No. 84 "EVIDENCE FOR AN ATMOSPHERE ON IO"* AND "PHOTOMETRIC SEARCH FOR ATMOSPHERES ON EUROPA AND GANYMEDE"† (SYNOPSES)

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ABSTRACT

Photometric observations of eclipse reappearances of satellites Jupiter I, II, and III were carried out in the interval 1962–1965 to search for possible temporary brightening of the satellites after eclipse. If present, this could be attributed to a frost, snow, or haze layer caused by the drop in surface temperature during eclipse. Such an effect was observed on JI (0.09 mag) and JII (0.03 mag), but no effect greater than 0.01 mag was present on JIII. A freezing-out of CH_4 snow onto 20 percent and 10 percent of the satellite surfaces in the first two instances, respectively, is hypothesized to account for the observations.

Although there is no spectroscopic evidence for atmospheres on the four Galilean satellites of Jupiter (Kuiper 1952, p. 368; Owen 1965), their presence has long been suspected because of the moderate albedos and large sizes of the bodies. Continuing the search for these atmospheres, we made photometric observations of the disappearances and reappearances of the satellites into and out of the shadow of Jupiter in 1962–1965. The duration of eclipse is about 2.25 hrs for JI (Io) and about 2.5 hrs for JII (Europa). Because of the satellite orbit inclinations, the eclipse lengths of JIII (Ganymede) and JIV (Callisto) are more variable, about 2.7–3.7 hrs and up to 5 hrs, respectively.

During eclipse, the satellites receive only a minute amount of long-wave radiation from Jupiter's dark side and no direct sunlight. For bodies with tenuous atmospheres, the surface temperature must drop by several tens of degrees during a 2.5 hr eclipse. Kuiper (1965) gives the average radiation temperatures based on absorbed sunlight: JI, 101° K; JII, 88° K; JIII, 110° K; JIV, 117° K. Here we examine the possibility that a satellite's surface temperature drops during eclipse and that part of the hypothetical atmosphere may condense on the surface or in the atmosphere causing an increase in the albedo that can be detected upon reappearance from Jupiter's shadow. The albedo anomaly would persist until the satellite returns to more normal temperatures and the "snow" sublimes or the haze dissipates.

Observations were made with photoelectric photometers with standard B (blue) filters (λ 4500 A) and RCA 1P21 photomultipliers. A diaphragm of 10 sec of arc diameter was used to minimize the scattered light from the nearby disk of Jupiter. It was necessary to observe the sky both north and south of the satellite to obtain sufficient data for scattered-light corrections. The blue filter was chosen because the albedo of the Galilean satellites is lower at shorter wavelengths, making changes in albedo more easily detectable. However, the scattered light from Jupiter also increases and prevents the use of a U (ultraviolet) filter.

Preliminary observations were made with the Steward Observatory 36-in. reflector after Jupiter's opposition in 1962. Later observations were made with the 36-in. and 16-in. reflectors of the Kitt Peak National Observatory.

Figures 1 and 2 show the observations of JI and JII respectively, proving conclusively the existence of a short-lived anomalous brightness upon reap-

