Current status of Dark matter Axion search with riNg Cavity Experiment (DANCE)

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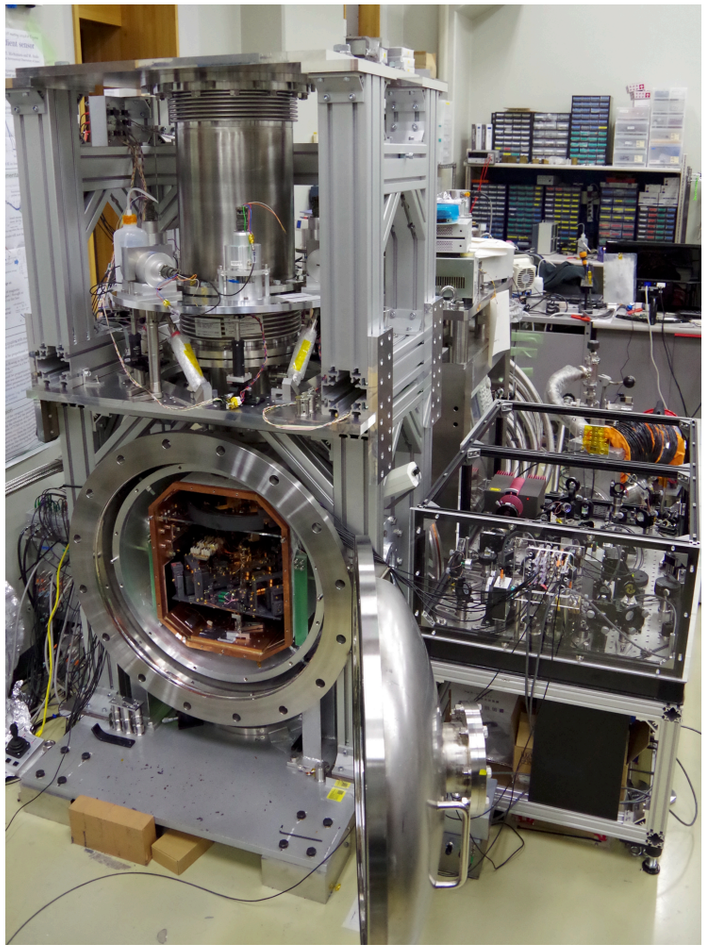
Self-introduction

- Hinata Takidera (M2)
- Gravitational wave astronomy
- Experimental research on gravity and relativity
- Laser interferometer

DECIGO



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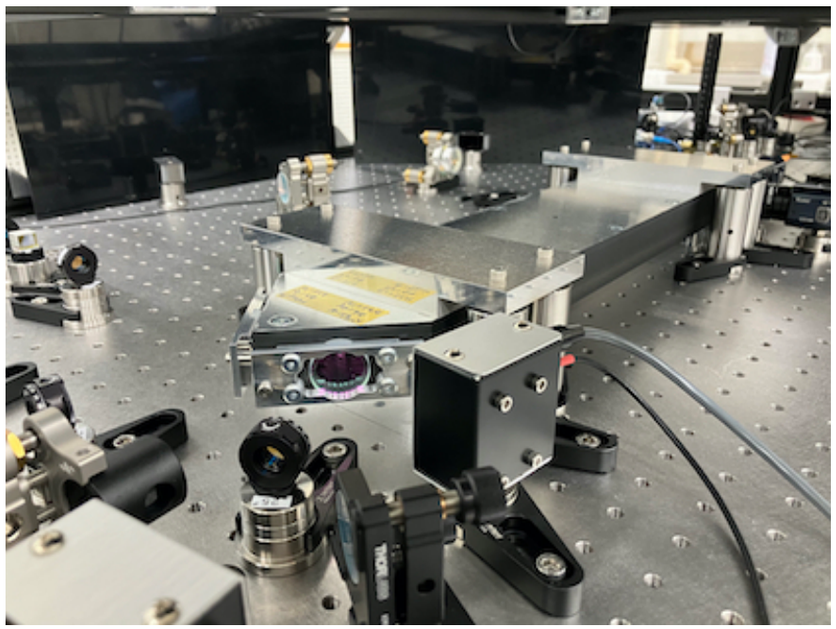


DANCE

Contents

Contents

Dark matter

- Suggested in 1933 from observation of galaxy rotation curves
- Accounts for about 80% of all the matter
- Extensive research is being conducted

Dark matter mass [GeV]

10^{-30} 10^{-20} 10^{-10} 10^{0} 10^{10} 10^{20} 10^{30} 10^{40} 10^{50} 10^{60}

Ultralight DM | **Light DM** | **WIMP** | **Heavy DM** | **Composite DM & Primordial BHs etc.**

