# **SSHADE:** THE EUROPEAN SOLID SPECTROSCOPY DATABASE INFRASTRUCTURE

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### Introduction

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eur Planet

Spectroscopy and spectro-imagery are increasingly used in space missions towards planets and small bodies, including the Moon (NIR/Clementine, SIR/Smart-1, MI/Selene-Kaguya, SIR-2 and M3/Chandrayaan-1, IIRS/Chandrayaan-2, ...), to study the solid phases at their surface (ices, minerals or organic materials).

- Infrared, Raman, fluorescence and X-rays micro-spectroscopies are also used to study planetary materials, such as Lunar samples, meteorites and cometary dust, in the laboratory and onboard some space missions (landers, rovers).
- A major contribution to the analysis of these observations is the measurement in the laboratory of UV, Visible, IR, sub-mm, Raman and XANES spectra of a variety of or synthetic materials expected to be present at the surface of the bodies of the solar system or in their ejected grains (e.g. comets, asteroids, Pluto, Mars, the Moon, ...).

### Solid spectroscopy data in Europe

A large number of laboratories in Europe have developed experiments to measure and study the spectroscopic properties of a variety of solid materials of astrophysical interest, either natural (terrestrial or extra-terrestrial) or synthetics.

### **SSHADE** interface : search tool

A user can search either spectral data or publications through two distinct forms:

- ✓ a simple 'Google-style' search tool
- ✓ a number of specialized filters to refine the search.
- The amount of data collected is huge and many of these laboratories boast leading-edge expertise in some solid spectroscopy fields. However most of the published data are very difficult to access in a usable form (i.e. electronic) to compare with observations or to use in radiative transfer codes.
- > We thus decided to extend our datamodel of solid spectroscopy (SSDM) and expand the GhoSST database (http://ghosst.osug.fr) to build a database infrastructure able to gather and distribute the spectroscopic data of most of the European **laboratories** working on solids with astrophysical and terrestrial applications.

#### What is **SSHADE**? https://www.sshade.eu

**SSHADE** ("Solid Spectroscopy Hosting Architecture of Databases and Expertise") is a project of a set of databases on solid spectroscopy that started its development in September 2015 and is now open to the community since 5th February 2018.

The SSHADE databases cover laboratory, field and simulated spectral data including various levels of products (transmission, reflectance, optical constants, band list, ...) ✓ for many different types of synthetic, natural and extraterrestrial solids: ices, snows and molecular solids, minerals, rocks, inorganic solids, natural and synthetics organic and carbonaceous matters, meteorites, IDPs and other cosmo-materials,...

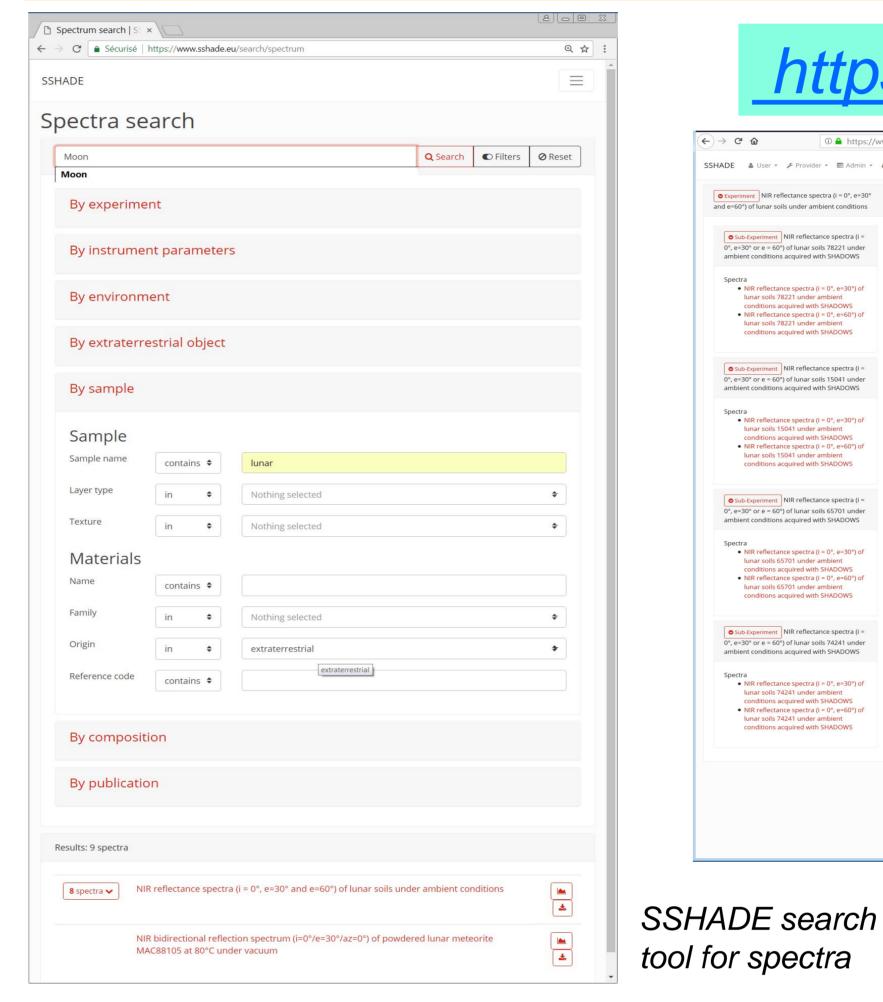
- ✓ They come from a wide range of measurement technics: transmission, bidirectional reflection, Raman, fluorescence, microscopy...
- over a wide range of wavelengths: X-rays, UV, visible, infrared, mm to radio

