A simple wavemeter with GHz accuracy

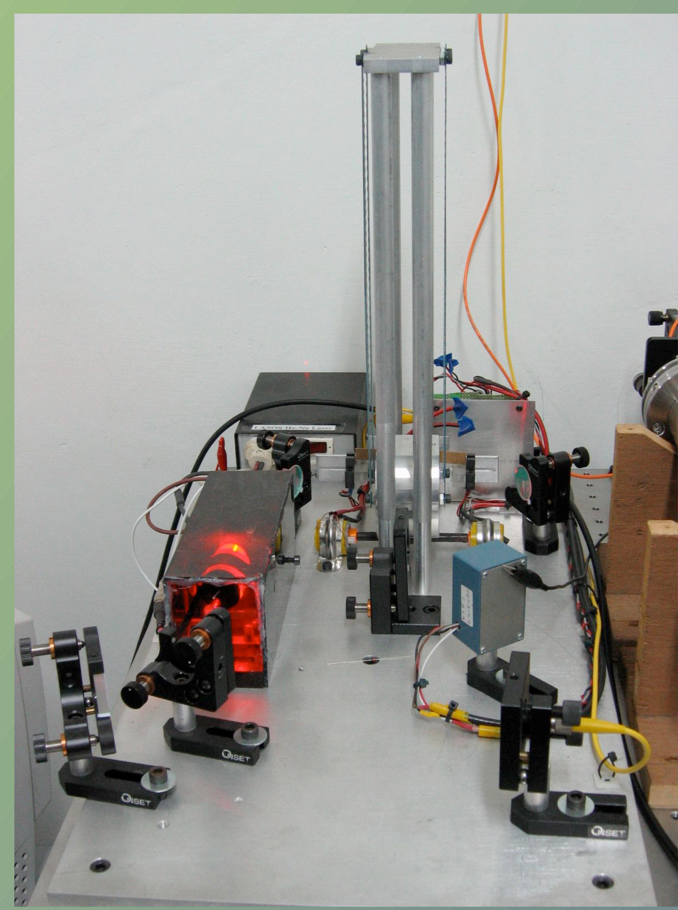
We report a simple wavemeter of the structure of Michelson interferometer with an accuracy of 1 GHz. This wavemeter, which is composed of a pendulum to drive moving corner cubes and simple electronics with a PC for fringes counting, is a useful tool for Doppler-free laser spectroscopy research and also suitable for an undergraduate laboratory.

Wei-Ling Cheng (鄭瑋凌)
Si-Mo Yang (楊士模)
Yi-Wei Liu (劉怡維)

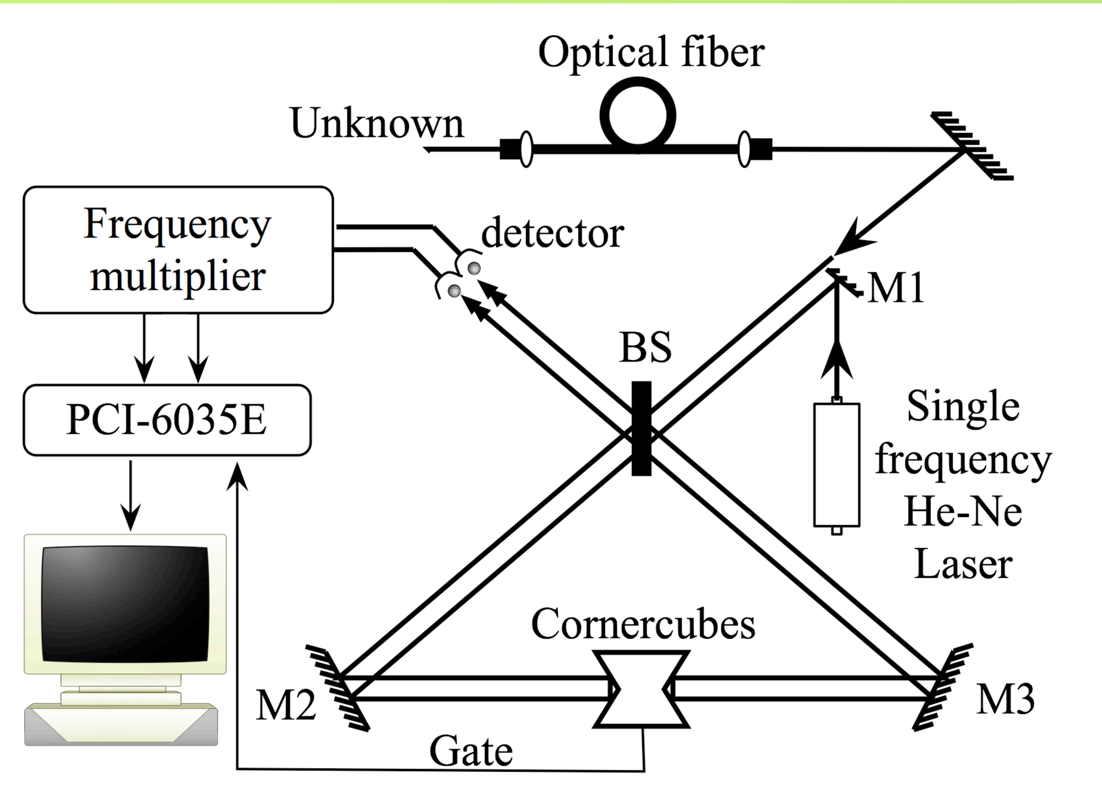
Atom Manipulation Lab
Department of Physics
National Tsing Hua University
Hsinchu, Taiwan, R.O.C.

