiant
Turing Award
2010

Kees Immink
IEEE Medal of Honor
2017

Alain Fischer
Chair of Experimental Medicine at Collège de France
Guest Speaker

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GYSS2020 Highlights Video

Participants from UTokyo

- Yukako Fujishiro (物理工学専攻, 十倉・金澤研)

- Saya Kashiwakura (生命環境科学系, 本吉研)

- Keigo Matsumoto (知能機械情報学専攻, 廣瀬・葛岡・鳴海研)

- Yuta Michimura (me)

- Jumpei Yamagishi (相関基礎科学系, 金子邦彦研)

- Meeting with 本部国際戦略課 on Feb 3

- Also from RIKEN, UEC, Osaka U, NIMS (mostly funded by JST)

Random Notes

- Princess of Thailand
- I don't do science as a business, nor for the awards and accolades. I do science because I like looking at a beautiful math structure with good proof. -- Wendelin Werner
- Conference App; You can even search for participants
- What to do if you invented something? Kees Imminik
- Got autographed book by Tim Hunt
- Learned a lot on attitude towards scientific research
- Many people can speak English and Chinese

GYSS 2020 [17+]
I-PROMO Pte Ltd

Free

Visit to NUS

- Presidential Young Professorship
  - Start-up grants of up to the following: $1m for STEM experimental; $500k for STEM non-experimental;
  - Additional, white space funding of $250k to provide additional flexibility for appointees to purse their ambitious academic goals.

- Tables for Medicine, Computer, Engineering, Science

Prof Chen Tsuhan
Deputy President (Research and Technology) and Distinguished Professor

☎ +65 6601 7308
✉ dprtchen@nus.edu.sg

AGEING
Gain a deeper understanding of ageing at a cellular, individual and societal level, which will help the formulation and execution of policies on ageing in Singapore and Asia

SMART NATION
Develop strategic capabilities in data science, analytics and optimisation, and cybersecurity

ASIAN STUDIES
Develop special expertise, insights and connections relating to key issues of critical importance to Asia

MATERIALS SCIENCE
Carry out innovative basic and applied research that enriches society and business enterprise in Singapore and the world

8 Research Clusters

BIOMEDICAL SCIENCE & TRANSLATIONAL MEDICINE
A key hub for medical and public health research and advances, with a focus on Asian populations

MARITIME
Sustain cutting-edge research, enhance synergistic industry university partnerships and contribute to the Singapore model for maritime development

INTEGRATIVE SUSTAINABILITY SOLUTIONS
Develop new integrated sustainability solutions for a rapidly urbanising Asia

