Forecast:
Optical Quadrature Detection
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The Relaxation Times

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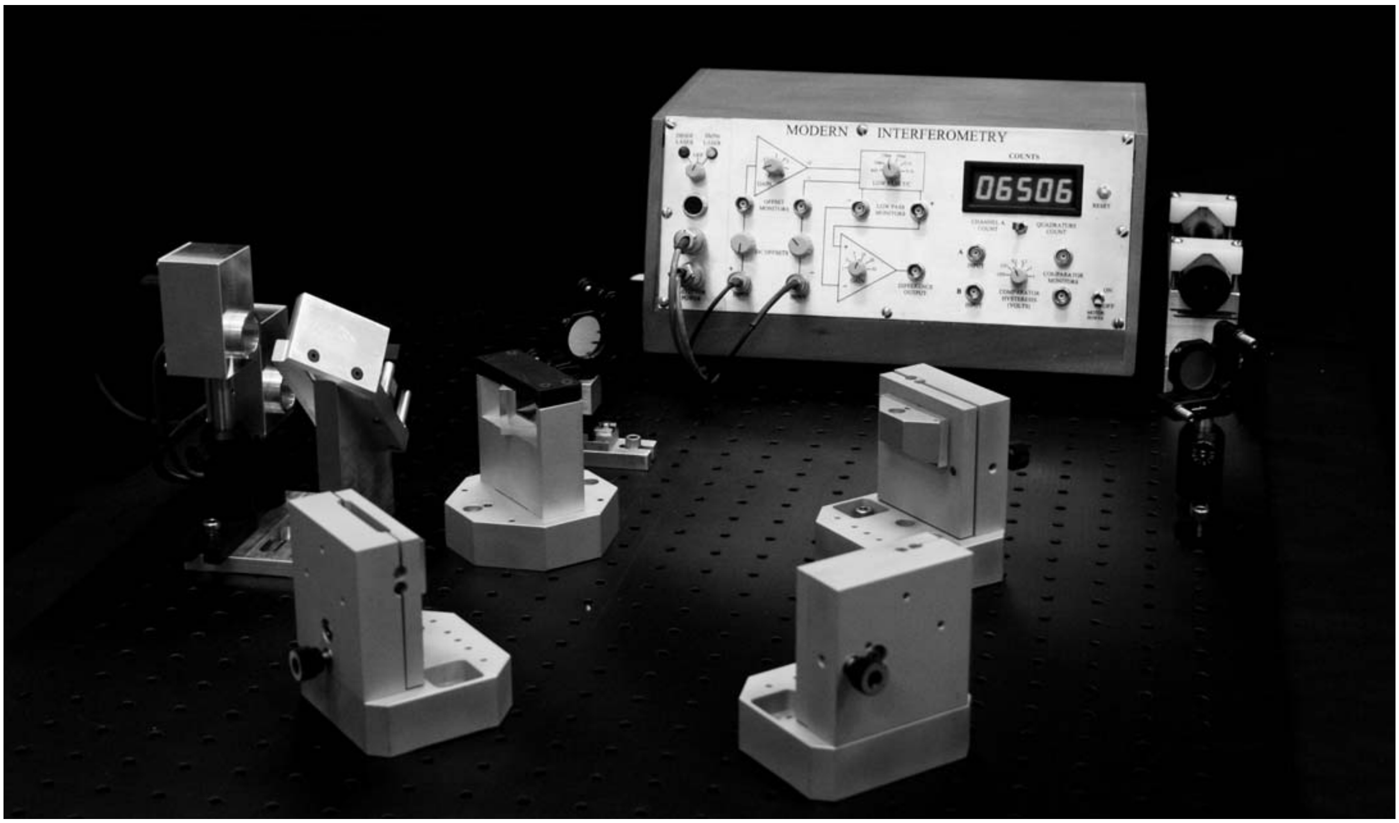
TEACHING MODERN INTERFEROMETRY

Wavelength Measurement • Index of Refraction • Thermal Expansion • Magnetostriction Piezoelectric Deformation • Electro-Optic Effect • White Light Interferometer • Optical Alignment Polarization Techniques • Interferometry and Relativity • Interferometry and Quantum Mechanics



Here at TeachSpin, we are excited to bring to the physics community a research grade interferometry “kit” designed specifically for advanced student laboratory instruction. And ***excited*** is the operative word, since many of us had never before observed optical quadrature detection, seen a flexure translational stage that could move a mirror two millimeters without changing fringe contrast in a Michelson Interferometer, or watched 10^{-2} λ changes with a Sagnac interferometer. We think that you and your students will be as excited as we are when putting this new kit through its paces.

