

Assessing the analytical potential of optical tweezers for sample return missions

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Optical tweezers are novel tools based on highly focused laser beams enabling contactless, non-invasive trapping and manipulation of particulate matter in different media like liquids, air and vacuum. When coupled with Raman spectrometers (Figure 1), optical tweezers allow high-resolution (i.e., no background noise from substrate) spectroscopic analysis of physico-chemical properties. Although in recent years they have been widely and successfully used in a variety of research fields [1], their application in space science is in its infancy [2, 3].

In principle, optical tweezers have key prerequisites for maximizing the scientific return from the analyses of planetary dust samples collected by the current and future sample return missions (e.g. Hayabusa-2, OSIRIS-Rex, Mars 2020), particularly during the preliminary investigation procedures in receiving/curatorial facilities. High-resolution, contactless and non-invasive analyses of planetary dust are actually expected to i) provide unprecedented information on the astrophysical origin and geologic evolution of their parent bodies and ii) be instrumental for biohazard assessment for constrained sample return missions – like those targeting Mars or icy bodies in the outer solar system, and the detection of past or extant extraterrestrial life.

Optical tweezers, developed in our laboratories [4], were used to collect individual dust grains from powdered analogues and extraterrestrial materials of known composition and to determine their composition and response to optical forces without substrate effects. Results (e.g., Figure 2) document the high potential of this novel technique and will be used to assess its effectiveness in the micromanipulation and analysis of extraterrestrial dust from sample return missions in

receiving/curatorial facilities and its potential role within coordinated multiscale analytical protocols.

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References

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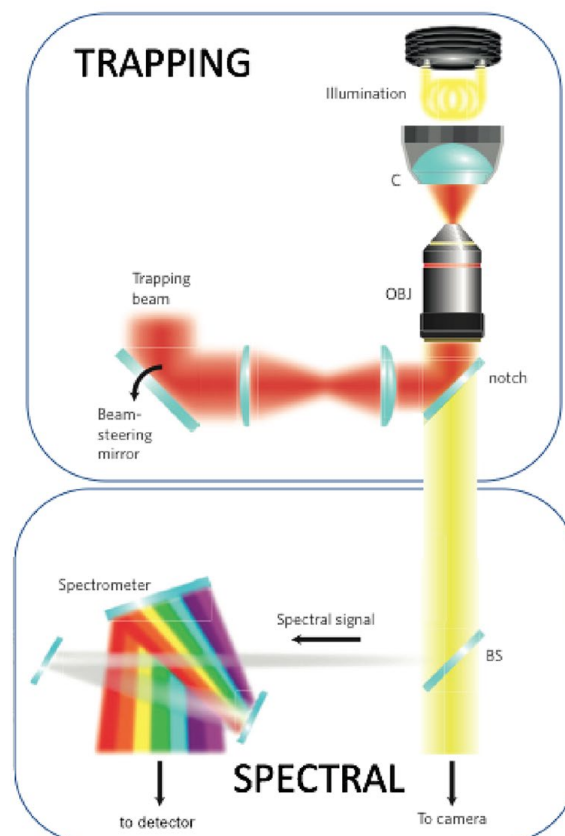


Figure 1: Sketch of the optical tweezers setup with Raman spectroscopy integration.

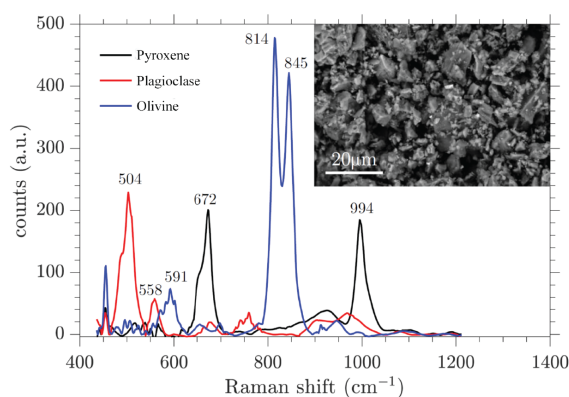


Figure 2: Raman spectra of optically trapped micron-sized fragments from the DEW 12007 meteorite (lunar regolith breccia) showing a good match with the expected mineral composition from literature [5].