have remained bound to the solar system, if no source of replenishment of comets is assumed.

The study strongly suggests that the comets cannot be original members of the solar system and that the presence now of some 200 000 or more long-period comets implies that some process of addition of comets occurs from time to time.

Observations of an Asteroidal Meteor and a New Estimate of the Meteoric Luminous Efficiency. RICHARD E. MCCROSKY, *Smithsonian Astrophysical Observatory and Harvard College Observatory*.—One usually determines the mass of a meteoroid by an established empirical relationship that involves the mass, velocity, and the luminosity of the meteor and a proportionality factor, the luminous efficiency. Estimates of this proportionality factor have been made by a variety of methods, the results of which differ appreciably; the estimate of E. Öpik differs by several orders of magnitude from that of A. F. Cook and F. L. Whipple. Consequently, the mass of a meteoroid cannot yet be given with any degree of confidence.

The drag equation offers a method that is independent of the luminous efficiency factor. This application requires that the density and the shape of the body be known. The density of the cometary meteoroid, however, is unknown, and meteors that are indisputably the product of an asteroidal body have heretofore been absent among those photographed.

A unique example of a meteor with the physical and orbital characteristics of an asteroidal body has recently been analyzed. A spherical shape has been assumed. The existing uncertainty in the luminous efficiency is such that only large and unlikely departures from sphericity will vitiate the value of the result. The high luminous efficiency that was found is compatible with the value suggested by Öpik. The low value of the luminous efficiency determined empirically by Cook and Whipple may be valid for cometary meteoroids if these bodies contain a smaller fraction of elements that are responsible for the meteoric luminosity.

A Dynamical Determination of the Astronomical Unit by a Least-Squares Fit to the Orbit of Pioneer V. J. B. MCGUIRE, D. D. MORRISON, AND L. WONG, *Space Technology Laboratories, Inc., Los Angeles, California* (introduced by GUIDO MÜNCH).—The astronomical unit has long eluded precise determination because it enters the two-body Kepler problem as a scale factor, and as a scale factor changes in the size of the astronomical unit do not change any angular measurement. Since angles are the primary measured quantities of classical astronomy, the astronomical unit does not enter the dynamics and thus the astronomical unit has been

determined by geometrical means (i.e., measuring solar parallax).

If, however, one is concerned with a three-body problem, the effect of a change in the astronomical unit is to add a secular (i.e., time-increasing) perturbation to the motion. This effect has been utilized by E. K. Rabe (1950, *Astron. J.* **54**, 112) in the so-called dynamical method of astronomical unit determination.

It was first suggested by R. C. Booton (1960, *Space Technology Laboratories Tech. Rept.* 60-0000-00215) that the orbit of an interplanetary probe could be affected (since it is a three-body problem) by a change in the astronomical unit, and thus the astronomical unit should be measurable by a least-squares fit to the radio Doppler data from such a probe.

Previous determinations of the astronomical unit have been made by both dynamical and geometrical means. The most recent of the dynamical measurements is that of Rabe, which has a quoted accuracy of ± 4.4 parts in 10^5 . The most recent geometrical measurement is that of Spencer-Jones (1941, *Mem. Roy. Astron. Soc.* **LXVI**, Part II) which has a quoted accuracy of ± 1.1 parts in 10^4 . The measured values of the astronomical unit, however, differ by one part in 10^3 .

At the time of writing of this abstract the tracking of the Pioneer V probe is incomplete; thus the accuracy of the measurement of the astronomical unit is as yet unknown. Unfortunately, radio contact with Pioneer V will not be maintained to a sufficient distance from the earth to effect any improvement in the uncertainties in the astronomical unit quoted by Rabe. It is hoped, however, that sufficient accuracy will be attained to lend more weight to either Rabe or the Spencer-Jones value of the astronomical unit.

It will be shown that Doppler tracking of an interplanetary probe to a distance of 80 000 000 miles from the earth could yield a value of the astronomical unit which is competitive in accuracy with Rabe's determination.

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Rotational Velocities of B Stars in the Orion Association. D. H. MCNAMARA, *Physics Department, Brigham Young University*.—A spectrographic investigation at a dispersion of 10 Å/mm of B0.5-B3 stars in the Orion Association has revealed that they possess remarkably small rotational velocities when compared with general field stars of similar type. The average value of $v \sin i$ for 28 stars (all except four are luminosity class V) is 99 km/sec. This compares with the average value of $v \sin i$ determined by Slettebak and Howard for a group of 67 B1-B3 (luminosity class V) field stars of $\langle v \sin i \rangle = 157$