Laser interferometer

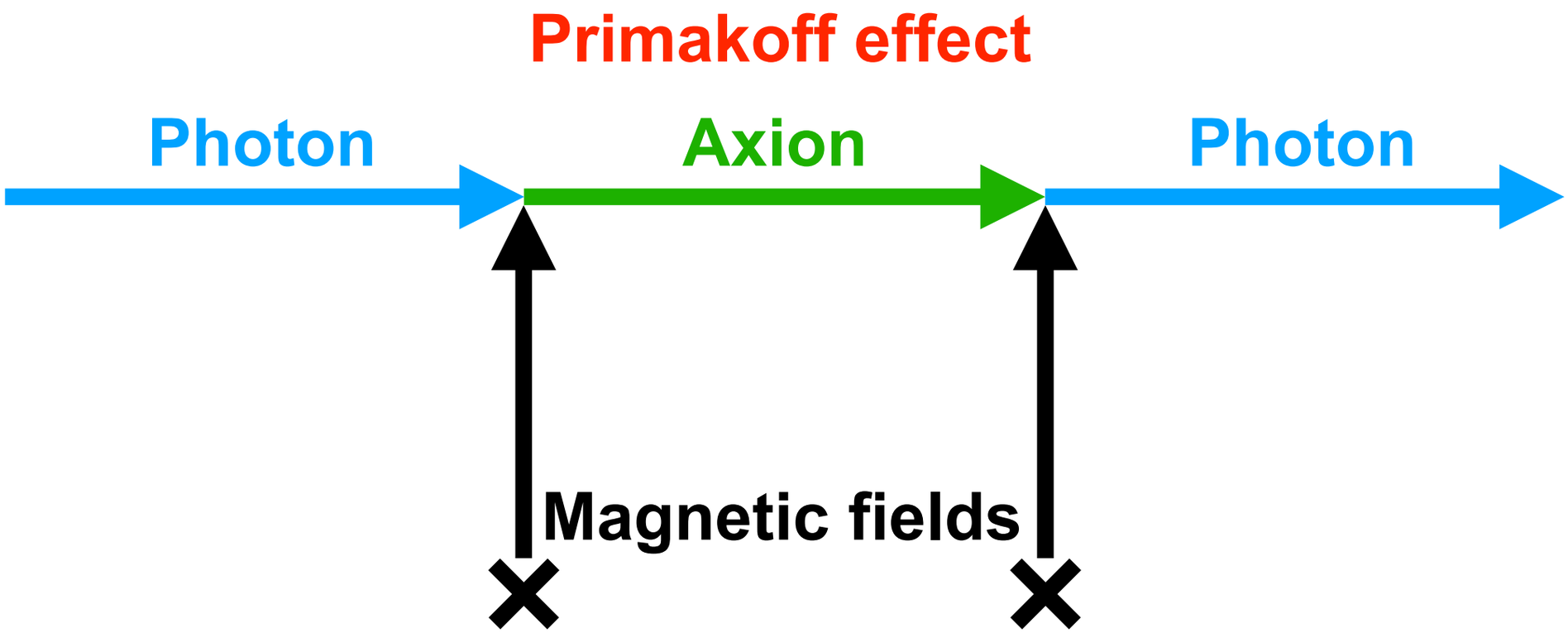
KAGRA

XENON

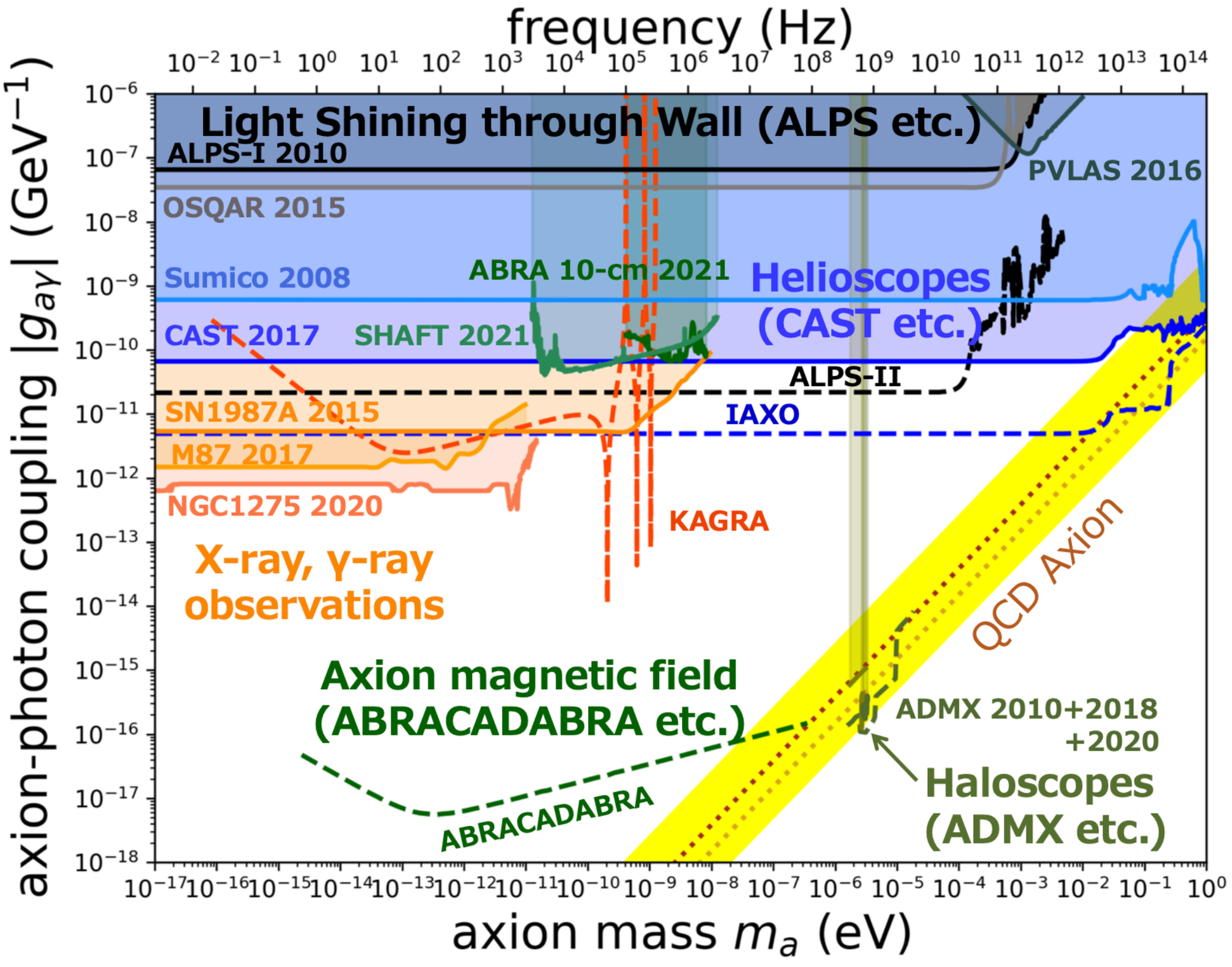
Subaru telescope

Axion and Axion-Like Particles (ALPs)

- Axion dark matter: unidentified particle
- Pseudo-scalar particle was originally proposed by Peccei and Quinn to solve the strong CP problem in quantum chromodynamics (QCD axion)
- Axion weakly interacts with photon, electron, proton
- Many experiments have been using axion-photon conversion under magnetic fields (Primakoff effect) to search for ALPs



