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COMPENSATED POLARIZATION SCRAMBLER FOR RAMAN DEPOLARIZATION AND INTENSITY MEASUREMENTS ON MICROSAMPLES

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INTRODUCTION

It has long been recognized[1,2,3,4,5] in measuring relative intensities and depolarization ratios of Raman lines that prism and grating spectrometers have different transmittances for light polarized parallel ($T_{\parallel}$) and perpendicular ($T_{\perp}$) to the slit. Several methods have been used to give equal instrument response to parallel and perpendicular polarization. Stitt and Yost[3] used a Nicol prism parallel to the high-transmittance direction of the spectrometer, combined with a rotatable mica half-wave plate to transmit either vector to the Nicol prism. This method has the advantage of having a higher spectrometer transmittance, but the mica plate gives exact half-wave retardation at only a single wavelength. A mica quarter-wave plate[4,5] averages the transmittances of the spectrometer for the two polarization directions, but is also wavelength dependent. Virtually achromatic circular polarizers have been designed and constructed[6,7], but these devices are too bulky and expensive for the clear apertures needed for fast spectrometers.

The most commonly used device, described by Hanle[1], is a thin birefringent wedge called a polarization scrambler (PS), fabricated with the optic axis in the plane perpendicular to the optical path through the wedge, and at 45° to the slit. The plane of the wedge angle (vide Fig. 1) passes through the slit to remove lateral displacement of the pair of images projected on the slit. The number of wavelengths retardation along the slit depends on the path difference (PD) through the PS from top to bottom. From optical data for calcite[8] a PS with 1.0 mm thickness range would introduce 259 wavelengths retardation at 0.6563 μ or 364 wavelengths retardation at 0.4861 μ. From the optical data for quartz[9] a similar quartz PS with 1.0 mm thickness range would introduce 13.7 and 19.1 wavelengths retardation at 0.6563 and 0.4861 μ, respectively.

Opposing requirements limit the range of useful values of wedge angle of the PS. There must be several cycles of retardation along the slit, so that the transmitted light of an incomplete cycle is not a significant fraction of the total. Recent techniques of Raman microsampling[10,11] may illuminate as little as 0.4 mm length of the

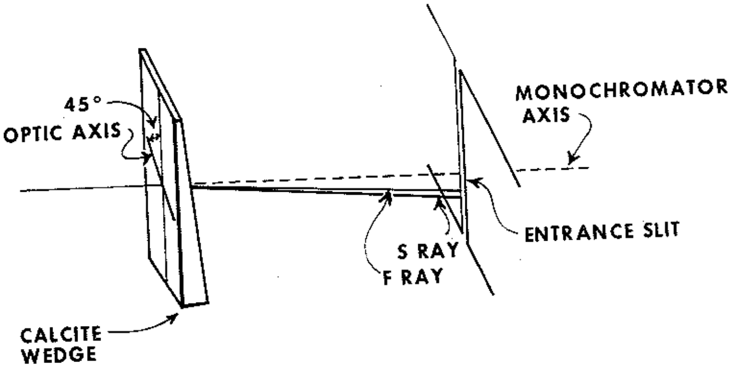

FIG. 1

Schematic diagram of uncompensated polarization scrambler arrangement entrance slit. If a polarized source is imaged on a short section of the calcite PS, the magnitude of intensity fluctuations (polarization interference fringes) with wavelength is a function of $T_{\parallel}/T_{\perp}$. Since the PS cannot be located in the plane of the slit because of obstruction by the slit assembly, we make a virtue of necessity by locating the PS 15 mm from the slit. With a collimator focal length of 750 mm and 100 mm grating height, the converging rays intercept a height of 2 mm on the PS in addition to the 0.4 mm working slit height. At 3600 Δ cm^{-1} from the 0.6328 μ exciting wavelength, the 2.4 mm working aperture height on a calcite PS with 0.5 mm thickness change in 15 mm amounts to 16 cycles PD minimum. It can be shown that for the worst case, where the PD is 16.5 cycles and where the observed monochromator transmittance $T_{\parallel}/T_{\perp}$ is 5:1, the maximum deviation of $T_{\parallel}/T_{\perp}$ for the PS-equipped monochromator from 1.0, the perfect case, should be $\pm$ 0.013. A scan made under these conditions shows no noticeable polarization interference fringes with signal/noise >50.

The deviations imposed on the slow (S) and fast (F) rays complicate the alignment of the microsampling system in front of the entrance slit, and make it more difficult to specify the viewing geometry for depolarization and intensity measurements[12]. For example, the calcite PS described above, with 0.5 mm thickness change in 15 mm along the wedge, causes deviation of 0.0218 and 0.0162 radians for the S and F rays, respectively, at 0.6563 μ. A compensating glass wedge of the same angle whose refractive index equals the mean of the S and F indices of the calcite through the wavelength range of interest would minimize the deviation of both the S and F rays. We find that the tabulated optical values for Bausch and Lomb's Light Barium Crown #573574[13] differ from the corresponding calcite n_{mean} values by much less than the manufacturing tolerances at all wavelengths between 0.36 and 1.0 μ. A comparison of the deviation of a compensated PS having this combination, with an uncompensated PS, is shown in Fig. 2. The mean of the two deviations for the compensated PS varies from -16 to +2 microradians over the range from 0.36 to 1.0 μ wavelength.

A compensated PS constructed to our specifications by Karl Lambrecht & Co. performs in accordance with our expectations.

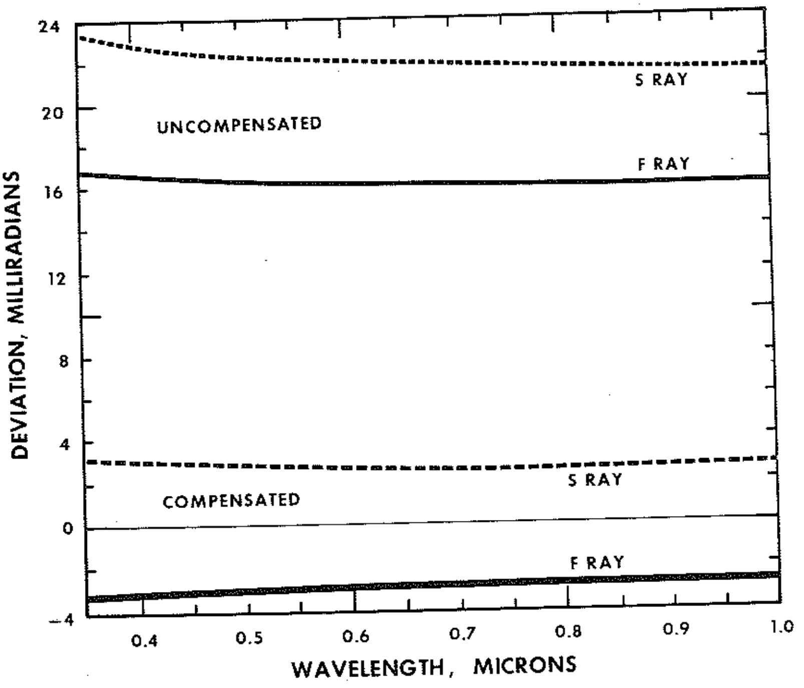

FIG. 2

Deviations introduced by an uncompensated and by a compensated polarization scrambler

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