depends upon the value of the partition function and of the transition probability of TiO. These values directly affect the numerical values of the abundances.

The above results indicate an oxygen abundance of the order of 100 times that of titanium.

Now, applying the numerical value of $\log N_{\mathrm{O}}$ which has been calculated from $\log N_{\mathrm{Zr}}$ we are able to derive the value of $\log N_{\mathrm{ZrO}}$. The value of $\log K_{\mathrm{ZrO}}$ is $\overline{12}\cdot47$, using a dissociation energy of 7·8 electron volts. Then the results show that from $\log N_{\mathrm{O}} = 20\cdot7$ we have $\log N_{\mathrm{ZrO}} = 20\cdot16$. This means that the abundance of ZrO is about four times less than that of TiO.

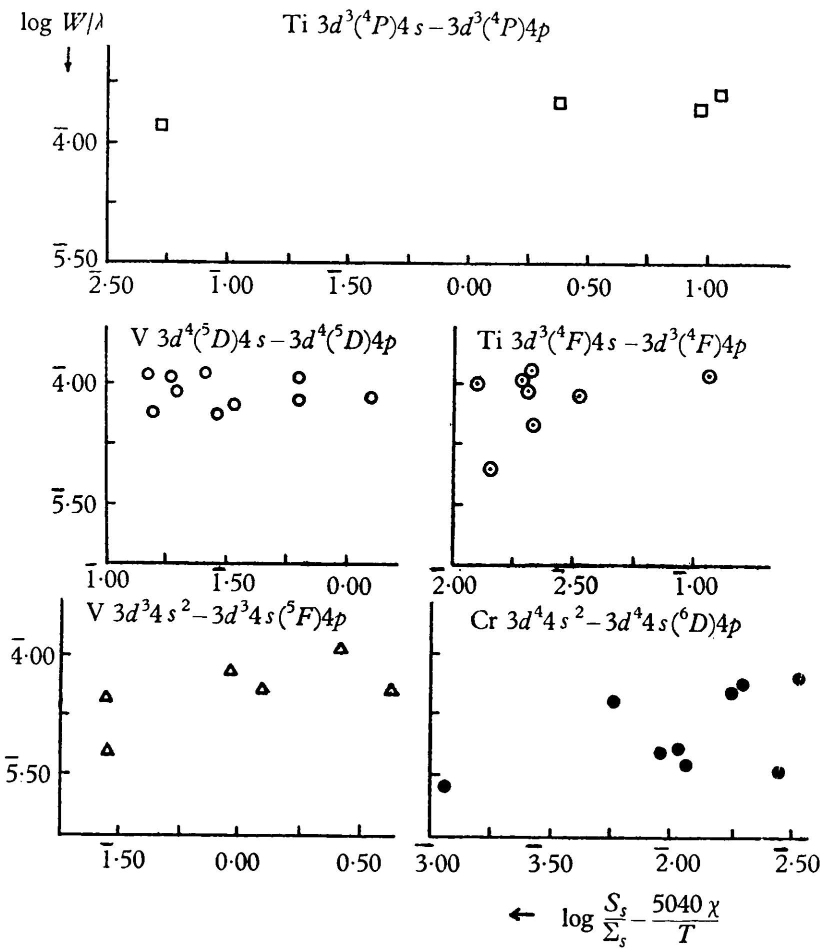

Fig. 4. Intensity plots for lines of Ti, V and Cr in the spectrum of χ Cygni (II).

17. TECHNETIUM IN S-TYPE STARS

By Paul W Merrill. (*Presented by* I. S. Bowen)

Element number 43, now called technetium, has had a curious history. As a hypothetical element, when the implications of the periodic table were first realized, it was called eka-manganese after its chemical homologue. In 1925 three German chemists announced its detection by means of lines in the X-ray spectrum, and gave it the name masurium; but their discovery has not been confirmed and is now considered erroneous, although their parallel discovery of rhenium, element number 75, was valid.

Element number 43 was identified in 1937 by Perrier and Segre in a piece of molybdenum that had been bombarded with neutrons in the cyclotron at Berkeley. It was named technetium because it was the first element to be prepared artificially. In 1939