Previous Searches

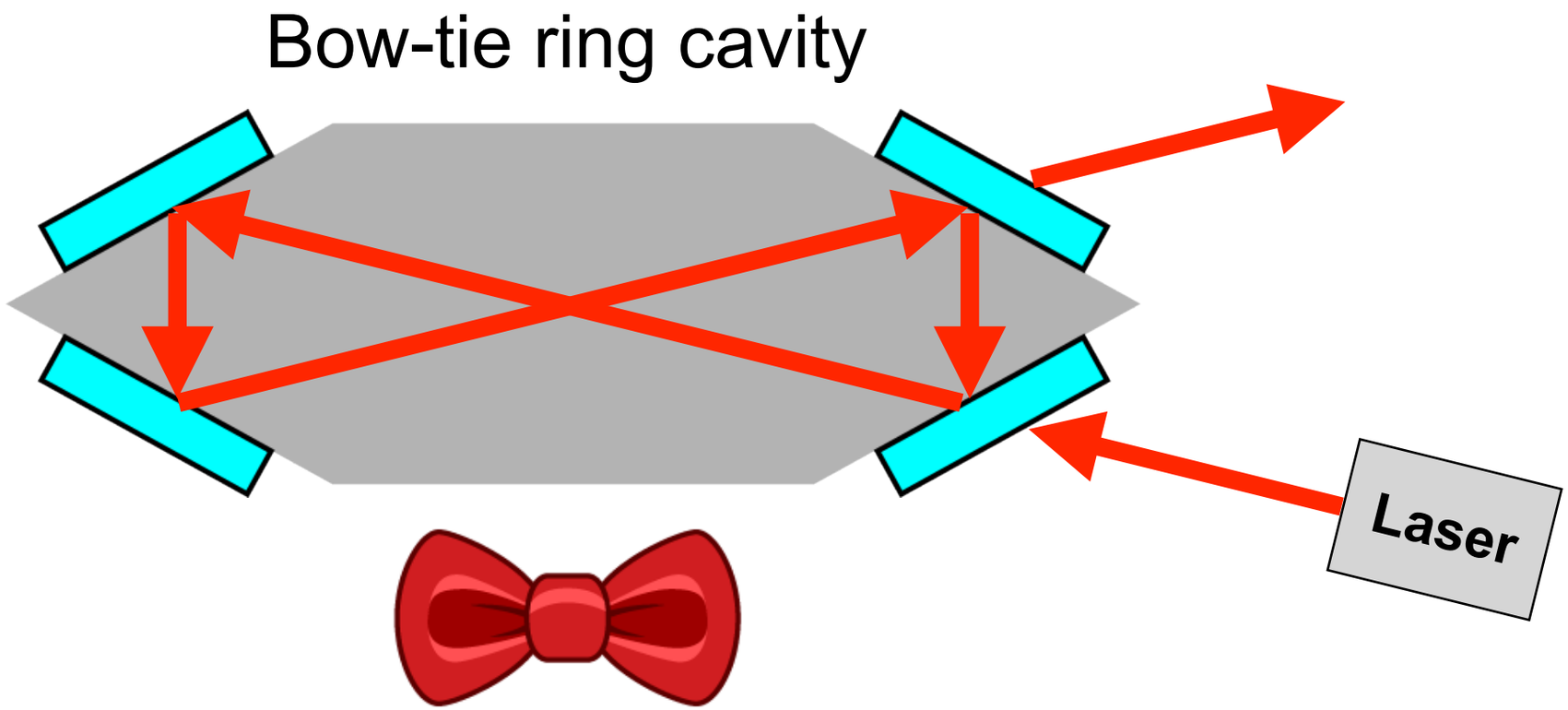


Contents

DANCE

DANCE (Dark matter Axion search with riNg Cavity Experiment)

- Bow-tie ring cavity
- Dark matter search experiment by interferometer
- Axion-photon interaction
- Prototype experiment (DANCE Act-1) is ongoing
- No need for magnetic fields



Axion-photon interaction

$$c_{\mathrm{L/R}}(t) = 1 \pm \frac{g_{a\gamma} a_0 m_a}{2k} \sin(m_a t + \delta_\tau)$$

