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The miniaturized Mössbauer spectrometer MIMOS II for the in situ exploration of Mars, the Moon, and asteroids

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The miniaturized Mössbauer spectrometer MIMOS II [1] is an off-the-shelf instrument with proven flight heritage. It was successfully during NASA's Mars Exploration Rover (MER) mission [2-4] and was on-board the UK-led Beagle 2 and the Russian Phobos-Grunt missions.
MIMOS II consists of a sensor head and an electronics board. The sensor head can be mounted on e.g. a robotic arm and needs to be brought in contact with the sample to be analyzed. No sample preparation is necessary. The sensor head carries the radiation source (57-Co, halflife 270 d) and detector system, and has a volume of 50×50×90mm³. The electronics board holds data acquisition and instrument control units (CPU + FPGA), voltage converters, and electrical and data interfaces to the spacecraft. It is 100×160×25mm³. The whole system including connecting cables weighs <500 g, power consumption is 4W during data acquisition, and data product size per analysis is 512kiB (4Mbit).
Mössbauer spectroscopy determines oxidation states of the element Fe and Fe-bearing mineralogy, and quantifies the distribution of Fe between oxidation states and mineral phases. This information is vital to assess the habitability of Mars: The Fe sulphate hydroxide jarosite [3], for example, provides evidence for past liquid water at the surface albeit at low pH, while (Fe,Mg)-carbonates [4] are evidence of abundant liquid water at neutral pH. Lunar In Situ Resource Utilization field experiments have successfully demonstrated the feasibility of oxygen production from lunar regolith [5,6]. Mineral FeO is reduced to metallic Fe in this process, and monitoring the change in oxidation states allows quantification of the amount of oxygen produced. Meteorites were discovered on the surface of Mars on the basis of their metallic Fe content during the MER mission [7,8]. Asteroids are the parent bodies of most meteorite group, and their Fe mineralogy is important to understand their and the Solar System's evolution. Asteroid surface and immediate subsurface Fe oxidation states help understanding the effects of space weathering.
MIMOS IIa is a next generation development currently at TRL 5.8. It combines a Mössbauer spectrometer and an X-ray fluorescence spectrometer for elemental analysis under the same weight, space, and power constraints as MIMOS II [5,9]. The main difference is a change from silicon PIN

diodes to silicon drift detectors. The latters' enhanced energy resolution enables a significantly faster acquisition of Mössbauer spectra.

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