LETTERS TO THE EDITOR

ASTROPHYSICS

Abundance Analysis of a Supergiant in the Large Magellanic Cloud

THE Magellanic Clouds are the nearest extragalactic systems and differ considerably in structure and stellar content from our own galaxy. The chemical compositions of individual objects in the clouds are consequently of great interest. So far some gaseous nebulæ have been examined by Aller and Faulkner[1] and found to differ but slightly from corresponding galactic nebulæ, but stars have so far been treated by rather general arguments and none has yet been analysed in detail.

Even the brightest stars in the clouds are normally beyond the reach of the Coudé spectrograph of Mount Stromlo Observatory. However, in the hope that a reasonably good spectrum of the brightest member of the Large Cloud, *HD* 33579 (α = 5 h 6·1 m, δ = 67° 57′, 1950·0, 9·4 mg), could be obtained in exceptionally good atmospheric conditions, an attempt to observe this star was made on December 24, 1963. In order to minimize light losses the slit-width of the spectrograph was increased to 400μ corresponding to a projected slit-width of 57μ, which is equal to double the average size of the photographic grain. The resulting loss in resolution is compensated by the high micro-turbulent velocity of 6·3 km/sec.

The attempt was successful and quite a good spectrum of 0·4 mm width and of 10·6 Å/mm dispersion was obtained on a baked Kodak II *aO* plate. The exposure time was 5 h. The useful range extends from 3700 Å to 4830 Å.

The effective temperature of *HD* 33579 is not well known. Six-colour photometry by G. E. Kron (private communication) shows that this star is at least 400 degrees cooler than the galactic supergiant α Cygni unless it is heavily reddened by interstellar absorption, which is unlikely. Assuming T_e = 9,170° for the effective temperature of α Cygni (H.-G. Groth[2]) we obtain 8,765° as the highest possible effective temperature of *HD* 33579. On the other hand, from a consideration of the energy distribution, bearing in mind the effects of electron scattering, it is unlikely that the effective temperature is less than 7,750°, even in the absence of reddening. Unfortunately it was not possible to determine the temperature more precisely.

In view of these difficulties a coarse analysis of the spectrum of *HD* 33579 was carried out using Wrubel's curve of growth for four different reciprocal temperatures $\theta = 5040/T$ = 0·575, 0·600, 0·625, 0·650. In all cases the electron pressure p_e was chosen to satisfy Saha's ionization equation for iron, the only element for which reliable line strengths could be found in two stages of ionization (FeI and FeII). From this, the continuous absorption coefficient (due to Thompson scattering by free electrons and bound-free neutral hydrogen transitions) was calculated. Abundances were determined for the three most important elements of the iron peak group, iron, chromium and titanium.

The *gf* values were taken from Corliss and Warner's[3] critical survey for neutral iron and from Corliss and Bozman's[4] monograph for ionized titanium and a few lines of neutral iron. Stellar values derived by Groth[2] in his analysis of α Cygni were used for ionized iron and chromium.

The results are shown in Table 1. They are normalized to the logarithm of the abundance of hydrogen log N(H) = 23·52 corresponding to Unsöld's mixture. Likely errors due to the uncertainties in curve of growth fitting are of the order of ± 0·15 in the logarithm.

Table 1

θ	0·575	0·600	0·625	0·650
T	8,765·0°	8,400·0°	8,064·0°	7,754·0°
log p_e	+0·44	0·00	−0·27	−0·42
log N(H)	23·52	23·52	23·52	23·52
log N(Fe)	18·64	18·63	18·61	18·59
log N(Cr)	16·80	16·80	16·79	16·72
log N(Ti)	16·31	16·33	16·13	16·08

As Table 1 shows, the abundances of three elements of the iron peak depend very little on the adopted temperature. This is due to the fact that the metals are predominantly in the singly ionized state and the variation in the continuous absorption coefficient is small.

In view of the fact that the results obtained in an analysis are affected by errors in *gf* values, it was deemed advantageous to repeat exactly the same procedure for the galactic supergiant α Cygni. The equivalent widths of spectral lines were taken from Groth's[2] publication. The results are shown in Table 2 together with Groth's results and Suess and Urey's[5] cosmic abundances, all normalized to log N(H) = 23·52.

Table 2

	α Cygni A.P.	Groth's analysis Coarse	Fine	Suess–Urey
θ	0·55	0·55		
T	9,163·0	9,163·0		
log p_e	+0·39	+0·76		
log N(H)	23·52	23·52	23·52	23·52
log N(Fe)	18·88	19·10	19·14	18·79
log N(Cr)	16·93	16·10		16·90
log N(Ti)	16·53	16·89	16·65	16·40

A comparison of results shows that Groth's abundances for iron and titanium are higher roughly by a factor of two. There is a large discrepancy for chromium in spite of the fact that Groth's stellar *gf* values were used for this element in my analysis.

Although two independent absolute analyses were made for *HD* 33579 and α Cygni, the adopted procedure and the *gf* values were exactly the same for both stars. The differences in the abundances derived for both stars should therefore be quite reliable. A comparison between Tables 1 and 2 shows that the metal content of the iron peak group is lower in *HD* 33579 by a factor not exceeding 2. In view of possible systematic differences in equivalent width measurement between the present investigation and that of Groth, one may conclude that the abundance ratio of the metals iron, chromium and titanium to hydrogen in *HD* 33579 differs from that in α Cygni by:

$$-\ 0{\cdot}2 \pm 0{\cdot}2$$

in the logarithm. This means that the rate of formation of stars and the closely related nucleogenesis may be slightly lower in the Large Magellanic Cloud than in our own galaxy.

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