

the wavelength range of 0.4–5  $\mu\text{m}$ . Basically, the AOTF multispectral imaging instrument measures incoming light intensity as a function of spatial coordinates, wavelength, and polarization. Its operation can be in either sequential, random access, or multiwavelength mode as required. This provides observational flexibility, allowing real-time alternation among desired observations, collecting needed data only, minimizing data transmission, and permitting implementation of new experiments. These will result in optimization of the mission performance with minimal resources.

This instrument can be used for two types of applications for future planetary exploration missions. First, the instrument is placed on a flight platform for mapping the interesting features on the surface and in the atmosphere of a planet or a moon. For example, this instrument is an excellent candidate as a visible-infrared imaging spectrometer for the Lunar Observer and a polarimetric imaging spectrometer for the Pluto Fast Flyby. The same instrument can be used to investigate atmospheric physics and chemistry of Jupiter and Saturn. In the other application, the instrument is used on a rover or a surface package on Mars and the Moon as an intelligent vision instrument for searching, identifying, mapping, and monitoring geological features, characterizing atmospheric contents and their time variability, as well as collecting valuable samples. For example, these instrument applications will support major scientific objectives of the Mars Environmental Survey (MESUR) program and the Evolutionary Mars Sample Return Program.

In the past we built two AOTF imaging spectrometer breadboard systems covering visible to short-wavelength infrared ranges and successfully demonstrated capabilities for identifying minerals and mapping content distributions, characterizing botanical objects, and measuring polarization signatures. In addition, we demonstrated the use of an optical fiber bundle as an image transfer vehicle in the AOTF system with the objective of developing an AOTF system with a flexible observation head for rover applications.

Recently we completed a polarimetric multispectral imaging prototype instrument and performed outdoor field experiments for evaluating application potentials of the technology. We also investigated potential improvements on AOTF performance to strengthen technology readiness for applications. This paper will give a status

report on the technology and a prospect toward future planetary exploration.

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**A REMOTE LASER-MASS SPECTROMETER FOR DETERMINATION OF ELEMENTAL COMPOSITION.**

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Determination of the elemental composition of lunar, asteroid, and planetary surfaces is a major concern for science and resource utilization of space. The science associated with the development of a satellite or lunar rover laser-mass spectrometer instrument is presented here. The instrument would include a pulsed laser with sufficient energy to create a plasma on a remote surface. Ions ejected from this plasma travel back to the spacecraft or rover, where they are analyzed by a time-of-flight mass spectrometer, giving the elemental and isotope composition. This concept is based on the LIMA-D instrument onboard the former Soviet Union Phobos-88 spacecraft sent to Mars.

A laser-mass spectrometer placed on a rover or satellite would substantially improve the data return over alternative techniques. The spatial resolution would be centimeters, and a complete mass spectrum could be achieved in one laser shot. An experiment is described (Fig. 1) that demonstrates these features.

A 400 mJ Nd:YAG laser is focused, to an intensity of  $10^{11}$  w/cm<sup>2</sup>, onto a Al, Ag, Cu, Ge, or lunar simulant target. A plasma forms from which ions are ejected. Some of these ions travel down an 18-m evacuated flight tube to a microchannel plate detector. Alternatively, the ions are captured by an ion trap where they are stored until pulsed into a 1-m time-of-flight mass spectrometer, giving the elemental composition of the remote surface. A television camera monitors the plasma plume shape, and a photo diode monitors the temporal plasma emission. With this system, ions of Al, Ag, Cu, Ge, and lunar simulant have been detected at 18 m. The mass spectrum from the ion trap and 1-m time-of-flight tube will be presented. Figure 2 shows ions of Al (1803 ev), Cu (1483 ev), Ag (1524 ev),

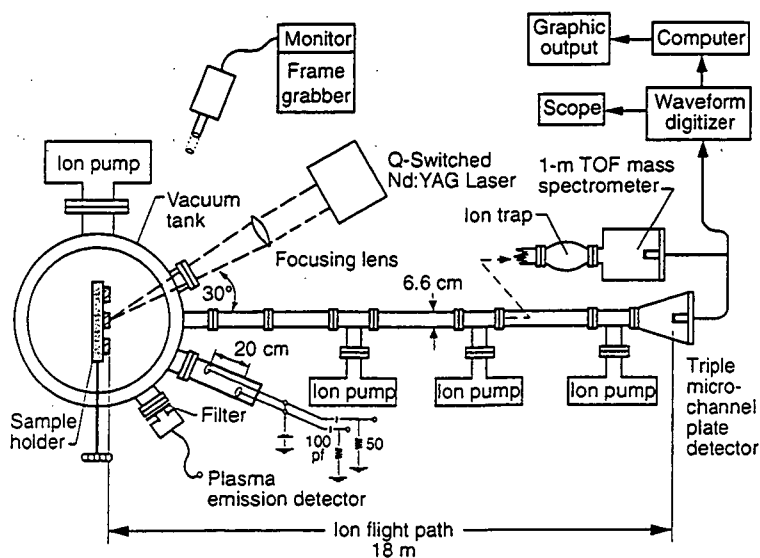


Fig. 1.

