EPSC Abstracts
Vol. 13, EPSC-DPS2019-306-4, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Some of Saturn's Small Satellites have Surprisingly Stygian Surfaces: Evidence for Proton-Induced Darkening in the Saturn System.

M.M. Hedman (1), P. Helfenstein (2) R. Chancia (1), E. Roussos (3), C. Paranicas (4), A. Verbiscer (5)
(1) Physics Department, University of Idaho, Moscow ID, USA (mhedman@uidaho.edu) (2) CCAPS, Cornell Unviersity, Ithaca NY, USA, (3) Max Planck Institute for Solar System Research, Goettingen, Germany (4) APL-John Hopkins University, Laurel MD, USA (5) University of Virginia, Charlottesville VA, USA

The Saturn system contains a large number of moons with a range of surface properties that reflect various aspects of their environments. In particular, the whole-disk albedos of the mid-sized icy moons Mimas, Enceladus, Tethys, Dione and Rhea are strongly correlated with the expected fluxes of the E-ring particles that surround all of these moons [1, 2]. Since the E-ring originates from Enceladus' plume, this correlation means that Enceladus' geological activity strongly affects the surface properties of Saturn's mid-sized moons [1]. However, these mid-sized moons are not the only objects in this region. Smaller moons can be found at several locations between the main rings and Mimas' orbit (Janus, Epimetheus and Aegaeon), between the orbits of Mimas and Enceladus (Methone, Anthe and Pallene), and along the orbits of Tethys and Dione (Telesto, Calypso, Helene and Polydeuces). These moons are also embedded in the E ring and so one might expect their surface brightnesses to follow the same trends as their larger neighbors. However, quantitatively testing this hypothesis with albedos obtained from available Cassini imaging data is a challenge, firstly because these smaller moons have significantly non-spherical shapes [3], and secondly because most of the observational geometry coverage needed to accurately constrain models of their photometric behavior are in the form of images with very low spatial resolution that are suitable only for disk-integrated measurements [4].

We have developed a new disk-integrated photometric model that explicitly accounts for the smoothly ellipsoidal shapes of the small moons Aegaeon, Methone and Pallene, and thus allows us to derive estimates of whole-disk albedos that can be compared between moons of different shapes. We find that all these moons are surprisingly dark at visible wavelengths. For one, we find that Methone and Pallene are darker than Mimas. This result was unexpected because both of these moons orbit between Mimas and Enceladus, and so the E-ring flux is higher onto these moons than it is onto Mimas, which would naturally tend to make them brighter. Aegaeon is even more extreme, being about as dark as Iapetus' leading side and thus much darker than any other nearby moon, despite orbiting within the inner flank of the E ring.

The comparatively dark surfaces of Methone, Pallene and Aegaeon imply that something besides the E ring is affecting their surface properties, and we propose that the most likely explanation are Saturn's radiation belts. Cassini measured high fluxes of high-energy (> 25 MeV) protons between the orbits of the larger moons Janus/Epimetheus, Mimas and Enceladus [5]. These four moons are all large enough that they create persistent regions of low energetic proton flux along their orbits known as macrosignatures, and so their surface weathering is limited by the slow radial diffusion that works to fill in the macrosignature. By contrast, Aegaeon, Methone and Pallene are too small to produce such depletions and so orbit in regions with much higher fluxes of energetic protons, and so are weathered at a much higher rate. The exact mechanism by which this radiation darkens the surfaces of these small moons is still not completely clear. However, further investigations of both the spectral and photometric properties of these and other satellites should help clarify how radiation affects the surfaces of icy moons in the outer Solar System.

References

[1] Verbiscer, A., French, R., Showalter, M. and Helfenstein, P.: Enceladus: Cosmic Graffiti Artists Caught in the Act, Science Vol 315, pp. 815, 2007.

[2] Hendrix, A., Filacchione, G., Paranicas, C., Schenk, P., Scipioni, F.: Icy Saturnian satellites: Disk-integrated UV-IR characteristics and links to exogenic processes, Icarus, Vol 300, pp. 103-114, 2018.

[3] Thomas, P., Tiscareno, M., Helfenstein, P. The Inner Small Satellites of Saturn and Hyperion in Enceladus and the Icy Moons of Saturn, P. Schenk, R. Clark, C. Howett, A. Verbiscer, H. Waite, Eds. (University of Arizona), 2018.

[4] Verbiscer, A., Helfenstein, P., Buratti, B. and Royer, E.: Surface Properties of Saturn's Icy Moons from Optical Remote Sensing in Enceladus and the Icy Moons of Saturn, P. Schenk, R. Clark, C. Howett, A. Verbiscer, H. Waite, Eds. (University of Arizona), 2018.

[5] Kollmann, P., Roussos, E., Paranicas, C., Krupp, N. and Haggerty, D.: Processes forming ans sustaining Saturn's proton radiation belts, Icarus, Vol 222, pp 323-341, 2013.