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Time-Domain Spectroscopy: an emerging alternative to Raman and FTIR Spectroscopy in Space Exploration?

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Robotic missions to extraterrestrial objects in our solar system are nowadays often equipped with instruments allowing to explore the geochemistry of the surfaces by e.g. identification of their characteristic vibrational fingerprints. Femtosecond lasers have in recent years been shown to be in principle space qualified, opening up the opportunity to explore the potential of different time-domain techniques as compact, robust alternatives to e.g. Raman spectroscopy or FTIR spectroscopy [1,2]. In this contribution the potential of two time-domain techniques: (i) coherent phonon spectroscopy (CPS) and (ii) THz Time-Domain Spectroscopy (THz-TDS), as emerging in-situ spectroscopic techniques to identify solids by their characteristic phonon spectra is discussed based on exemplarily measurements of different (planetary) materials. It is shown that: (i) CPS can give access to the raman-active phonon spectra equibvalent to Raman spectroscopy but is not hampered by fluorescence backgrounds and (ii) THz-TDS allows to probe the infrared-active fingerprint of matter while avoiding bulky (cryogenic) spectrally broadband infrared detectors. It is outlined how the bandwidth of the techniques is related to the available laser pulse duration. CPS and THz-TDS measurements with a bandwidth of beyond 1000 cm^{-1} (30 THz) and a resolution of better than 4 cm^{-1} (100 GHz) are demonstrated and compared to complementary Raman and FTIR measurements.

[1] J. Lee et al, Testing of a femtosecond pulse laser in outer space. *Scientific Reports* (2014); **4**, 5134.

[2] M. Lezius et al, Space-borne frequency comb metrology. *Optica* (2016); **3**, 1381.

[3] O. Gueckstock et al, Radiation hardness of ultrabroadband spintronic terahertz emitters: en-route to a space-qualified terahertz time-domain gas spectrometer*, Applied Physics Letters* (2024); **124**, 141103.