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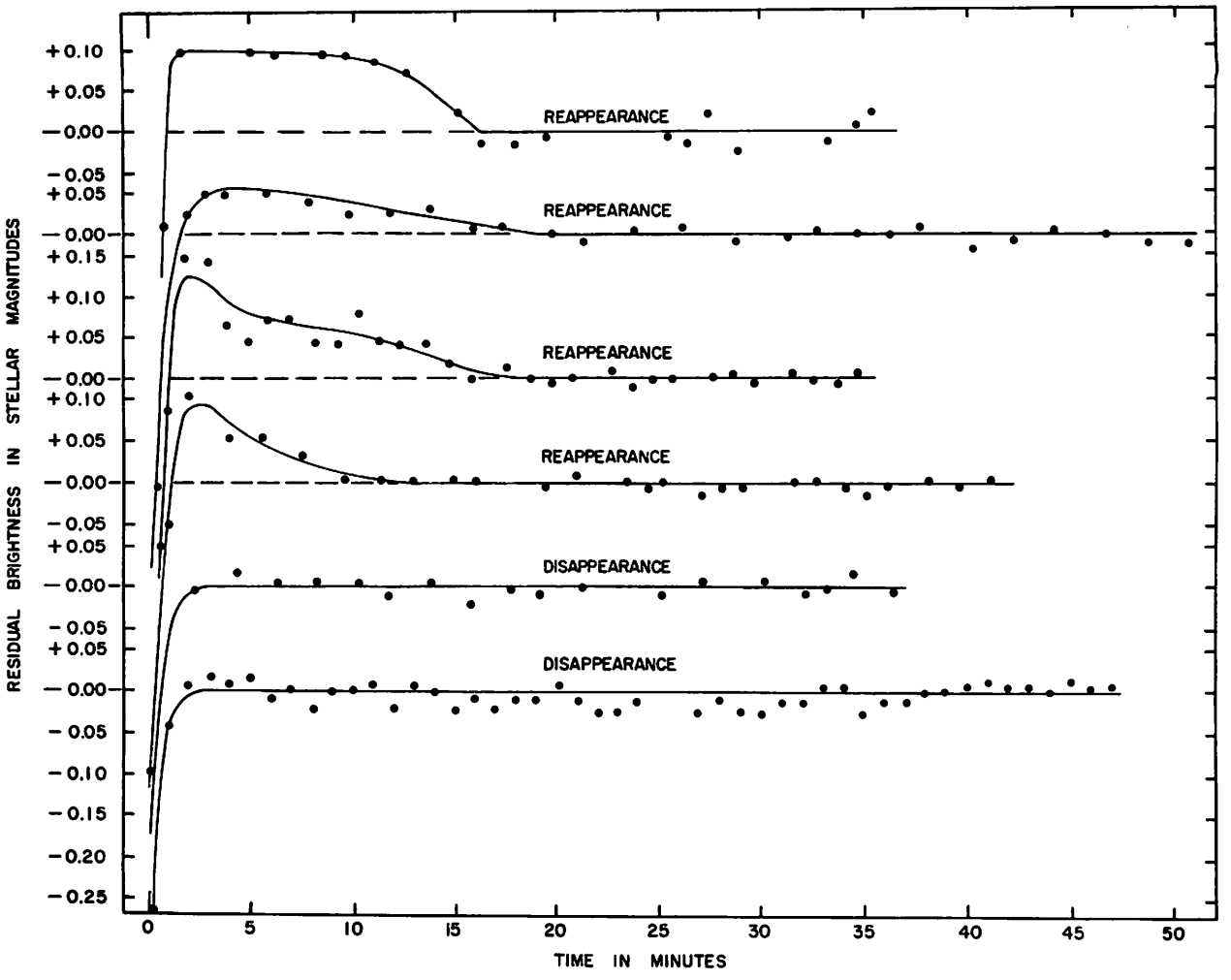

Fig. 1 Anomalous brightening of JI (Io) after eclipse.

