Comet coma brightness simulations in ESA Comet Interceptor

Meri Kolehmainen

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Comets are the best-preserved remnants of the evolution of our Solar system owing to their highly eccentric orbits that cause comets to be less exposed to space weathering by Sun's radiation compared to other Solar System objects. Research of comets is challenging due to comets being small and dark objects that spend most of their time in the outer parts of the Solar System.

Comet Interceptor is a European space agency mission that aims to fly by a previously undiscovered long-period comet (LPC) at the comet's closest approach to Earth. It is the first fast-track mission of ESA. After launch, the spacecraft will wait for a suitable comet at the Sun-Earth L2-point before reaching the target and deploying two probes. Currently, the Comet Interceptor is in the planning phase with intended launch in 2029.

A crucial part of planning a space mission is simulating the possible conditions the spacecraft will meet during the mission so that it can withstand such conditions and the instruments can deliver optimal data. The Asteroid Image Simulator (AIS) has been developed to simulate imaging instrument operations for Solar System missions with emphasis on the Comet Interceptor and Hera missions.

This work presents a comet coma model for AIS to simulate the images that could be obtained with the Comet Interceptor imaging instruments. From the model the possible gas and dust environment of the comet's coma can be estimated and applied to the development of imaging instruments aboard Comet Interceptor spacecrafts. The images are simulated by combining use of Blender, a 3D-modeling program, with Python coding. The model utilizes a physically based render engine in Blender to model light scattering from a spherical volume. This is done by constructing the physical formulae from Comet Interceptor initial estimate models Engineering Dust Coma Model (EDCM) and Engineering Gas Coma Model (EGCM) with Blender shader volumetrics.

The model is validated by comparison to the Radiative Transfer Coherent Backscattering (RT-CB) program, which numerically solves the scattering properties of discrete sparse random media. The results are validated by comparing solutions for scattering from a spherical volume with Rayleigh scatterers inside. Validation shows the model agrees with RT-CB solution with acceptable accuracy.