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13. ABSTRACT (Maximum 200 words)

The MWIR imaging system acquired under the DURIP grant was incorporated into a rotating compensator imaging polarimeter. In such systems, several images of the target scene are captured through a retarder and analyzer, with the retarder rotated to a different orientation for each image. With each retarder position, the system is sensitive to a different polarization state at the input. By collecting data with the retarder in several positions, the entire polarization state of the light entering the system can be reconstructed. Since the polarimeter in question is an imaging instrument, a polarization state is reconstructed at every pixel of the scene.

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Introduction

Expenditures under DURIP grant DAAD19-00-1-0098 have been divided between two major research efforts in imaging polarimetry. Approximately two thirds of the funds were used in the acquisition of a mid-wave infrared (MWIR) camera system for an imaging Stokes polarimeter. The remainder of the funds was used toward a camera system for a snapshot imaging spectropolarimeter for the visible region of the spectrum. Table 1 breaks down these expenditures. Concise summaries of each of these research programs follow.

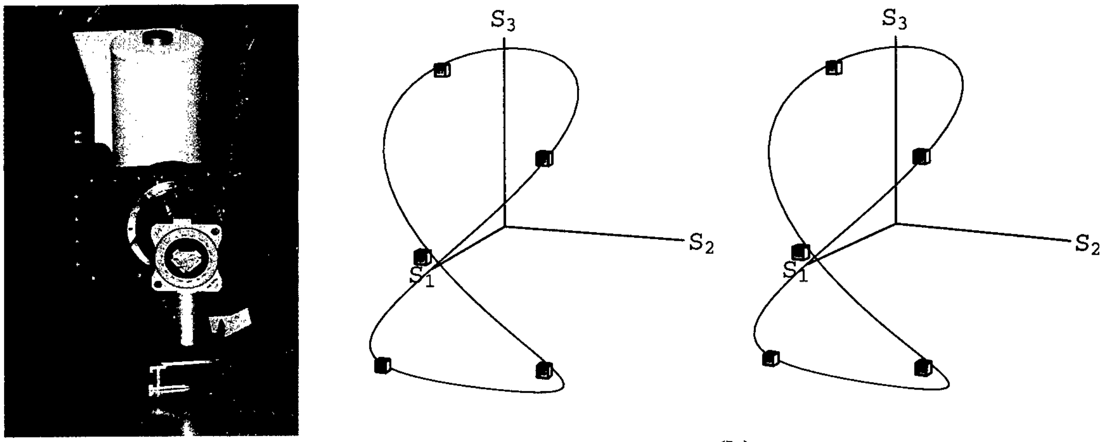
Table 1: Expenditures under DURIP grant DAAD19-00-1-0098

Item	Cost
Indigo Systems Merlin Mid laboratory camera, with objective, data acquisition system, and filter wheel	$68,025.00
OCLI bandpass filters	$550.00
Optometrics wire grid polarizer	$1,560.00
National Instruments GPIB controller	$570.00
miscellaneous	$357.57
Roper MegaPlus ES4.0, 2048x2048, 12 bit camera with Forster Systems Engineering data acquisition system	$34,032.43
total	$105,095.00

MWIR imaging polarimetry

The MWIR imaging system acquired under the DURIP grant was incorporated into a rotating compensator imaging polarimeter. In such systems, several images of the target scene are captured through a retarder and analyzer, with the retarder rotated to a different orientation for each image. With each retarder position, the system is sensitive to a different polarization state at the input. By collecting data with the retarder in several positions, the entire polarization state of the light entering the system can be reconstructed. Since the polarimeter in question is an imaging instrument, a polarization state is reconstructed at every pixel of the scene.

The new camera replaced an older HgCdTe imager, substantially improving upon its resolution, noise characteristics, and reliability. The improved performance afforded by the camera upgrade enabled a substantial investigation of calibration methods for polarimeters in the MWIR. We were able to successfully demonstrate a calibration method which uses a separate polarizer and retarder as a polarization state generator (PSG). The polarimeter was characterized by measuring its response for each of several known polarization states prepared with the PSG. Figure 1 shows the polarimeter (part a) and a graphical representation of several calibrated measurements (part b). Future research with the MWIR camera may include improvements in calibration techniques and acquisition of polarimetry data in the field. The camera may also be used in MWIR versions of the snapshot imaging spectropolarimetry technique to be described next.



(a) **(b)**

Figure 1. (a.) Indigo Systems InSb Camera with rotating retarder. A linear wire grid polarizer and 4.42 – 5.46 μm bandpass filter are mounted inside the dewar. (b) Stereo pairs showing the s_1, s_2, and s_3 Stokes components output by the polarimeter at one pixel for 5 states generated by the polarization state generator (as cubes). The figure-of-eight curves show all possible states that can be generated by rotating the PSG retarder while keeping its polarizer's transmissive axis horizontal..

