Observational constraints on interstellar diamonds

SIR—In a recent study Lewis *et al.*[1] discovered in meteoritic material small (50 Å) diamond grains of extrasolar origin. They were apparently unaware of the previous work[2] which had proposed that interstellar dust contains diamonds. Adequate observations are now available to test this hypothesis.

Diamond has an absorption edge in the ultraviolet[3] beginning at ~ 7 eV with an absorption coefficient, α, of 5×10^5 cm^{-1} at 7.5 eV. Following earlier work[4-6], the optical depth, in magnitudes, can be expressed as

$$\tau(\lambda) = 1.1\, C_{abs} NL \quad (1)$$

where C_{abs} is the absorption cross-section for a small spherical grain, N is the number of grains per cm^3 and L is the path length in cm. The quantity NL can be expressed as

$$NL = \frac{N_H E(B-V)}{6\times10^{23}} \frac{W_C}{n_C} \frac{A_C}{\left(\frac{4}{3}\pi a^3\right)} f_C \quad (2)$$

where N_H is the number of hydrogens per cm^2-magnitude, $E(B-V)$ is the reddening, W_C is the atomic weight of carbon, n_C is the density of the condensed diamond grain, a is the grain radius, A_C is the relative abundance of available carbon, and f_C is the fraction of avaliable carbon condensed in grains.

To evaluate equation (1) we have used appropriate values for N_H (5.8×10^{21}, ref. 7), A_C (4.8×10^{-4}, ref. 6), α (5×10^5 at ~ 7.5 eV, ref. 3), n_C (3.5, ref. 7), and $\tilde{\varepsilon}$, the dielectric constant of diamond[3] ($11+4i$ at ~ 7.5 eV). The value for α is taken[3] as 0 below ~ 7 eV. Using these values and appropriate expressions[3,8] for α and C_{abs}

$$\frac{\tau(7.5\text{ eV})-\tau(7\text{ eV})}{E(B-V)} = \frac{\tau_{aec}}{E(B-V)} = 1.6 f_C \quad (3)$$

where τ_{aec} is the differential absorption for the diamond absorption edge. This expression is independent of particle radius for $a < 100$ Å.

Because the absorption edge, which continues to increase with increasing energy, occurs in the same energy region as the proposed crystalline MgO feature[5] we can apply the recent results derived by Massa *et al.*[9]. They found no fine structure in the interstellar extinction curve between 3,000 and 1,200 Å. Using this and equation (3) puts an upper limit of 1% for the amount of interstellar carbon condensed as small crystalline diamond grains. While this upper limit does not rule out the extrasolar origin of the meteoritic diamonds, as only 1% of the meteoritic carbonaceous material was in the form of small diamonds, it should be compared with the results of recent models that show 60–80% of carbon condensed in grains[6,8]. Thus, if small diamonds exist in interstellar dust they are a minor species.

Laboratory studies may provide a possible solution to the origin of the meteoritic diamonds. These studies[10] show that condensation from a vapour containing C and H results in an amorphous material which has properties and bonding that are characteristic of both diamond (sp^3) and graphite (sp^2). The proportion of the two types of bonding varies, and heating of this amorphous CH material can cause graphitization. Based partly on these results, Hecht[8] proposed a model for interstellar and circumstellar dust where nearly 20% of C was in the condensed form, as either small amorphous CH grains or small partially graphitized grains formed from heating the original amorphous material. A possible explanation for the meteoritic diamond grains consistent with this model would be as follows. Some of the small amorphous CH grains may have a large excess of diamond bonds. Subsequent shock heating or particle bombardment would result in partial crystallization in a diamond form. This would explain the observed character of the meteoritic diamond[1]: that is, a diffraction pattern indicating the presence of crystalline diamond, a low density indicating the presence of amorphous material, infrared features indicating the presence of soot, and a varying colour of the bulk material. The phase change from amorphous CH to crystalline diamond probably does not occur in circumstellar shells, as no infrared features[2] associated with diamond have yet been seen. Because the diamonds already show evidence of supernova interaction, it may be that the crystallization occurred as the grains passed by a supernova and the isotope enrichment occurred after this. An alternative explanation is that formation actually occurred in the ejecta from a supernova. Thus, evidence for the grains such as increased ultraviolet extinction near 7 eV or infrared features[2] from 4–5 μm and 8–9 μm should be looked for in the current supernova. This work was supported by the Aerospace Sponsored Research Program.

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Causal factors in generational IQ gains

SIR — I enjoyed Chris Brand's News and Views article[1] that discusses my work[2] showing that young adults in 1980 outscored young adults in 1950 by 18 points, at least on culturally-reduced IQ tests. However, Brand assumes that he and I disagree about the implications of massive IQ gains more than we actually do.

The fact that IQ tests cannot compare successive generations for intelligence does not necessarily mean that they cannot measure intelligence within a particular generation. My best guess is that the tests cannot compare nations, say the United States and Japan, with certain ethnic groups, say American whites and American Orientals. They can certainly compare the gifted and the retarded and may work reasonably well between social classes. Presumably it is the cultural distance travelled from one generation to another that increases IQ scores without increasing intelligence.

Only when we know what casual factors are at work will we be able to assess the significance of the cultural distance between other groups.

The importance of the causal question prompts a few comments on factors Brand suggests. The gains are too great for test sophistication to be significant. Administering and scoring Raven's is virtually automatic, which excludes tester laxity and skills; Brand's table casts doubt on nutrition as the Dutch 18-year olds tested in 1962 were born during the great Dutch famine of 1944 and yet introduce no incongruity in the pattern of gains; increased outbreeding is supposed to have occurred far more before 1950 than after; and family size has both increased and decreased during the period of massive gains. Flieller *et al.*[3] give data showing that urbanization is responsible for only three points of a 24-point French gain. The number of years of schooling is a negligible factor at least in Holland[3]. The qualitative changes in schooling Brand describes might explain gains on some IQ tests but would dictate losses on others, which have not occurred.

Massive IQ gains are truly baffling: it is as if we had suddenly discovered a dramatic but unexplained escalation in juggling skills, and no one could find a carry-over to socially significant sports such as soccer and cricket.

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