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From machine learning to transfer learning in laser-induced breakdown spectroscopy analysis of rocks for mars exploration

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With the ChemCam instrument, laser-induced breakdown spectroscopy (LIBS) has successively contributed to Mars exploration by determining the elemental compositions of soils, crusts, and rocks. The American Perseverance rover and the Chinese Zhurong rover respectively landed on Mars on February 18 and May 15, 2021, further increase the number of LIBS instruments on Mars. Such an unprecedented situation requires a reinforced research effort on the methods of LIBS spectral data analysis. Although the matrix effects correspond to a general issue in LIBS, they become accentuated in the case of rock analysis for Mars exploration, because of the large variation of rock compositions leading to the chemical matrix effect, and the difference in surface physical properties between laboratory standards (in pressed powder pellet, glass or ceramic) used to establish calibration models and natural rocks encountered on Mars, leading to the physical matrix effect. The chemical matrix effect has been tackled in the ChemCam project with large sets of laboratory standards offering a good representation of various compositions of Mars rocks. The present work more specifically deals with the physical matrix effect which is still lacking a satisfactory solution. The approach consists in introducing transfer learning in LIBS data treatment. For the specific application of total alkali-silica (TAS) classification of rocks (either with a polished surface or in the raw state), the results show a significant improvement in the ability to predict of pellet-based models when trained together with suitable information from rocks in a procedure of transfer learning. The correct TAS classification rate increases from 25% for polished rocks and 33.3% for raw rocks with a machine learning model (Fig. 1), to 83.3% with a transfer learning model for both types of rock samples (Fig. 2). This method has been also used to predict the trace and mobile alkali and alkaline earth elements in rocks e.g. Li, Rb, Sr and Ba are important for water activity on the surface of Mars.

Biography

Chen Sun is a Research Assistant of Shanghai Jiao Tong University (SJTU), developing her research activities in the Institute of Optical Science and Engineering in the School of Physics and Astronomy. Her current research interests are focused on the data treatment of the laser-induced breakdown spectroscopy (LIBS) spectra. She has used the machine learning and deep learning algorithms to deal with the LIBS spectral data, effectively reducing the matrix effects and experimental conditions fluctuations of spectral data.