could be explained by the size distribution-induced change in total cross sections of scattering and absorption. In this case, the specific beam attenuation coefficient was much larger at approximately 1.35×10^{-6} m^{-1} cell-1. Such a difference in the specific attenuation between the two experiments is most probably explained by the larger size of the cells in the laboratory experiment (roughly 2.5 μm versus roughly 0.3 μm at sea).

Now that the role of microparticles has been recognized in the attenuation of light in the sea, studies will focus on the mechanisms of attenuation. Techniques of flow cytometry will be employed, in which large numbers of cells can be analyzed rapidly for light scatter. These techniques have recently been developed to the extent of providing realistic quantitative assessments of the size and complex refractive index of marine organisms[3]. The difficulty in this technique lies in the potentially confounding effects of shape. Non-spherical particles have historically been difficult to characterize optically. Potentially, techniques of single-particle polarimetry suggest that exploitation of the full angular dependence of the Mueller matrix might offer new insight into addressing the parameter of particle shape.[4]

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Acousto-optics

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During the past half century, the problem of strong two-dimensional acousto-optic interaction has been attacked by a variety of analytic and numerical methods. The model most frequently used is one in which a rectangular, non-spreading sound column is illuminated by a single plane wave of coherent light. The analysis then proceeds along the classical lines of wave propagation in periodic media. When framed in terms of the coupled modes of the unperturbed medium, this leads to an infinite set of coupled equations—the well known Raman-Nath equations. Using the eigenmodes of the perturbed medium results in Mathieu functions.

Both techniques, although mathematically elegant and practically relevant when applied to configurations that approximate the model, are nevertheless physically unrealistic and in many cases—for instance, the interaction of strongly diverging beams—of limited usefulness. The physical configuration of real diffracting beams of light strongly scattered by equally real beams of sound has been solved exactly in two dimensions by Feynman diagrams and their corresponding path integrals.[1] The problem of three-dimensional weak interaction has been approximated by an eikonal theory that provides appropriate rules for diffracted ray tracing[1] and by a paraxial wave theory that uses the angular spectrum of the interacting fields.[2]

In general, the path integrals of the Feynman diagram method cannot be evaluated analytically. They can, however, be interpreted in terms of quantum mechanical probability amplitude densities of photons making transitions into neighboring orders at random locations along the interaction length. A Monte Carlo simulation along these lines has been carried out recently.[3] As few as 10^4 randomly chosen paths (sequences of transitions) were used out of the total of approximately 10^{300} that apply when the interaction length is subdivided into 1000 transition locations. Nevertheless, satisfactory agreement was obtained with known results for conventional (sound column) models of Raman-Nath diffraction, Bragg diffraction, and near-Bragg diffraction, for sound intensities not exceeding twice the intensity needed for maximum diffraction in the Bragg region. Having verified the correctness of the interpretation and its simulation, the next major step will be to apply the method to the case of physically realistic soundfields.

The eikonal theory of acousto-optics, specifically its ray tracing aspect, has previously been applied to conventional Bragg diffraction imaging requiring highly astigmatic illumination. In most cases, illumination by spherical lenses would simplify the configuration and cause less aberration.[4] This case has recently been analyzed with the same ray tracing techniques mentioned before and shown to result in an astigmatic image with vertical and horizontal detail being sharply defined at different locations.[5] A simple, weak cylinder lens will make the images coincide.

Experimental measurements corroborate the theory. This simple technique is especially useful for a quick diagnosis of transducer fields. Of particular practical interest is that, as in conventional Bragg diffraction imaging, the vertical resolution is largely independent of the numerical aperture of the incident cone of light and may approach the wavelength of sound.

The precise nature of the Schlieren image of a high-frequency acoustic field, important for acousto-optic signal processing, has recently been explained in a heuristic fashion by ray interaction arguments[6] that show the image to be essentially diffraction free. This has been confirmed by the wave analysis using the angular spectra of the interacting fields.[7] An extension to the band pass case shows explicitly how to analyze the distortion inherent in Schlieren imaging based, acousto-optic processing of wide band signals.

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EDUCATION

A new twist to optical polarization theory: Color U(2) computer graphics

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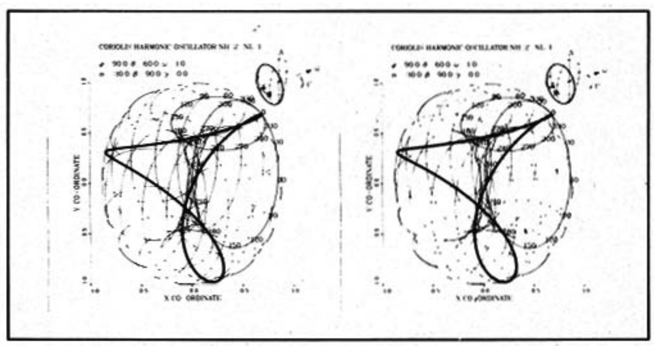
The mathematical theory of optical polarization has been used many different ways since it was originated by Stokes and Poincare. In terms of group theoretical acronyms, polarization theory is called an "R(3)-SU(2) homomorphism," that is, a relation between a real three-dimensional (vector) space and a complex two-dimensional (spinor) space. The three-vector description of a two-level quantum system was popularized by Feynman, Vernon, and Hellwarth. Since then, other examples of quasi-spin vectors have been introduced in areas such as molecular physics.[1–2]

Recently, some applications of quasi-spin vectors to molecular rotation[3] and vibration[4–5] dynamics have been made that have an added twist, and a computer program[6] has been developed to help visualize phase space dynamics. The molecular applications use the original Stokes quasi-spin vector to help characterize states of coupled oscillators. The Stokes vector picture is augmented by introducing a quasi-rotor—a quasi-spin vector with an extra twist angle. The four parameters of the quasi-rotor in the R(3) picture are related to four phase space variables of the two coupled oscillators in the U(2) picture. The extra twist angle is related to part of the overall phase of two oscillators or the "gauge" of a 2-level state, but it is most easily visualized as the third Euler angle of a processing rotor in the Berry phase, among other things.

A graphical animation program COLOR U(2) has been developed for MacIntosh-II computers that simultaneously displays R(3) rotor picture and U(2) oscillator picture of the dynamics. The quasi-rotor approach gives an improved picture of nonlinearly coupled molecular vibrations and rotations. The labeling of molecular modes as "normal" vs. "local" or "coriolis" has been clarified considerably using quasi-rotor phase diagrams.[3–6] By analogy, some nonlinear Schrodinger equations may be similarly analyzed. The new phase space pictures also provide useful semiclassical approximations to the molecular quantum eigensolutions and spectra. These have been used to



Computer drawn stereo images of vibrational motion of a rotating molecule are being used to help understand rotation-vibration (coriolis) interactions. For a simple harmonic case, a coriolis oscillator orbit is seen to be a line of constant slope (2:1) on the surface of an invariant toris embedded in four-dimensional phase space of the U2) picture. Meanwhile, the R(3) picture (upper right-hand inset) for the harmonic case contains a uniformly processing quasi-spin vector.