Spectro-gonio radiometer at LPG

This *spectro-gonio radiometer* has been specially designed to measure with a high photometric accuracy the bidirectional reflectance of bright planetary materials over most of the solar spectrum and under wide illumination/observation configurations.

- Location / owner : Laboratoire de Planétologie de Grenoble
CNRS - Université J. Fourier
Saint Martin d'Hères, France

- Persons in charge:
- Scientific : Bernard Schmitt, Research director
- Technical : Olivier Brissaud, Engineer

- Type: Laboratory

- Spectral range : 0.3 - 4.5 µm (-> 5.0 µm: lower S/N) (4.2-4.3µm: atm. CO_2 limited)
- Spectral resolution : variable
- mini : < 0.1 nm (but S/N limited)
- maxi : 6 nm (<750nm), 12 nm (<1500nm), 24 nm (<3000nm), 48nm (>3000nm)

- Bidirectional Reflectance
- Incidence angle : 0° to 85°
  resolution: 0.1°
  maximum sampling : 0.1°
- Emergence angle : 0° to 80° (to 83° for dark / fine grained samples)
  resolution : ± 2° (may be reduced to < ± 0.5°, but S/N limited)
  max. sampling : 0.1°
- Azimuth angle : 0° to 180°
  resolution : ± 2° (may be reduced to < ± 0.5°, but S/N limited)
  max. sampling : 0.1°
- Phase angle : mini to 165°
  mini : ~ 8° for bright / large grained samples
  ~ 4° for dark / fine grained samples

- Illumination diameter (nadir) : 200 mm
- Observation diameter (nadir) : 20 mm

- Samples
-Type : rocks, minerals, snow / ice, sulfur, ... (from very bright to dark)
- Texture : compact or granular
- Grain size : micrometer to a few millimeters
- Size : maxi: 300mm diameter, 250 mm deep (bright & coarse grained samples)
  120 mm in diameter, 2-10 mm deep (dark or fine grained samples)
  mini: 25 mm x 120 mm (for principal plane observation down to 80°)
  25 mm x 45 mm (for principal plane observation down to 60°)
- Temperature : room temperature or heated
  down to -20°C (in cold room)
  down to -40°C (in SERAC environmental cell)

- Photometry : absolute: 0.3-1.0 µm: better than 1% over all configurations
(relative to a calibrated Spectralon 0.99 reference panel)
1.0-2.5 µm: better than 1% over all configurations
2.5-5 µm : better than 2% over all configurations
relative : better than 0.5% (0.3-2.5 µm)

- Polarimetry options (only partly tested)
Illumination : linear polarization : variable 0 to 90°
spectral range : 0.3 - 2.8 µm
Observation : 1 component over the 0.3 - 5µm range + unpolarized
or || and ⊥ components over restricted spectral range

- Experiment control : PC/Windows, fully software controlled (LabView©).
automatic acquisition of all spectral/geometric configurations

- Acquisition time : typical 15 mn for 200 spectral channels in visible (S/N dependent)
total : 15 hours for 100 spectral channels and 100 geometries

- Current state of system : 0.3 - 5 µm range : fully calibrated
polarization : tested -> 2003
low temperature : tested in cold room down to -15°C

- Availability to community : Technical improvements/calibration (20%)
LPG + associated laboratories measurements (60%)
open to specific collaborations w. funding (20%)

- References :

Bonnefoy, N., O. Brissaud, B. Schmitt, S. Douté, M. Fily, W. Grundy, and P. Rabou 2000. Experimental system for the study of planetary surface materials' BRDF. *Remote Sensing. Rev.*, **19,** 59-74.

Bonnefoy, N. 2001. Développement d'un spectrophoto-goniomètre pour l'étude de la réflectance bidirectionnelle des surfaces géophysiques. Application au soufre et perspectives pour le satellite Io. *PhD Thesis,* LPG - Université Joseph Fourier, Grenoble (20/11/2001).

