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PHYS 454

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HW#4

# Question 1 – Limb Darkening

a) From NASA’s SDO (Solar Dynamics Observatory) [[1]](#one), the HMI (Helioseismic and Magnetic Imager) intensitygram of the sun [[2]](#two) will be used to investigate the drop in brightness from its center to the outer radius/disk. This is known as *Limb Darkening*. The HMI intensitygram is shown in **Figure 1**.

A close-up of a sun

Description automatically generated

Figure 1: HMI Intensitygram of the Sun, displayed using python. The x and y axis are positions in pixels (4096 x 4096)

A line profile was extracted from this image. Since the only the distance from the center to the edge radius is needed, the image was cropped in half. Additionally, the intensities of the brightnesses were normalized. **Figure 2** shows the cropped image and the graph of normalized intensity as a function of the distance from the center of the sun (in pixels).

A graph of a sun

Description automatically generated with medium confidence

b) From Chapter 9 of Intro to Modern Astrophysics [[3]](#three), Limb Darkening can be estimated as a function. This approximation, known as the theoretical Eddington approximation of solar limb darkening, is shown in **Equation 1**.

|  |  |  |
| --- | --- | --- |
|  |  | (1) |

where is the intensity, and are wavelength-dependent coefficients, and is the angle from the line of sight toward the center of the sun and the line of sight a distance away from the center of the sun perpendicular to the surface of the sun. The right-hand side of the equation is the simplified equation. The angle is visualized in **Figure 3**.

A diagram of a circular object

Description automatically generated

However, this is assuming we know the angle. We can transform the equation to be dependent on another variable by relating and , the distance from the center of the sun. Using basic trigonometry, we can obtain **Equation 2**.

|  |  |  |
| --- | --- | --- |
|  |  | (2) |

A screenshot of a graph

Description automatically generated

Figure 2: Plots of Swift-Tuttle's orbit. The view angle is defined as 20 deg elevation, 55 deg azimuth, and 0 deg roll.

# Question 2 – Balls of Gas

# Question 3 – Eclipse

a)

# References

[1] <https://sdo.gsfc.nasa.gov/data/>

[2] <https://sdo.gsfc.nasa.gov/assets/img/latest/latest_4096_HMII.jpg>

[3] <https://hedberg.ccnysites.cuny.edu/PHYS454/SPRING-2024/assignment-4/limb-darkening.pdf>

[4] Source Code -