Axion mass

The phase velocity

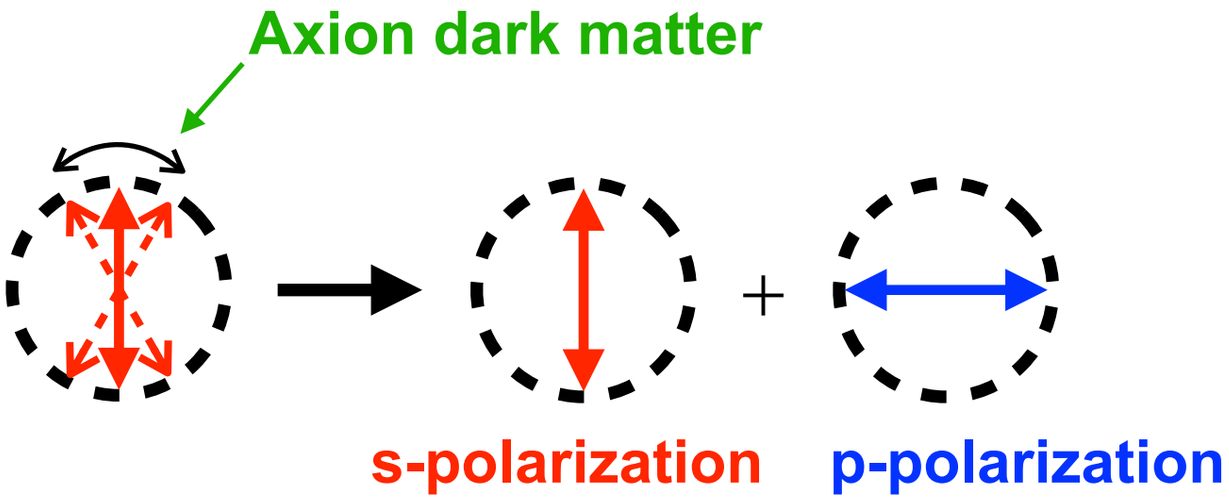
Axion-photon coupling constant

Axion field

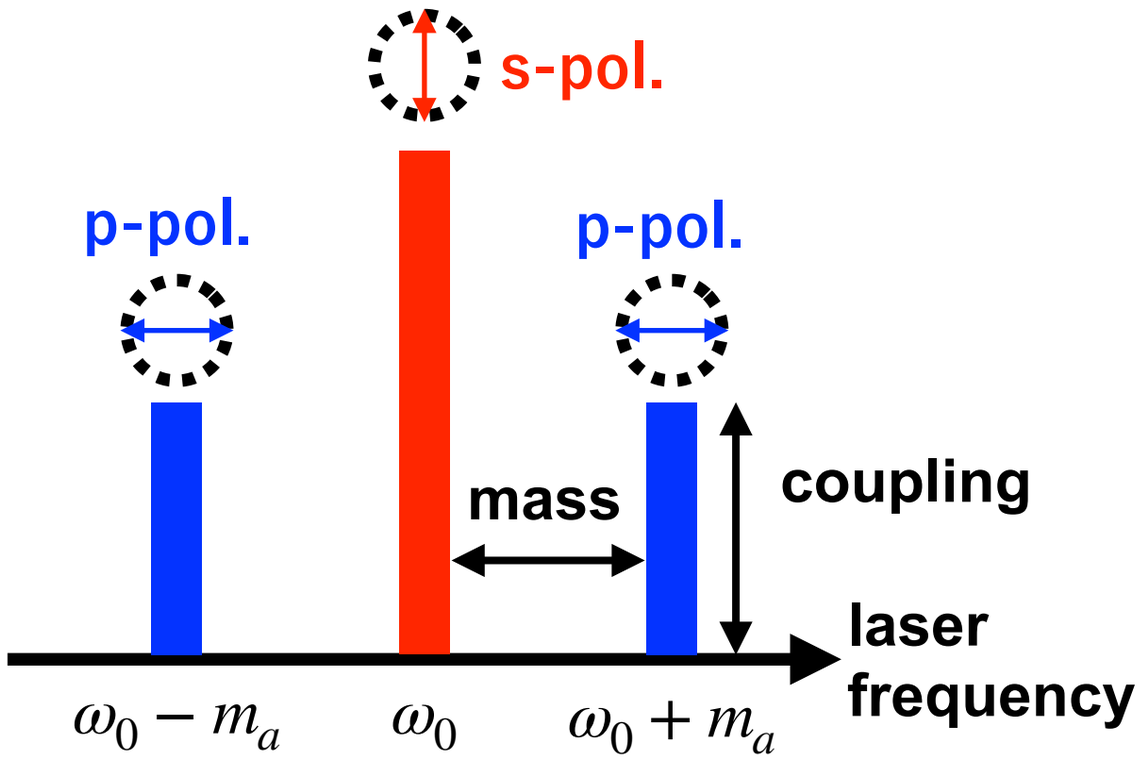
Phase factor

Axion-photon interaction gives the phase velocity difference

→ Regard it as a rotation of linearly polarized light



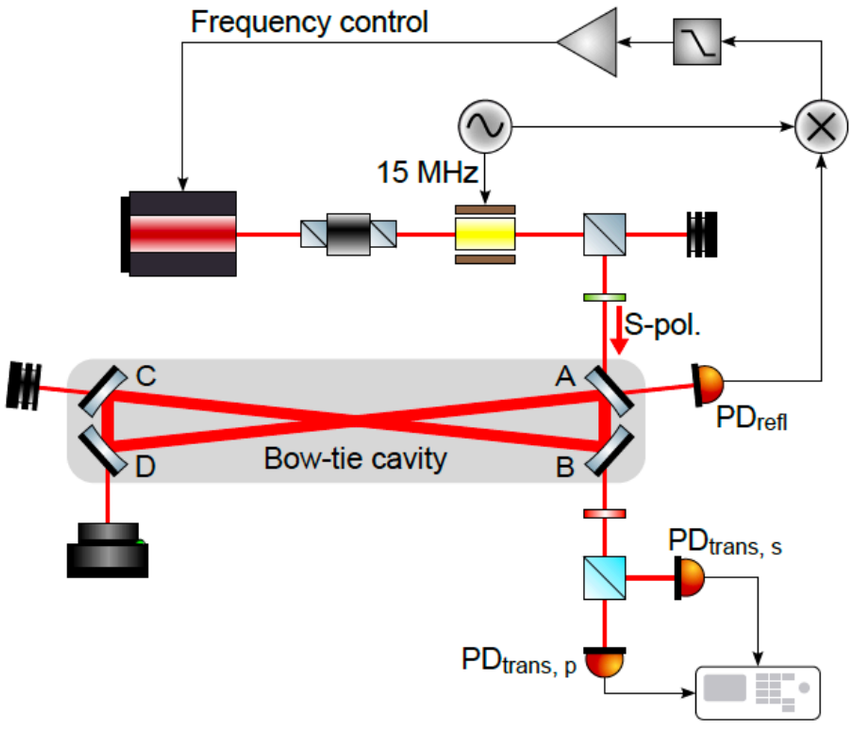
p-pol. is produced from **s-pol.**

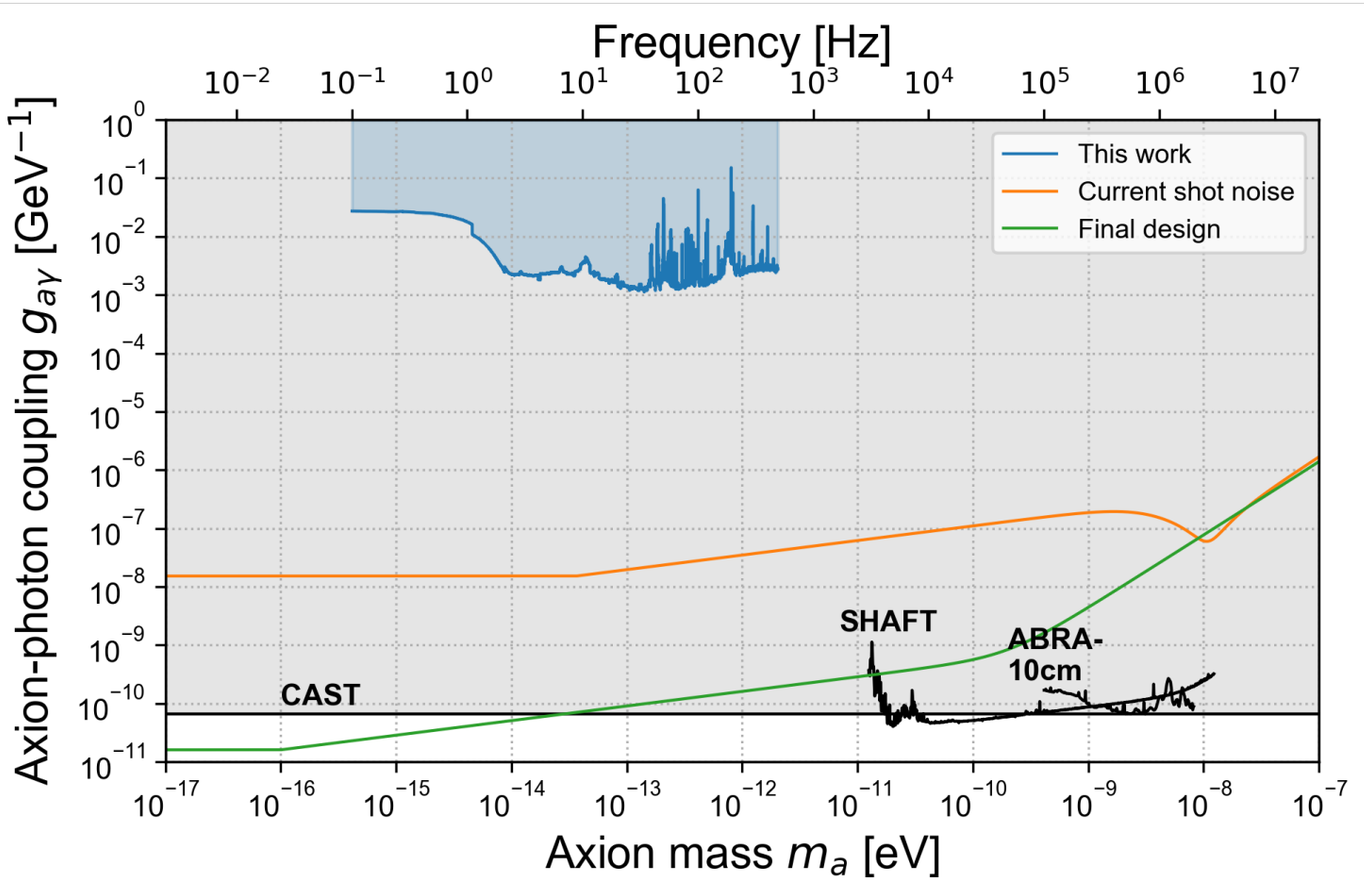


