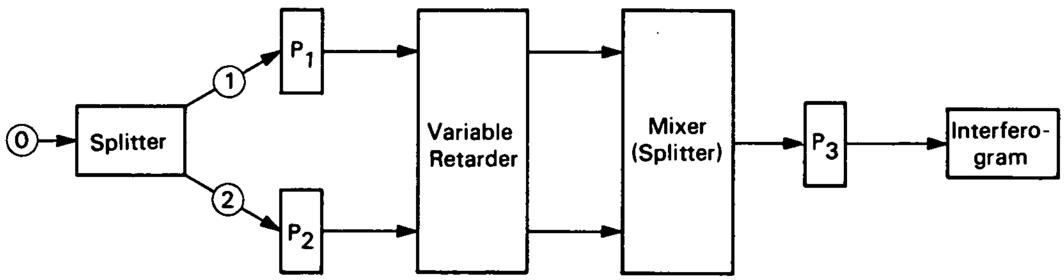
NASA TECH BRIEF

Interferometer for Measurement of Optical Polarization



The problem:

To provide a means for measuring variation of polarization (intensity, degree of polarization, orientation of the plane of polarization, and ellipticity of polarization ellipse) within a spectral line and in the surrounding continuum with a high degree of resolution. This degree of resolution, necessary for analysis of the spectra of unknown gaseous, solid or liquid media, or media containing elements in some or all of these phases, is not obtainable by other methods such as those using doubly-refracting systems.

The solution:

The use of a standard two-beam interferometer with polarizers (P_1 and P_2) in each beam and an analyzer (linear polarizer, P_3) at the recombined focal point provides accuracy and resolution far beyond any other means known, and represents an important new development in the field of interferometer-spectrometer analysis.

How it's done:

The novelty of this innovation lies in the addition of a polarizer in each path of an interferometer, shown in the figure, of the Michelson type or other double-beam type, and a linear polarizer (analyzer) at the recombination point so that the three interferograms obtained with both polarizers P_1 and P_2 parallel to the X-direction, parallel to the Y-direction, and mutually perpendicular (arrangement A_3), contain information about the four Stokes parameters of the incident radiation. The advantages include the possibility of measuring both the intensity (spectral energy distribution) and state of polarization of optical radiation by means of the high resolution Fourier spectroscopic method, and obtaining information about the composition, structural and optical properties of the absorbing or emitting medium.

Interferometric (Fourier) spectroscopy, particularly in the infrared region of the spectrum, has been made possible by the research of numerous scientists. This method is based on the property that when no polarizers are introduced in the interferometer, the intensity of radiation of a given wave number, at a known path difference, can be obtained by adding the intensities obtained with the parallel arrangements and multiplying by a factor to remove the effect of the analyzer. However, this is but one possibility which has been utilized for obtaining high resolution spectra (of radiation intensity only) by using the Fourier transformation. The full capability of the interferometric technique, in the measurement of both the intensity and state of polarization within any given spectral band, has only been demonstrated theoretically.

(continued overleaf)

In principle, the instrumental imperfections such as imperfect polarizers, dependence of their performance on wavelength, and effect of beam splitter (such as fractional transmission or reflection and residual polarization introduced into the beams) have already been considered. It should be possible, in practice, to deal with these factors by a proper method of calibration aimed at determining the Jones' matrices characterizing the analyzer and the combined action of the splitter with each of the two polarizers (P_1) and (P_2). Further, the usual limitations about the source size, bandwidth, and frequency of sampling also apply in these polarization measurements.

Finally, the proposed method relies heavily on the deliberate introduction of a rather large asymmetry in the interferogram. This requires recording the interferograms on both sides of the origin. Also, the process of information retrieval which necessitates the use of exponential transforms is known to be nonlinear. However, this nonlinearity will be of real consequence only when the signal/noise ratio is small.

Notes:

1. This technique should be of interest to all laboratories engaged in spectroscopic and polarimetric analysis, and could have direct application to astronomical, geophysical, meteorological, and chemical problems such as measurement of polarization of absorption or emission lines in the radiation from atmospheres and surfaces of planets, including Earth, from planetary nebulae, and in chemical analyses of constituents.
2. Requests for further information may be directed to:

   Technology Utilization Officer
   NASA Pasadena Office
   4800 Oak Grove Drive
   Pasadena, California 91102
   Reference: B70-10405

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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