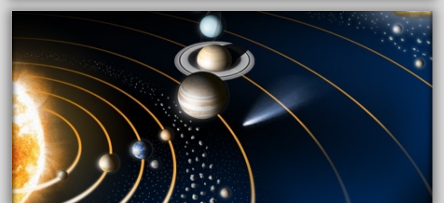
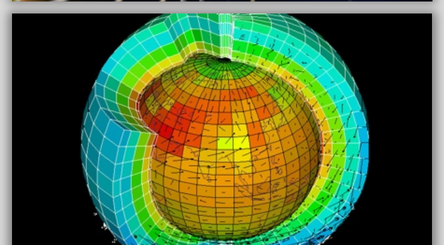
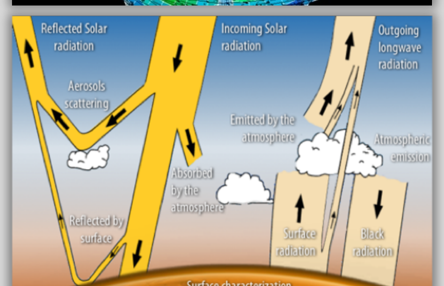
Planetary Spectrum Generator (PSG)

An online tool for synthesizing spectra of planets, exoplanets and small bodies

The Planetary Spectrum Generator (PSG) is an online tool for synthesizing planetary spectra (atmospheres and surfaces) for a broad range of wavelengths (0.1 µm to 100 mm, UV/Vis/near-IR/IR/far-IR/THz/sub-mm/Radio) from any observatory (e.g., JWST, ALMA, Keck, SOFIA), any orbiter (e.g., MRO, ExoMars, Cassini, New Horizons), or any lander (e.g., MSL). This is achieved by combining several state-of-the-art radiative transfer models, spectroscopic databases and planetary databases.





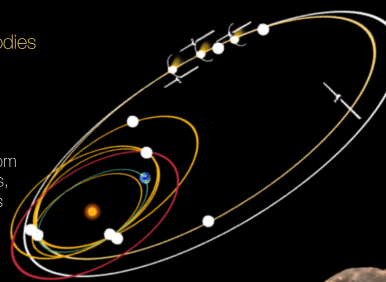


- The tool ingests **billions of spectral lines** of more than 1,000 species from several spectroscopic repositories: HITRAN, GEISA, JPL, CDMS and ExoMol, and **hundreds of surface constants**.
- A **3D orbital calculator** for most bodies in the Solar system, and all confirmed exoplanets. Possible observing geometries are: observatory, from surface, nadir, limb, occultation.
- **Atmospheric climatological models and templates** and for many planets (e.g., Mars, Earth, Titan) and exoplanets, and general atmospheric and surface parameters are available for comets and other bodies.
- Radiative transfer performed with several models: **PUMAS**, **correlated-K**, **non-LTE** fluorescence, and **surface models**.
- The code synthesizes spectra in **any desired radiance unit, and spectral unit and resolution.**
- The tool allows applying **terrestrial transmittances** for a broad range of conditions (altitude and water, also from SOFIA).
- For exoplanets, it includes the possibility to integrate **realistic stellar templates** (0.15-300 µm), and the high-resolution ACE Solar spectrum (2-14 µm) for G-type stars.
- It includes a **noise and signal-to-noise calculator** for quantum and thermal detectors, at any observatory.

3D orbital calculator

All exoplanets and all solar system bodies

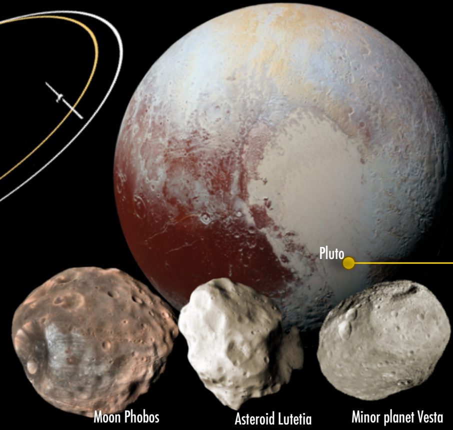
PSG performs three-dimensional orbital calculations for **all bodies in the Solar System** and **all confirmed exoplanets**, considering a broad range of observational geometries (e.g., from observatory, from orbiter, limb, occultations, from surface). Integration of **SPICE** kernels Is available for selected missions (e.g. ExoMars), and PSG predicts **transit times** for exoplanets.

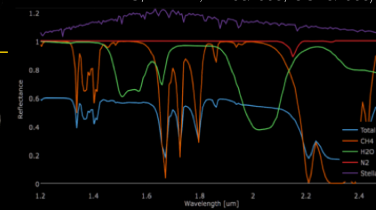


Modeling of planetary surfaces

Asteroids / TNOs / Small-bodies / Moons

PSG employs a sophisticated **surface scattering model** for computing reflectance spectra of icy and rocky bodies. The model allows to integrate **optical constants, alpha parameters** and **reflectance** spectra from a wide variety of repositories (e.g., USGS, OCDB/Jena, Lowell/Grundy, Bus-DeMeo, PDS, RELAB, Ames/ices, GSFC/ices)

