The absence of Class VI stars to the left of this line can be explained if it is accepted that these stars were produced early in the life of the Galaxy and that sufficient time has elapsed for all the more massive stars to have evolved off the main sequence and to have left the diagram altogether. The fact that the boundary line coincides with a blanketing line indicates that these Class VI stars were formed within a very short period of each other, that there was already a wide range of metal content in the interstellar medium at the time of their formation, and that the rate of stellar evolution has been independent of the metal content.

The second diagram follows up a hint given by Eggen, Lynden-Bell, and Sandage. It shows a plot of $(U-B)_C$ against $B-V$ for stars with z-velocities (i.e. w) greater than 30 km/sec. The stars all lie to the right of the blanketing line $(B-V)_H=0{\cdot}60$. If stars with $w<30$ km/sec were included, some of them lie to the left of the line.

The third diagram shows $(U-B)_C$ against $B-V$ for the southern stars earlier than K2 in Gliese's catalogue of stars within 20 pc of the Sun. Of the 79 stars involved, only six lie to the left of the blanketing line $(B-V)_H=0{\cdot}60$, though there is no sign of the stars thinning out as this line is approached from the right. There is no possibility of this arrangement of points being due to observational selection, so that it seems probable that most of the nearby stars found to the right of the $(B-V)_H=0{\cdot}60$ line are there simply because they were formed during the first few hundred million years following the formation of the Galaxy and that, even at this early stage, the interstellar medium was already as rich in metals as the Hyades.

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Discussion

Pagel: The conclusion that there is little correlation between age and metal abundance has also been reached from a study of old subgiants in the solar neighbourhood, based partly on differential curve of growth analysis and partly on the results of six-colour photometry. There is, however, a correlation with z-motion, similar to that illustrated by Eggen, Lynden-Bell, and Sandage.

9. MEASUREMENTS OF NEUTRAL HYDROGEN IN GALACTIC STAR CLUSTERS

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A search was made for neutral hydrogen in the following galactic star clusters — the Pleiades, NGC 1502, the Trapezium-Orion cluster, NGC 2244, and NGC 6910 (Davies and Tovmassian 1963). Observations were made with a six-channel receiver having a 5 kc/s bandwidth; it was used with the 250-foot radio telescope which has a

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beamwidth of 12′ by 18′. The first stage of the receiver was a parametric amplifier with an excess temperature of 200 °K. Simultaneous measurements with a 5 Mc/s bandwidth showed the existence of ionized hydrogen associated with the clusters.

Drifts across the centre of the Pleiades cluster showed five clouds located within 1° of the centre of the cluster and lying within a velocity range of 16 km/sec. Since the scatter in observed radial velocity of the cluster stars is 1 km/sec it is evident that all these clouds cannot belong to the Pleiades. Even if all the clouds were associated with the cluster the total mass of neutral gas would be only 10 solar masses compared with a stellar content of 900 solar masses (Limber 1962).

No neutral or ionized hydrogen was detected at the position of the O-type cluster NGC 1502. An upper limit of the gaseous mass was estimated from the limit of the measured brightness temperature of the continuum and line emission on the assumption that the gas was distributed over an area with twice the diameter of the optical cluster. The corresponding value was less than 10 solar masses compared with a stellar mass of several hundred solar masses.

The Trapezium-Orion cluster, which is associated with the Orion nebula, is well known to contain a significant mass of ionized hydrogen. Hydrogen-line drifts across the cluster showed the existence of an expanding shell of neutral hydrogen centred on the cluster. The diameter of the shell was 42′ (5·5 pc) and the expansion velocity was 15·8 km/sec. The radial velocity of the shell was found to be closely similar to that of the cluster. The total gaseous mass in the cluster amounted to 200 solar masses, which may be compared with ~2000 solar masses in the form of stars.

The O-type cluster NGC 2244, which is responsible for the excitation of the Rosette nebula, has an expanding neutral hydrogen shell associated with it having a diameter of 2° and a thickness of 40′. The expansion velocity of the shell (15 km/sec) and its radial velocity correspond closely to that of the Rosette nebula. The neutral hydrogen, ionized hydrogen, and stellar mass of the cluster were $3{\cdot}8 \times 10^3$, $1{\cdot}1 \times 10^4$, and 10^4 solar masses respectively.

The fifth cluster studied was NGC 6910, which lies within the Cygnus X complex. It is surrounded by an expanding shell of neutral hydrogen with an expansion velocity of 10 km/sec. The total gaseous mass associated with the cluster was found to be 100 solar masses compared with a stellar mass of ~1000 solar masses.

The results giving the ionized and neutral gas masses and the stellar mass for each cluster are shown in Table 1.

The cluster type given in the table for each cluster is that published by Markarian (1951) and the ages are values taken from various sources. The results show no clear relationship between the age and the gaseous content of a cluster and the only correlation appears to be between the ratio of gaseous to stellar mass and the total mass of O-type clusters. This suggests that the gravitational forces in a more massive cluster can better retain the gas against the various forces which tend to sweep the gas from the cluster.

An older cluster like the Pleiades will lose its original gas owing to the pressure of the heated gas in the vicinity of the stars and to the motion of the cluster through the gas and magnetic fields of the interstellar medium. For example, the Pleiades moving at 5 km/sec will have travelled 300 pc in the lifetime of the cluster and it is unlikely that the cluster will still be imbedded in any of the gas with which it was originally associated.

A supplementary study was made of the distribution of neutral and ionized hydrogen in a strip across the thermal radio source Cygnus X. Excess neutral hydrogen was found in the position of four centres of ionized gas. In two cases the neutral hydrogen distribution was sufficiently resolved in angle to indicate that it was in the form of an expanding shell.

TABLE 1

GASEOUS MASS ASSOCIATED WITH CLUSTERS

Cluster	Type	Age (years)	HII Mass (solar masses)	HI Mass (solar masses)	Stellar Mass (solar masses)	$\frac{M\ \text{gas}}{M\ \text{stars}}$
Pleiades	B	6×10^7	—	10	900	0·011
NGC 1502	O	10^6	$<3\cdot2$	<6	~300	$<0\cdot03$
Trapezium-Orion	O	3×10^5	150	~50	$\sim2\times10^3$	0·10
NGC 2244	O	3×10^6	$1\cdot1\times10^4$	$3\cdot8\times10^3$	10^4	1·5
NGC 6910	O	3×10^6	~25	75	10^3	0·1

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Discussion

Tifft: NGC 6910 is in a very complex region. How certain can you be that the HI source seen is actually associated with the stellar group?

Davies: The neutral hydrogen was thought to be associated with NGC 6910 because it had the same radial velocity and the same position. This part of the sky is complex; in any case the gaseous mass given is an upper limit.

Kerr: How do the features that you attribute to the clusters compare in size with the background fluctuations?

Davies: The background variation in brightness temperature is $\pm2\,°$K and the effects observed are $5\,°$K. The angular size of the clusters was chosen to be less than the diameter of background variations.

Blaauw: In the case of the Trapezium cluster in Orion, we know that this is located in the Orion cloud complex, and the ratio you give depends very much on what one chooses for the gas volume.

Davies: These clusters form part of larger associations of stars and gas. The gas masses given here refer to material in the close vicinity of the cluster.

Bolton: You ought to get confirming evidence for the association of the HI and the cluster from absorption measurements. The reason I ask this is that I tried it some years ago for NGC 2244 and failed to get a positive answer.

Davies: The neutral gas associated with the bright Orion nebula source is seen in absorption but no measurements were made on the weaker Rosette nebula source.

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