

**EVALUATION OF SIMILITUDES BETWEEN SUPERCAM AND SIMULCAM, A LABORATORY STANDOFF SETUP FOR SUPPORT SCIENCE.** J.A. Manrique<sup>1,2</sup> ([joseantonio.manrique@uva.es](mailto:joseantonio.manrique@uva.es)), Juan Santamaría-Sancho<sup>1</sup>, G. Lopez-Reyes<sup>1,2</sup>, M. Veneranda<sup>1</sup>, G. Arana<sup>3</sup>, K. Castro<sup>3</sup>, J.M. Madariaga<sup>3</sup>, S. Maurice<sup>4</sup>, C. Prieto Garcia<sup>1</sup>, F. Rull<sup>1</sup>, A. Sanz-Arranz<sup>1</sup>, R.C. Wiens<sup>5</sup>, and the SuperCam team. <sup>1</sup> ERICA research group, <sup>2</sup> Department of Theoretical Physics, University of Valladolid (Spain), <sup>3</sup> University of the Basque Country (UPV/EHU), <sup>4</sup> Institut de Recherche en Astrophysique et Planétologie (IRAP), <sup>5</sup> Los Alamos National Laboratory (LANL),

**Introduction:** SuperCam instrument [1,2,3], onboard Perseverance Rover, of Mars2020 mission, consists, in a nutshell, of a standoff instrument that uses a complete analytical suite composed of various spectroscopic techniques, including Time Resolved Raman and Time Resolved Luminescence to provide compositional information of targets at distances of several meters around Perseverance Rover.

Having a laboratory system that is able to mimic, to a certain level, the capabilities and operational parameters of SuperCam allows the development of support science experiments, being of great interest for the science team during operations. This work presents the setup prepared at the University of Valladolid to assist the science team during SuperCam operations in the assessment of Raman and luminescence spectra collected on Mars. This instrument is – apart from the two replicas on LANL and IRAP – one of the setups available at different laboratories of SuperCam Science Team like the ones in Hawaii University [4] or at the Institut de Minéralogie, de Physique des Matériaux et de Cosmochimie (IMPMC) in Paris, this last one also build to mimic SuperCam's Raman and Luminescence capabilities.

**SimulCam design:** The setup is based on previous developments from our group and reuses parts of their hardware. In this setup, the instrument performs Time Resolved Raman Spectroscopy and Time Resolved Luminescence, leaving out the IR spectroscopy and imaging. For certain analyses, a side mounted system can be used to acquire LIBS (200-850 nm in atmosphere), given the shorter wavelength range required for Raman spectroscopy.

Starting with the spectrometer, in our case – and since we are focusing on the spectral range for Raman spectroscopy – our spectrometer is a transmission spectrometer with two tracks, covering a range from 532 nm to 690 nm, which corresponds to a coverage of up to 4300 cm<sup>-1</sup> for Raman spectroscopy. SuperCam's transmission spectrometer covers a wider range, including the LIBS range of interest that goes up to 850 nm, and uses three tracks to do so [1]. The detector in SimulCam consists of an Andor iStar intensified camera that includes the synchronism electronics between the laser and the photocathode. SuperCam's spectrometer operates with gate widths down to 100 ns, falling

under the capabilities of SimulCam's detector (it was tested down to 3 ns width). Another interesting capability of this detector is the ability to do different discharges of the photocathode before a readout of the CCD, this is accumulating the spectra from different pulses of the intensifier and the laser in one readout of the detector (coadds), feature that SuperCam uses on Mars.

In SimulCam, the light is conducted from the collection optics by means of a round-to-linear bundle of seven fibers from the same manufacturer as SuperCam's. In the case of SuperCam, an additional slit is glued to the linear end of the fiber, while, in SimulCam, this slit is not included. Hence, the spatial resolution of the instrument is then related to the 40 microns diameter of the individual cores in the bundle, which is bigger than the 28.7 microns slit used in SuperCam. The fiber of our setup has a length of 2 meters. Despite of the inclusion of interferential filters in the collection, remains of the excitation laser (in SuperCam we filter up to 95% of the laser line [1]) can transmit across the collection optical fiber exciting modes of the amorphous silica [5]. These features can be transmitted to the spectrometer along with the Raman spectrum of the target, affecting the detection of other silicates as olivines, or some feldspars, presenting features in the same region. In the case of our setup is important to remark that these possible contributions are expected to be less intense when compared to SuperCam given the much shorter length of the fiber.

