Clementine Startracker Images of the Zodiacal Light

Bonnie Cooper, Oceaneering Space Systems • Andrew Potter, National Solar Observatory
Herb Zook, NASA Johnson Space Center • Joseph Hahn, Lunar and Planetary Institute

Figure 1. A grey-scale composite of about 40 images from Clementine orbit 193. This view shows the Moon, which occults the Sun, partially illuminated by earth-shine. The faint glow outside the lunar limb is the zodiacal light depicted as a logarithmic grey-scale. Many stars are seen, with the brightest being Venus.

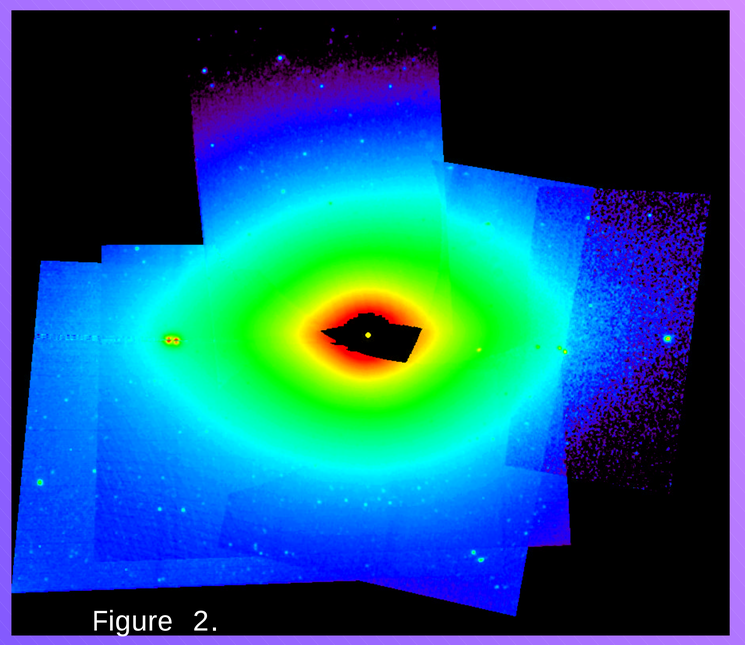

Figure 2. A composite false color image composed of over 200 fragments of images from Clementine orbits 66, 110, 164, 193, and 206. Only the most useful fractions of each image are used. Very little of the occulting Moon is shown in this composite, as it is removed whenever one or another of the images shows the zodiacal light in that region of the sky. The zodiacal light image intensities fall off logarithmically with elongation from the Sun, which is shown to scale as a yellow dot near the center of this mosaic. The ecliptic plane is approximately horizontal in this view.

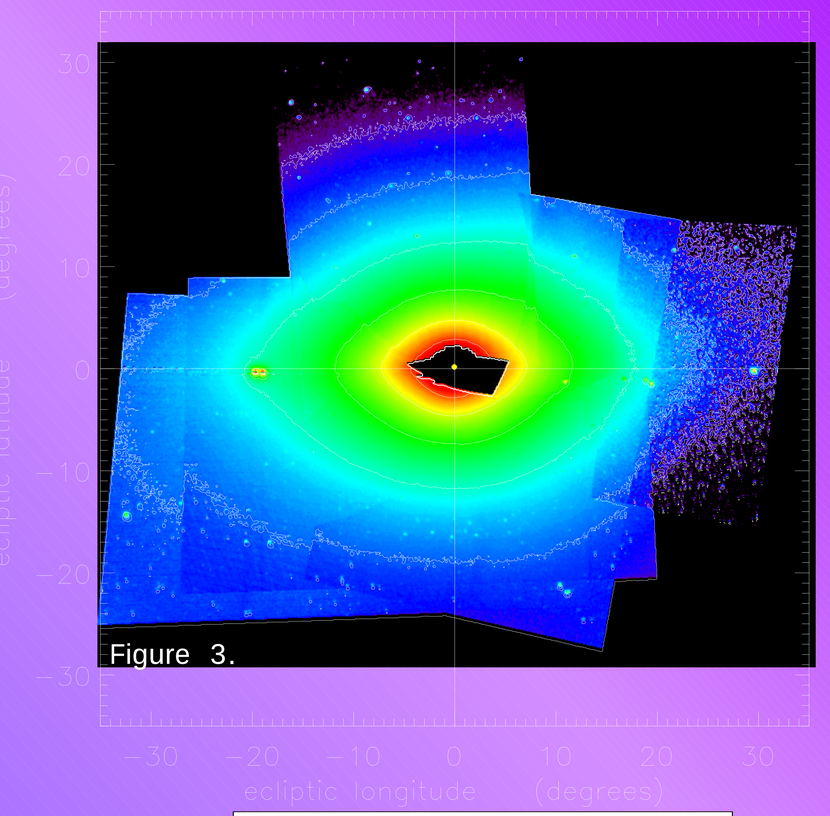

Figure 3. Isophotes of the zodiacal light for the mosaic given in Figure 2. Adjacent isophotes differ in intensity from each other by a factor of about 6. With additional flat-field and thermal electron background corrections, we expect soon to get smooth continuity on all the isophotes.