FINANCE AND RISK MANAGEMENT
Contribute to Singapore's goal of becoming a world-recognised leading financial centre in Asia
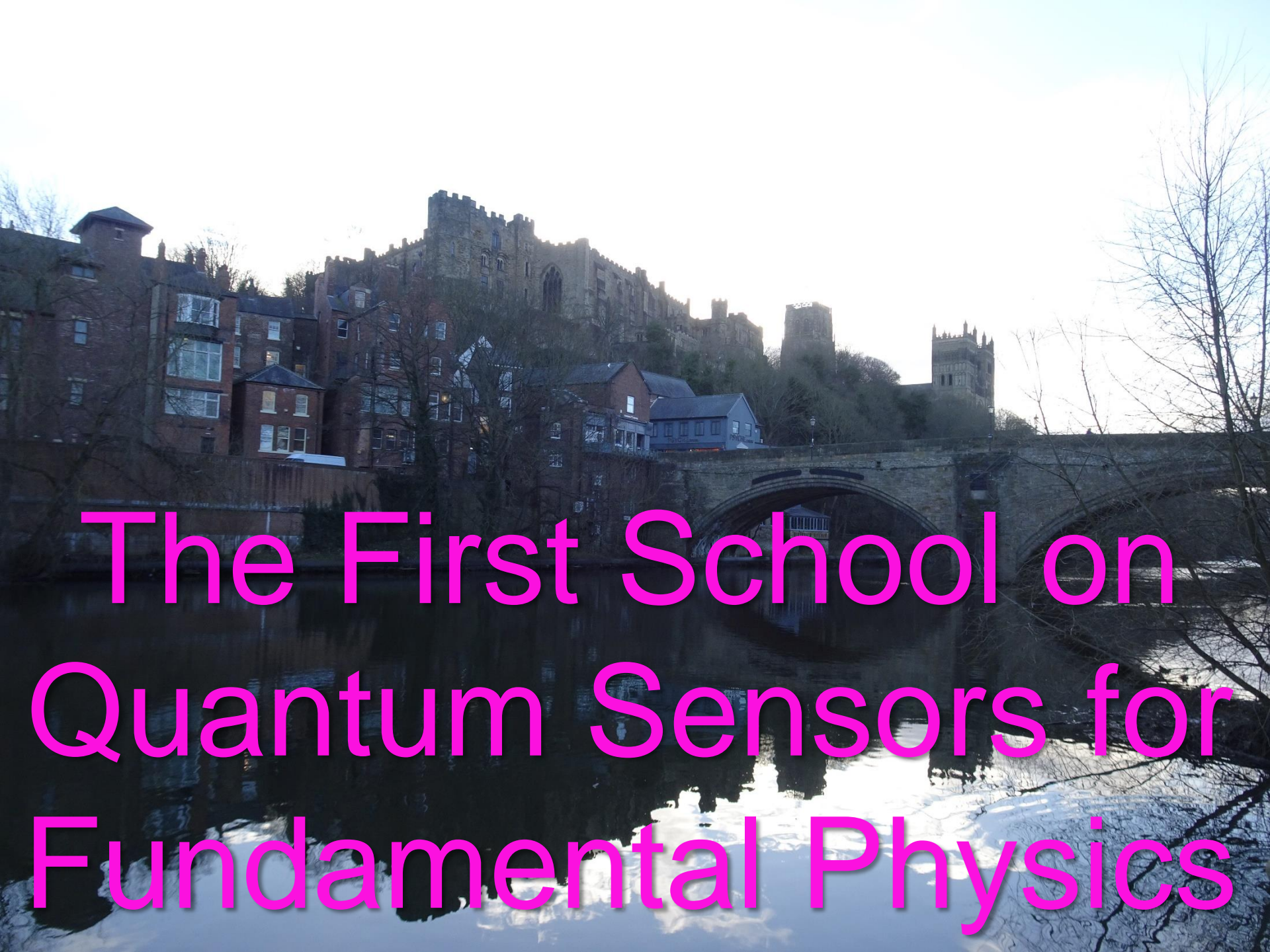
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Night Safari

Gardens by the Bay

Merlion

National Museum of Singapore

SYONAN-TO
1942-1945

The First School on Quantum Sensors for Fundamental Physics

QSFP2020

- Durham University
- ~70 participants
- 8 lecturers

https://conference.ippp.dur.ac.uk/event/831/

QSFP 2020

First international school on Quantum Sensors for Fundamental Physics

6 - 10 January 2020, Durham

Angelo Bassi - Tests and limits of the quantum superposition principle

Jonathan Braden - False vacuum decay and non-equalilibrium QFTs

Edward Daw - Sikivie-style resonant axion haloscopes

Yuta Mishimura - Laser interferometer search for non-standard physics

Marianna Safronova - EDMs, ions, atoms and molecular probes for new physics

Ralf Schuetzhold - Gravity Simulators

Michal Zawada - Atomic clocks and spectroscopy experiments

Jure Zupan - Beyond the Standard Model theories

Please register at https://conference.ippp.dur.ac.uk/e/qsfp

Organizing Committee:
Martin Bauer, Diego Blas,
Jon Coleman, Ruth Gregory, Denis
Martynov, Gavin Morley, Ruben Saakyan,
Silke Weinfurtner

EPSRC
Engineering and Physical Sciences
Research Council

Science & Technology
Facilities Council

IP3

QSFP Consortium

- Started (probably) in 2018
- 32 UK institutions, 7 international institutions and five partners
- 11 Workpackages (all look very exciting!)

WP1	WP2	WP3	WP4
Using Quantum Technology to Search for Low-mass Particles in the Hidden Sector	MaQS (pronounced "Max") Macroscopic quantum superpositions for physics beyond the standard model	AION A UK Atom Interferometer Observatory and Network	Absolute neutrino mass
Participants/Collaborators > Join this group >	WP2 workshop slides > Participants/Collaborators > Join this group >	Join this group >	Participants/Collaborators > Join this group >

WP5	WP6	WP7	WP8
Quantum Simulators of Fundamental Physics	QSNET Networked Quantum Sensors for Fundamental Physics	Searches for a Fifth Force and Dark Matter using Precision Atomic Spectroscopy	Fundamental physics from precision studies of exotic atoms
Participants/Collaborators > Join this group >	Join this group >	Join this group >	Participants/Collaborators > Join this group >

