Title:
Titan Light Curve Analysis with Python
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Subsection:
Data Acquisition

ALL data(in the form of images) is downloaded from [OPUS](). You can read relevant information and background on the Cassini Ring-Moon Systems Node [HERE]().

Calibrated I/F Images

1. On OPUS, the following filters in search data are applied:
    a. General Constraints
        i. Instrument Name: Cassini ISS
        ii. Intended Target: Saturn -> Titan
        iii. Observation Type: Image
        iv. Measurement Quantity: Reflectivity
    b. Surface Geometry Constraints:
        i. Surface Geometry Target Selector: Saturn -> Titan
            1. *This is important for metadata selections*
    c. Cassini ISS Constraints
        i. Camera: Select NAC or WAC
            1. Narrow angle camera or wide angle camera
        ii. Filter: Select the filter of choice
            1. *Filters are denoted, e.g., BL1, CB1, etc., but the configuration of ISS is such that there are two filters in a filter wheel, eg, CL1+BL1, or CB1+CL2, where CL1 and CL2 are clear. Which one it is depends on where you choose the NAC, or the WAC, combinations are given here:*
            2. https://pds-rings.seti.org/viewmaster/volumes/COISS_0xxx/COISS_0011/calib/xpsf
            3. *Additionally, there are also filters with polarizers, denoted at BL2+P60 and so on.*
        iii. Missing Lines: Set Min and Max to 0

[The following link is step up such that all you have to do is select the image filter and camera(either NAC or WAC)]

2. Once the filter and camera of preference are selected, click on Browse Results on the top left. This will show you all available images.
3. We need specific metadata, so click on Select Metadata, choosing to display:
    a. OPUS ID
    b. Observed Phase Angle (Min) [Titan] (degrees)
    c. Body Center Resolution (Min) [Titan] (km/pixel)

Again, the link above is set up such that after selecting filters, it already shows this metadata.

4. You can visually inspect images to ensure no overexposure or missing lines, and add to cart by checking the box all the way to the left of the image or selecting to add to cart. Adding images that will be used for analysis to cart.
    a. For the current project and probably yours, we select images that show the full disk or full projected disk of Titan, i.e., Titan is not cut in half by the border, or it is not too close to the edge as we account for haze.
5. Once the images are selected go to the shopping cart, and because the files tend to be big in size, to reduce the size, I usually only select the Calibrated Image option.
6. Then click on Data Archive, which produces a link on the bottom right corner. Clicking that link will download a zipped file of the images.
7. Extract all when done and place the file in the location of choice.

Of course, not all images will be perfect even if they appear visually so. Notably, images from the files COISS2007 and below tend to give skewed results. It should be obvious to further inspect images by running them against an original, or even the included code to see if they follow an expected trend. For images that seem to be outliers, inspect them more thoroughly through a metadata analysis or through documentation provided by the node.

Calibrated Polarized Images

Acquiring polarized images for analysis of polarization phase curves is somewhat roundabout, but I will go in detail in a way that worked for me without buying an IDL license.

1. You will go through the exact same procedure described above, differently, however, during STEP 1, instead of just selecting ONE filter, you select 3 or 2 corresponding filters.

    a. In the NAC, images are polarized at 0, 60, and 120 degrees, so the corresponding filters would be something of the form BL2_P0, along with BL2_P60, and BL2_P120.
    b. For WAC, images are polarized at 0 and 90 degrees so it would be something of the form, MT2_IRP0, and MT2_IRP90.
2. Then following along the same procedure, for STEP 4, you must carefully select images that go with each other. An easy way to go about this is by adding to the metadata, filter_name. Usually, three or two images that are next to each other correspond to the same image, or you can see that the OPUS ID of the three side by side images will be similar with a small deviation in the last two or three numbers. They MUST come in pairs of two or three.
3. Follow the remaining procedure.
4. Register for and download IDL.
    a. You do not need to pay to download and install, only to get a license. But without a license, we can run an IDL Virtual Machine and call a virtual code.
5. Download the provided file: **make_polar_virtual_machine.sav**
6. Since you know the location of the images, you will put the three (or two) images into a single folder, and into the folder you will drag the .sav file.
7. Once all 4 (or three) objects are in the folder, double click or run the .sav file.
    a. It will take up to a minute but usually a very short amount of time.
    b. If there are three images, it will populate the folder with three new images, I_over_F.vic, _Pol.vic, and _theta.vic which correspond the the brightness image, the polarized image in units of degree of linear polarization, and another image in units of angle of linear polarization.
    c. If there are two images, it will produce I_over_F.vic, but also Q.vic.
    d. .vic can be ran the same way as .IMG
8. As a final tedious step, when the polarized images are created, only the first numbers that match from the pair of images are taken to rename the polarized images, so you will have to create a metadata file by manually matching each new OPUS ID with its corresponding resolution, opus id, and phase angle.