Paper ID: 78950
student

IAF SPACE EXPLORATION SYMPOSIUM (A3)
Mars Exploration – Science, Instruments and Technologies (3B)

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IMPROVING SPECTRAL QUALITY IN SUPERCAM LIBS ANALYSIS THROUGH LASER FOCUSING OPTIMIZATION

Abstract

NASA's Perseverance rover has been exploring the Jezero crater on Mars since February 2021. The SuperCam instrument on board, employs several spectroscopic techniques, including Laser-Induced Breakdown Spectroscopy (LIBS). LIBS allows for the rapid and remote measurement of targets up to several meters away from the rover by shooting a pulsed laser that ablates targets. The laser pulse vaporizes and ionizes a small amount of material from a sample, creating a plasma. As the plasma cools, excited ions and atoms emit photons that can be analyzed to determine the sample's elemental composition. The technique has several advantages, including its ability to analyze samples in real time without the need for sample preparation or complex instrumentation, as well as its high sensitivity and versatility. However, several parameters can affect the quality of the plasma and spectra, such as the laser focus, thereby affecting the accuracy and precision of the quantitative values. Incorrect focus can result in a weak or unstable plasma and a reduced ability to identify specific elements. Therefore, optimizing the laser focus in LIBS spectrometry is crucial for obtaining high-quality spectral data without compromising the sample's integrity. To investigate this further, the first objective is to flag and automatically detect poor-quality spectra. This is done by analysing the total intensity for the different wavelength ranges in combination with the Signal-to-Noise Ratio (SNR). The Undecimated Wavelet Transform (UDWT) and its Inverse (IUDWT) are implemented to obtain the SNR values. The UDWT decomposes the noisy signal into different scales, while the IUDWT reconstructs the denoised signal from the wavelet coefficients. The SNR is estimated by examining the wavelet coefficients at various scales, allowing for the evaluation of spectrum quality and optimization of experimental conditions. This methodology is applied to a diverse range of LIBS spectra obtained under different experimental conditions during the first 300 sols of the mission, providing valuable insights into the performance of SuperCam LIBS. The second objective is to investigate the effects of a subtle focus degradation in the spectra. For this, the analysis focuses on the ratio between neutral and ionized emission lines (i.e. silicon, magnesium, and calcium), using data collected on Mars, and through laboratory experiments with the SuperCam ground setup at IRAP (Institut de Recherche en Astrophysique et Planétologie). This investigation offers a glimpse into an ongoing study aimed at obtaining the most precise chemical characteristics with SuperCam, with potential applications in future LIBS instrumentation.