WP9	WP10	WP11
LIST – Lorentz Invariance Space Test	Quantum sensors for fundamental physics: Collective quantum excitations as quantum sensors	QI: Quantum-enhanced Interferometry for New Physics
Participants/Collaborators > Join this group >	Participants/Collaborators > Join this group >	

http://qsfp.physics.ox.ac.uk/

Glasgow, Strathclyde
Aberdeen
St Andrews
Edinburgh, Heriot Watt
Newcastle
Lancaster
Durham
Belfast
Leeds
Liverpool
Sheffield
Manchester
Birmingham
Nottingham
Warwick
Cambridge
Oxford
Swansea
Cardiff
ICTS, King's, UCL, NPL,RH
RAL
Brighton, Sussex
Plymouth
Southampton

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WP2: Macroscopic Quantum

- *we seek to put 10-1000 nm particles into quantum superpositions of different positions*

Macroscopic Quantum Superpositions – MaQS

Is there a macroscopic limit to the quantum superposition principle?

Home   Contact   Meetings   People

$$|\psi\rangle_{cat} = \frac{1}{\sqrt{2}}\left(\left|\begin{array}{c}\text{🐱}\end{array}\right\rangle + \left|\begin{array}{c}\text{🐱}\end{array}\right\rangle\right)$$

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WP9: Lorentz Invariance

- LIST: Lorentz Invariance Space Test

Kai Bongs

- Aiming for Michelson-Morley experiment at 1e-19 level

Figure 1. Given an energy scale E, if Quantum Gravity effect is important then Lorentz Invariance would cease to be valid. As a result, an anisotropic and inhomogeneous speed of light with $\Delta c/c \approx E_{ph}/E$ is expected, where E_{ph} is the photon energy. Without a complete quantum theory of gravity, E is a model-dependent parameter. For 1eV-photons used by Michelson-Morley experiments, the Lorentz Invariance of various theories with the corresponding energy scale up to 10^9 GeV have been tested. LIST aims to achieve at least the 10^{-19} level for $\Delta c/c$ anisotropy and probe Lorentz violation induced by Standard Model Extensions and spacetime fluctuations for a minimum $E \approx 10^{10}$ GeV. This scale covers the entire electroweak epoch and the crucial separation stage of strong and electroweak forces. The anticipated results of this work package would therefore set an important marker in testing our fundamental understanding of the Universe.

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WP11: Quantum-enhanced Interferometry

- Axions (possible enhancement by white light cavity?), Test of holographic principle, Semi-classical gravity, ALPS detector
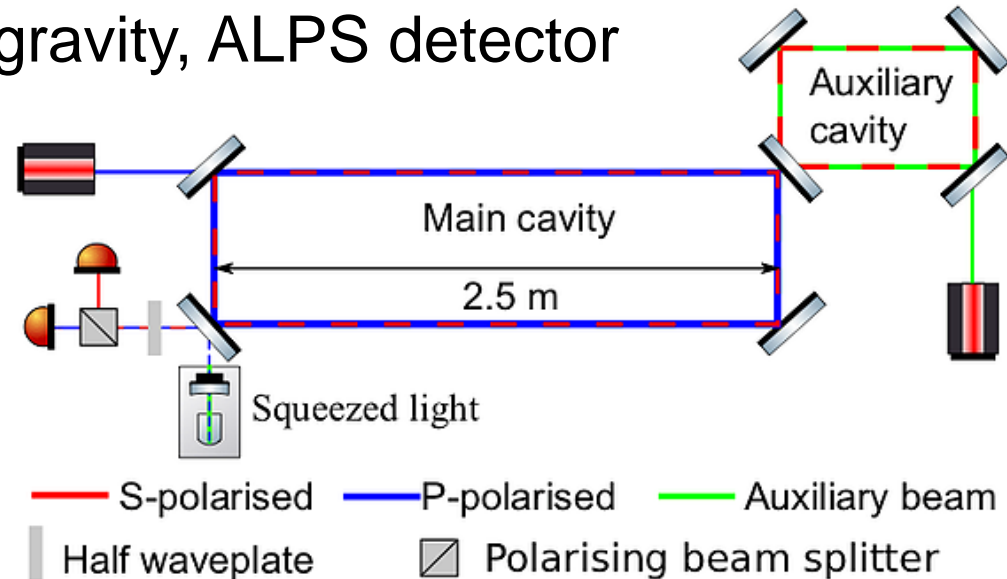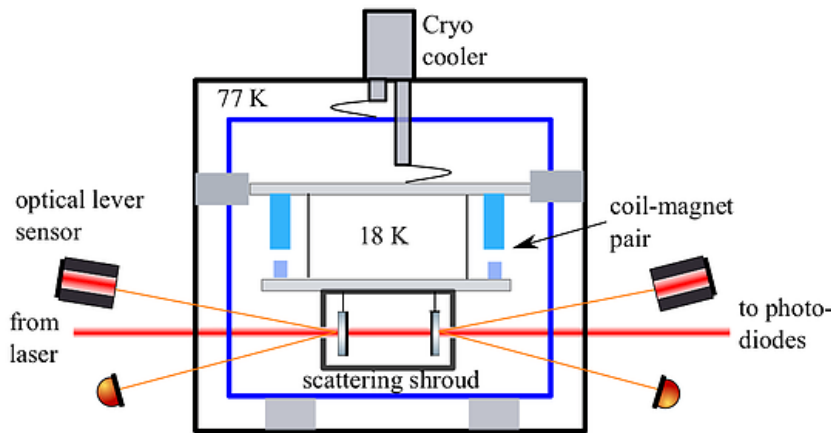
University of Birmingham: Dr Denis Martynov, Dr Haixing Miao, Dr Vincent Boyer

