INTERSTELLAR PROTEINS AND THE DISCOVERY OF A NEW ABSORPTION FEATURE AT $\lambda = 2800$ Å

(Letter to the Editor)

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Abstract. The discovery of a broad interstellar absorption feature centred on $\lambda 2800$ Å in the extinction curve of starlight confirms the presence of proteinaceous material in grains.

Although there are several strong arguments to show that large quantities of biochemical material exist in interstellar space, the detection of such material by direct spectroscopy is not straightforward, because the absorption bands produced by biogenic substances are weak and are readily obscured by much stronger nearby absorptions that can arise from comparatively small amounts of non-biochemical materials. The situation is well illustrated by the broad 3.4 μm band produced by C–H linkages in organic substances. The measured absorption coefficient for this band differs between its centre and wings (defined to be ±0.1 μm from the centre) by only about 500 cm$^2$ g$^{-1}$, very small indeed compared to the absorption of ~30 000 cm$^2$ g$^{-1}$ produced by water-ice at ~3.1 μm. Given any appreciable amount of ice, the immensely strong absorption which it produces spreads from ~3.1 to 3.4 μm, where it dominates the weak C–H band, converting it into a minor wiggle or shoulder (Hoyle et al., 1983). Only if water-ice is essentially absent altogether can a distinctive absorption at 3.4 μm be detected from even a large quantity of organic material. It is remarkable that this stringent requirement happens to be met along the ~10 kpc path length to the galactic centre, permitting a distinctive absorption of ~0.3 mag. at 3.4 μm to be detected in the source GC-IRS 7 (Wickramasinghe and Allen, 1980; Hoyle et al., 1982). A simple calculation shows that to produce even so small an absorption over even so large a path length the average mass density of absorbing organic particles must be ~2 × 10$^{-26}$ g cm$^{-3}$, which is comparable with the total density of all the interstellar grains. Hence, one arrives at a direct observational demonstration that most of the interstellar grains are of an organic nature—a conclusion that can also be reached from abundance requirements, which shows that the maximum possible density of non-organic interstellar grains is in deficit of the observationally determined density by a factor 3 at least.

The situation in the ultraviolet appears at first sight to be similarly awkward. While organic molecules of biochemical interest have many absorptions in the ultraviolet, the associated wavelengths tend to be clustered around 2200 Å (Hoyle and Wickramasinghe, 1977, 1979), where small graphite particles have the enormous absorption coefficient of

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Molar absorption coefficients as functions of wavelength for Tryptophan, Tyrosine, and Phenylalanine (White et al., 1973).

~ 600,000 cm² g⁻¹. DNA has a strong absorption at ~ 2600 Å, sufficiently removed from 2200 Å, but the DNA content of microorganisms is so small that prospects of detecting this particular absorption are not encouraging. Of the 20 amino acids commonly found in biogenic proteins only tryptophan (Try), and to a lesser extent tyrosine, has a strong absorption in the near-ultraviolet. Thus the molar absorption coefficient $E$ for tryptophan near 2800 Å is ~ 5000 (cf. Figure 1 from White et al., 1973). Since the molar absorption coefficient used by chemists is related to the mass absorption coefficient $\kappa$ by the equation

$$\kappa = \frac{2300}{M} \times E \text{ cm}^2 \text{ g}^{-1},$$

where $M$ is the molecular weight (204 for Try), it is seen that $\kappa$ for tryptophan near 2800 Å is ~ 60,000 cm² g⁻¹, about one-tenth of the absorption coefficient of graphite at 2200 Å. However, so long as graphite particles among the interstellar grains are small, say with radii ~ 0.02 μm, the graphite absorption is peaked sufficiently strongly at 2200 Å for there to be a chance of detecting Try at 2800 Å, if this particular amino acid is present among the interstellar grains in sufficient abundance. The simplest procedure for determining the absorption produced by Try in bioproteins generally is to measure $\kappa$ at 2800 Å for some virus or bacterium, thereby determining the average effect of Try (and to a lesser extent of tyrosine) for all the relevant proteins. Laboratory measurements at ~ 2800 Å for the proteins of Tobacco Mosaic Virus (TMV) and the envelope proteins of E. coli give $\kappa \approx 3500$ cm² g⁻¹ (Taniguchi et al., 1971; Rosenbusch, 1974). One can then calculate that for bacterial grains of spatial mass density ~ $2 \times 10^{-26}$ g cm⁻³ distributed along a path length of 1 kpc – typically the distance of