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JPL ACTIVITIES ON DEVELOPMENT OF ACOUSTO-OPTIC TUNABLE FILTER IMAGING SPECTROMETER

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This paper reports recent activities of JPL in the development of a new type of imaging spectrometers for earth observation and planetary exploration. This instrument uses the acousto-optic tunable filter (AOTF) as high resolution and fast programmable bandpass filter. AOTF operates in the principle of acousto-optic interaction in an anisotropic medium. This filter can be tuned in sequential, random, and multiwavelength access modes, providing observational flexibility. The diffraction process in the filter generates two diffracted monochromatic beams with polarization orthogonal to each other, creating a unique capability to measure both polarimetric and spectral properties of the incoming light simultaneously with a single instrument. The device gives wide wavelength operations with reasonably large throughput. In addition, it is in a compact solid-state structure without moving parts, providing system reliability. These attractive features give promising opportunities to develop a new generation of airborne/spaceborne and ground, real-time, imaging spectrometer systems for remote sensing applications.

The operation principle of the AOTF imaging spectrometer is different from that of current airborne multispectral imaging instruments, such as the airborne visible/infrared imaging spectrometer (AVIRIS). The AOTF instrument gives a two-dimensional image at a desired wavelength at one time, whereas AVIRIS takes a spectrum over a predetermined wavelength range at one pixel at a time and the image is constructed later. Each technique has its own merit. AVIRIS is an excellent tool for high spectral resolution remote sensing of earth. AOTF instrument has its unique properties. For example, AOTF allows observations to be tailored in real time to perform the desired experiments and to collect only required data. For example, an AOTF imaging spectrometer has the potential to monitor distributions of several gaseous pollutants in air and its time variation in real time. In addition, the flexibility enables the instrument to address a wide range of objectives and permits the observation parameters to be modified in flight as new objectives are developed. Consequently, the performance in each mission can be increased with minimal resources.

Up to now, two microcomputer-controlled AOTF multispectral imaging breadboards were designed, assembled, and demonstrated at Jet Propulsion Laboratory(JPL) (Chao, et al. 1990; Yu, et al, 1990; Chao, et al.1991; Cheng, et al. 1992). One operates in the wavelength range of 0.48-0.76 microns and the other between 1.2 and 2.5 microns. The optical system of the visible/near-infrared breadboard has foreoptics, an AOTF, imaging optics, and a silicon charge coupled device (CCD) camera. An ordinary camera zoom lens is used for foreoptics. A field lens is placed behind the AOTF. The combination of the field lens and the camera lens generates the diffracted image at the CCD detector array. The optical system design and analysis of this breadboard were reported previously. Two types of the CCD cameras are used in the system, an electrically cooled integrating CCD camera for precision measurements in the laboratory and an ordinary CCD video camera for real-time observations. The breadboard system consists of a 386 IBM-PC compatible computer for control and data acquisition, a RF generator, a RF power supply, and an image grabber.

Several experiments to demonstrate the feasibility of using the visible/near-infrared AOTF-based breadboard for a number of applications were done. They include: identification and mapping of mineral contents; observations of botanical objects; demonstration of using optical fiber bundle to make observational flexibility; real-time spectral imaging at the video rate; and measurements of polarized signatures.

The optical system architecture of the infrared breadboard is the same as that of the visible/near-infrared breadboard, except that a liquid nitrogen-cooled HgCdTe detector array and a set of ZnSe lenses are used. Limited experiments using this breadboard system were carried out. They included identification and mapping of mineral contents as well as observation of botanical objects.

In this workshop presentation, results of experiments with the objective to demonstrate potentials of the AOTF instrument for remote sensing applications will be presented. The technology issue associated with the development of AOTF imaging spectrometers will be addressed. Finally, current JPL activities on the subject will be given.

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