Cardiff University: Prof Hartmut Grote and Dr Katherine Dooley

The University of Warwick: Dr Animesh Datta

The University of Glasgow: Dr Dmitry Morozov and Prof Robert Hadfield

University of Strathclyde: Prof Stuart Reid

Lectures

- Atomic clocks by Michal Zawada
    - DM search through fine-structure constant measurement
    - Optical clock search for Lorentz violation
      [Nature 567, 204 (2019)](#)

- Atoms and molecular probes by Marianna Safronova
    - Based on [RMP 90, 025008 (2018)](#)

- Review on CSL by Angelo Bassi
    - non-interferometric test is also important

- I gave lectures on
  Lorentz invariance test, axion,
  macroscopic quantum mechanics,
  and KAGRA

Rochester Building

Durham Castle

Durham Cathedral

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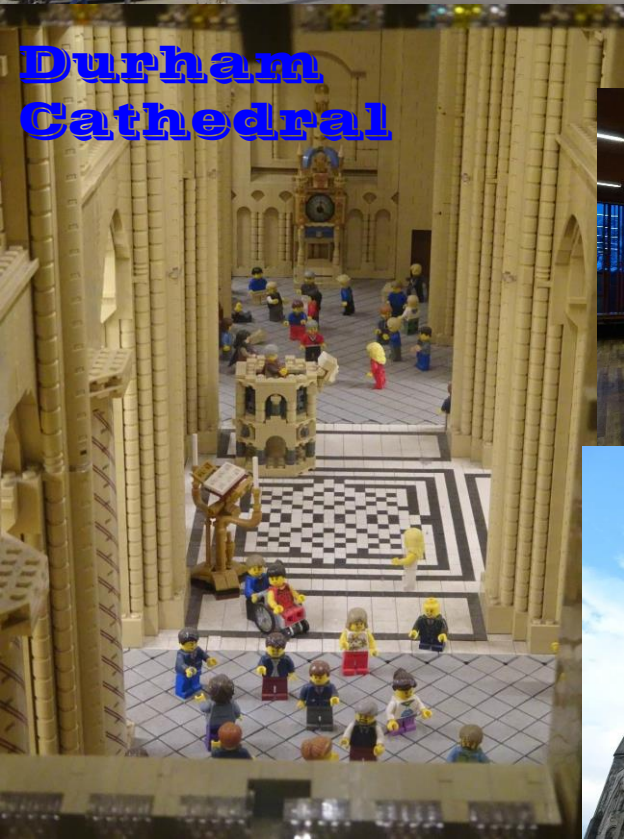
Other Topics
(on Equivalence Principle)

Equivalence Principle in Quantum

- Equivalence Principle

$$m_{\text{I}} \frac{\text{d}^2 x}{\text{d}t^2} = G \frac{m_{\text{G}} M}{r^2}$$

- Weak EP do not hold in Quantum Mechanics?

$$i\hbar \frac{\partial \Psi}{\partial t} = \left[-\frac{\hbar^2}{2m} \frac{\partial^2}{\partial x^2} - G \frac{mM}{r} \right] \Psi$$

(h/m always remains in Schrödinger equation)

- Possible connection with gravitational decoherence?

