

## XIII. LASER APPLICATIONS\*

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## RESEARCH OBJECTIVES

Our interest is primarily in the application of lasers to a variety of measurement problems. In many cases, the available lasers are not too suitable and considerable research has to be done to improve or modify the laser performance. Several projects are already in progress.

### 1. Laser Frequency Stabilization

The motivation stems from the need for a long-term frequency stabilized laser in the precision measurement of length, i. e., length standards. Such a laser would find applications in earth strain seismometry, in optical communication, and in fundamental measurements, in particular, those related to experimental relativity.

The effort, at present, is to stabilize the frequency of the 5145 Å Argon ion laser. The stabilization scheme employs a resonance absorption line, observed in a molecular beam of iodine, which we have recently uncovered, as an absolute frequency reference. The absorption is measured by the resonance fluorescence induced by the laser in the molecular beam. Such an absorption line is an ideal reference element, because of the isolated and unperturbed conditions in the beam. Moreover, since the molecular beam can be oriented at right angles to the laser beam, the width of the iodine resonance is limited to its natural width which is inferred to be 50 kHz from lifetime measurements. Preliminary experiments indicate that it should be possible to stabilize the frequency of the laser to one part in  $10^{13}$ .

### 2. Pulsed Ion Laser Holography

The objective is to investigate possibilities for generating pulsed, high-power, multi-color laser output using a mixture of Noble gases such as Argon, Krypton, and Xenon for interferometric and holographic applications.

For pulsed color holography, a laser is needed that puts out three primary colors of equal intensity simultaneously in one short pulse. The research involves the study of excitation mechanisms in the presence of a mixture of Noble gases to yield the desired laser output. Other areas to be investigated are (i) single-frequency generation in each of the three primary colors, (ii) propagation of the three light beams external to the cavity, and (iii) color holography using such a laser beam.

Aside from color holography, a hologram that is recorded with two colors (or frequencies) and reconstructed with only one color displays contour lines (lines of equal distance from the hologram plate) superposed over the surface of the holographic image.

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The spacing between contour lines, which represents surface changes, is proportional to the frequency separation of the two colors used in the recording of the hologram. For this type of application an investigation will be conducted into schemes for generating two-frequency laser output where the frequency separation can be varied. Ultimately, we would like to use this surface contour generation method, which requires only a single short exposure, to study dynamic behavior of structures and materials and also for growth measurement in biological subjects.

#### 3. Velocity Measurement

A program has been started recently to investigate techniques for measurement of laminar and turbulent flow in gases and liquids. Several methods are being examined.

(a) Homodyne schemes in which the Doppler-shifted scattered light from particles injected into the flow is mixed with the unshifted laser light to generate a beat frequency that is proportional to the flow rate.

(b) Use of an optical frequency discriminator such as a stable confocal Fabry-Perot cavity, particularly for high Mach number flow where homodyne beat frequency would be high, in excess of 100 MHz.

(c) Use of the time-variant behavior of the laser light diffracted by the particles in the flow as a measure of velocity.

Several other projects of potential interest are now being pursued in conjunction with other groups. These include: application of holography to nondestructive testing and analysis of holographically generated three-dimensional fringes; subfringe holography for detection of minute changes in surface thickness of the order of  $1 \text{ \AA}$ ; measurement of the stretching of the sclera of the eye by use of a rotation-insensitive interferometer implanted in the eye (for glaucoma research).

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