THE ORIGIN OF UNIDENTIFIED INTERSTELLAR ABSORPTION LINES.

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The new interstellar lines discovered by P. W. Merrill [1] and the broad diffuse stationary band observed by C. S. Beals and B. H. Blanchet [2] have roused considerable interest recently. For spectroscopic as well as astronomical reasons, it has been suggested by Merrill and by Beals that these lines must be due to very small solid particles. Among these reasons we may quote, namely, the absence of coincidence with resonance atomic transitions, the improbability that gaseous molecules can explain all the observed lines and the strong correlation between the intensity of Merrill's line at $\lambda 6284$ A and the colour excess attributed to the small diffracting interstellar particles.

The width of the absorption bands of a solid is essentially due to the thermal agitation and to the broadening of the levels of each constituent (atom or molecule) owing to the interactions of neighbouring particles. In order to explain relatively narrow bands (of the order of 3 A for Merrill's lines and of 40 A for Beals' band), the required assumptions for solids are low temperature and weak interactions between the constituents. The first requirement is fulfilled in interstellar space. The second one enables us to exclude fairly surely the metals in the crystalline state (conductors) and the crystals with ionic lattice. In both cases (see the investigations by R. de L. Kronig, Sergeiev and Tchernikovsky, Fröhlich, etc., for metallic lattices [3]; by N. F. Mott, R. W. Pohl, D. Blochinzew, etc., for ionic crystals [4]), the interactions are strong and give broad bands, even at very low temperatures. On the other hand, weak interactions are present in molecular (or atomic) crystals and in amorphous metals; thus these seem to be two directions in which identifications may be searched for *.

If we adopt for interstellar space relative abundances similar to those of stellar atmospheres, we may expect relatively frequently small crystals of light elements (solid hydrogen or oxygen, ice, CO_2, etc., or mixtures of them). The spectra of such solids at very low temperatures should exhibit great similarities to those of the

* See P. Swings and M. Désirant, *Ciel et Terre*, no. 5, p. 160, 1939.

corresponding atoms or molecules as vapours at high pressure or as liquids; but the influence of the crystalline lattice is manifest also, as it appears from the absorption spectra of solid oxygen in the γ and β forms at 43·8° K. In the case of molecular crystals, the rotation vanishes, but the vibrational bands are still separable (see the theoretical investigations by Frenkel and Peierls [5]) and we should thus find approximately the fundamental vibrational frequencies of the molecules in the gaseous state. Needless to say, much experimental work is needed in this direction.

The amorphous metals have also a conspicuous interest. Their electric properties (insulators) have been investigated especially by J. Kramer [6]; unfortunately very little is known regarding their optical properties. Such solids are obtained by condensation at low temperatures and are favoured by small dimensions; it seems thus fairly safe to assume that at least part of the small interstellar "metallic" particles must be in the amorphous state *. All the amorphous metals so far investigated have exactly the same brown-yellowish colour and similarities in the absorption spectra are thus expected. Unfortunately only the absorption spectrum of amorphous antimony has been investigated so far and yet in a rather preliminary way; thus conclusions based on possible coincidences are premature. Experimental and theoretical work in this field of Optics is urgently needed. Pure particles consisting of only one relatively abundant element, such as iron, may play a role, although it is presumable that many interstellar amorphous particles will be formed of various elements (atoms or molecules). This does not introduce complications, as interactions must be weak both between identical and between different metallic atoms or molecules †.

Another point may be of interest in connection with this matter. For each pure metal, there is a critical temperature at which the solid undergoes a transition from the amorphous into the crystalline state; such a transition is accompanied by an emission at about 40 e.V., *i. e.*, around 200 or 300 A [7]. If interstellar space contains

* This suggestion is of special interest in connection with Lindblad's condensation theory of interstellar particles (*Nature*, **135**, 133, 1935).

† Certain metallic atoms or molecules will also be inbedded in atomic or molecular crystals of light elements.

amorphous and crystalline metallic particles in addition to atoms, molecules, and radiation, the transition between the two types of solids which originates from the heating by collision or by absorption of long wave-lengths is accompanied by an emission in the far ultra-violet (around 250 A). This process may be of importance in the mechanisms of excitation of bright line nebulæ, furnishing possibly an explanation when only a late type star or a general luminous field is present; possibly also, it could for the O-type stars give lower surface-temperatures than the figures calculated from a direct application of Zanstra's theory.

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A WEEK WITH HALE.

It must have been early in July 1908 that accounts came through to the Lick Observatory, where I was then a Fellow, of a great discovery made at Mount Wilson. This referred of course to the magnetic field in sunspots. At the end of the month, according to plan, I left Mount Hamilton and travelled to Pasadena to spend a month at the Solar Observatory.

Hale at the time had sent his family and staff to the seaside, but was himself staying behind for another week. To me he was kindness and hospitality itself. He insisted that I should stay in his house and took me for meals to a boarding house at no great distance.