Beginner's Guide to `rss_ringoccs`

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1 Introduction

Describe goal of this document, intended audience, expected background level, emphasis on clarity and simplicity rather than on achieving ultimate results - this is to provide permanent access to the treasury of RSS ring occultation observations from Cassini without requiring expertise in diffraction theory and signal processing techniqes. At the same time, we hope that it will encourage future generations of scientists to develop improved analysis techniques

1.1 What is the `rss_ringoccs` package?

1.2 What's an RSS ring occultation?

Include simple figure, define a few key terms (HGA, DSN, USO, S, X, Ka) direct and scattered signal, optical depth, diffraction, Fresnel inversion, Rev, ingress, egress, chord occultation. Show simple example of raw diffraction pattern, phase, and retrieved signal (power and optical depth) for Maxwell Ringlet.

1.3 Overview of Cassini RSS ring observations

Jolene's ring opening angle plot and a few gallery shots of earth view of occultation. We handle up to the time of the USO failure.

1.4 Required and recommended reading

1.4.1 Cassini RSS User's Guide

Point to table of observations and extract a few key figures, such as sample power vs time plot.

1.4.2 Marouf, Tyler, and Rosen (1986) - MTR86

Show ring occultation geometry figure and include the main two equations showing the transform pairs.

1.4.3 For more information...

Space Science Reviews, and list examples of published papers using the RSS occultations. (explain that we don't discuss scattered signal here – only the direct signal) - Cite Thomson et al. paper.

1.5 A brief tour of what is to follow

2 Setting Things Up

2.1 System and software requirements

This software has been developed and tested on the following operating systems and versions of Python.

(Ryan - insert a table here, including GB of RAM)

hoho	haha
HOHO	HAHA

Table 1: Operating Systems and Python Versions

2.2 Installing the software

Describe the directory structure assumed. Expert users may wish to set up symbolic links for some subdirectories that contain large volumes of data, but we don't provide instructions on how to do that here. Raw RSS data files are large! We recommend that users install the repository on a high-capacity disk (1 TB or more), and ensure that it is routinely backed up.

2.3 Python

Can we identify a list of required python packages that need to be installed?

2.3.1 `rss_ringoccs` from GitHub

Describe what we mean by open-source or freeware. Show how and where to install the repository. Appendix A gives a descriptive listing of the contents and directory structure of the repository. (or put it here)

2.3.2 `spiceypy` from GitHub

Give link to GitHub and installation instructions. Show how to do this using Enthought and Anaconda. Show a simple test command (print spicypy.pi()).

2.3.3 Jupyter notebooks

Explain that all of our tutorials use Jupyter notebooks - show where to obtain Jupyter.

2.4 Obtaining Cassini RSS data

Describe NASA PDS and locations of two types of files.

2.4.1 Raw RSS data files

Describe RSR files and give link to documentation.

2.4.1.1 16 kHz RSR files

These are available from the NASA PDS Atmospheres Node

2.4.1.2 1 kHz RSR files

These are soon to be available on the PDS Rings and Small Moons (name?) archive - currently under review. One sample file is included in the GitHub repository (true?).

2.4.2 Higher order products

Describe what is on the PDS.

2.5 Obtaining required JPL/NAIF kernel files

Describe file types briefly, and assumed directory structure.

3 Getting Started

Explain where tutorials are and how they are organized. First, you'll test each part of your installation. Then, you'll produce your first ring occultation profile. Next, you'll

3.1 Testing your installation

3.1.1 Python

Show few-line sample python code to ensure that required packages are available.

3.1.2 Spicypy

Show few-line sample python code to print pi().

3.1.3 RSS data files

Use script to grab a few RSS data files and store them in the correct subdirectories. Then try rerunning the code to confirm that if you have the files already, it won't bother retrieving them. Say how long it will take to run. If you feel brave and have time, you can run a command to download the complete archive of RSS 16 kHz data files using the following command - best to run this overnight!

