SOME OF SATURN’S SMALL SATELLITES HAVE SURPRISINGLY STYGIAN OR STRANGELY SNOWY SURFACES. M.M. Hedman¹, P. Helfenstein², R.O. Chancia³, P. Thomas⁴, E. Roussos⁵, C. Paranicas⁶, A.J. Verbiscer⁷, ¹Department of Physics, University of Idaho, Moscow ID 83844, ²Cornell Center for Astrophysics and Planetary Science, Cornell University, Ithaca NY 14853, ³Max Planck Institute for Solar System Research, Goettingen, Germany 37077, ⁴APL, Johns Hopkins University, Laurel MD 20723, ⁵Department of Astronomy, University of Virginia, Charlottesville VA 22904.

The Saturn system contains a large number of moons with a range of surface features and photometric properties that, in part, 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. Much smaller moons can be found at several locations between the main rings and Mimas’ orbit (Janus, Epimetheus and Aegaeon), between moons of different shapes [3], and secondly because most of the observational geometry coverage needed to accurately constrain models of their photometric behavior are low spatial resolution images 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 and thus allows us to derive estimates of whole-disk albedos that can be compared between moons of different shapes [5]. We find that Aegaeon, Methone and Pallene are surprisingly dark at visible wavelengths. More specifically, 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.

On the other hand, we also find that Calypso and Helene have substantially brighter surfaces than their co-orbital companions Tethys and Dione. This suggests that Calypso and Helene might have experienced higher particle fluxes, but there are no obvious structures in the E ring that would preferentially brighten these particular moons, so there must either be something subtle in the E-ring particles’ orbital properties that leads to substantial asymmetries in the particle flux, or something happened recently to temporarily increase both these moons’ brightnesses.