In principle the interferometric wavemeterlength □measurement is a determination of the order number N=L/□, where L is the difference in optical pathlength between the interfering beams. The optical path difference between the two interfering beams is changed as the pair of cornercubes moved. The number of fringes counted as the cornercube is moved distance d is

$$N_R = 4d/\lambda_R$$



The photo



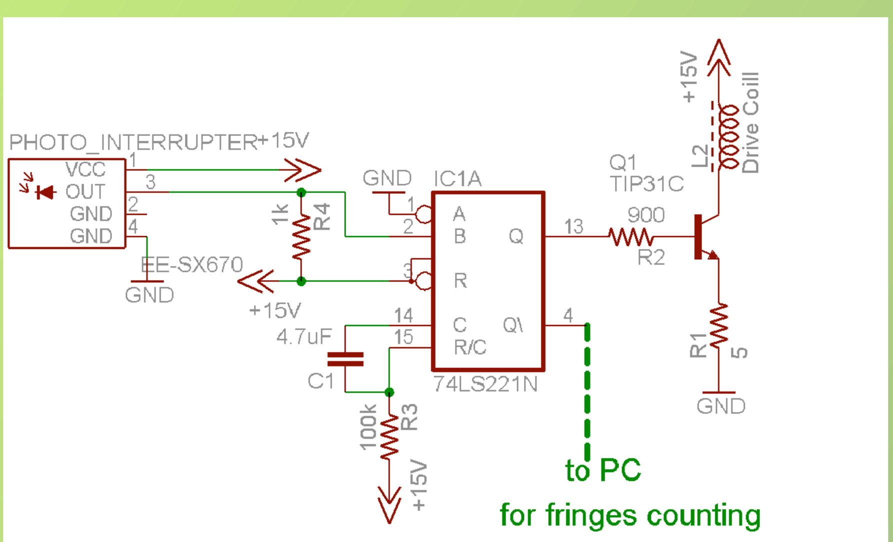
The wavemeter layout. Optical fiber: single mode, BS: nonpolarizing beamsplitter, M1~M3: plane mirrors

If both reference laser and unknowen laser propagate through the interferometer simultaneously, then the difference in optical pathlength must be the same for each, giving

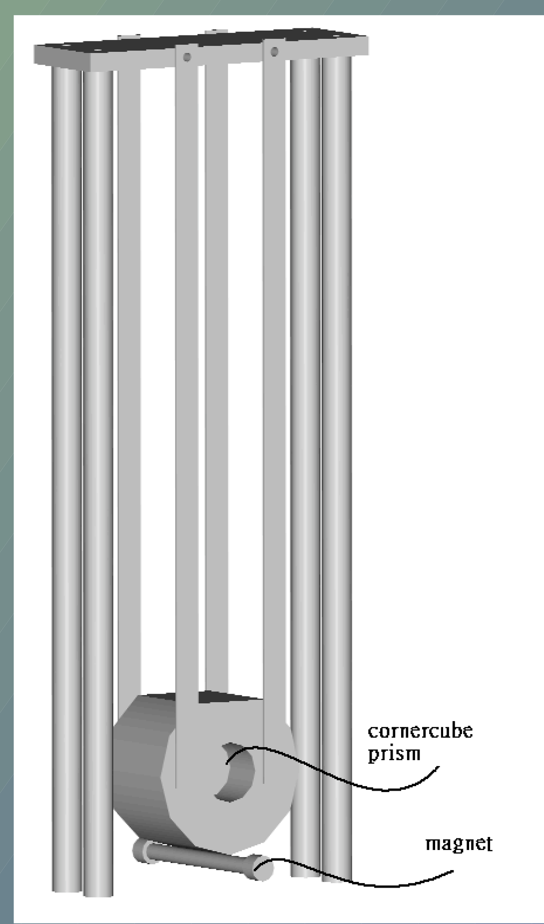
$$\lambda_U = \frac{N_R}{N_U}\lambda_R \quad or \quad f_U = \frac{N_U}{N_R} f_R$$

The subscripts of R and U are for reference and unknown. *f* is the frequency. If the number of frequency of the reference laser fringes are counted from the reference laser, the number of fringes counted from the unknown laser will be the frequency of the unknown.