Contents

DANCE Act-1

- Started in 2019
- First observation is complete [1]
- Issue: No-simultaneous resonance between s- and p-pol.
- Designed an auxiliary cavity and realized simultaneous resonance for the first time in November 2021





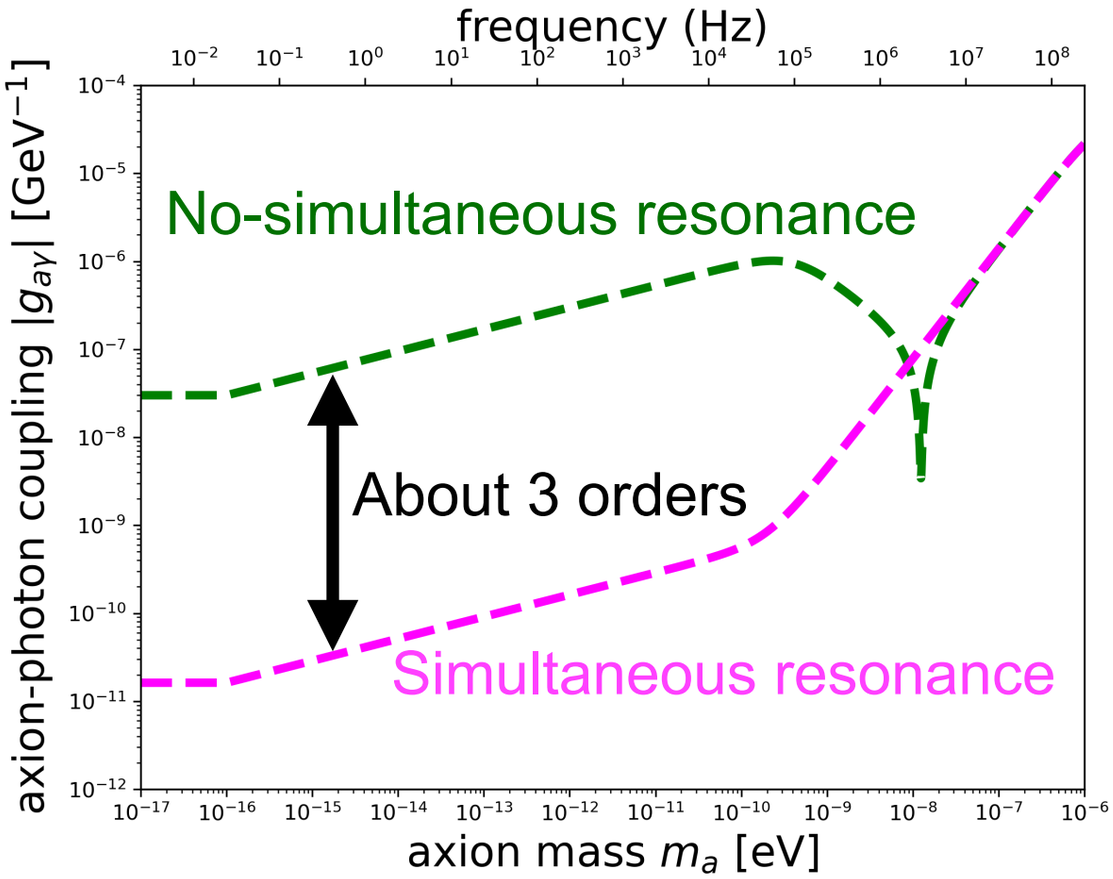
[1] Y. Oshima *et al.* : arXiv:2303.03594

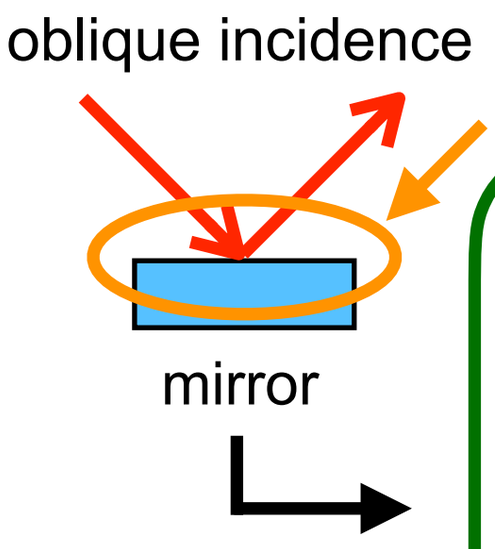
Reflection phase difference between s- and p-pol.