Gauge Boson DM Search

- If there's a vector field which couples to B-L (barion number minus lepton number), mirrors are shaken at oscillation period

- If two cavity mirrors are apart or two mirrors are made of different material with different B-L, we can search for the signal
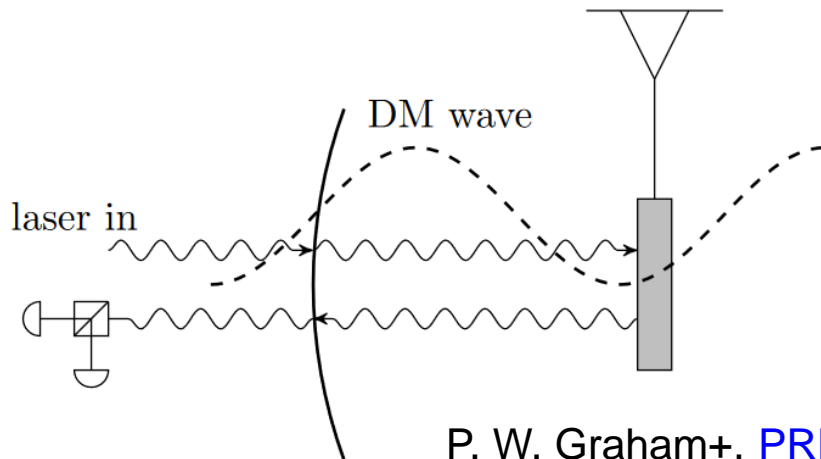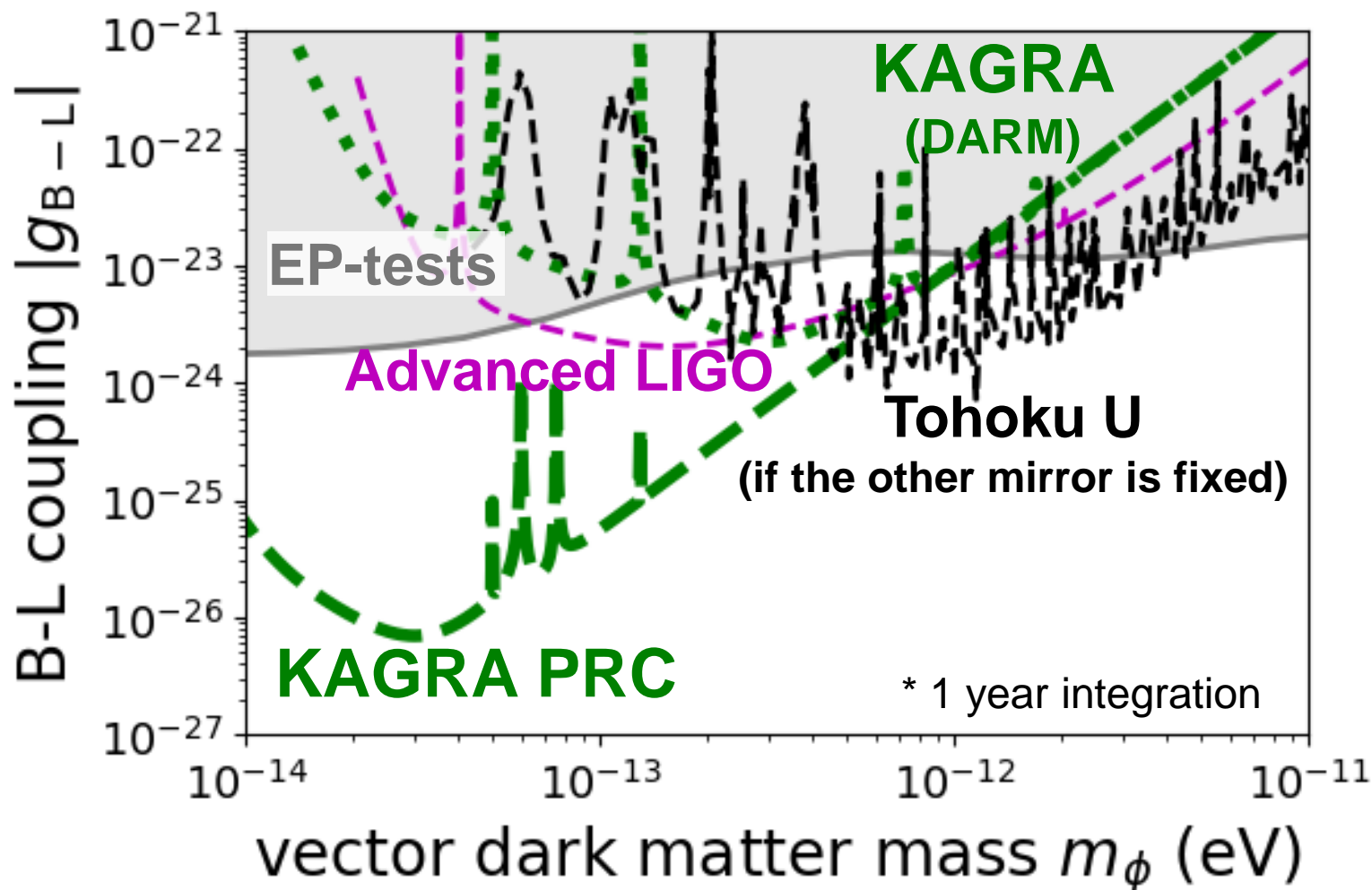
P. W. Graham+, PRD **93**, 075029 (2016)
A. Pierce+, PRL **121**, 061102 (2018)
D. Carney+, arXiv:1908.04797
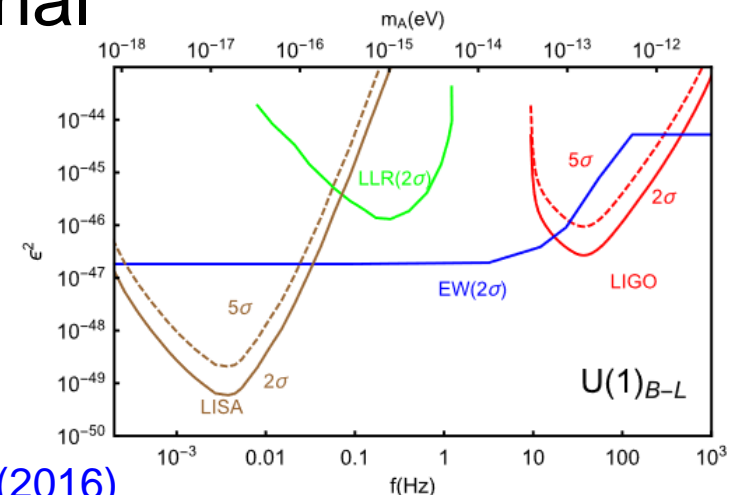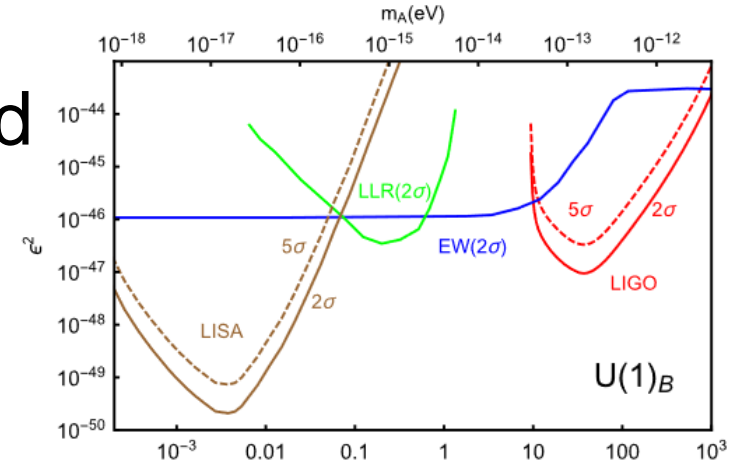
With KAGRA

