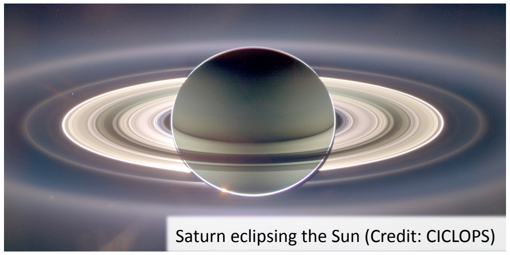

Saturn eclipsing the Sun (Credit: CICLOPS)

A Computational Approach to Ringshine on Saturn

Ryan W. Skinner
Advisor: Professor John W. Weiss
Carleton College
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Carleton College

Introduction

Even though it has been four centuries since Galileo initially mistook Saturn's rings for moons or 'arms,' their vast swaths of orbiting particles continue to play tricks on us. For example, the light illuminating Saturn comes not only from the Sun, but from light reflected off the rings.

This 'ringshine' contributes a substantial enough amount of intensity to obscure lightning and other curiosities on the surface, preventing us from studying them. Worse, even the midnight side gets illuminated by the rings, and the contribution changes depending on location and solar elevation. We set out to predict how much ringshine hits the planet at every possible geometry using computational integration, with the hope of removing a layer of mystery from the planet's surface.

Methodology

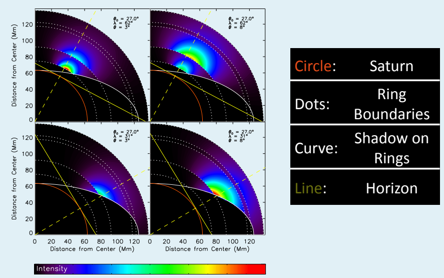
To begin, we model the intensity of light coming from the Sun *S* reflected by a point on the ring *R* towards a point on the planet *P*. This amount depends on the solar elevation angle θ_0, angles associated with the locations of *S*, *R*, and *P*, and two properties of the rings at R: albedo A and optical depth τ. The intensity reflected is 0 if *R* is in Saturn's shadow, and if the planet comes between *P* and *R*.

Integration is the next step: adding up the intensity contributions of every piece of ring for each location on the planet. An analytical solution for the integral we want is terribly difficult to solve, if not impossible, so we use a Riemann sum, dividing the ring into patches and then summing the intensities the patches reflect towards a given *P*. For our purposes, the divisions are made every 2° around the rings and every 500 km out. This equates to 180x127 ring patches, which is a pleasant compromise between accuracy and computational efficiency. To further speed calculations, we simply ignore all ring patches over the horizon at *P* and within the radius of Saturn's shadow.

Results

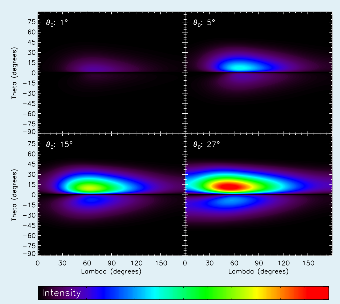
A large part of our time focused on determining where on the rings the most intensity was coming from. A worry was that the B ring contributed lots of ringshine, because it contains gravity wakes which are not modeled well by the classical equations we used in this project. Fig. 1, a plot of ring intensity coming toward various *P*s, shows that this is actually the case for most points on the planet, except very close to 0°N.

1



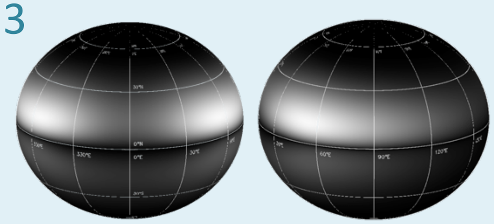
Adding up all the ring contributions like those in Fig. 1 for many different *P*s, we can create a map showing intensity of ringshine on one whole side of the planet (Fig. 2). The Sun hits the planet most directly near 27°N and 180°E, but the ringshine peaks on the back sides of the planet, near 15°N and 60°E. As the sun rises out of the ring plane and θ_0 increases, intensity increases and spreads toward the poles near 0°E.

2



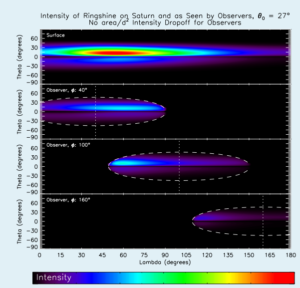
We can also project these maps onto the surface of Saturn, (Fig. 3); here was have done so for $\theta_0 = 27°$ as viewed from 0°E and 90°E, both from 15° above the ring plane.

3



When viewing Saturn, however, we are never on the Surface. Thus, it is necessary to recreate the view of the planet as seen by an outside observer. This data can be produced by implementing a surface reflectivity function for each *P* and an extension of previous logic. Fig. 4 displays our results for observers in the middle of the B ring looking down at different planetary longitudes. Noticeably, the morphology of the observed ringshine does not differ much from the original intensity map.

4



Conclusion

Because the B ring is such a large source of ringshine, further simulations need to be conducted outside the scope of this project to account for both gravity wakes and multiple scattering of photons within the rings. Still, we offer an interesting quantitative glimpse of how ringshine affects Saturn and moves us closer to imaging the true dark side of the planet.