JWST Moving Targets in ETC

The ETC has not implemented any specific features for Solar System targets, but can be used to approximate reflected sunlight and thermal emission from them.

Introduction

> *Main article: JWST Exposure Time Calculator Overview*

The JWST ETC can be used to model the spectra of moving targets, but is limited to doing so for a single target brightness. For distant targets (those at least as far from the Sun as Jupiter) on nearly circular orbits, this isn't a major problem because their brightness is fairly constant during the period when the the target is within the JWST field of regard. For more nearby targets the brightness can change by much more than 50%, so observers must account for those variations manually when creating ETC sources and scenes to represent the target.

Reflected light can be approximated using the Phoenix stellar model G2V template spectrum, and thermal emission can be approximated using the blackbody template. The user must determine the correct normalizations to apply to those template spectra in order to accurately represent the emission from their target on a given date. Targets expected to have both reflected-light and thermal emission components within the wavelength range of interest can be specified as two sources that coincide in the ETC scene.

Normalizing target spectra

The emission from a target has to be normalized in a way to represent the physics controlling the flux density of the spectrum as received at JWST. These factors include:

- Observing circumstances such as heliocentric and observatory-centric distances
- Phase angle
- Size and albedo
- Thermal properties

Observing circumstances can be retrieved from the JPL Horizons web service by entering the string "@JWST" (no quotes) in the observatory search field (see JWST Moving Target Ephemerides).

> It is critical to include solar elongation constraints of 85° - 135° when using Horizons to generate target ephemerides for JWST observations.

Point and extended sources

For targets too small to be resolved by JWST, the spectrum can be modeled using the ETC point-source target type.

Extended targets can also be specified in the ETC as elliptical shapes with brightness distributions that are flat, Gaussian, or Sersic profiles (the last is typically used for galaxies). An r^{-k} power law for modeling comet comae is included starting in ETC v1.3.

For observers interested in Jupiter, Saturn, Mars, and highly-extended comets, capabilities of the web interface of the ETC limit the size of the scene to a few arc seconds across. This doesn't prevent estimates of SNR for a given observation, but does require observers to properly normalize the surface brightnesses of these sources, a feature available starting in ETC v1.2.

User supplied spectra

> *Main article: JWST ETC User Supplied Spectra*

The ETC allows users to upload their own spectra for sources. ASCII and FITS format are supported, and the spectrum in either case consists of two vectors containing wavelength and flux density. Format and other requirements are described in the ETC documentation and help (see JWST ETC User Supplied Spectra).

Example workbooks

> *Main article: JWST ETC Using the Sample Workbooks*

The ETC contains a moving target sample workbook with two scenes specified:

1. An asteroid modeled as a point source using the superposition of a reflected-light and thermal component.
2. A comet modeled as a point-source nucleus and two extended sources representing the coma. Reflected-light and thermal emission components are included for nucleus and coma.

See JWST Moving Target Useful References and Links for instructions on how to access the sample workbook. These workbooks are primarily focused on providing examples of how to construct an ETC scene useful for solar system observers. Details of how to specify ETC calculations (which equate to observations in APT) are given in detail in other workbooks that are specific to the instruments.

Limitations

The ETC does not currently have:

- A method for using an albedo spectrum to modify the predicted reflected-light spectrum.
- More realistic models for thermal emission, such as the standard thermal model (STM) or near-Earth asteroid thermal model (NEATM).
- A way to compute a target spectrum based on basic inputs such as the size of and distance to the target, and an albedo.
- A short-cut to use typical background values near the ecliptic plane. Instead, users must specify an RA and DEC corresponding to a position near the Ecliptic plane.

Future improvements

Template spectra

- A template spectrum for the Sun, absolutely calibrated to represent flux density at 1 AU, and at a spectral resolution high enough to support modeling for the high-resolution gratings of NIRSpec and for the MIRI MRS is under development.
- Template spectra for the giant planets (disk-integrated) are also under development.
- A community-based effort to create template spectra for a range of spectral classes and/or representative examples of asteroids and TNOs will be explored at various community forums.

One or more of these template spectra may be implemented instead as a library of spectra users can share external to the ETC, and then upload rather than residing within the ETC as true template spectra. As these materials are completed, observers can find additional information on this page, and should look for announcements on solar system community forums such as the DPS and PEN newsletters.

Pandeia tools

The engine driving ETC calculations, along with necessary throughput curves for imaging and spectral performance data and a library of monochromatic PSF models, are available to the community as the Pandeia Python package, which can be installed from here (Pontoppidan et al., 2016). As with template spectra, a community-based effort to develop an interface to Pandeia that can serve the needs of the solar system science community will be discussed at various community forums.

References

JWST Exposure Time Calculator Tool

Pontoppidan, K. M., Pickering, T. E., Laidler, V. G. et al., 2016, Proc. SPIE9910, Observatory Operations: Strategies, Processes, and Systems VI, 991016
Pandeia: a multi-mission exposure time calculator for JWST and WFIRST