In many ways, Modern Interferometry **(MI1-A)** is the ideal TeachSpin apparatus. Unlike so many on the market, this is not a set of prefabricated instruments. Instead, it has all the necessary components to create a variety of versions of three distinctly different types of interferometers, Michelson, Sagnac, and Mach-Zehnder. I wish it were practical to build all of our TeachSpin instruments in this modular form, since it gives students such a large “intellectual phase space” in which to learn experimental physics. No black boxes here!

The picture on the cover shows a group of the **MI1-A** components mounted in a Sagnac configuration on the 24" x 36" x 1/2" black anodized aluminum optical breadboard. The two large objects in the foreground are TeachSpin's proprietary optical mounts, developed in collaboration with Scientific Research Labs Inc., Boston. These mounts are the "heart" of the kit, providing unique ultra-high mechanical stability for the crucial mirror elements. In the background is the electronic controller used to count the fringes as well as to support the optical detectors and the power supplies needed for the various light sources included in **MI1-A**.

The kit includes beam steering mirrors, several translational stages, the motor driven precision flexure stage, various beam splitters, polarizers and optical detectors. The self-contained kit provides all of the light sources needed, including a HeNe laser. A variable temperature red diode laser, a bi-colored LED and a halogen lamp are included for the study of white-light interferometry. The unit even has its own custom vibration isolation support system, and a draft shield. It comes with a collection of samples, a gas cell with a pressure transducer monitor, electro-optics crystals, a solenoid, and other parts needed for the many varied suggested experiments. In fact, the complete kit comes with all of the components students need to perform an impressively large number of investigations from the exploration of the interferometers themselves to sophisticated advanced laboratory experiments.

As an initial investigation, students can set up a Michelson interferometer from scratch, learning how to align this sensitive instrument. In addition to investigations with fixed mirrors, students can see the effect of translating one or both mirrors in the interferometer using the 25mm translation stage and TeachSpin's proprietary, ± 1mm, precision, monolithic-flexure mount. The flexure mount comes equipped with a hand or motor-driven differential micrometer, allowing stable control over individual interferometric fringes and thus position control on the order of 0.1μm. Hundreds, to thousands, of fringes can be counted, allowing absolute wavelength measurements of outstanding precision.

Within the Michelson geometry, **MI1-A** makes it possible to investigate and use two rarely observed interferometer configurations. The use of a series of light sources and diagnostics, leads students to establish the equal-arm-length condition, to a precision of micrometers, and allows the direct viewing of white-light interference fringes. This is the doorway to understanding both Fourier-transform spectroscopy and the temporal coherence of light waves.

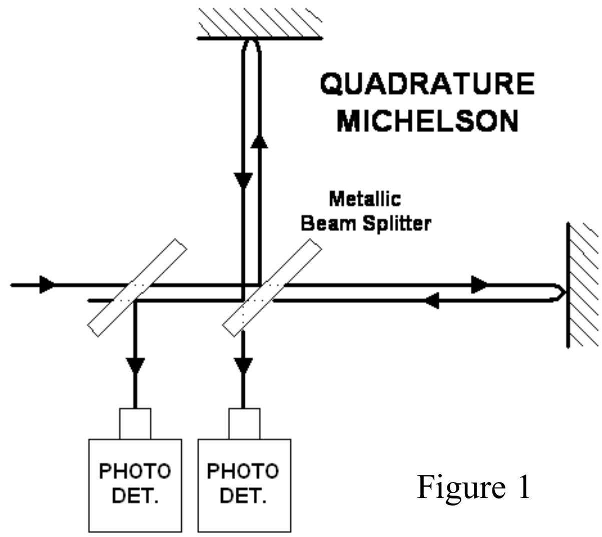


Figure 1

Using the metal-film beam splitter supplied with **MI1-A,** students can view signals from ***both*** output ports of the Michelson interferometer, and thereby diagnose the optical phase difference and ***sign*** of its changes. This is shown in Figure 1. Using these "quadrature" signals and the TeachSpin electronic controller, it is now feasible to perform up/down counting of fringes allowing bi-directional motions of the end mirror to be tracked reliably over thousands of fringes. This configuration gives our interferometer amazing vibration immunity.

