

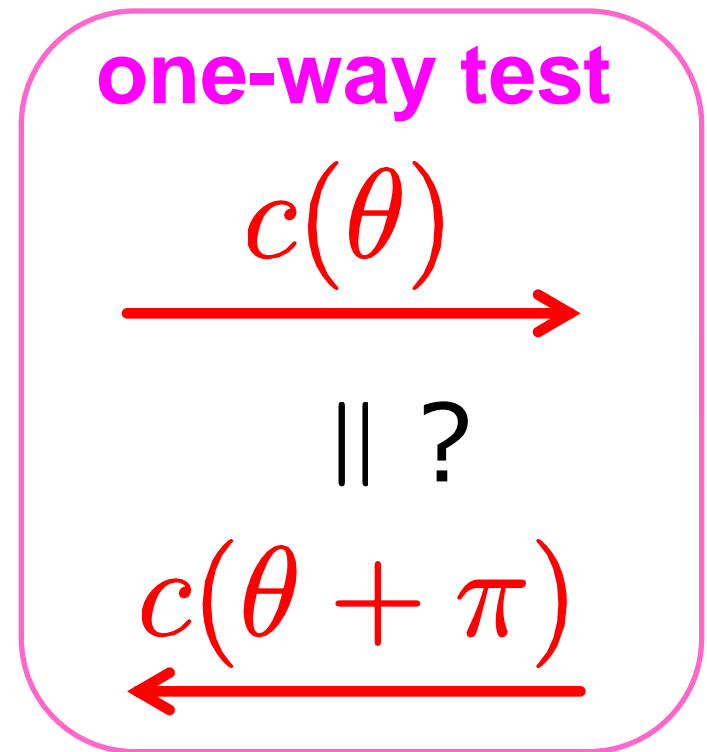
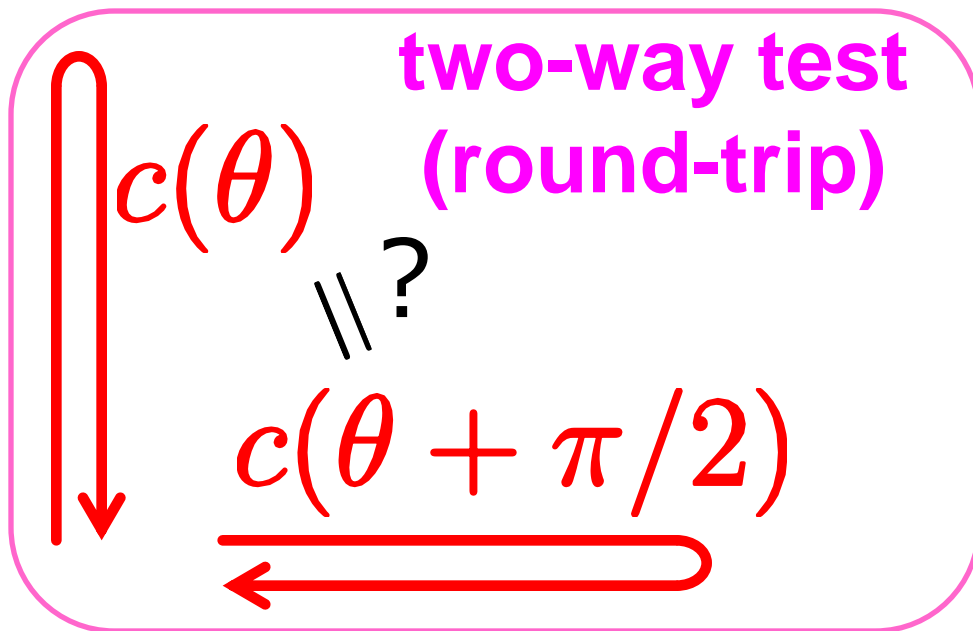
Search for Anisotropy in the One-Way Speed of Light Using an Optical Ring Cavity