The collection optics of SuperCam consist of a 110 mm aperture Schmidt-Cassegrain telescope with ~700 mm focal length. SimulCam uses, for the collection, a 300 mm focal f:4 refractive objective. Both the collection surface and the focal length are lower for SimulCam, impacting two main aspects: the analytical footprint of the instrument and the detection limit (as less light is collected).

The final element in play – the laser – is a frequency-doubled Nd:YAG, providing pulses of 120 mJ and 6 ns width in 532 nm. The energy output is then considerably higher in our lab setup, but the energy is electronically tunable, and the irradiance on the sample can be adjusted by means of a zoomable beam expander. The combination of both elements provides a wide variety of irradiances on the sample.

**Methodology:** The differences between the hardware of the Martian instrument and our lab setup are to be compensated by adapting different acquisition parameters to obtain spectra with similar quality parameters (mainly resolution and Signal to Noise Ratio). The evaluation of these parameters will be done using samples that were analyzed by SuperCam and can be analyzed in our lab setup – in this case, the targets contained in the SuperCam Calibration Target (SCCT) EQM model [3] and a piece of marble provided by the Basque Country University that was analyzed by SuperCam during prelaunch tests.

Different operational parameters are to be evaluated on these targets:

- Resolution (FWHM measured on a spectrum of a diamond target).
- Behavior of the intensifier (SNR with different gains).
- SNR in single shot acquisition. Compare with Mars and prelaunch data, evaluate irradiances of laser.
- SNR evolution with the number of shots.
- SNR evolution by accumulating different discharges of the photocathode in one readout of the CCD (coadds).
- Time resolved luminescence acquisition on different targets.
- Test on the SCCT using closer setup to SCAM.

**Results:** When measuring the FWHM of the diamond mounted in the SCCT, SuperCam's spectrum had a calculated width of  $14\text{ cm}^{-1}$ , similar to our laboratory setup that had a width of  $13.5\text{ cm}^{-1}$  on the same target. Introducing the restriction of 400 laser shots, we split the total amount of shots between coadds and averaged spectra. This was done on the apatite target from the SCCT EQM, similar to experiments done on Mars to evaluate if coadding would provide any advantage. Here, our setup demonstrated to diverge from SuperCam behavior, as we found a lower SNR when using coadds. A sweet spot, however, was found using 8 coadds, nearing the 10 coadds used by SuperCam. Using a low power of laser, keeping it to a set point at which the pulse power is stable, we measured the SNR vs the gain of the intensifier of a marble sample that was analyzed previously by SuperCam. In these conditions, a great variety of SNR values can be achieved, including those similar to SuperCam's spectra on this target.

Finally, we evaluated the performance of our setup on different targets of the SCCT and carbonate samples from the Ca-Mg-Fe compositional families. As a result of our evaluation, we found that it showed a good performance in the discrimination of carbonates (calcite,

dolomite, magnesite, siderite and ankerite) based only in Raman spectra. As for luminescence, we obtained different spectra from different apatites and a calcite, allowing the detection of fluorophores in different mineral matrices.

Overall, the presented setup demonstrated that it could be used to obtain results close enough to those obtained on Mars, allowing a great variety of experiments to be developed to support and help in the interpretation of SuperCam's Raman spectra.

**Acknowledgments:** This work is financed through the Spanish Ministry of Economy and Competitiveness (MINECO, grant PID2019-107442RB-C31).

**References:** [1] Wiens R.C. et al. (2021) *Space Sci Rev*, 217, 4. [2] Maurice S. et al. (2021) *Space Sci Rev*, 217, 47. [3] Manrique J.A. et al. (2020) *Space Sci Rev*, 216, 138. [4] Sharma S. et al. (2002), *App. Spectrosc.*, 56(6):699-705. [5] M. Chligui et al. (2010) <https://hal.archives-ouvertes.fr/hal-00520823>.