Snapshot imaging spectropolarimetry

The second imager purchased with DURIP funds is a large-format CCD camera for the visible spectrum. It is being incorporated into a prototype snapshot imaging spectropolarimeter, *i.e.* an instrument which will be capable of measuring the polarization state of light as a function of wavelength and position in the target scene.[1] The instrument will operate through the fusion of two techniques: channeled spectropolarimetry and computed tomography imaging spectrometry. Figure 2 illustrates the principle of operation of a channeled spectropolarimeter. The radiation under analysis is passed through two thick (high order) retarders and a polarizer, and the spectrum of the exiting light is recorded by a spectrometer. The fast axis of the first retarder is aligned with the transmissive axis of the polarizer, and the second retarder is oriented with its fast axis at 45° to the polarizer's axis. The recorded spectrum is a linear superposition of the Stokes component spectra of the incident light, in which the coefficients are sinusoidal terms depending on the retardances of the retarders. Since each retardance is nominally proportional to wave number σ, the Stokes component spectra are modulated. With proper choice of modulation frequencies (*i.e.* proper choice of retarder thicknesses) the Stokes component spectra can be separated in the Fourier domain. This technique is analogous to sideband modulation in radio communications.

If used in combination with a snapshot imaging spectrometer, the channeled spectropolarimetry technique acquires snapshot imaging capability. The computed tomography imaging spectrometer (CTIS), developed in large part in our laboratories, is just such a spectrometer. CTIS obtains spatial and spectral data simultaneously by imaging through a computer-generated holographic disperser and carrying out a reconstruction using the mathematics of limited-angle tomography. The combined system is illustrated in Figure 3.

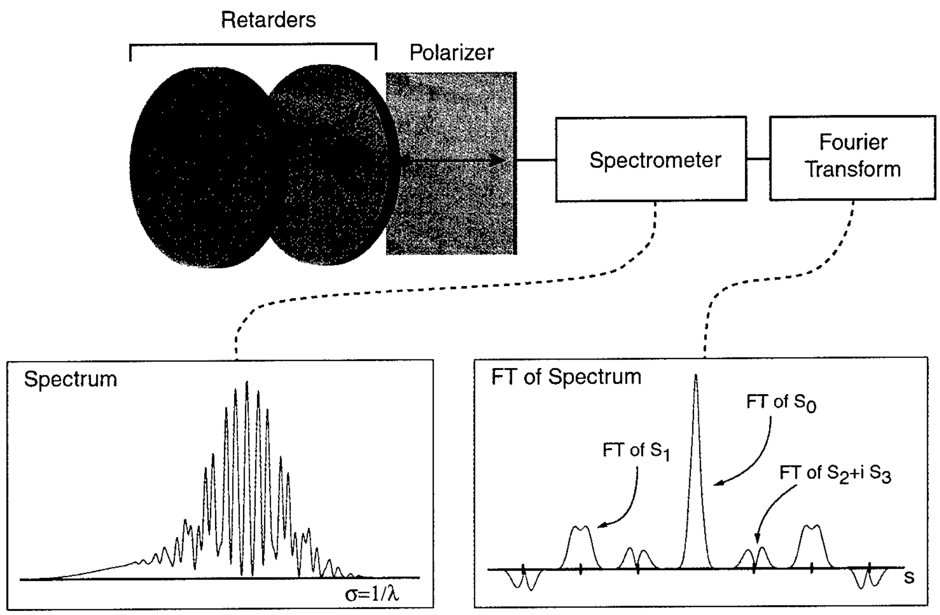


Figure 2: The channeled spectropolarimeter. The complicated spectrum recorded at the output of the polarization optics is formed by a superposition of the Stokes component spectra after modulation. With proper choice of modulation frequencies, the Stokes components can be isolated in the Fourier domain.

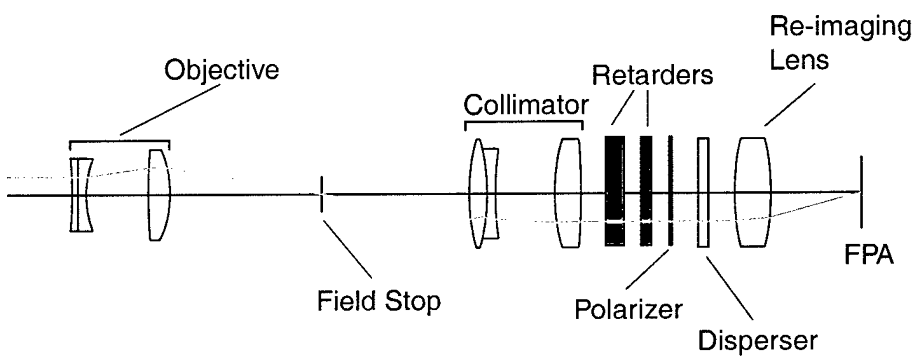


Figure 3: Optical layout of the CTICS.

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[i] A. M. Locke, D. S. Sabatke, M. R. Descour, E. L. Dereniak, J. P. Garcia, T. K. Hamilton, and R. W. McMillan, "Snapshot imaging spectropolarimeter," in *Polarization Analysis and Measurement IV*, D. H. Goldstein and D. B. Chenault, eds., *Proceedings of SPIE* Vol **4481**, (2001).