- **s-** and **p-pol.** can not resonate simultaneously due to oblique incidence
- There is resonant frequency difference between **s-** and **p-pol.**

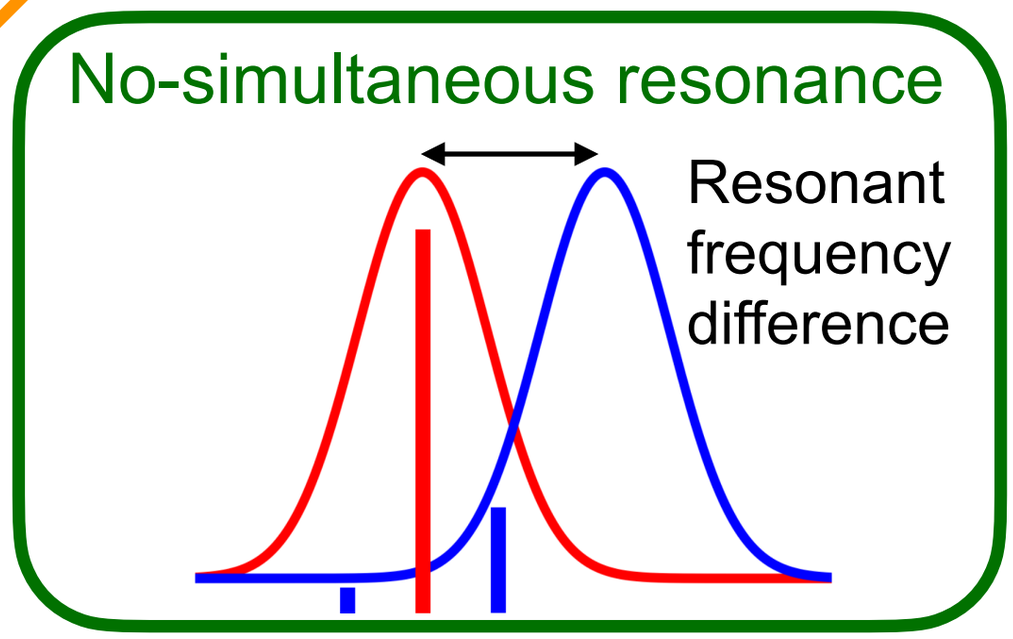
↓

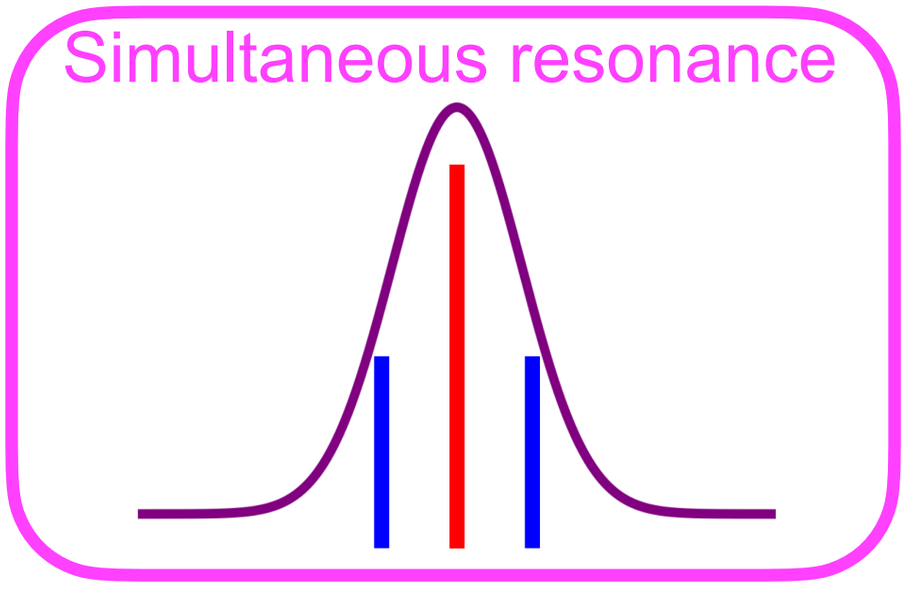
Simultaneous resonance is necessary for improving the sensitivity





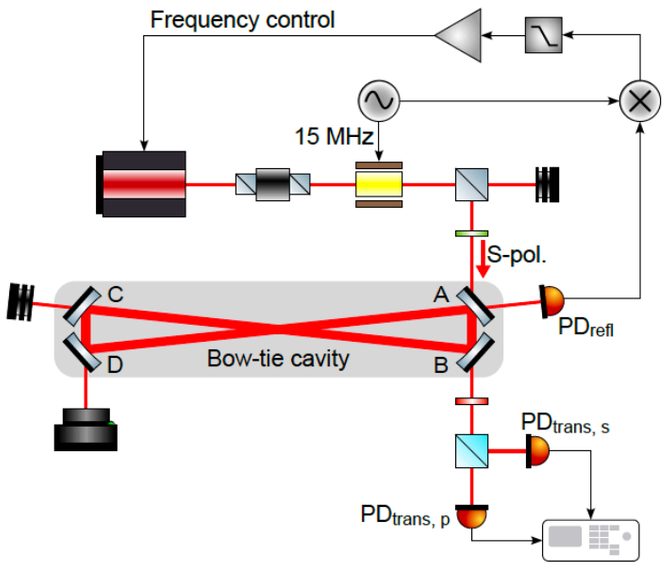
Reflection phase difference between s- and p-pol.