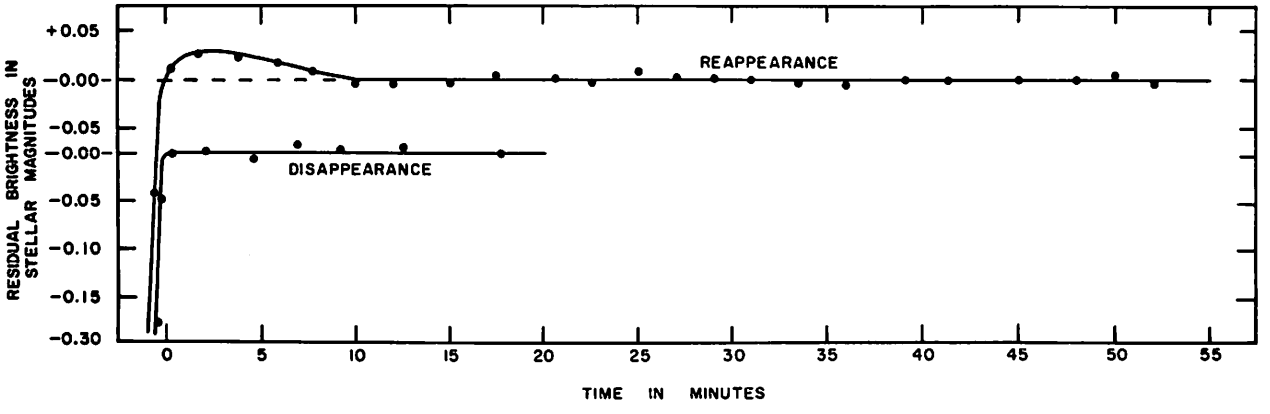

Fig. 2 Anomalous brightening of JII (Europa) after eclipse.

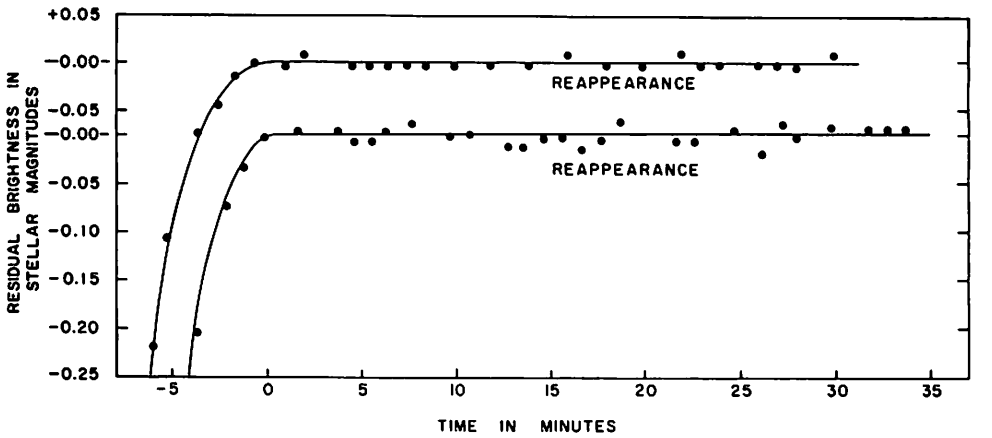

Fig. 3 Eclipse reappearance and disappearance of JIII (Ganymede) showing no anomalous brightening.

pearance after eclipse. Disappearance observations showed no such effect, indicating that scattered light from the bright planet or other systematic errors are not responsible for the excess at reappearance. Figure 3, the best observations of JIII, shows no measurable effect. The decay time of the phenomenon on JI is about 15 min. On JII, it is about 10 min.

Theoretical considerations indicate that of reasonable candidates for the atmospheric gases of these satellites, H_2O, NH_3, N_2, and CH_4, the first two would be frozen out or would have escaped, and the third and fourth would be gaseous. On JII, the presence of CH_4 is questionable, the escape time being near the age of the solar system, unless it is continually being replenished from the crust.

Assuming that some sort of deposited layer of snow or frost condenses out of the atmospheres during eclipse, and that its albedo is 0.8, we compute the fractional area of the planet covered by the deposit. For JI we find 20 percent, and for JII, 10 percent. The albedo of the hypothetical deposit must be greater than 0.67, which is the blue albedo of JII.

It is concluded that atmospheric phenomena have been observed on Io (JI). The single high-quality observation of Europa (JII) leads tentatively to the same conclusion. Two high-quality observations of Ganymede (JIII) give no evidence of atmospheric phenomena.

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