CRYOGENIC, POLAR LUNAR OBSERVATORIES

J. D. Burke
NASA Jet Propulsion Laboratory
Pasadena, California 91109

Discussion

Though it has been known for centuries that the Moon's polar axis is nearly normal to the plane of the ecliptic (ref. 1 and fig. 1), not much attention seems to have been paid to the resulting astronomical possibilities. In permanently shadowed crater bottoms near the lunar poles (figs. 2 and 3), very low temperatures must prevail. Just how low is unknown because no direct measurements have yet been made. However, measurements in other lunar regions and various theoretical investigations (refs. 2 to 6) suggest that ambient ground temperatures, resulting from the balance among radiation to space, sunlight scattered into the shadowed areas, starlight and other cosmic energy sources, and the Moon's internal heat flow, may be as low as 40 K.

A telescope located in one of these low, dark, polar regions could operate with only passive cooling at that temperature or perhaps lower, depending on how well it could be insulated from the ground and surrounded by radiation shields to block heat and light from any nearby warm or illuminated objects. Of course, such a site affords access to only half of the sky at most, but within the sky not masked by the horizon, the telescope could continuously track any object for as long as desired. Ideally, there would be two telescopes, one at each pole. With this arrangement, all but a small part of the sky (near the ecliptic) could be covered without the engineering problems of the 2-week hot days and the 2-week cold nights encountered anywhere else on the Moon.

At lower latitudes on the Moon, both the U.S. Surveyor spacecraft and the U.S.S.R. Lunokhod rovers observed a postsunset glow (fig. 4) believed to be sunlight scattered from small dust particles moving under electrostatic forces within a few meters of the surface. Since the Sun is always near the horizon at the poles, this phenomenon may be different there. It could, from the point of view of light scattering into a telescope, be either better or worse than at the equator. The only way to tell is to make measurements. These, with other environmental and topographic data, would be part of the site surveys that are essential for planning a lunar polar observatory.

The possibility of passive cooling to temperatures of tens of kelvins or lower makes it logical to consider this unique lunar polar environment as a locale primarily for infrared and submillimeter astronomy and secondarily for any other instrumentation benefiting from low thermal noise. Other advantages of lunar polar base sites are discussed in reference 7.

Why should astronomers concern themselves now with this prospect? There are two reasons. First, automated lunar exploring missions are, after a gap of many years, now being seriously proposed by the U.S.S.R., the United States, and Japan. These missions can and should make the first polar measurements needed in an astronomical site survey. Astronomers should seek to influence the mission planning which would otherwise be done entirely in the geosciences community. Second, the suitably dark and cold territories on the Moon are surely small, probably only hundreds of kilometers in extent, and thus need to be protected by international agreement just as does the radio-quiet region on the Moon's far side. Astronomers have a long and successful background in establishing such agreements. With these preparatory steps in progress, scientists requiring cryogenic instruments will be in a good position to benefit when, for whatever reasons, the United States, the U.S.S.R., or both decide to resume the exploration and settlement of the Moon.

References

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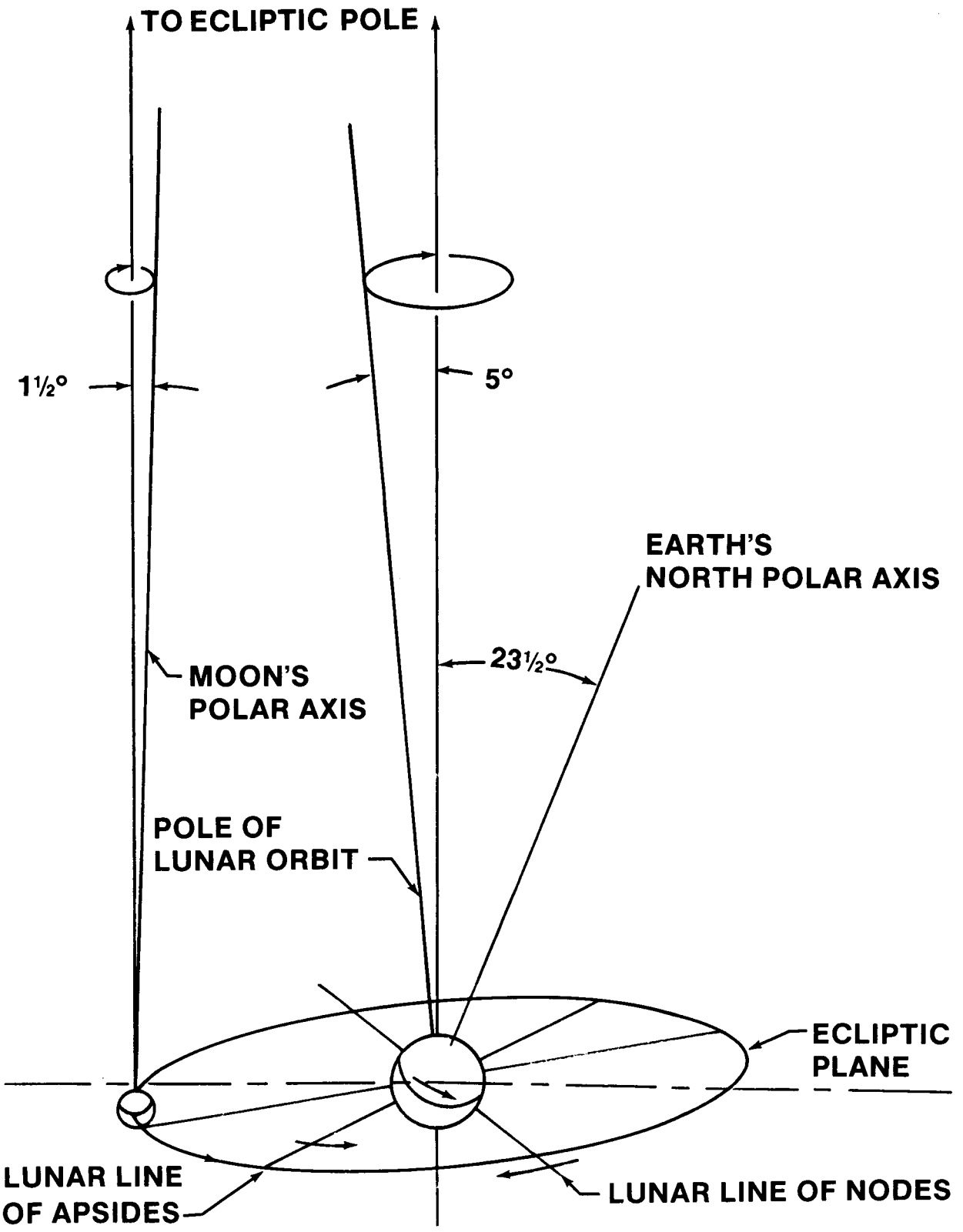