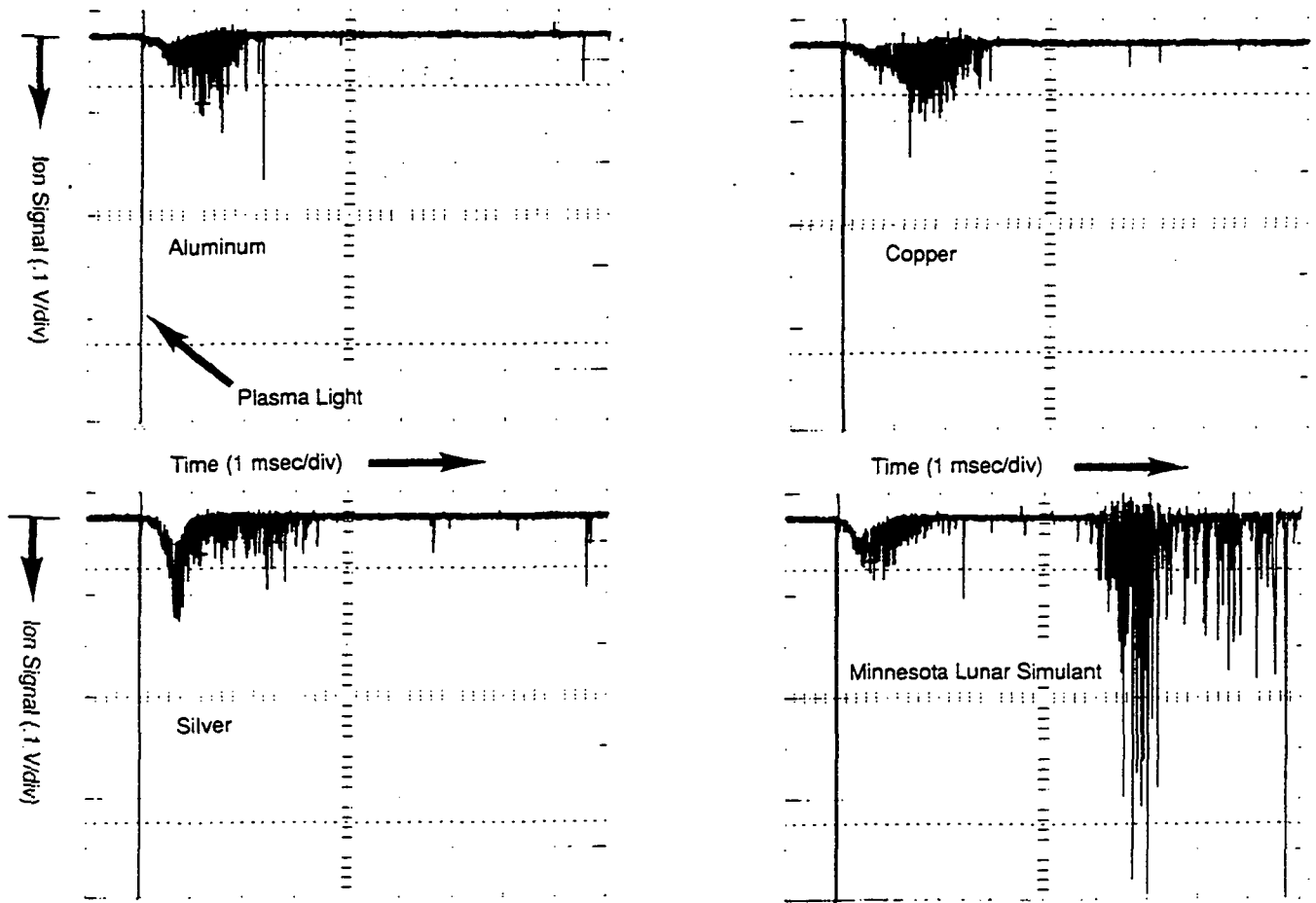


Fig. 2.

and lunar simulant detected at 18 m (bulk chemistry and mineralogy similar to Apollo 11 lunar mare basalts).

Experimental results will be presented that demonstrate the characteristics and ability of detecting laser-produced ions over very long distances.

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**THE APX SPECTROMETER FOR MARTIAN MISSIONS.** T. Economou, Laboratory for Astrophysics and Space Research, University of Chicago, Chicago IL 60637, USA.

Obtaining the chemical composition of any planetary body should be a prime science objective of each planetary mission. The APX spectrometer has been designed to provide a detailed and complete chemical composition of all major (except H) and minor elements with high accuracy, *in situ* and remotely. From such complete analyses a first-order mineralogy of analyzed samples can be deduced. Laboratory studies in the past have shown that rock types (e.g., dunites, basalts, Philippinate 300 sample) were identi-

fied uniquely in blind test analyses. Such identification is more accurate than can be obtained from any other remote spectroscopic technique.

The APX technique is based on three modes of nuclear and atomic interactions of alpha particles with matter resulting in three different energy spectra containing the compositional information. The instrument uses 50 to 100 mCi of <sup>242</sup>Cm or <sup>244</sup>Cm transuranium radioisotopes to provide a monoenergetic beam of alpha particles (6.01 MeV and 5.80 MeV respectively) and solid-state detectors for acquiring the energy spectra.

The technique has been used for the first time on the Surveyor missions in 1967-1968 to obtain the first chemical composition of the Moon. Since then the instrument has been miniaturized and refined to improve its performance. The alpha and proton detectors were combined into a single telescope with a very thin Si front detector that acts like an alpha detector and at the same time as an absorber of alpha particles for the proton detector in the back. An X-ray mode was incorporated into the instrument that is by itself equivalent to an X-ray fluorescence instrument. A rather complicated logic determines if the particle is an alpha, proton, or an