The Michelson geometry is also suitable for detecting extremely small physical effects. A gas cell, introduced into one of the interferometer's orthogonal beams, allows direct measurement of the index of refraction of the gas. The translatable mirrors allow detection of the thermal expansion of a short metal sample or the magnetostriction of a ferromagnetic sample.

The graph in Figure 2 shows the data for magnetostriction of a polycrystalline nickel sample in a magnetic field created by the unit's solenoid.

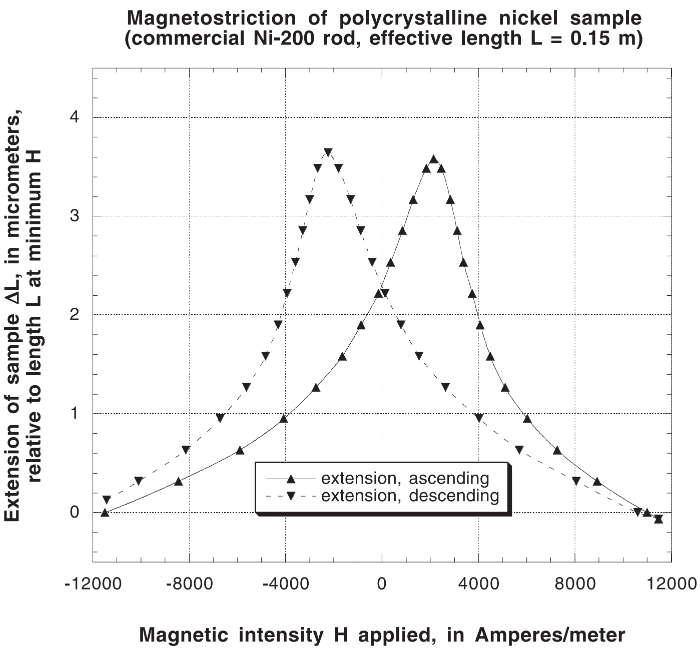


Figure 2

In the Mach-Zehnder interferometer, light is divided at one corner of a rectangle, propagates in separate beams, and is recombined at the opposite corner of the rectangle. This type of interferometer can be used with either unpolarized or polarized light. This configuration is ideally suited to stimulate deep thought about 'which way' experiments and photon delocalization.

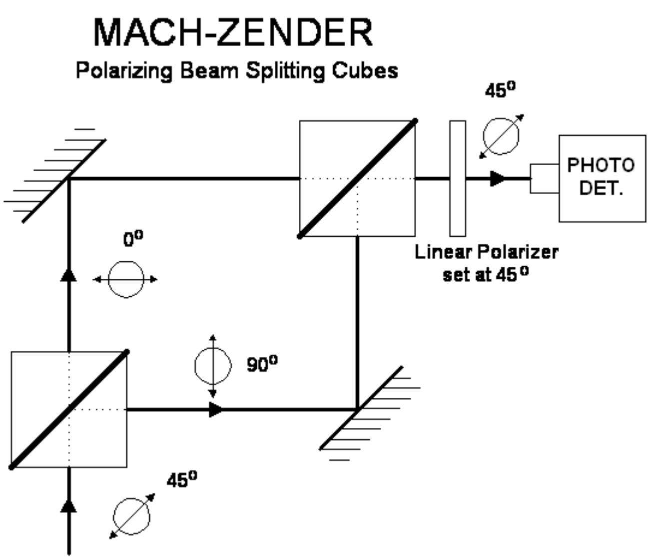


Figure 3

In the Sagnac interferometer, light propagates simultaneously in both directions all the way around a rectangular area, with beams recombining at the original beam splitter as shown in Figure 4.