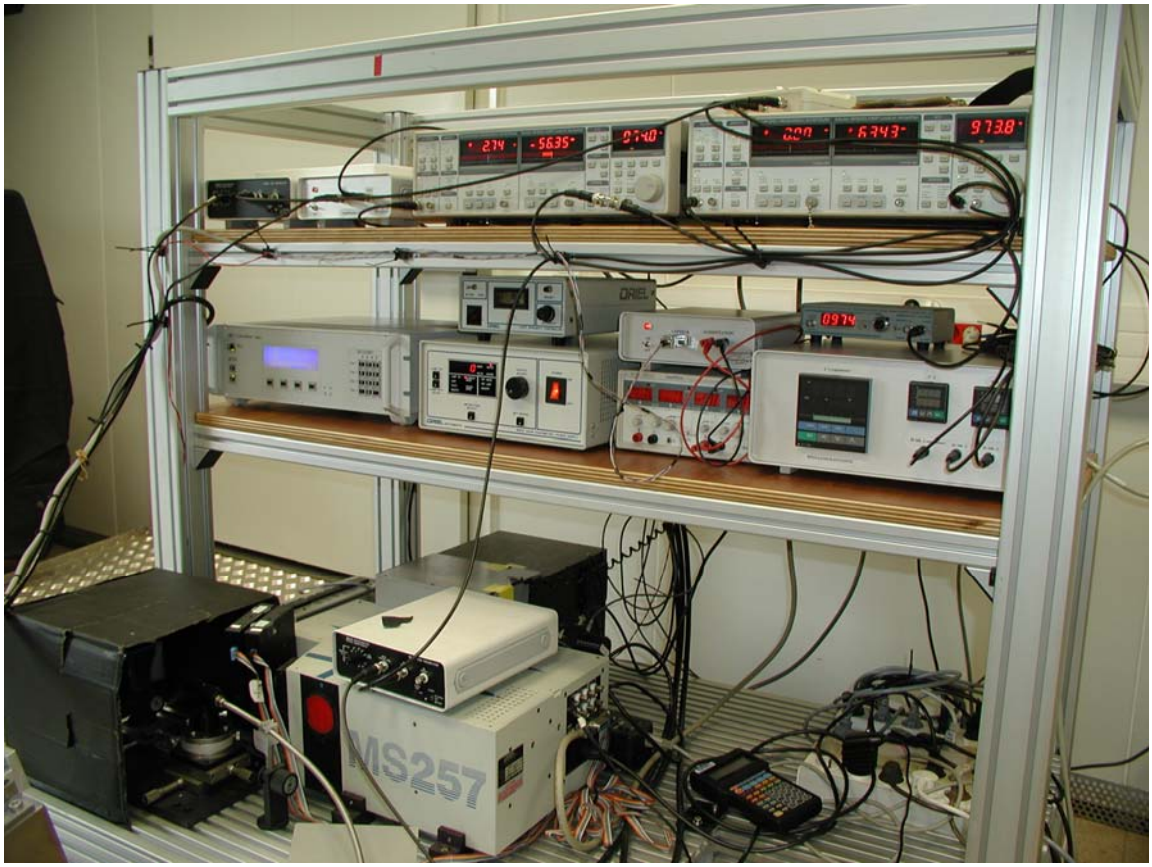
Brissaud, O., B. Schmitt, N. Bonnefoy, S. Douté, P. Rabou, W. Grundy, and M. Fily 2004. Spectrogonio radiometer for the study of the bidirectional reflectance and polarization functions of planetary surfaces: I. Design and tests. *Appl. Optics,* **43** (9), 1926-1937.

Pommerol, A., and B. Schmitt 2008. Strength of the H_2O near-infrared absorption bands in hydrated minerals: Effects of particle size and correlation with albedo. *J. Geophys. Res E,* **113,** E10009 [doi:10.1029/2007JE003069]

Pommerol, A., and B. Schmitt 2008. Strength of the H_2O near-infrared absorption bands in hydrated minerals: Effects of measurement geometry. *J. Geophys. Res E*, 113, E12008 [doi: 10.1029/2008JE003197].

Pommerol, A., Schmitt B., Beck, P., Brissaud, O. 2009. Water sorption on Martian regolith analogs: thermodynamics and near-IR reflectance spectroscopy. *Icarus* soumis

General view of the Spectro-gonio photometer at LPG



General view of the instrumentation