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PLASMA: A Miniature LA-MIP-MS for *in situ* Geochemistry of Planetary Surfaces

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Major, minor, and trace element abundances and their isotopic ratios in geologic samples can be used as markers for a wide variety of planetary processes, including (but not limited to): planet formation and differentiation, evolution of environmental conditions, timing of major geologic events, and emergence of biological activity. Geochemical analysis of planetary material can be done *in situ* via techniques such as spectroscopy (e.g. laser-induced breakdown spectroscopy (LIBS) and/or alpha particle x-ray spectroscopy (APXS)), or by laboratory-based techniques such as inductively coupled plasma mass spectrometry (ICP-MS) analysis of returned samples or meteorites.

Here, we present a novel instrument for measuring and quantifying elemental abundances and isotopic ratios in solid materials derived from planetary surfaces through the miniaturization and ruggedization of laser ablation (LA-) microwave-induced plasma mass spectrometry (MIP-MS) technology specifically designed for landed spaceflight missions. The Pulsed Laser Ablation and Sampling Mass Analyzer (PLASMA) investigation leverages a laser that can produce multiple output wavelengths (from 1064 nm down to 213 nm), facilitating photon-substrate coupling with a wide range of matrices. Ablated material is directed to a microwave-induced plasma source, requiring only a fraction of the power (<35 W) and gas flow (<0.1 L/min) of commercial ICP-MS systems, coupled to a heritage-derived quadrupole mass spectrometer (QMS) that meets the form/fit/function of the Sample Analysis on Mars (SAM) instrument on the Curiosity rover. Additionally, PLASMA contains a gas reaction cell capable of chemically modifying isobaric interferences, such as ^{87}Rb and ^{87}Sr, enabling separation and achieving key *in situ* geochronology science objectives.

Initial results collected with the prototype of the PLASMA instrument demonstrate successful ablation, particle transport, and chemical analysis of CsI, a reference material for the ExoMars/MOMA and Dragonfly/DraMS spaceflight instruments, as well as measurement of Zn and Kr isotope ratios and oxidation of $^{87}Sr^{+}$. The operation of PLASMA on planetary surfaces opens a new paradigm for *in situ* exploration of the solar system, enabling trace element and isotope geochemical analysis via landed spaceflight missions targeting the Moon, Mars, or various asteroids.