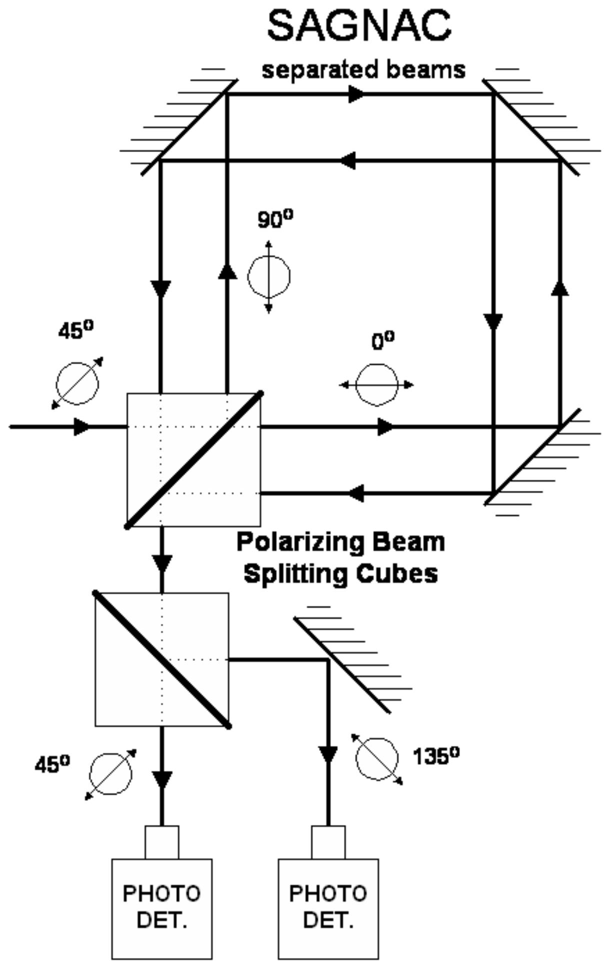


Figure 4

An ingenious polarimetric detection system allows the direct detection of the difference in phase accumulated by the two counter-propagating beams. And, since the two beams share in any mechanical motion of the optical components, the phase difference can be detected with amazing stability and sensitivity, on the order of 10^{-3} radians or 10^{-4} fringes. This sort of phase stability makes possible, among other experiments, the direct detection of the electro-optic effect in a crystalline sample placed in the beams.

In addition to research, Michelson, Sagnac, and Mach-Zehnder interferometers are widely used in optical testing. A thorough understanding of their attributes will be a valuable asset in industrial settings. For those with a historical bent, the Michelson and Sagnac interferometers have a historical connection to the theory of relativity.

Combining flexibility of layout, with a manual stressing understanding of issues like geometrical alignment, polarization control, and interferometric phase, the comprehensive set of components that make up **MI1-A** allow a wide variety of experiments that introduce students to the best of modern interferometry.

TeachSpin anticipates delivering the first units before the fall semester of 2006 begins. That is, sometime this summer. As of this writing, we do not have a price or a complete parts list. A crude estimate of the price is about 10 ± 2 k. We should have a fixed price and parts list by June 1 of 2006. We are willing to hold a kit for you and to guarantee that the price will not exceed 12k for the first ten units sold. This may be quite a deal, so get your orders in!

New Air Pump for Magnetic Torque

We have located a new manufacturer of air pumps for **MT1-A.** These new pumps significantly decreases the ball-to-airbearing friction and thus increases the spin time of the ball. With a little carpentry and soldering, you can install the pump yourself with a kit we will send you. The cost of the kit is $75.00. Or, we will install the new pump if your unit is out of warranty, for $110.00, but you must bear the shipping cost. We anticipate this pump having a longer life than the one originally installed.

New Space Addition

We are pleased to announce that TeachSpin has added about 50% more space to our facility in the Tri-Main Center. This should give us some breathing room for the next few years, although, if the company continues to grow at the rate it has over the past two years (35%/year) we may be looking for additional space sooner than we think. Thanks for your confidence in our products and services.

TEACH SPIN

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