### Solid planetary materials in SSHADE

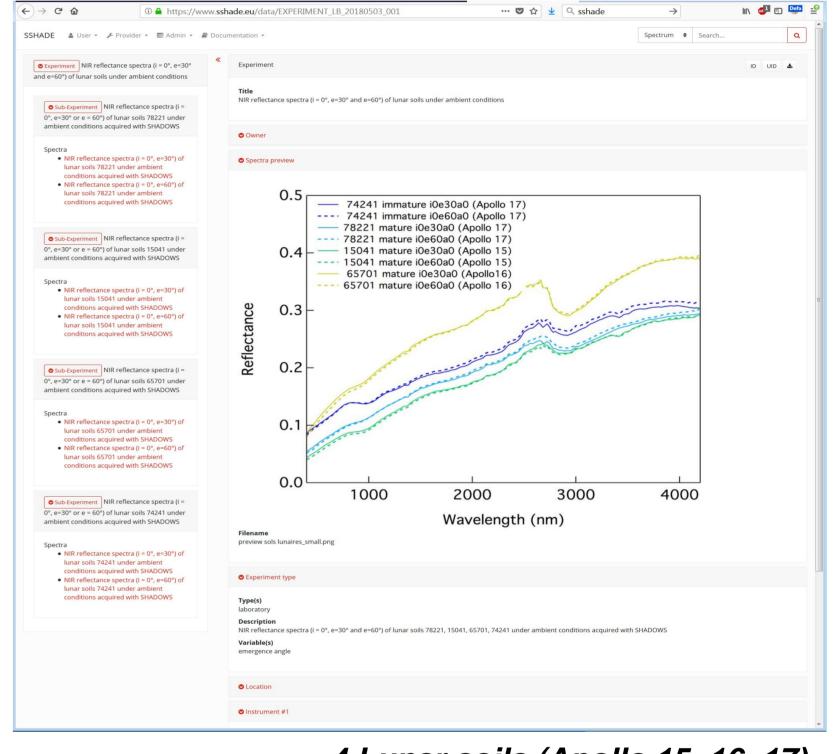
✓ **Ices**, hydrates, clathrates, ... + irradiation

For the spectral data he can filter his search according to a series of topics:

 $\checkmark$  by experiment, by instrument parameters, by environment, by extraterrestrial object, by sample, by composition and/or by publication.