- Much better search could be done with KAGRA power recycling cavity

Scalar DM Search through α

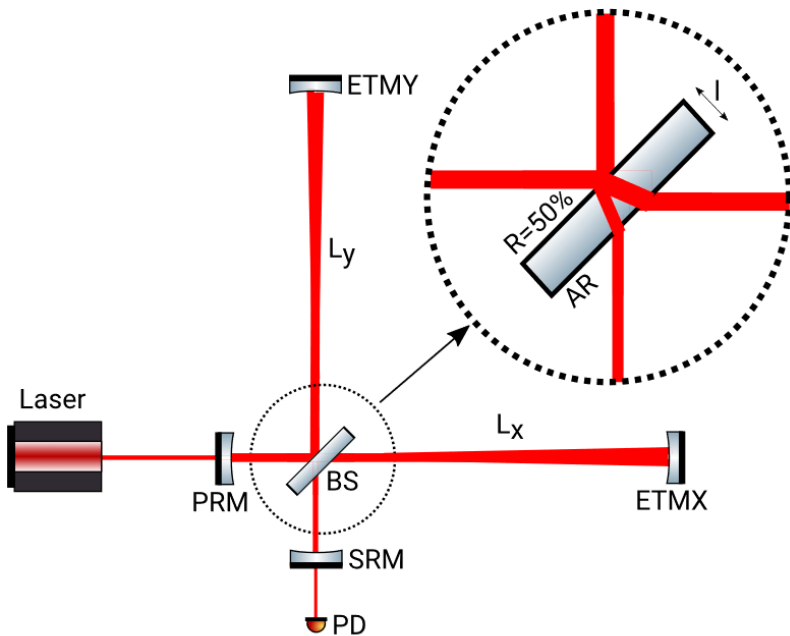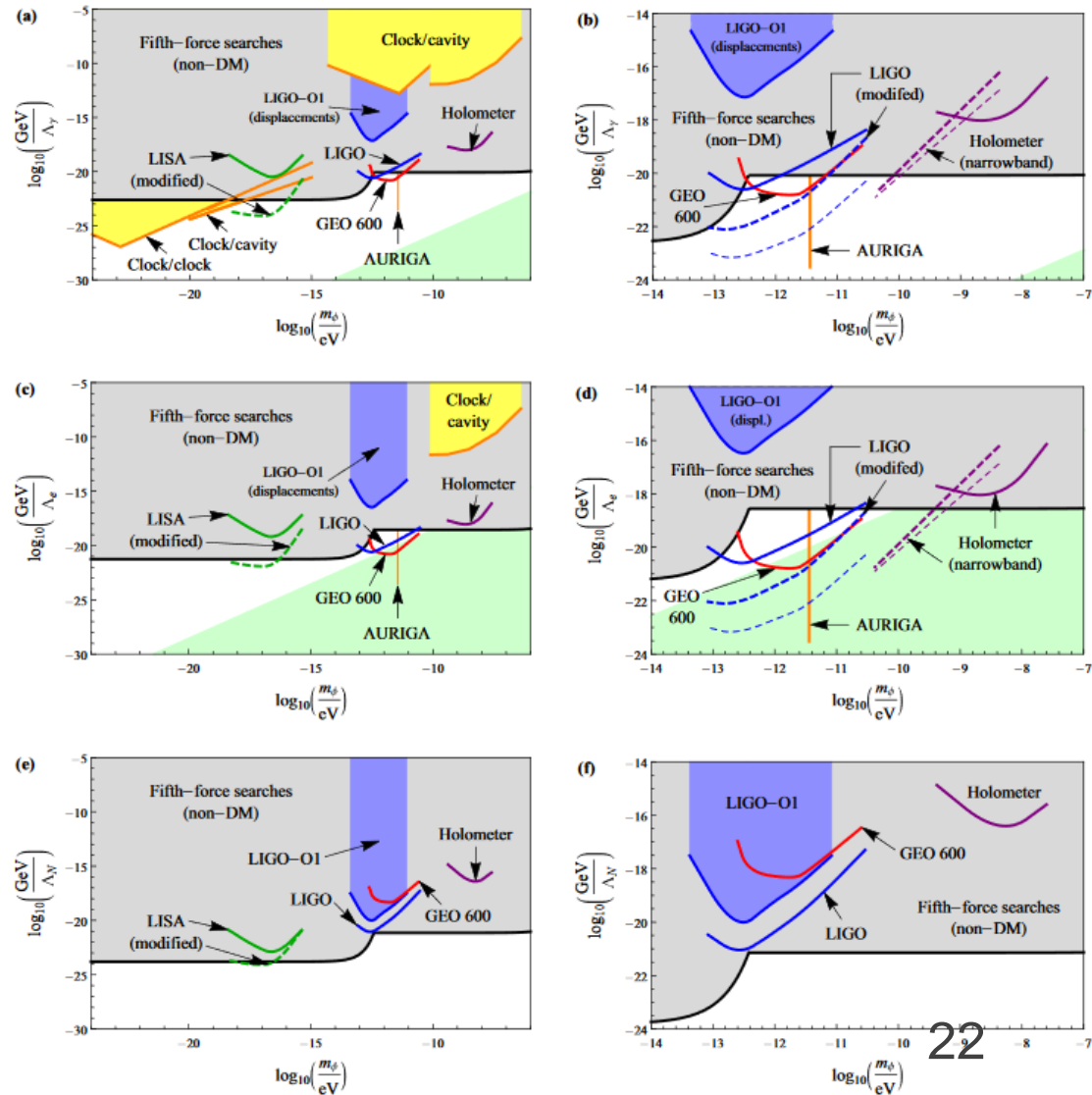- H. Grote & Y. V. Stadnik, PRR 1, 033187 (2019)
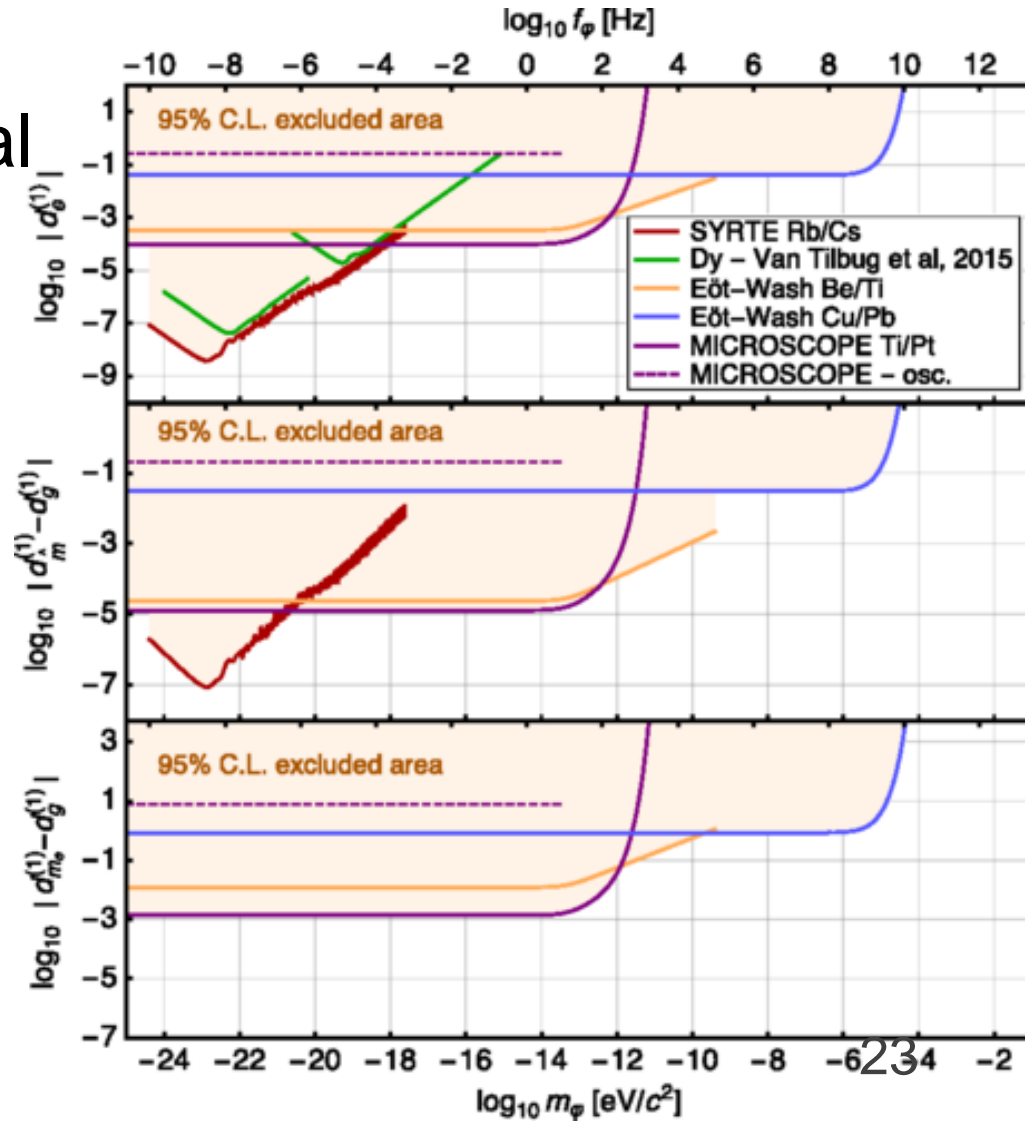- Can do better with MICH?

FIG. 1. Simplified layout of a dual-recycled Michelson interferometer, such as GEO 600 [13,14] and the Fermilab holometer [15,16]. Dual recycling denotes the combination of power recycling

Limits from EP Tests

- A. Hees+, PRD 98, 064051 (2018)

- Static search for Yukawa-type potential with MicroSCOPE and Eot-Wash

PRL 119, 231101 (2017)