DEVELOPMENT OF A SOLID–STATE MÖSSBAUER SPECTROMETER FOR PLANETARY MISSIONS; D. G. Agresti, E.L. Wills, T.D. Shelfer, Department of Physics, University of Alabama at Birmingham, Birmingham, AL 35294; J. S. Iwanczyk, N. Dorri, XSIRIUS Scientific, 4640 Admiralty Way, Suite 214, Marina del Rey, CA 90292; and R. V. Morris, Code SN2, NASA Johnson Space Center, Houston, TX 77058.

Iron Mössbauer spectroscopy provides quantitative information on the distribution of iron among its several oxidation states, the mineralogy of iron–bearing phases, and the relative proportions of these phases. Many extraterrestrial materials are known to be iron rich and thus Mössbauer spectroscopy can be a powerful analytical tool for the remote analysis of planetary surfaces [1].

At NASA's Pathfinder Sample Acquisition, Analysis, and Preservation (SAAP) Instrument Technology Workshop, we proposed the use of a Mössbauer spectrometer for studying extraterrestrial materials *in situ* [2]. The conventional spectrometer is not directly suitable for this purpose and would need to be redesigned to reduce space, mass, power consumption, and data acquisition time. This implicitly requires the use of solid–state components for the detector and velocity drive. Here we report on progress in the development of a solid–state Mössbauer spectrometer suitable for use on planetary surfaces (or as a terrestrial field spectrometer).

Detector. We have examined the use of mercuric iodide (HgI_2) detectors as replacement for conventional gas–filled proportional counter (PC) detectors. Fig. 1 shows, for the 32 mCi ^{57}Co (in rhodium) source used in these studies, the pulse–height spectrum, taken with a HgI_2 detector (3.2 mm^2 active area with 0.8 mm^2 mask; 480 μm thickness) at room temperature. The energy resolution at 14.4 keV (the Mössbauer γ–ray line) was 580 eV FWHM. A one–hour transmission spectrum for an enriched ^{57}Fe foil is shown in Fig. 2, which demonstrates that HgI_2 detectors are at least as effective as PCs for Mössbauer spectroscopy. A readily achievable 10–fold increase in detector area would result in $\approx 10^6$ counts per day in the background, which is typical of PCs. Furthermore, HgI_2 offers a significant improvement in signal–to–noise (the low background in Fig. 1), which results in the large effect (47%) in Fig. 2.

For an extraterrestrial spectrometer, backscatter geometry (source and detector on the same side of the sample) is desirable because sample preparation is unnecessary. A 21–hour backscatter spectrum from the ^{57}Fe foil, obtained using three elements (39 mm^2 active area; 780 μm thickness) of a 5–element HgI_2 detector array [3], is shown in Fig. 3. A 3–point smoothing function has been applied to the data to emphasize the peaks. Source–scatterer distance was limited to $\approx$20 cm by the detector housing with $\approx 0.02\pi$ detector–scatterer solid angle. Generally, backscatter geometry requires a detector system which will subtend a large solid angle. Thus, assuming decreased source–scatterer distance and 2π steradians, which should be possible with a HgI_2 detector array, we project $\approx$150 kcounts per day above background.

Drive. The conventional electromechanical drive is bulky and particularly susceptible to disturbances by extraneous vibrations to which a portable instrument might be subjected. We have adapted a piezoelectric positioner (MicroKinetics Corp., Laguna Hills, CA 92653) with a maximum excursion of 26.5 μm at 1250 volts to drive the source. Fig. 4 shows the spectrum of the ^{57}Fe foil taken with this drive. A sinusoidal signal of 98 Hz and $\approx$500 V amplitude provided a velocity of $\pm$ 6.5 mm/s. The detector was a conventional gas–filled proportional counter. While the velocity range is sufficiently large for all iron Mössbauer work, the peak shapes and positions show some distortion.

Further development of a solid–state Mössbauer spectrometer will require improvements in the linearity of the piezoelectric drive as well as larger–area HgI_2 detector arrays optimized for the Mössbauer geometry. Finally, these components, together with control electronics and data storage, will have to be integrated into a single package.

References: [1] Morris et al., (1989) *Lunar and Planetary Science XX*, 723; [2] Morris et al., SAAP Instr. Tech. Workshop, Houston, November, 1988; [3] Iwanczyk et al., (1989) *Rev. Sci. Instr.* 60, 1561.

FIG. 1

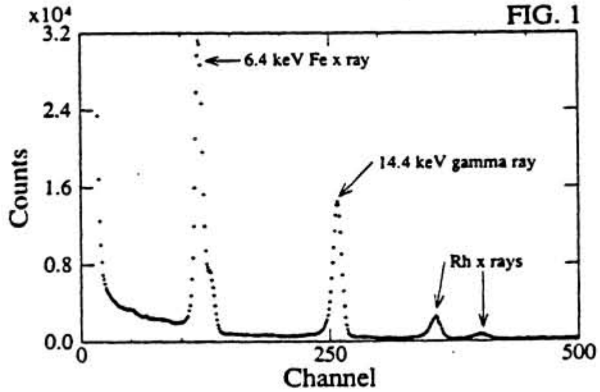

FIG. 2

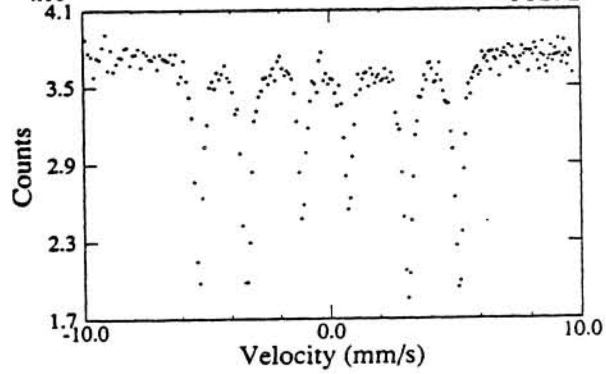

FIG. 3

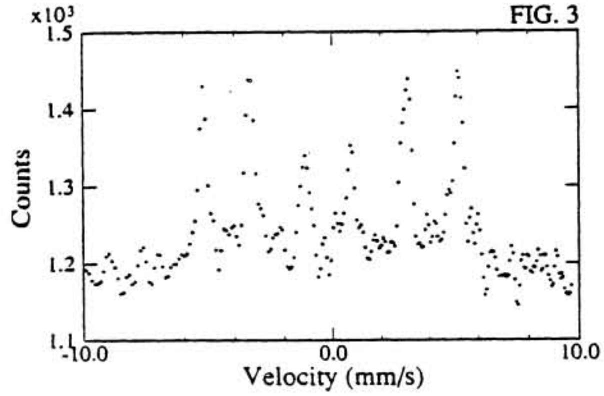

FIG. 4