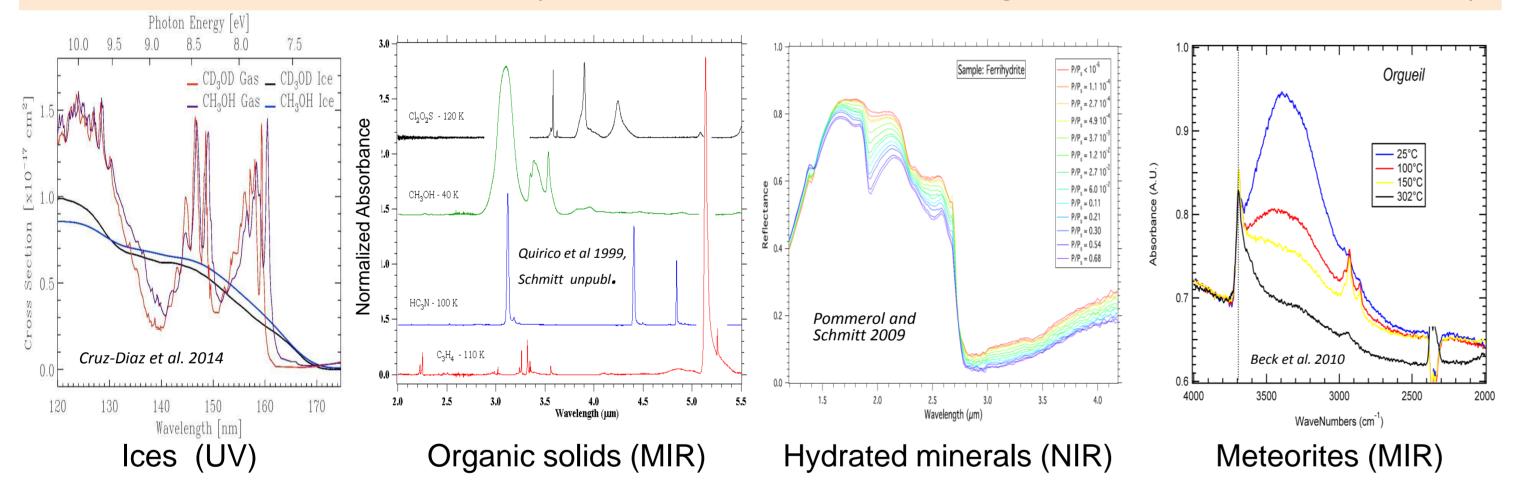
## https://www.sshade.eu



4 Lunar soils (Apollo 15, 16, 17) Experiment with Near-IR reflectance spectra at 2 angles

#### **SSHADE Interface : Display tool**

- ✓ **Organic solids**: simple, macromolecular materials, polymers, ...
- ✓ Rocks, **minerals**, salts, hydrated materials, adsorption, ...
- Other compounds (sulphur compounds, ...) + irradiation
- Extraterrestrial samples (meteorites, IDP's, Stardust grains, Lunar soils/rocks...)



### The SSHADE Projet and Consortium

The SSHADE project, based on the GhoSST database developments (Europlanet-RI + VAMDC 2009-2012) is part of the VESPA activity within the European einfrastructure Europlanet 2020-RI of the Horizon 2020 program (2015-2019). ✓ The SSHADE infrastructure is hosted at OSUG Data Center (Univ. Grenoble Alpes).

The SSHADE consortium has currently 23 partner groups in 21 laboratories from 10 different countries (F, UK, I, D, E, HU, PL, CH, IN, TW). Information about this project http://wiki.sshade.eu can be found in the SSHADE wiki:

- ✓ The can select and visualize a spectrum. A page displays the user experiment/spectra and the sample/layer/material/constituent(s) structures.
- ✓ The page also display a preview of the spectrum together with the main information on the spectrum and on the measured sample.
- The user can visualize the spectrum interactively or have a look at the detailed information on the experiment or on any element of the sample structure.

	← → C	CTRUM_LB_20180326/details Q ☆ :
	SSHADE 🛔 User 👻 🖉 Documentation 👻	Spectrum 🕈 Search Q
	Experiment NIR reflectance spectra (i = 0°, e=30°) of powdered lunar meteorite MAC88105	≪ Spectrum 🛓
Lunar meteorite (MAC88105)	Spectra • NIR bidirectional reflection spectrum (i=0°/e=30°/az=0°) of powdered lunar meteorite MAC88105 at 80°C under	o 🗈 🔍 🕂 🗷 🖻 😒 ת 🦈 📬 🚍 🚛
Experiment structure	Sample Junar meteorite MAC88105	0.3 0.25 0.25
+	Cayer crushed lunar meteorite	
Sample structure	Material adsorbed H2O	0.5 1 1.5 2 2.5 2.9 <sup>3</sup> 3.5 4 4.5
+	Constituents • adsorbed H2O	Wavenumber
Interactive spectrum	Matter     crushed lunar meteorite	NR bidirectional reflection spectrum (i=0°/e=30°/az=0°) of powdered lunar meteorite MAC88105 at 80°C under vacuum Unit  µm
+	MAC88105	Scale Wavenumber: linear   Intensity: linear
Spectrum information	Material lunar meteorite     MAC88105	© VO
	Constituents	© Owner
		Spectrum type
		Type bidirectional reflectance factor

