though the direct color effect of the dust particles of the assumed size is found to be small, it is shown that the dust and clouds indirectly cause the nonreddening by enhancing the importance of the diffused light in the umbral region.

From the numerical results it is shown that the theory provides a conclusive means of distinguishing between extinction due to dust particles and that due to clouds. It has been found that the unusual darkening at midtotality observed at the December 1963 eclipse may be explained by assuming, in addition to various other sources, the dust extinction coefficient of about 0.19 mag per air mass. Such an extinction may be obtained by assuming a model including volcanic ashes with an average radius of a half micron spread through the atmosphere up to a maximum altitude of 20 km. The total mass thus assumed corresponds to approximately one percent of the mass of the dust and ashes known to have been ejected into the atmosphere by large volcanoes of the past such as the one in Krakatoa in 1883. Thus, it is concluded that the cause of both the unusual darkness and the nonreddening effect of the eclipse observation was the atmospheric contaminations produced by the eruption of Mt. Agung on Bali Island which occurred on 17 March 1963.

A Re-Examination of the Light Variation of Pluto. ROBERT HARDIE, *Dominion Observatory*.—Photometric observations of Pluto, carried out on 14 nights in the late spring of 1964, at the Dyer Observatory, define a light curve of essentially the same shape as, but possibly of slightly larger amplitude than, that found in 1955. The strong asymmetry is confirmed, with the descent in brightness from maximum to minimum occurring in about one third or less of a period. The mean brightness may be slightly fainter than formerly found, but this is not clearly established because of uncertainties in the zero point, particularly in the earlier work. The synodic period has been refined and is $6^d 9^h 16^m 54^s \pm 26^s$. This characteristic implies that limb darkening is appreciable and that the radius and density estimates require revision.

On the Use of Short Arcs in Orbit Determination. HANS G. HERTZ, *National Aeronautics and Space Administration*.—At the IAF Congress in Stockholm in 1960, Kowalevsky urged that osculating elements of satellite orbits be determined for individual station passages. This implies determinations from short arcs. The present investigation shows that, with the exception of the semimajor axis, the elements of the orbit of Echo I can indeed be determined from arcs with a half-arc length of $1^h.4$ to 4^h to the

same accuracy as from conventional 1-day arcs. Several such determinations over an interval as short as 29^h reveal deviations from gravitational behavior. Using 1-day arcs, such deviations can be readily found only from determinations spanning a longer interval.

Binary Frequency as a Probable Index of Secular Changes in the Main Sequence. J. ALLEN HYNEK, *Dearborn Observatory*.—As Aitken pointed out long ago, stars of late spectral type have a lower proportion of visual companions than do stars of early spectral type. This appears to apply to spectroscopic binaries as well. According to present theories of stellar evolution, this implies a secular change in the frequency of binaries along the main sequence.

The reality of the binary frequency imbalance between giant and main sequence stars has been re-examined with emphasis on possible selection factors and on its relation to space motions of the stars concerned. The discussion is limited to the Yale Bright Stars, for which stars there exists maximum homogeneity of observations of multiplicity, radial velocity, and spectra. It is concluded that observational selection, difference in Population, and space motions are not sufficient to explain the deviation from a "steady-state" main sequence implied by the binary-poor nature of the present giant population. The more recently formed stars appear to have a marked increase in the number of binary stars.

The Lithium Content of Capella "F" and "G". ICKO IBEN, JR., *Massachusetts Institute of Technology*.—Wallerstein (to be published) has recently found that the surface Li abundance in the F8 component of α Aurigae is over 100 times larger than that in the G5 component. A theoretical explanation of this difference, based on stellar model calculations, is possible.

During the hydrogen-burning phase of evolution Li is destroyed in the inner 98.65% of the mass of a $3 M_{\odot}$ model. At the tip of the red giant phase of evolution, just before He burning begins in the core, a convective zone extends over the outer 82% of the mass of the star. Through mixing, the surface Li content is thus reduced by a factor of about 60. It is to be emphasized that the temperature at the base of the convective envelope never exceeds 1.25 million degrees.

As the star enters the core helium-burning phase, the envelope recedes and the surface Li abundance remains constant.

From the position of the F and G components of Capella in the H-R diagram, one may say that the F8 component ($M=2.91 M_{\odot}$) has not yet reached