Physical properties of the small moon Aegaeon (Saturn LIII)

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Abstract

Aegaeon (Saturn LIII) is located within an arc of debris near the inner edge of Saturn's G ring [1], and is the currently the smallest isolated moon of Saturn known [2]. On January 27, 2010 the Cassini spacecraft flew within 15,000 km of Aegaeon, obtaining images with sufficient spatial resolution (better than 100 meters/pixel) to resolve this tiny moon. These data reveal that the moon is strongly prolate, being between 1.2 and 1.6 km long but only 0.3-0.6 km wide, and that the long axis was aligned with Saturn during these observations. Images taken through different filters show that Aegaeon is red, and that its albedo is much lower than those of the other icy moons interior to Titan. Finally, long exposure images document structures in the nearby G-ring arc that appear to be generated by Aegaeon's gravitational perturbations and thus can be used to constrain the moon's mass and density.

1. Background

Aegaeon is an interesting object because it lives within an arc of debris near the inner edge of the G ring. This arc is confined by the 7:6 corotation eccentricity resonance with Mimas [1]. This resonance also perturbs Aegaeon's orbit keeping it near the center of the arc [2]. Similar combinations of resonant perturbations and debris arcs are associated with the small moons Anthe and Methone [3], but Aegaeon's situation seems to be an extreme case. In particular, the arc surrounding Aegaeon is much denser than those associated with Anthe and Methone.

All three arcs are composed primarily of micron-sized grains that can be eroded or displaced on timescales of hundreds to thousands of years [4], so the visible material must have been recently produced from the surfaces of larger bodies like these small moons. Thus Aegaeon's denser arc could indicate that a relatively recent event like an impact caused Aegaeon to shed a significant amount of material. Alternatively, Aegaeon may share its resonance with additional meter-scale objects that could serve as additional sources of dust [5].

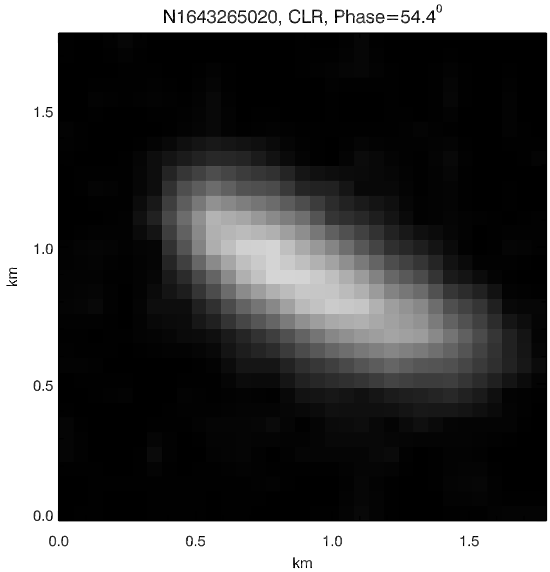

Figure 1: Image of Aegaeon obtained during the close encounter on January 27,2011. The raw imaging data have been re-sampled by a factor of two in this image for the sake of clarity. The elongated shape of the moon is clearly evident.

2. Observations

Cassini had a close, un-targeted encounter with Aegaeon on January 27, 2011. At closest approach, Cassini came within 15,000 km of the moon, and thus was able to image the moon at better than 100 meters/pixel resolution. A total of 18 narrow-angle camera images were obtained during this time, covering a range of phase angles between 45° and 75° in multple color filters.

3. Discussion

The images clearly show that Aegaeon is non-spherical; fits to the images indicate that the moon is 1.2-1.6 kilometers long and 0.3-0.6 kilometers wide. The long axis points towards Saturn during these observations, and so Aegaeon may be in the expected tidally locked rotation state.

With the moon resolved, we can estimate its surface brightness at phase angles between 45° and 75°. The brightest pixels all have I/F values below 0.06, which suggests that the geometric albedo of this satellite is well below 0.15. Thus Aegaeon is much darker than any other satellite interior to the orbit of Titan. One possible explanation for this finding is that unlike other moons, which are embedded in the E ring, Aegaeon is embedded in the G ring. The E ring appears to be composed of fine, clean ice grains derived from the interior of Enceladus, and seems to be able to brighten satellite surfaces [6], whereas the G ring is presumably derived from the surfaces of small objects like Aegaeon, which have been exposed to comet and meteoroid bombardment and thus are likely dirtier. In this case, Aegaeon's spectrum could help clarify the composition of the meteoritic debris in the outer solar system. Alternatively, Aegaeon might have had its bright, ice-rich surface recently stripped off by an impact, leaving its darker interior exposed. In this scenario, the moon's spectrum would provide information about the material content of the Saturn system itself.

Finally, the images with the longest exposures have sufficient sensitivity to detect the G-ring arc in the vicinity of Aegaeon. These images reveal a structure consisting of two bright streaks extending on either side of Aegaeon along the direction of the moon's orbit. The streak running ahead of Aegaeon is displaced slightly interior to the streak running behind the moon, similar to the so-called propellers in Saturn's main rings [7]. If this identification is correct, then the radial displacement between these streaks depend upon the moon's mass. Preliminary calculations indicate that the observed displacements are consistent with those expected for an ice-rich object of Aegaeon's size, and further suggest that these observations can place non-trivial constraints on the moon's porosity.

Acknowledgements

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