subdwarf B stars lie between +2 and +5. Galactic velocity components were computed for a number of absolute magnitudes between −3 and +5. For $M_v = +2{\cdot}5$ we find $u = +200$ km/s, $v = -60$ km/s, $w = +160$ km/s, at a distance of 250 pc. In this case the height of 190 pc above the plane would place the star just outside the dust stratum[8]. Removing the circular velocity in the solar region of 250 km/s[9] gives velocity components in a stationary coordinate system of $u = +200$ km/s, $v' = +190$ km/s, $w = +160$ km/s. Although the absolute magnitude is so uncertain, the assumption that the star is subluminous makes the z velocity positive, while the assumption that it is a normal B star makes the z velocity negative and therefore unlikely. Errors in the proper motion do not affect this conclusion.

It is well known that peculiar B stars cannot often be detected on the basis of relatively low dispersion spectroscopy and three-colour photometry alone. Graham[10,11] has demonstrated the advantages of intermediate-band photometry for observations of high latitude, early-type stars. Consequently, HD 125924 is suggested as being worthy of spectroscopic observation at higher dispersion since the kinematic argument shows that it is probably subluminous and thus one of the brighter representatives of the halo population.

I am most grateful to Mr. T. Lloyd Evans for a second opinion on the spectral type.

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CORRESPONDENCE

To the Editors of 'The Observatory'

The Major-Axis Distribution of Long-Period Comets

GENTLEMEN,—

The talk[1] which Lyttleton has delivered at a meeting of the Royal Astronomical Society gives rise to some comments.

From the more detailed article on the same subject which has since appeared[2], it is clear that Lyttleton is anxious to point out an, according to him, elementary mistake in Oort's articles concerning the structure and origin of the cloud of comets. He maintains to have detected an "error of principle in interpreting the distribution plot with $1/a$", which is of a mathematical nature.

According to him Oort infers from a maximum in the distribution of observed long-period comets with $1/a$ at some value $1/a_0$ a corresponding maximum in the space-density of aphelion points at a distance a_0. He then points out that this is mathematically impossible for any finite value of a_0. Unfortunately his proof includes a very special assumption concerning the dependence of the distribution of orbit-eccentricities on the aphelion-distance. He believes his proof to hold generally without reference to the above complication, or as he states it, "other things being ignored".

This, of course, invalidates the generality of his conclusion, and thereby his main objection. What is worse, however, is the fact that, even if his proof were correct, this would not constitute justified criticism, since Oort never made the inference attributed to him.

All one needs is the direct observational fact that there is a large number of comets whose orbits, when computed back, extend to distances of more than 20,000 a.u. From this simple observation the existence of a reservoir of comets at large distances from the Sun follows without any hypotheses or "special assumptions". It follows also, as Oort has extensively worked out in his first article[3], that this suffices to predict the entire distribution of major axes of comet orbits, *if due account is taken of effects of evaporation and disintegration.*

Apart from this "objection" Lyttleton raises other problems concerning Oort's concept of the "cloud of comets". From those remarks it seems to us, that Lyttleton has not noted the following basic properties of Oort's model[3,4].

(1) *Origin.* The comets have originated in the inner parts of the solar system, that is with $<1/a>$ of the order of 10^{-1} a.u.$^{-1}$.

(2) *Diffusion.* Provided that perihelion passages continue to occur through the inner parts of the solar system, subsequent planetary perturbations will diffuse this peaked distribution in binding energy by yielding a $\Delta(1/a)$ with an absolute mean $<|\Delta(1/a)|>$ of the order of 5×10^{-4} a.u.$^{-1}$ *per perihelion passage.* As these perturbations occur near perihelion only no significant change in the perihelion distances can occur, indicating that the above requirement is met. This mechanism thus spreads the $1/a$ distribution. As long as the comets keep passing through the inner parts of the solar system they will either disintegrate in such a way as to be unobservable, or be ejected in hyperbolic orbits. Both processes have a time-scale which is short compared with the age of the solar system. Since we saw that the small perihelion distances would indeed persist, this would lead to the conclusion that observable comets should not exist at this time any more.

(3) *Building process of "cloud".* However, it is here that stellar perturbations provide the solution. A certain fraction will happen to leave the inner parts of the solar system (after undergoing their planetary perturbations) with $0 < 1/a < 3 \times 10^{-5}$ a.u.$^{-1}$. This special group will subsequently spend so much time at sufficiently large distances from the Sun as to enable stellar encounters to have a small but highly significant effect. Although these perturbations yield only a $|\Delta(1/a)|$ of the order of 10^{-8} a.u.$^{-1}$ during one aphelion passage (completely insufficient effectively to change the binding energy of the comets) they *do* change the perihelion distance by an average amount of ~ 30 a.u. This is enough to ensure that the next perihelion passage of the majority of these comets will be outside the region where planetary perturbations are significant.

This mechanism thus yields a group of comets with highly elongated orbits with semi-major axes exceeding some 3×10^4 a.u. These orbits are now quite stable on a time-scale of one period, since both planetary and stellar perturbations yield variations in binding energy per orbit several orders of magnitude less than the binding energy of the orbits themselves.

(4) *Properties of cloud after formation.* It is shown that on a time-scale of the age of the solar system the total energy exchange between passing stars and comets is of the same order as the energy of such a cometary orbit ($\Sigma|\Delta(1/a)| \approx 10^{-5}$ a.u.$^{-1}$). This indicates that a large fraction of those comets, which were "captured" with $1/a < 10^{-5}$ a.u.$^{-1}$, must have been lost by escape into interstellar space through the accumulated effects of stellar perturbations. This yields, together with (3) above both an upper and a lower limit for $1/a$, in order to have a set of cometary orbits that are "stable" on a time-scale of the age of the solar system. The evolutionary picture also at once indicates that a large fraction of such orbits must still be strongly elliptical, and more so, the more $1/a$ approaches its upper limit, because of the relatively smaller stellar perturbations.

(5) "*New*" *comets.* Since stellar perturbations yield a $\Delta\mathbf{v}$ with a random orientation, it may happen that the orbit of such a "captured" comet is so perturbed that its next perihelion passage will once again occur through the inner parts of the solar system, where planetary perturbations are important. In that case (2) and (3) are applicable again. If the perihelion distance happens to be even less than about 2 a.u. we have a fair chance of observing the comet, in which case we would be seeing a "new" comet. It should be mentioned that its $1/a$ is likely to be less than about 0·1 per cent different from what it was before its last aphelion passage and stellar perturbation.

From the foregoing it is seen that Oort's model requires *all* observable comets (both long- and short-period) to have been stored in these semi-permanent orbits for most of their lifetime, and thereby kept away from the destructive influence of the immediate solar neighbourhood.

It appears to us that Lyttleton's misinterpretation of Oort's hypothesis may have arisen from:

First, the word "cloud", describing the comet reservoir;

Second, the rough coincidence of the distance at which a maximum is shown in column 4 of Table 3 in ref. (3), and the inverse of the value of $1/a$, at which a maximum occurs in the $1/a$ histogram.

We therefore conclude that Lyttleton's seemingly convincing criticism should not enter textbooks as serious objections against Oort's theory.

We are, Gentlemen,

Yours faithfully,

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1968 June 7.

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