Advantages of Combined LIBS and Raman Data for the Identification and Quantification of Hydrated Salts for in-situ Planetary Exploration

Kristin Rammelkamp,[1] Susanne Schröder,[1] David Sebastian Vogt,[1] Simon Kubitza,[1] Sven Frohmann,[1] Franziska Hanke,[1] Ute Böttger,[1] and Heinz-Wilhelm Hübers[1,2]

[1]German Aerospace Center, Institute of Optical Sensor Systems, Rutherfordstr. 2, 12489 Berlin, Germany,
[2]Humboldt Universität zu Berlin, Institute of Physics, Unter den Linden 6, 10099 Berlin, Germany
E-mail: kristin.rammelkamp[at]dlr.de

The combination of Raman spectroscopy and Laser-induced breakdown spectroscopy (LIBS) is promising for in-situ planetary exploration. The first LIBS instrument in space, ChemCam that is part of NASAs Mars Science Laboratory mission has been successfully analyzing Martian targets since 2012[1]. The follow-up instrument SuperCam of NASAs Mars2020 mission joins LIBS with Raman spectroscopy[2]. Both techniques are fast, need only optical access to the samples and can share several hardware components. Raman data yields information about molecules and mineralogical structures. Complementarily, LIBS data reveals the elemental composition of a target. It has been shown in terrestrial applications that LIBS-Raman data fusion can improve the classification of explosives[3] or inks[4] and first attempts of data fusion for planetary exploration have been reported[5].

Hydrated salts such as sulfates, chlorides and perchlorates play an important role in the geological analysis of the Martian surface as they are linked to areas where liquid water has evaporated in the past[6]. Using only LIBS data, the quantification of hydrogen[7], sulfur or chlorine is challenging[8]. Their detection, however, can improve with the help of Raman spectroscopy, since sulfate and perchlorate anions have Raman active modes. Additionally, the stretching modes of water molecules in a mineral matrix lead to characteristic Raman bands that can be used to determine the degree of hydration of a salt.

We study LIBS-Raman data fusion strategies for optimized identification and quantification of these salts. All measurements were performed in simulated Martian atmospheric conditions with a miniaturized Raman-LIBS setup that includes prototype components.

[1] Maurice et al., *J. Anal. At. Spectrom.*, **2016**, 31, 863-889.
[2] Wiens, Maurice, Rull Perez, *Spectroscopy*, **2017**, 32, 50-55.
[3] Moros, Laserna, *Talanta*, **2015**, 134, 627-639.
[4] Hoehse et al., *Anal Bioanal Chem*, **2012**, 402, 1443-1450.
[5] Sobron et al., *LPSC* , **2014**, #2875.
[6] Ehlmann et al., *Nature*, **2011**, 479, 53-60.
[7] Schröder et al., *Icarus*, **2015**, 249, 43-61.
[8] Anderson et al., *J. Geophys. Res. Planets*, **2017**, 122, 744-770.