Yuta Michimura

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Testing Isotropy of c

- test of Lorentz invariance in electrodynamics
- 2 types of test



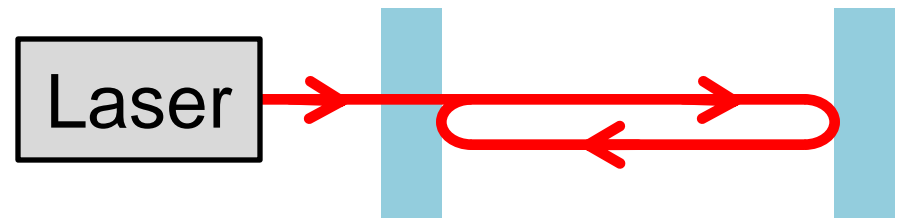
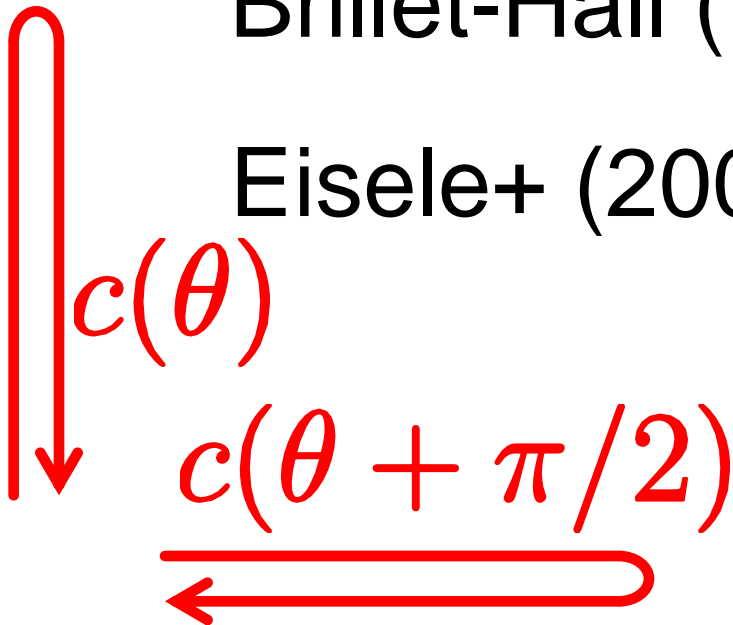
Previous Two-way Tests

- improved sensitivity by utilizing lasers and optical cavities

Michelson-Morley (1887) $|\delta c/c| \lesssim 10^{-9}$

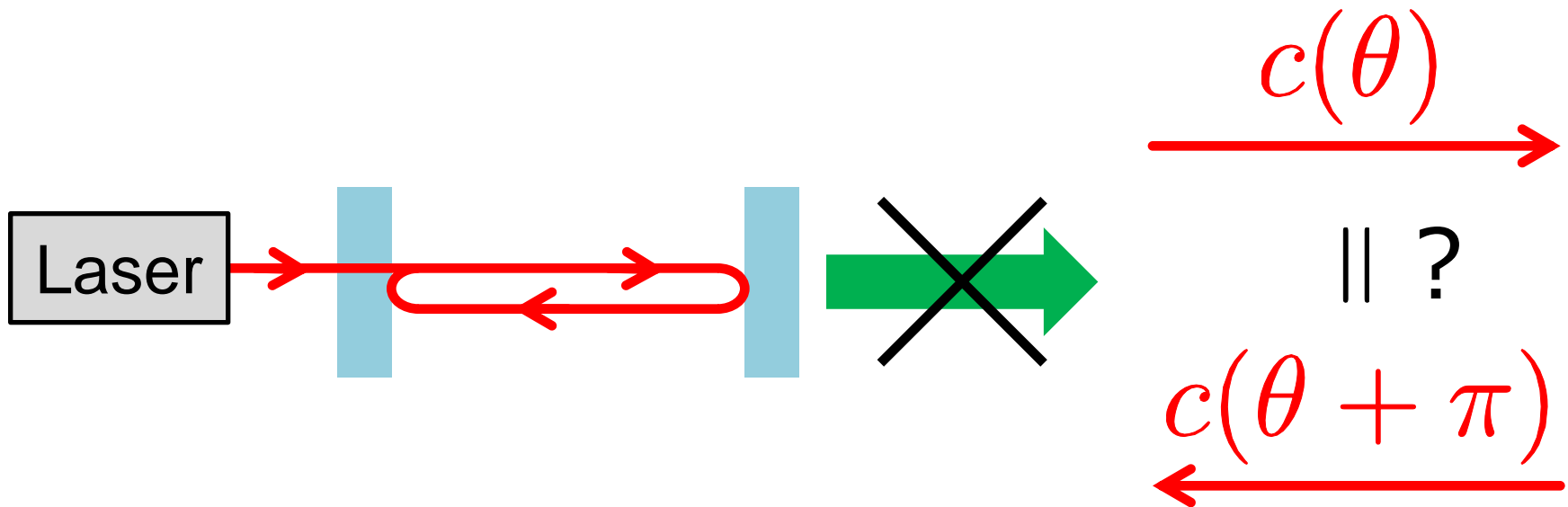
Brillet-Hall (1979) $|\delta c/c| \lesssim 10^{-15}$