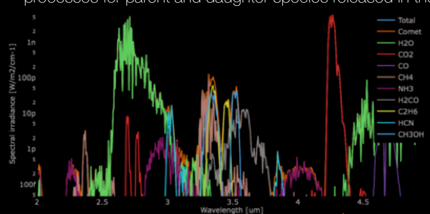


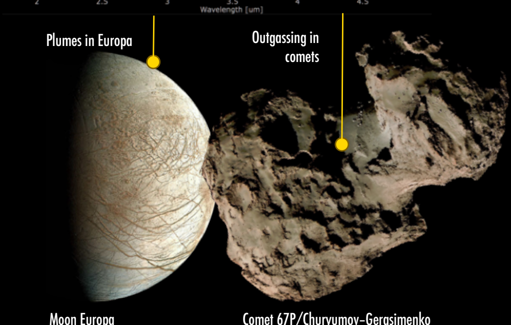


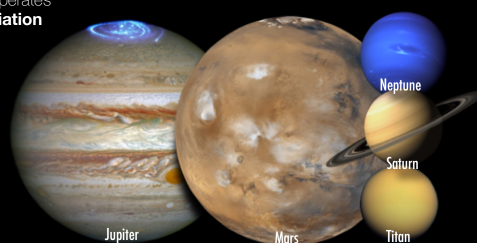
Cometary molecular emissions

Non-LTE fluorescence and radio emission

PSG synthesizes **molecular**, **dust**, **grains** and **nucleus** emission of comets by integrating **billions** of **ro-vibrational transitions** and spectroscopic databases. At short wavelengths, PSG considers excitation processes via non-LTE fluorescence (employing GSFC databases), and ingests JPL and CDMS spectral databases to compute line-by-line radiation at long wavelengths. It operates with **expanding coma** atmospheres, and computes **photodissociation** processes for parent and daughter species released in the coma.



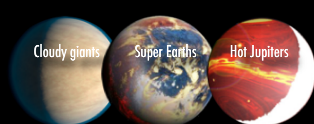


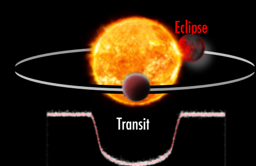


Terrestrial and gas-giant atmospheres

Line-by-line and correlated-k scattering modeling

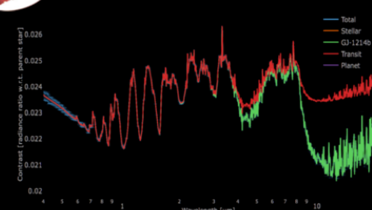
PSG integrates the latest radiative-transfer methods and spectroscopic parameterizations, in order to compute high-resolution spectra **via layer-by-layer line-by-line calculations**, and utilizes the efficient correlated-k method at moderate resolutions. The scattering analysis is based on a Martian **scattering model** (Smith et al. 2009), while the line-by-line calculations have been validated and benchmarked with the accurate GENLN3 model. PSG includes a wide array of **atmospheric scenarios**, and accesses several climatological / equilibrium models (e.g. LMD GCM).





Transit and Coronagraphy of Exoplanets

Orbital, atmospheric and spectroscopic modeling

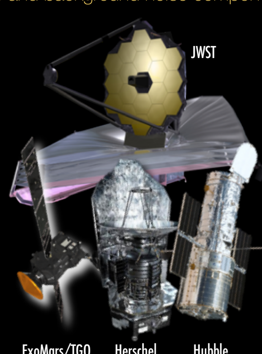


PSG computes exoplanet spectra as observed via **transit, direct spectroscopy** and **coronagraphy**. It computes **3D orbital** geometries, synthesizes **equilibrium chemistry** and computes layer-by-layer planetary **transmittances** and **radiances** employing modern planetary and spectroscopic databases.

Realistic instrument and noise simulators

Detector, observatory, atmospheric and background noise components

PSG currently includes a noise calculator for **quantum** and **thermal** detectors, with the primary goal of providing users with representative simulations for **planning observations**, and to assist with the development of **new instrument/telescope** concepts. Detector technologies handled by PSG include quantum-detectors (e.g., CCD, HgCdTe), bolometers and coherent detection. Beyond monolithic telescopes, PSG permits to model **interferometric** (e.g., ALMA) and **coronagraphic** (e.g., LUVOIR) observations. Background noise sources include zodiacal dust, airglow, telluric radiances, ISM/DIRB and cosmic microwave background.



When observing with ground-based observatories, PSG allows modeling of **telluric absorptions and emissions**. The tool has access to a database of telluric transmittances pre-computed for 5 altitudes and 4 columns of water for each case (20 cases in total). The altitudes include that of Mauna-Kea/Hawaii (4200 m), Paranal/Chile (2600 m), SOFIA (14,000 m) and balloon observatories (35,000 m).

Accessing the tool

Online website and via an API

PSG is an **online free tool** that can be accessed at **psg.gsfc.nasa.gov**. The tool has a user friendly interface, permitting to define complex observational scenarios and to run demanding simulations on **high-performance NASA servers**. PSG also allows to perform operations **remotely** by employing a versatile online **Application Program Interface** (API).

Worldwide access (Feb/2018) ~500 hits /day

For more information contact:

Geronimo Villanueva, Planetary Systems Laboratory

NASA/GSFC, Greenbelt, MD 20771, Tel: 301-286-1528

geronimo.villanueva@nasa.gov