Figure 1.- An illustration of the motions of Earth and Moon. Despite the inclination and precession of Earth's polar axis and of the Moon's orbit (as described by G. D. Cassini in 1693), sunlight is always nearly horizontal at the lunar poles.

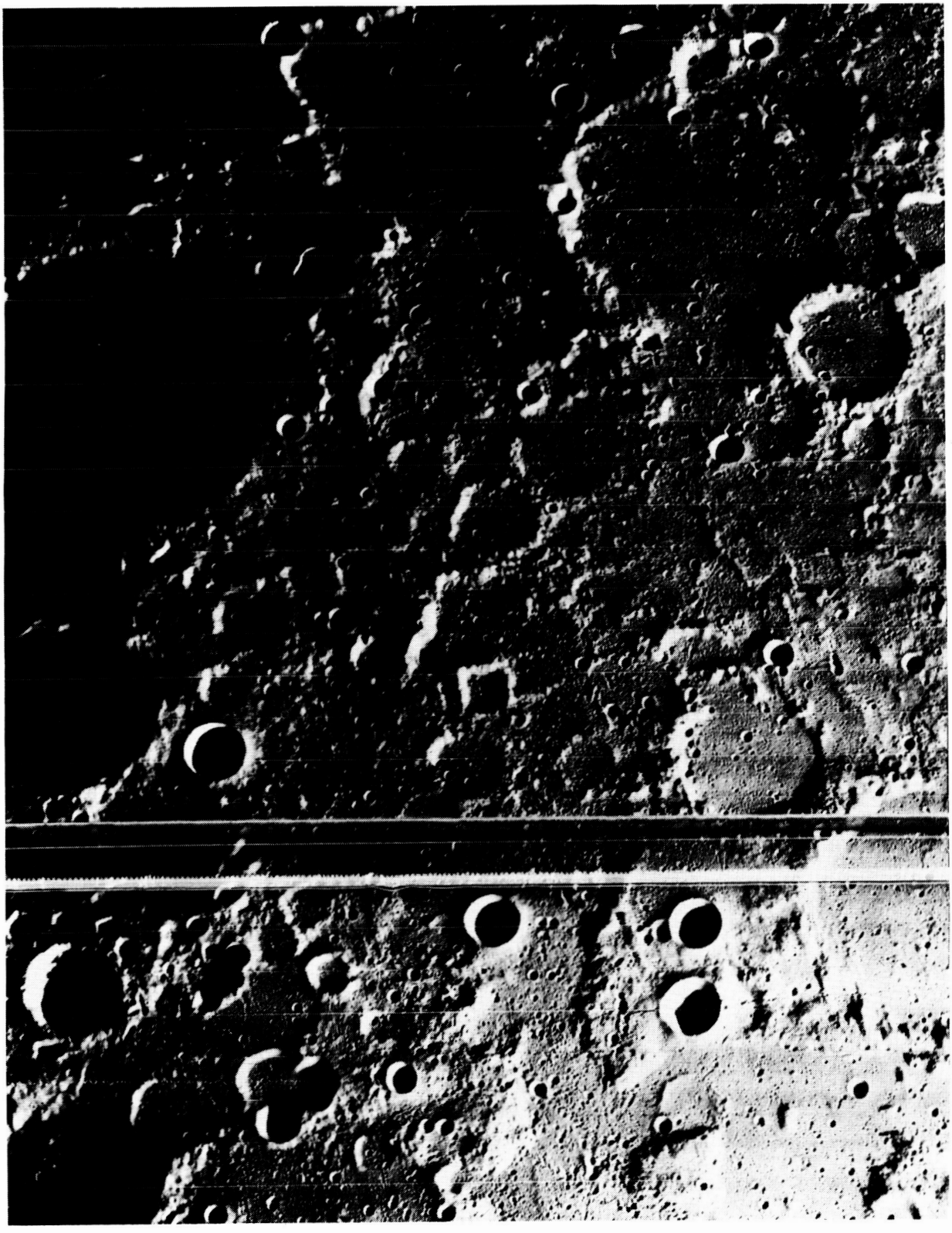

Figure 2.- North polar region of the Moon. Craters Peary and Byrd, at top center and upper right, are about 80 km across. Pole is at upper left. Portion of Lunar Orbiter 4 frame 176H1.

Figure 3.- South polar region of the Moon. Crater Amundsen, near center, is about 100 km across. Pole is about halfway from Amundsen to bottom of frame. Portion of Lunar Orbiter 4 frame 005H3.

Figure 4.- Postsunset glow along lunar horizon, observed by Surveyor spacecraft.