A MÖSSBAUER SPECTROMETER FOR THE MINERALOGICAL ANALYSIS OF THE MARS SURFACE: FIRST TEMPERATURE DEPENDENT TESTS OF THE DETECTOR AND DRIVE SYSTEM

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Introduction: Part of the scientific payload of the Mars-96 mission is a ^{57}Fe-Mössbauer (MB) spectrometer installed on a small rover to be placed on the surface of Mars [3, 5]. The instrument is under development at the University of Darmstadt. This instrument, with some modifications, is also included in the scientific payload of the proposed MARSNET mission of the European Space Agency (ESA). A similar instrument is currently under development in the US [4].
The reason for developing a Mössbauer spectrometer for space applications is the high abundance of the element iron, especially on the surface of Mars. The elemental composition of Martian soil was determined during the Viking mission in 1976 but not it's mineralogical composition. One believes that it is composed mainly of iron-rich clay minerals, with an iron content of about 14($\pm$2) wt-%, partly magnetic. Of extremely great interest are the oxidation state of the iron, the magnetic phases, and the mineral composition of the Mars surface. To these questions MB spectroscopy can provide important information [1, 2], which are not available by other methods. We report on first tests of parts of the experimental setup in the temperature range +20°C to -70°C, roughly corresponding to the temperature range on the surface of Mars. Also questions concerning the signal/noise ratio (s/n) are discussed.

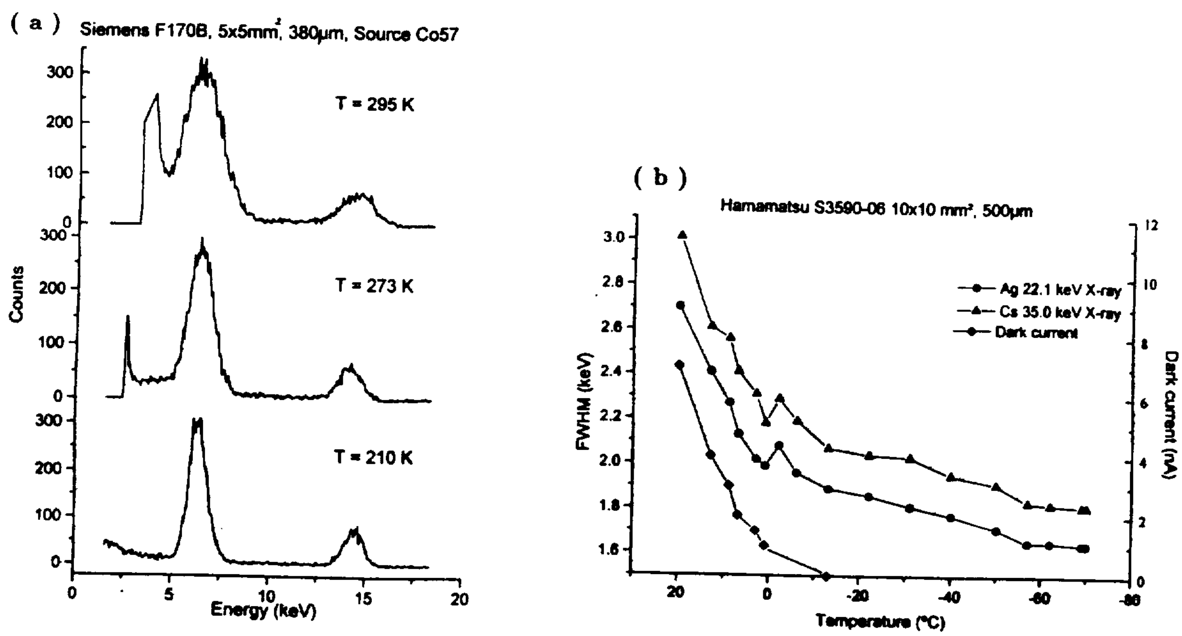

Figure 1: Temperature dependence of the energy resolution of Si-PIN-diodes: (a) 5 x 5 mm^2; 380 μm thick: 6.4 and 14.4 keV; (b) 10 x 10 mm^2; 500 μm thick: 22.1 and 35 keV;

The main parts of the **Experimental Setup**, which has been described previously [3], are the electromechanical vibrator, the detector system consisting of silicon-PIN-diodes, the electronics for the drive and the detectors, the ^{57}Co MB-source with an activity up to 1 Ci [3, 6], a multilayered radiation shield, and a γ- and x-ray window. The total weight of the system is less than 400g, with a maximum power consumption < 2 W. The total volume will be below 700 cm^3 (comparable to a coca-cola can). Backscattering geometry was choosen, to study the rocks and soil as found.

Detector system: Our detector system for Mössbauer spectroscopy consists of at least 4 Silicon-PIN-diodes [3], with active areas of about 1 cm^2. The operating voltage is (30-100)V. The energy resolution, influencing the s/n ratio of the MB spectrum, has been measured as function of temperature (see fig.1), within a temperature range comparable to Mars ambient temperatures. As seen in fig.1, the energy resolution is improved significantly by cooling only to about 0°C. Using smaller diodes (5x5 mm^2) with low capacitance, an energy resolution of about 1 keV (at 6.4 keV) was achieved at -60°C. This shows that x-ray fluorescence measurements should be possible by using small Si-PIN-diodes, cooled to the Mars surface temperature via heat exchange.

Drive system: An electromechanical velocity transducer is chosen [3], with a diameter and length of about 20mm and 45mm, respectively. It weighs about 50g. The accuracy of the drive is found to be better than 0.3% for a triangular wave form. Velocity calibration and control of linearity will be done by recording simultaneously a calibration spectrum using a second source and a combination of reference absorbers [3]. The temperature dependence of the drive system (magnets, springs, etc.) was investigated in the range +20°C to -70°C. The strength of the magnetic field in the gap of the magnetic system, and therefore the maximal velocity, changed according to the temperature coefficient of the magnetization of the SmCo-magnets. Also the main resonance frequency increased a few percent with decreasing temperature, due to the temperature coefficient of the spring constant. Both effects have to be taken into account when planing and performing measurements on Mars.

The signal/noise ratio of Mössbauer spectra will be influenced not only by temperature effects, as discussed above, but also by other parameters as for instance (i) surface roughness of the sample (Mössbauer Albedo), (ii) width of selected energy window, (iii) shielding of the source, etc.. Also the s/n ratio will be different for MB spectra recorded with the 6.4 keV x-rays and the 14.4 keV γ-rays, respectively. Due to the different escape depth of the 6.4 and 14.4 keV radiation the corresponding MB spectra can give us information on the depth profile of Fe phases.

The detector system, including its electronic part, as well as the drive system withstand a few temperature cycles (+20°C to -70°C) without damage. Nevertheless we are planing to use (may be partly) the technique of *Hybridisation* to improve the reliability of the system. Also these technique allows further reduction in volume and weight, which is important in the case of the MARSNET, and also the MESUR mission.

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