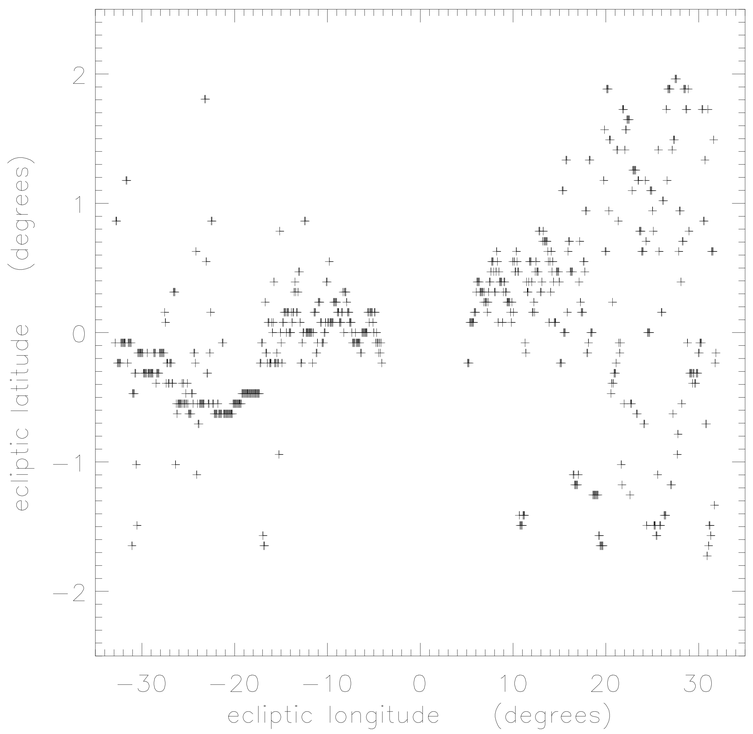

Figure 4. Ecliptic latitude of the brightest point on the symmetry axis versus ecliptic longitude. Some scatter is due to underlying stars. The symmetry axis lies at an angle of about 0.7º with respect to the ecliptic, and may be somewhat curved. Further processing is required to establish the curvature for certain.

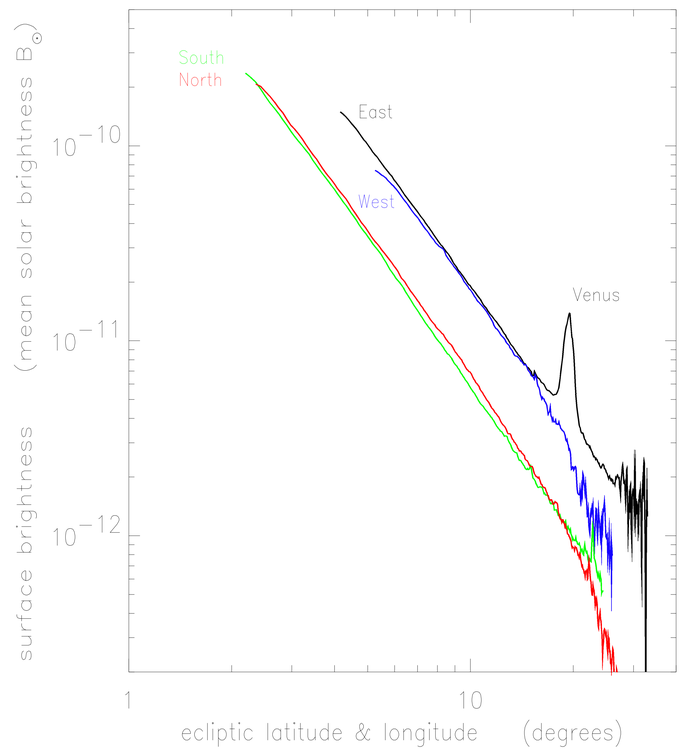

Figure 5. Zodiacal light intensity (in units of the mean brightness of the Sun) versus ecliptic longitude. Also shown is the brightness variation with angular distance from the Sun perpendicular to the Ecliptic. For reference, the full Moon is about 1.5x10-6 times as bright as the mean brightness of the Sun.

CLEMENTINE OBSERVATIONS OF THE ZODIACAL LIGHT

The zodiacal light is the result of the integrated effect of sunlight scattered off of dust particles orbiting about the Sun. To the naked eye on Earth, the zodiacal light projects dimly above the horizon and can be seen only under very dark sky conditions, either just after dusk or before sunrise. It brightens toward the Sun and toward the plane of the ecliptic (the Earth's orbital plane). The latter observation indicates that most meteoroids are in prograde orbits at relatively low inclination (< 30^o) to the ecliptic plane.

The zodiacal light brightness has been very difficult to measure inside about 30 degrees elongation from the Sun, both from the ground and from spacecraft in Earth orbit, because of light contamination from sunlight scattered off of the Earth's twilight atmosphere. Even at times of total eclipse of the Sun by the Moon, sunlight scattered by the Earth's atmosphere beyond the lunar limb greatly overprints terrestrial measures of the zodiacal light brightness.

We here report the near-sun zodiacal light brightnesses obtained by the 28^ox43^o field-of-view star-tracker cameras on the Clementine spacecraft while it was in orbit about the Moon in 1994. Using the Moon as an occulting disk, several hundred quality images of the zodiacal light were obtained in the region from about 2 to 30 degrees from the Sun.

SUMMARY

The spatial density of meteoroids at 1 AU, as obtained from near-earth meteoroid impact experiments, is about two meteoroids larger than 5 microns in diameter per cubic km. The corresponding cross-sectional area per unit volume and mass per unit volume are, approximately, $2x10^{-20}$ cm^2/cm^3 and $2x10^{-22}$ g/cm^3. Under Poynting-Robertson and solar wind drag alone, one would expect the spatial density of meteoroids to approximately increase with decreasing r as r^{-1}. The Clementine data show a brightness that increases with decreasing elongation angle to the 2.4 power, which corresponds to a spatial meteoroid density that increases with decreasing distance to the Sun as $r^{-1.4}$. This shows that a fair fraction of meteoroids in the inner solar system are probably directly deposited there, and do not get there via drag from near-circular orbits, such as collisional debris from main belt asteroids.