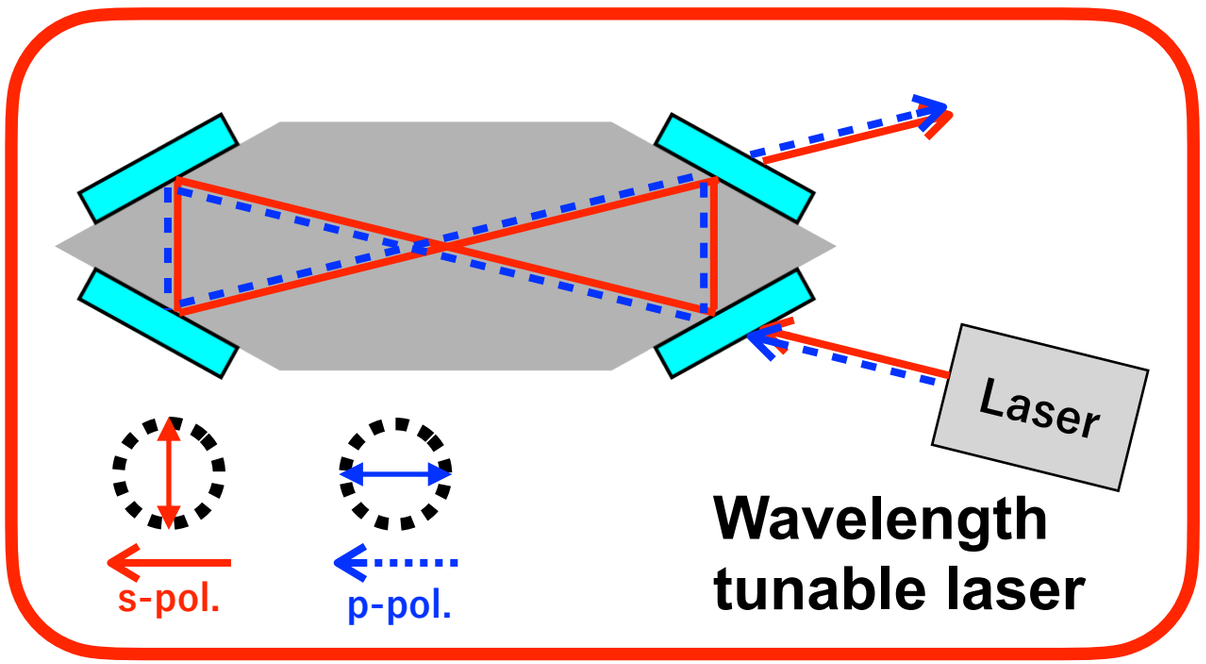




Realization of simultaneous resonance

DANCE Act-1





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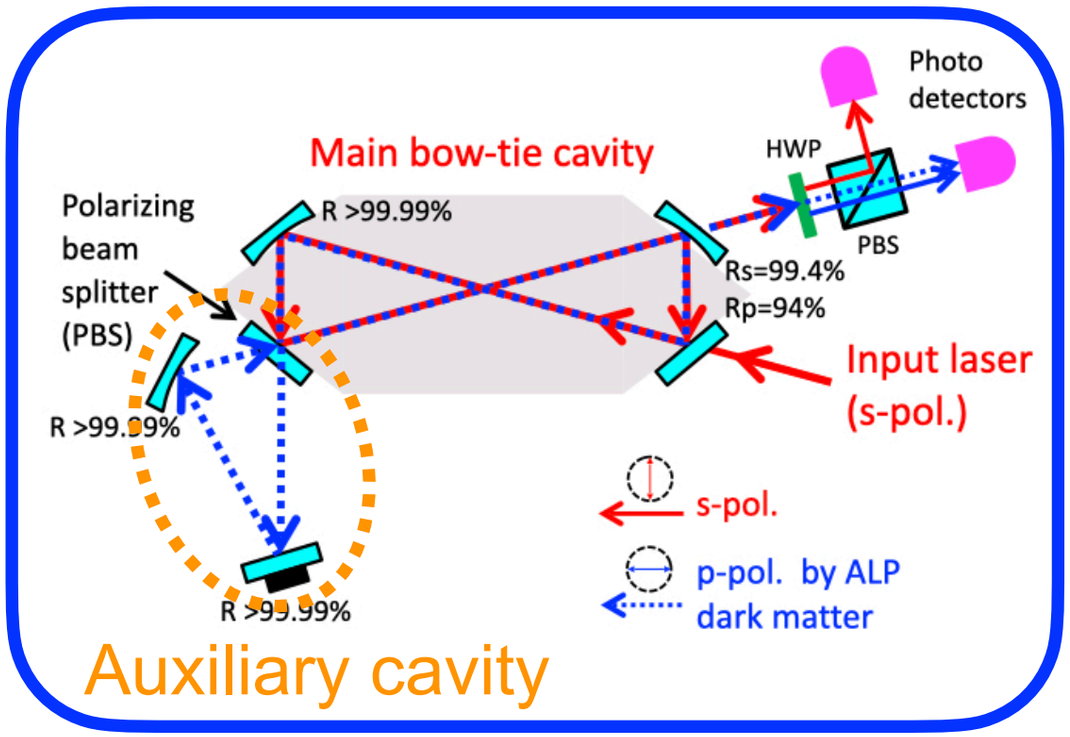


The method of auxiliary cavity (ongoing)