3.1.4 JPL/NAIF kernels

Use script to grab JPL kernels and store them in the correct subdirectories. Again, try rerunning the command to show that it recognizes whether the files exist already. Say how long it will take to run.

3.1.5 `rss_ringoccs`: Your first diffraction-corrected ring profile

This version makes use of pre-computed files, to save time.

3.1.6 A tutorial on tutorials - using a Jupyter notebook

Show how to read an existing Jupyter notebook to perform the previous steps.

4 Overview of the Processing Pipeline

Ryan's nice pipeline figure goes here. Say that our processing steps are designed to produce files that are the same type as what is on the PDS archive. Explain that using files is not required and that we have separate small routines to read and write the standard format files.

4.1 Computing the geometry of an occultation – producing a GEO file

Point to the required jupyter notebooks for the main command, and the separate one with a tutorial that goes through each step

4.2 Obtaining the diffraction-limited profile of an occultation

4.2.1 Frequency correction

Point to the Jupyter notebook for the main command, and the separate one with a tutorial that goes through each step.

4.2.2 Power normalization

Point to the Jupyter notebook for the main command, and the separate one with a tutorial that goes through each step.

4.2.3 Producing a CAL file

Point to the Jupyter notebook for the main command, and the separate one with a tutorial that goes through each step.

4.2.4 Producing a DLP file

Point to the Jupyter notebook for the main command, and the separate one with a tutorial that goes through each step.

4.3 Retrieving the ring optical depth profile from the diffraction pattern

4.3.1 Preparing for the diffraction correction

Two options - get the output from the previous code steps as a class instance, or read the necessary files. Need to specify desired radial range and resolution and window type.

4.3.2 Computing the diffraction-corrected profile

Point to the Jupyter notebook for the main command, and the separate one with a tutorial that goes through each step.

4.3.3 Producing a TAU file

Show simple Jupyter notebook that does this

5 More Detailed Examples

5.1 Full end-to-end example

Point to jupyter notebook that runs this command, with comments.

5.2 Zooming in on a particular ring feature for a specified resolution

Show example of Maxwell ringlet at 0.5, 2.0 resolution.

6 Where To Go From Here

6.1 The Cassini RSS data catalog

6.2 Selecting an RSR file to process

Depends on elevation angle, antenna size and snr, radius range covered, ring opening angle.

6.3 Practical considerations

execution time, SNR, radial resolution, sampling theorem

6.3.1 Benchmarks

Rev	RSR file	Band	Radial Range	ΔR_{res} (km)	GEO	CAL	DLP	TAU	Total (sec)

Table 2: Benchmarks

6.3.2 Potential speed improvements

FFTW
Cython
Algorithms

6.4 Assumptions and limitations

Comment on assumptions of MTR86

6.5 The Complete User's Guide

For those who wish to understand the theory behind the diffraction-correction methods in `rss_ringoccs`, we direct you to the much more comprehensive document.

7 Certification: Confirming that `rss_ringoccs` works

We've left until the end some important evidence that the diffraction correction methods we've used actually work!

7.1 Comparison with independent results on PDS

Important - our results are completely independent implementation of MTR86 - no software in common at all. Confirms both implementations.

7.1.1 Rev007E

Diametric occultation - show geometry plot from Earth. Show S, X, Ka band of Maxwell Ringlet at 1 km.

7.1.2 Rev054

This is a chord occultation and requires special attention. Show geometry plot from Essam. Show S, X, Ka band of Maxwell Ringlet I and E if present, otherwise a density wave.

7.2 Some idealized examples

7.2.1 A simple isolated sharp-edged ringlet

7.2.2 A more complex ringlet - forward and inverse calculations

7.3 Comparison with *Voyager* results

7.3.1 Reproducing MTR86 results for Voyager 2 at Saturn

7.3.2 Reproducing Gresh results for Voyager 2 at Uranus?

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