LETTERS TO THE EDITOR

ASTRONOMY

Origin of the Diffuse Interstellar Absorption Bands

THERE has recently been renewed interest in the nature of interstellar grains. The model of a grain consisting of a graphite core surrounded by a dirty ice mantle adequately accounts for the wavelength dependence of interstellar extinction[1] and interstellar polarization[2]. The question of the source of the large number of diffuse (but discrete) interstellar absorption bands, however, remains. A number of theories have been proposed to account for these bands[3-5].

My purpose is to point out a similarity between the diffuse interstellar bands and absorption features observed in the spectra of various neutral atoms trapped in low temperature molecular crystals. The idea that the diffuse interstellar bands are caused by "matrix isolated" atoms or molecules has been proposed before[6,7], although at that time little empirical information was available about the absorption spectra of neutral impurities in molecular crystals. I wish to re-examine this suggestion in the light of new experimental information[8-11].

When an atomic impurity is trapped in a low temperature matrix of one of the rare gases the absorption spectrum resembles that of the gas phase atom, with several important reservations[9]. These are that (*a*) there is usually a shift of the atomic transition to higher or lower energies amounting to $\simeq 2{,}000$ cm^{-1} in some systems[10,11] and (*b*) the transition is broadened. The amount of broadening depends on both the density of impurities and the temperature of the sample[11]. Absorption features in the spectra of rare gas matrices containing $\leqslant 1$ per cent of atomic impurities typically have widths of 100–2,000 cm^{-1}.

I suggest that the diffuse interstellar absorption bands may be caused by atomic impurities trapped in the dielectric mantles of interstellar grains. Grains of this sort with dirty ice mantles could act as powerful thermalizers through impurity oscillations in the far infrared[3]. It is interesting to note that H atoms trapped in Ar matrices at 4·2° K are predicted to have optically active modes of oscillation in the $\simeq 200$ cm^{-1} region[12]. Heavier impurities in matrices of low atomic weight would be expected to show resonances at much lower energies.

There is a striking coincidence between the wavelength of the most infamous interstellar band at 4430 Å and that of the resonance 4 $^1S_0 \rightarrow 4\ ^1P_1{}^0$ transition of CaI at 4226 Å. It has also been shown that the ratio of interstellar Ca^+ to Na is normal in high velocity clouds of dust but is anomalously small in low velocity clouds[13]. This indicates that much interstellar Ca is attached to interstellar grains. Furthermore, a correlation exists between the intensity of 4430 Å and interstellar extinction which suggests that 4430 Å arises in interstellar grains[7].

Fig. 1 shows the absorption spectrum of Ca atoms dispersed in a low temperature matrix of Xe. The 4226 Å 4 $^1S_0 \rightarrow 4\ ^1P_1{}^0$ transition of Ca is shifted to about 4300 Å and split into two components. The total width of this band is approximately 250 Å although the width depends on two factors: the concentration of Ca atoms and the temperature of the sample. Similar spectra of Ca atoms trapped in an Ar matrix are more complex, depending strongly on deposition conditions and the presence of small concentrations of impurities. The principal feature of the spectrum is, however, a broad band, occasionally with structure, located some 200 Å further to the blue. Obviously the solid inert gases are a poor approximation to the dirty ice matrix in which Ca atoms would be expected to be trapped in interstellar space. These results show, however, that the resonance transition of Ca can be shifted and broadened sufficiently when Ca atoms are trapped in low temperature molecular crystals to account for both the wavelength and width of the 4430 Å interstellar band. We are continuing our experiments with a view to trapping Ca atoms in solid hydrocarbon matrices.

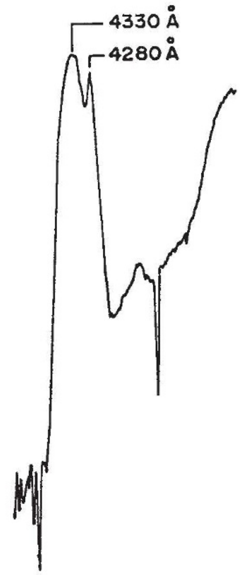

Fig. 1. Absorption spectrum of Ca atoms dispersed in a low temperature matrix of Xe.

It would be expected that other atoms could be trapped in the dielectric mantles of interstellar grains. This suggests that the other diffuse interstellar bands may also be caused by matrix isolated atoms. In particular, one wonders whether the two diffuse interstellar bands at 5780·6 Å and 5795·1 Å could be caused by matrix isolated Na atoms.

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Counts of Radio Sources at 2,700 MHz

ON the basis of some new observations made at a frequency of 2,700 MHz, Shimmins, Bolton and Wall[1] have derived radio source counts having a slope of $-1·4$. They claim that these differ significantly from the Cambridge results and cast doubt on the validity of the interpretation of the