Eisele+ (2009) $|\delta c/c| \lesssim 10^{-17}$



Previous One-way Tests

- unable to test by usual cavities
cavities are all round-trip
- 3 orders of magnitude weaker limit



Our One-way Test

- cavity with some **trick**
- set **world best upper limit** on one-way anisotropy

Forum for Prof. John L. Hall and young research careers (University of Tokyo, October 6, 2012)

Search for Anisotropy in the One-way Speed of Light Using an Optical Ring Cavity

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Abstract:
 A search for anisotropy in the one-way speed of light was performed by measuring resonant frequency difference between clockwise and counterclockwise mode of an optical ring cavity. Our cavity contains a piece of silicon, which is transparent to 1550 nm light. The laser frequency is stabilized using counterclockwise mode of the cavity, and transmitted light is reflected back into the cavity for resonant frequency comparison with clockwise mode. This double-pass configuration gives a high common mode rejection of environmental disturbances. By rotating the apparatus, our result set an upper limit on anisotropy in the one-way speed of light to a level of $\delta c/c \leq 10^{-12}$. Within Mansouri-Seel test theory[1], our result implies an isotropy violation parameter $\alpha + 1/2 = (-1.1 \pm 4.2) \times 10^{-12}$, which is more than an order of magnitude better than the previous best limit.

1. Motivation

Test of SR, Lorentz Invariance in electrodynamics

- no violation found so far
- quantum gravity theory suggests possible violation[2]
- $\delta c/c \leq 10^{-17}$?
- slight anisotropy in CMB
- CMB rest frame
- weak upper limit on one-way light speed anisotropy

Key features

- silicon block inside the ring cavity
- $v_e \neq v_o$, only if there's anisotropy
- double-pass configuration
- high common-mode rejection
- null experiment
- cavity rotation
- modulate anisotropy signal

2. Experimental Setup

3. Result

Data analysis

- data taken during ~3800 rotation in Sep., 2012
- data selection by monitoring the noise level
- demodulate anisotropy signal with rotational frequency
- amplitude and phase gives lab velocity with respect to a preferred frame
- convert it into the Sun frame

Current result

- no deviation found in the phase space
- upper limit on anisotropy

$\alpha + 1/2 = (-1.1 \pm 4.2) \times 10^{-12}$

WORLD BEST LIMIT

Comparison with other experiments

- Reinhardt[†] (2007) [3]
- Doppler experiment using ions
- Baynes⁺ (2011, 2012) [4]
- single-pass ring cavity

References

[1] R. Mansouri and R. U. Sexl, Gen. Relativ. Grav. 8 (1977) 497-516, 609.
 [2] D. Colasay and V. Alan Kostelecky, Phys. Rev. D (1998) 193602.
 [3] S. Reinhardt et al., Nat. Phys. 3 (2007) 861.
 [4] F. N. Baynes et al., Phys. Rev. Lett. 108 (2012) 260801.

4. Summary

Summary

- new type of apparatus for one-way anisotropy search
- set the world best limit (more than a tenfold improvement)

What limits current sensitivity?

- slight drift in the tilt of the optical table
- noise is limited by vibration mainly from the cables

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Want to know the trick?
Come and see our poster!