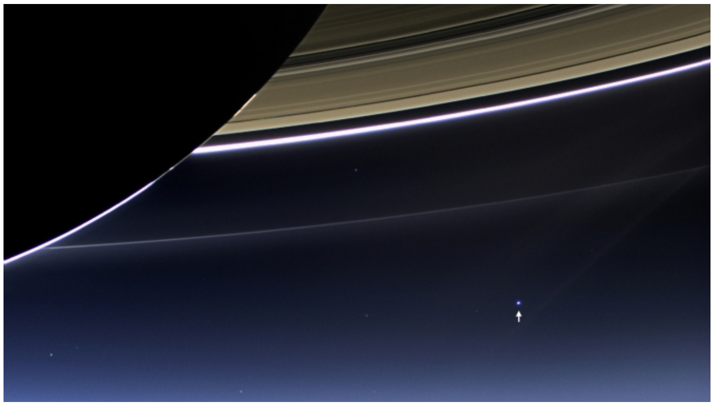
Cassini Sees Earth from Saturn – How bright is it?



The Cassini spacecraft captured this image of Earth seen through Saturn's rings (arrow).

At the distance of Saturn, our planet looks like many other bright stars in the sky, but with a noticeable blue color due to its oceans.

At the time of the photo, Earth was located 898 million miles (1.4 billion km) from Saturn.

Problem 1 –If Mars is about 250 million km from Earth and Saturn is about 1440 million km from Earth, using the Inverse-Square Law, how much fainter will Earth be from Saturn?

Astronomers use a logarithmic brightness scale called apparent magnitude, m. The formula that relates brightness to magnitude is given by

$$B = 10^{-.4m}$$

For example, a brightness change of 100-times means a magnitude difference of exactly 5.0 because $1/100 = 10^{-0.4(m)}$ so $10^{-2} = 10^{-0.4(m)}$ and solving for m, you get m = +5.0.

Problem 2 - At the distance of Mars, Earth appears as a star of magnitude -2.5, making it about as bright as Venus seen from Earth. How bright will Earth be from Saturn?

NASA Releases Images of Earth Taken by Distant Spacecraft
http://www.nasa.gov/mission_pages/cassini/whycassini/cassini20130722.html
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Answer: Brightness = $(250/1440)^2$ = 0.030, so Earth will be about **33 times fainter** from Saturn than from Mars.

Problem 2 - At the distance of Mars, Earth appears as a star of magnitude -2.5, making it about as bright as Venus seen from Earth. How bright will Earth be from Saturn?

Answer: It will be 33 times fainter than from Mars so 33 = $10^{-.4m}$ so m = +3.8 m fainter than seen at Mars, and so -2.5 + 3.8 = **+1.3m at Saturn**.

Note: This assumes that Earth is seen under the same illumination from both planets. In fact from Mars the disk of Earth is about 90% illuminated, while from Saturn, Earth is only 50% illuminated. This makes Earth appear 50%/90% = 0.55 = $10^{-.4m}$, m = +0.6 fainter or +1.9 m from Saturn.