The entire setup is mounted on a 20□300□500 mm aluminum block for stability. Two 25.4mm corner cube prisms are suspended using 4 flexible steel saw, as a pendulum. The amplitude of the oscillation of pendulum is about 8 mm and oscillating frequency is about 0.23 Hz. A magnet is attached to the pendulum and driven by two coils. The circuit for driving coils sends a signal to PC for triggering counting fringes, and driving coils keep the pendulum oscillating. The number of fringes of reference and unknown laser are counted using a general purpose IO card with two channel counters.

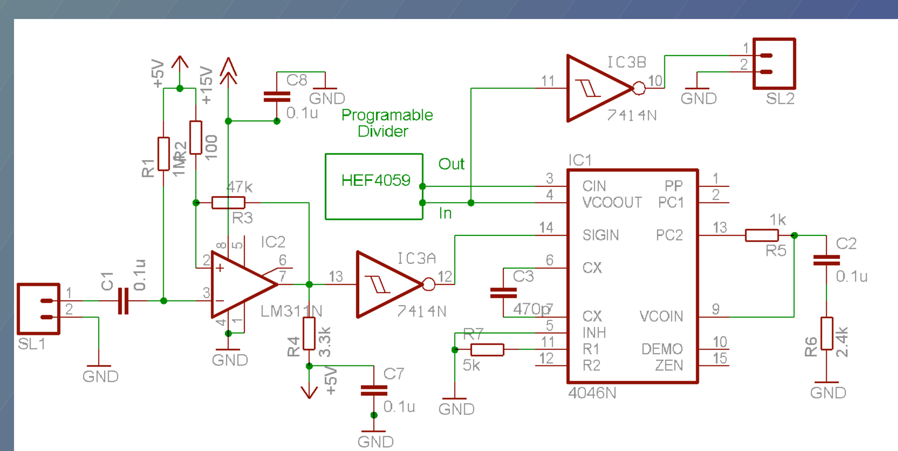


The circuit for driving coils

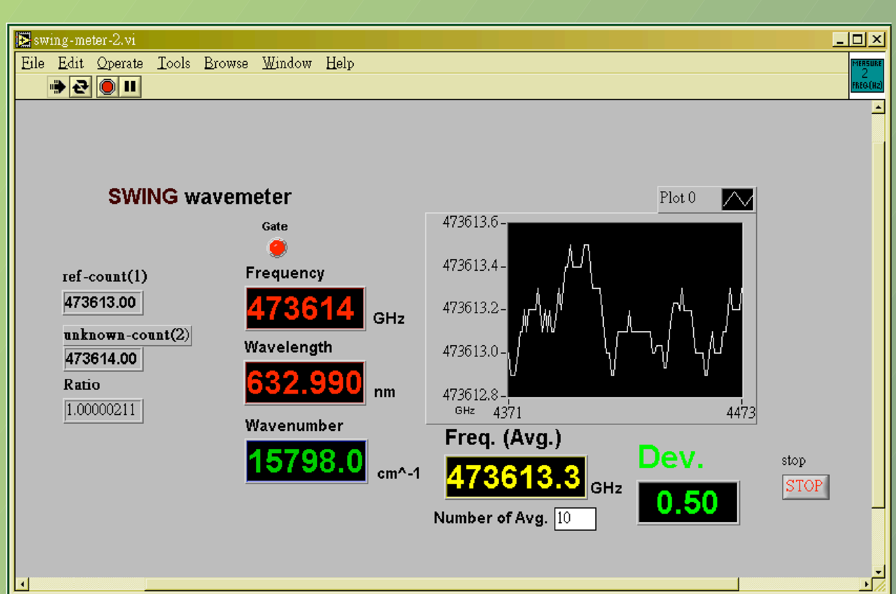


The illustration of pendulum

A 632.8 nm single frequency He-Ne laser is used for reference. However, the vertical motion of the pendulum limits the maximum lateral moving distance that is proportional to the total number of fringes of one counting. We only get about 5000 fringes of one counting which is more less then the frequency of He-Ne laser: 473613Hz. In order to reach the accuracy of 1 GHz (10^{-6}), we utilize a PLL (Phase-Lock-Loop) to multiply the number of fringes by 8-10. This wavemeter has been calibrated against the 780 nm rubidium D_2 line.The standard deviation is about 300 MHz in 10 measurements.



The frequency multiplier



The interface of counting program

Reference

1. P. J. Fox and R. E. Scholten and M. R. Walkiewicz and R. E. Drullinger, “A reliable, compact, and low-cost Michelson wavemeter for laser wavelength measurement”, Am. J. Phys. **67**, 624-630(1999)
2. Eugene Hecht, *Optics*(4th ed), Addison Wesley, 407-414 (2002)
3. M Braun and J Maier and H Liening, “A high precision compact Michelson-Sagnac wavemeter”, J. Phys. E, **20**, 1247-1249(1987)

If you think, you experience time.
If you feel, you experience energy.
If you intuit, you experience wavelength.
If you sense, you experience space.

Quoted by Fred Alan Wolf in Star Wave (p. 16)