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Angle Scanning Spectropolarimetry

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Previously participated in RCEU program: Yes, years ago, but not in its current incarnation

Project Summary:

Angle Scanning Spectropolarimetry

Research or Creative Experiences for Undergraduates Proposal
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Mueller matrix spectroscopy, or spectropolarimetry, combines a complete polarimetric characterization of light, after having passed through a medium, with conventional spectroscopy, providing information not only on chemical composition, but also on microstructure and internal inhomogeneity. This results in a substantially improved noncontact signature of the medium of interest. Sample-measuring polarimeters determine Mueller matrices and hence the relationship between incident and transmitted states of polarization. If this is done over a broad spectral range, additional information is obtained; far more than from spectroscopy or polarimetry alone. The basic interest is in investigating the underlying physics of how complex molecules scatter light and the immediate application is in atmospheric sampling to determine constituent (or perhaps pathogen) levels.

The polarimeter consists of a combination of linear retarders and polarizers. A series of irradiance measurements are made at unique rotational positions of these components. The output polarization state vector is given by,

$$S_{out}^{(q)} = P_2 \, R_2^{(q)} \, M_{sample} \, R_1^{(q)} \, P_1 \, S_{in},$$

where P_1 and P_2 are the (known) Mueller matrices of the polarizers and $R_1^{(q)}$and $R_2^{(q)}$ are the (known) Mueller matrices of the retarders. M_{sample} is the sample's Mueller matrix to be determined. S_{in} and S_{out} are the (measured) incident and transmitted Stokes vectors.

An instrument of this type capable of measuring the polarization properties of solids and aerosols from the 250nm region of the ultraviolet out to the 1100nm range of the infrared has been constructed and tested. Adding the ability to angularly scan from near 0 to near 180 degrees

will complicate the instrument significantly, but will also increase the amount of data collected by two orders of magnitude while substantially improving the flexibility of using such an instrument in real-world situations where the angle of incidence cannot be pre-arranged. This improvement is the cornerstone of research being done by a current Ph.D. student in the Optical Science and Engineering program at UAH, but much of the mechanical fabrication required is outside her immediate skillset. The RCEU student will have daily contact with her and the two of them will be expected to arrive at a design for the angle scanning hardware, procure the components, fabricate any additional parts required, and validate the operation of the new system.

Student Prerequisites: Student should be a college of science major in physics, chemistry, or biology with basic mechanical and computer skills. Prerequisite courses should include introductory physics (PH 110, 111/114, 112/115, 113/116), chemistry (CH 121/125 and 123/126), biology (BY 119), and math (MA 171, 172, 201) to be completed by the end of the Spring 2017 semester.

Student Duties: The RCEU student will be responsible for assisting in all phases of the mechanical construction of the additional hardware required, to include the design and fabrication of precision mounts, translation and rotation stages. Student will also be involved in initial data collection to determine unique signatures of specific aerosols and simulants of airborne pathogens. Student will become familiar with commercially available fiber optic spectrometers, Labview® software, basic machine shop tools, and optical components such as lenses, polarizers, and retarders. Students with these basic skills are in high demand and often receive job offers before graduating. A technical paper to be submitted to a refereed journal is anticipated based on the results obtained during the summer and the student will appear as a co-author.

Mentor Supervision and Interaction: The RCEU student will work daily with the Ph.D. student and both will meet with Prof. Gregory weekly in a scheduled one hour seminar arrangement where each will give a status report and receive input regarding plans and schedules for the coming week.