Realized simultaneous resonance by controlling s- and p-pol. independently

The method of wavelength tunable laser

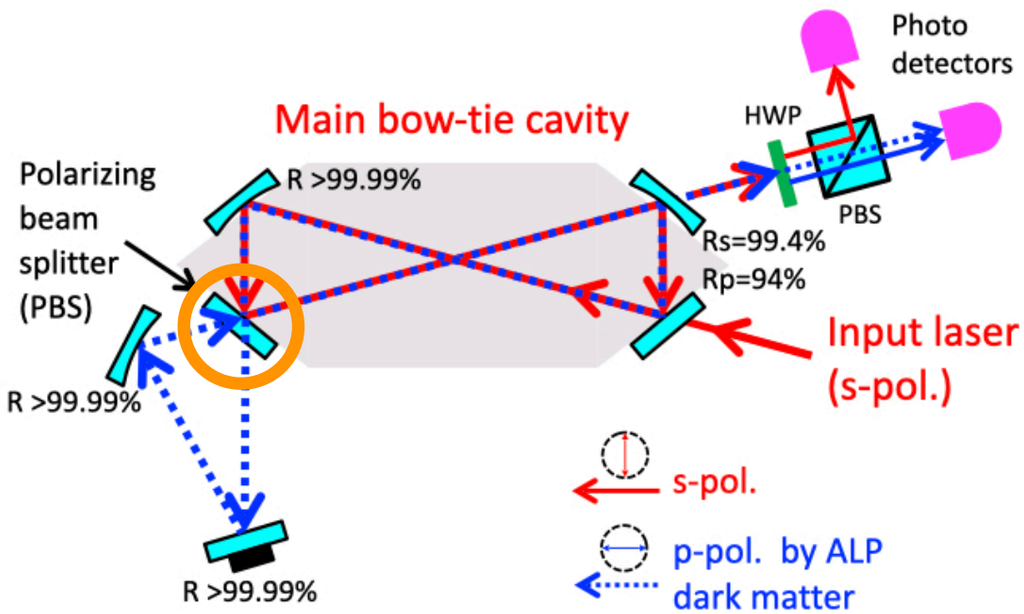
- Wavelength tunable laser

Search wavelength to cancel reflection phase difference between s- and p-pol. by sweeping wavelength

- Wavelength sensitive phase-shifting mirror

Realization of simultaneous resonance

The method of auxiliary cavity



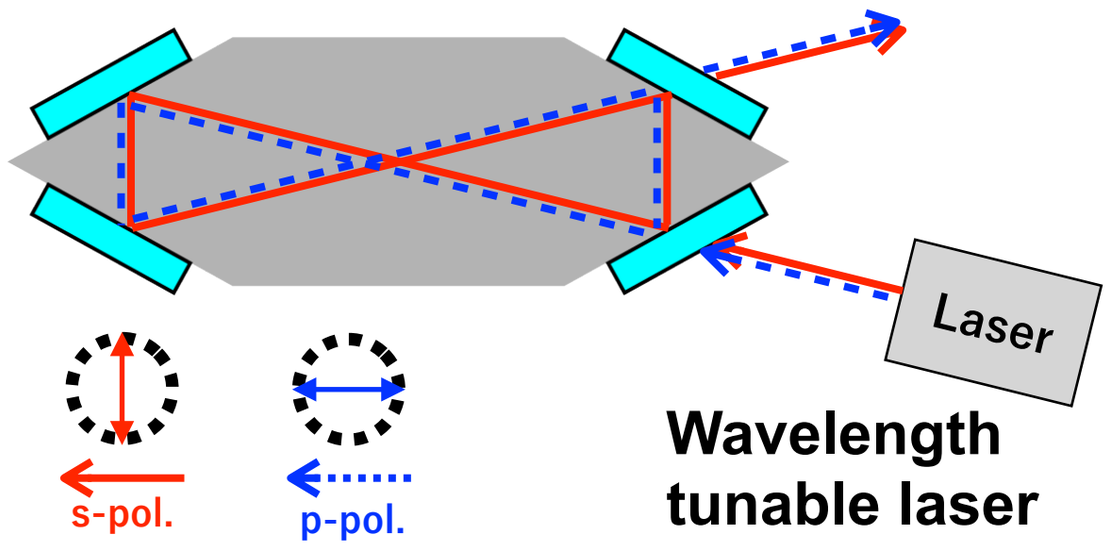
Advantage

Control the reflection phase difference between s- and p-pol. easily

Disadvantage

The loss on the AR coatings of the PBS

The method of wavelength tunable laser



Advantage

Solve the disadvantage of the method of auxiliary cavity

Disadvantage

Difficult to conduct mirror coating to cancel the phase difference between s- and p-pol.

Need to use stable wavelength tunable laser

Contents

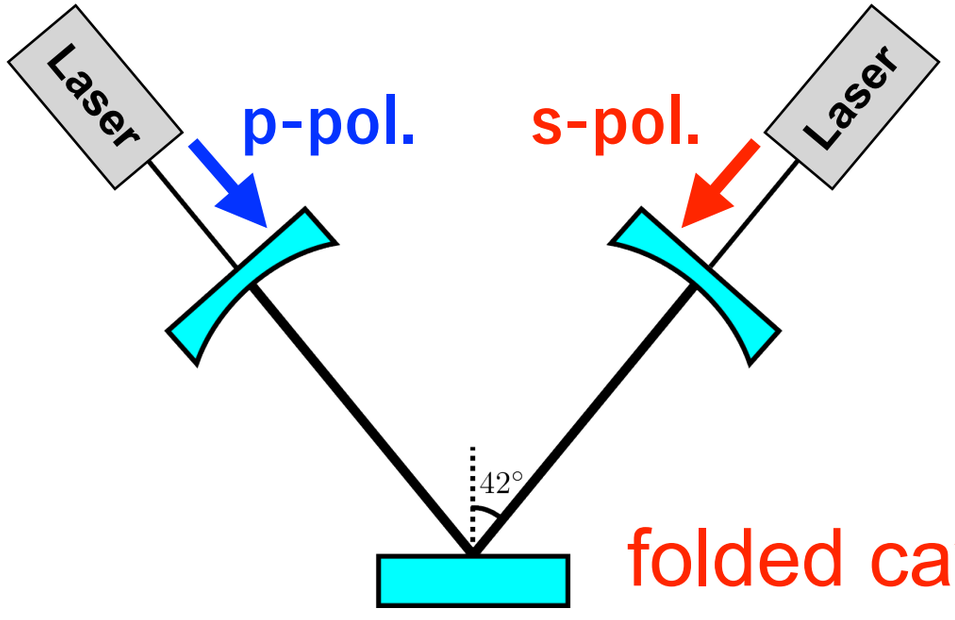
Summary

- DANCE: bow-tie ring cavity by interferometer
- Simultaneous resonance is necessary for searching axion dark matter

→Proposed the method of wavelength tunable laser

Future plans

- Designing folded cavity to investigate the reflection phase difference between s- and p-pol.
- Aim to realize simultaneous resonance with wavelength tunable laser



folded cavity