### **SSHADE Interface : Display tool & Export**

✓ At each level the OT. experiment sample or structure a page contains all relevant the parameters values with various links: to another level of the

- → C	Ide.eu/data/EXPERIMENT_LB_20180503_001/SPECTRUM_LB_20180503_003/SAMPLE_LB_20180503_002/LAYER_1_LB_20180503_002/MATSOL
SSHADE 🔒 User 👻 🖉 Documentation	Spectrum 🗢 Search
● Experiment NIR reflectance	« Matter
spectra (i = 0°, e=30° and e=60°) of lunar soils under ambient conditions	Name lunar soil sample 15040
Sub-Experiment NIR reflectance spectra (i = 0°, e=30° or e = 60°) of lunar soils 78221 under ambient conditions acquired with SHADOWS	S Family
	Family solid matter
<ul> <li>Sub-Experiment NIR</li> <li>reflectance spectra (i = 0°,</li> <li>e=30° or e = 60°) of lunar soils</li> <li>15041 under ambient</li> <li>conditions acquired with</li> <li>SHADOWS</li> </ul>	<b>Comments</b> in addition to the minerals, there are also: agglutinates: 47.9%, Basalt:5.1%, breccia: 8.5%, anorthosite: 0.2% + glass: 6.7%
	Owner of matter
Spectra • NIR reflectance spectra (i = 0°, e=30°) of lunar soils 15041 under ambient conditions acquired with SHADOWS • NIR reflectance spectra (i	♥ Matter origin
	© Geolocation
	♥ Image
15041 under ambient conditions acquired with SHADOWS	15040
reflectance spectra (i = 0°, e=30° or e = 60°) of lunar soils 65701 under ambient conditions acquired with SHADOWS	
• Sub-Experiment NIR reflectance spectra (i = 0°, e=30° or e = 60°) of lunar soils 74241 under ambient conditions acquired with SHADOWS	15030
Sample raw lunar soil 15041	Figure 1: Trench at Apollo 15, station 8, near the ALSEP station. AS15-92-12440. Trench is about 35 cm deep
Layer lunar soil 15041	and is known as the Soil Mechanics Trench. Note the apparent lighter color near the bottom of the trench.
Matter lunar soil sample 15040	sampling site of 15040: 15041 is a subsample of 15040 (392 g). 113.4 g of 15040 are currently in reserve
Material Iunar soil sample 15040  Constituents  pyroxene  plagioclase	• Matter preparation and component types
	Global shape and density
	♥ Grains
<ul> <li>nlagioclasso</li> </ul>	

### **SSHADE Infrastructure**

### The SSHADE infrastructure has:

- A common data model: SSDM
- A common 'solid spectroscopy' interface
- A common Import / Search / Visualization / Export engine
- A common fundamental database (species, phases, publications, objects, ...)
- A set of spectral databases: one per group/laboratory (GhoSST is one of them)

### **SSHADE** Databases implementation

We are progressively implementing in the SSHADE infrastructure the databases of each of the 23 partners of the SSHADE consortium.

✓ 12 databases are already active in SSHADE, and over 1400 spectra are already online (from 200 experiments on over 1100 samples).

✓ A 'band list' database of molecular solids will soon complement the spectral data...

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structure,

- other information to stored in SSHADE (such as publications)
- to external web pages (Wikipedia, WebMineral...)
- ✓ The users can download a spectrum or an experiment from the export page.
- ✓ The users may also add a spectrum or experiment in his 'dashboard' for future export.

Lunar soil 15041 (Apollo 15) Experiment structure + Sample structure + Detailled information