LETTERS TO THE EDITOR

PHYSICAL SCIENCES

Diamonds and the Interstellar Extinction Curve

It has been suggested[1] that the interstellar extinction might be explained by assuming that the interstellar dust is composed of an appropriate size distribution of diamond particles. The imaginary part of the index of refraction of diamond increases sharply from near zero to about 1·0 at $\lambda^{-1} = 5{\cdot}0\ \mu\text{m}^{-1}$, giving an albedo near unity in the visible and strong extinction in the ultraviolet, as required by recent observations.

Wickramasinghe[2] has recently published a theoretical extinction curve for diamond particles, using a distribution of particle radii

$$n(a) \propto a^{-3} \qquad (1)$$

The curve passes within the error bars of the observations of interstellar extinction from $\lambda^{-1} = 1{\cdot}0$ to $8{\cdot}0\ \mu\text{m}^{-1}$ but gives too little extinction in the infrared and also results in a ratio of total to selective extinction, $R \equiv A_V/E_{B-V}$, of 10·8. Wickramasinghe therefore concludes that the hypothesis of dust grains made of diamonds is in conflict with the observations. The purpose of my paper is to show that a simple size distribution of diamonds may be found which accounts for the interstellar extinction.

I have made a series of exact Mie calculations with various simple size distributions and have found that the distribution

$$n(a) \propto a^{-3{\cdot}8} \qquad (2)$$

fits the observations throughout the infrared, visible and near ultraviolet regions fairly well. The ratio R for this distribution is 4·3, in agreement with the accepted range of values between 3 and 6. The number of very small particles is very large in such a distribution, however. Kimura[3] has shown that small dust grains may be expected to be destroyed by cosmic rays of energy 10–100 MeV if the grains are not able to thermalize the energy of the collision. I have therefore modified the size distribution to have the form

$$n(a) \propto a^{-3{\cdot}8}(1 - \mathrm{e}^{-a/a_c}) \qquad (3)$$

A value of $a_c = 0{\cdot}03\ \mu\text{m}$ reduces n to 50 per cent of its value in distribution (2) at $a = 0{\cdot}02\ \mu\text{m}$ and to 10 per cent at $a = 0{\cdot}003\ \mu\text{m}$, and gives the best fit with the observations (see Fig. 1). For this distribution $R = 4{\cdot}9$.

The calculations were made by numerically integrating the extinction cross-section over the size distribution between particle radii 0·001 and 10 µm. The size of the increment in radius was made smaller at those wavelengths and radii where the cross-section shows rapid variations with the parameter $x = 2\pi a/\lambda$. The smallest increment used was 0·001 µm. The optical constants used were those of Phillipp and Taft[4].

In Fig. 1 is plotted the extinction in magnitudes, normalized to $V = 0$, $B - V = 1$, of the distribution (3) of diamond particles with $a_c = 0{\cdot}03\ \mu\text{m}$. Also plotted are the observations, similarly normalized, reported by Boggess and Borgman[5], those of Stecher[6] in the ultraviolet on five pairs of stars, those of Stecher[7] on one pair of stars, and those of Bless and Savage (private communication) made from the Orbiting Astrophysical Observatory on ten pairs of stars. The curve is nowhere more than one and a half error bars away from the observed points.

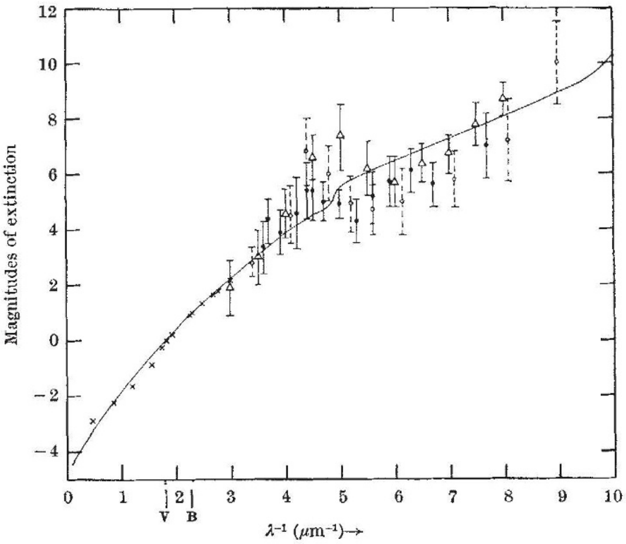

Fig. 1. Normalized extinction curve for a size distribution of diamond particles defined by $n(a) \propto a^{-3{\cdot}8}(1 - \mathrm{e}^{-a/0{\cdot}03})$. The observations of Boggess and Borgman[5] are shown as crosses; those of Stecher[6] as filled circles; those of Stecher[7] as triangles; and those of Bless and Savage (private communication) as open circles. The normalization is according to $\Delta m = 0$ at $\lambda^{-1} = 1{\cdot}8\ \mu\text{m}^{-1}$, $\Delta m = 1$ at $\lambda^{-1} = 2{\cdot}3\ \mu\text{m}^{-1}$.

It is concluded that a simple size distribution of diamond particles can be found which gives a calculated extinction curve satisfying the observational data as satisfactorily as any other model of interstellar grains so far proposed. It should be noted, however, that the existence of such a distribution does not constitute a strict test for the composition of the dust grains. A simple distribution which fits the extinction observations could probably be found for particles composed of many different materials.

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Mascons, Mare Rock and Isostasy

The nature of the large positive gravity anomalies discovered on the Moon[1] (mascons) has been the subject of lively discussion. The high density (3·1 to 3·5 g cm^{-3}) of mare rocks at Tranquillity Base[2] supports one hypothesis —that mascons are surface sheets of high density volcanic rock[3]. The non-isostatic conditions of the mascon areas shown by the free-air anomalies[4,5] may have terrestrial analogues in some regions of recent volcanism where breaks in the crust have allowed dense basalts to pile up on the surface faster than isostatic balance can be maintained.