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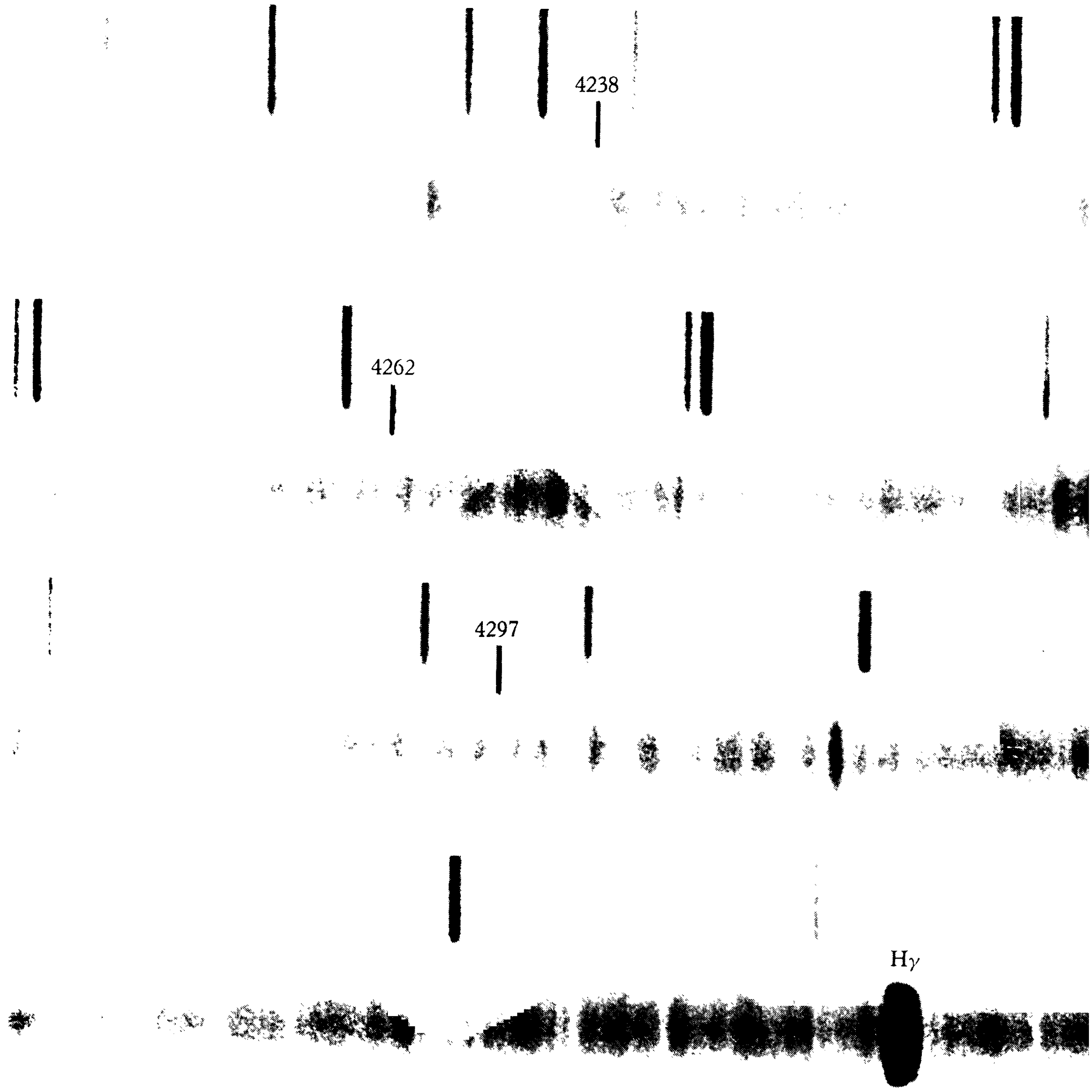

Fig. 1. Technetium in R Andromedae.

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it was detected among the products of fission of heavy atoms, and by 1948 several milligrams were available. No completely stable isotope is known; the most nearly stable has a half-life less than a million years. It is not known to occur in nature.

The spectrum was thoroughly investigated in 1950 by Meggers and Scribner at the Bureau of Standards. Their work has made astronomical investigations possible. In 1951 Charlotte E. Moore announced the possible presence of weak lines of ionized technetium in the solar spectrum.

The search for technetium in the crust of the Earth and in meteorites should be reopened now that the spectrum is available as a means of identification.

Several lines of neutral technetium have been found on spectrograms of the long-period red variable stars R Andromedae (Fig. 1), R Geminorum, and other S-type stars. The strongest of these lines (equivalent widths 0·2 to 0·4 A.) are in the $\lambda 4200$ region in the $a^6S - z^6P^\circ$ multiplet which is analogous to the well-known triplet at $\lambda 4030$ in the spectrum of manganese.

It is surprising to find an unstable element in the stars. Of several explanations none is compelling:

1. A stable isotope actually exists although not yet found on Earth. Many isotopes are known, all unstable. Physicists say the circumstantial evidence against the existence of a stable isotope is rather strong. Spectroscopic tests may soon give a still more positive answer.

2. The star somehow manufactures technetium as it goes along. One thinks of the possible bombardment of the star's atmosphere by cosmic rays. The rays would probably not be sufficiently intense unless generated in the star's outer atmosphere as they may possibly be in the solar atmosphere. Slow neutrons might come from inside but this too is unlikely. Also the parent material would become exhausted unless renewed by some cycle of transformation.

3. S-type stars represent a comparatively transient phase of stellar existence. This explanation would postulate the production or release of technetium in the star by some special event only a few million years ago. Perhaps this event started the cycle of light variation. S-type variables have extremely low densities and perhaps they are the youngest stars in the sky.

18. DIFFERENCES BETWEEN THE BAND SPECTRA OF M- AND S-TYPE STARS IN THE RED REGION

By PHILIP C. KEENAN. (*Presented by* J. W Swensson)

Wave-lengths measured on coudé spectrograms of three long-period variables near maximum light allow an extreme S-type star (R Gem) to be compared with two M-type stars (R Hya and R Leo) in the $\lambda\lambda 5600$–6500 region. The known bands of TiO, VO, and ScO, which are strong in this part of the spectra of the M stars, are too weak to be measured in R Gem. Conversely the bands of ZrO, which dominate the spectrum of R Gem, are extremely weak in the M stars. The only bands which are prominent in all three spectra are those of YO, and the intensity of the $\lambda 6132$ band of this molecule appears to be a sensitive means of interpolating between types M and S.

In R Gem a strong band which degrades to the red from a head at 5849·1 A. has not yet been assigned to a known source.

The bands Duner III near 5847 A. and Duner II near 6158 A., which are prominent only in the M-type spectra, have always been difficult to interpret. Although suspected of arising from TiO, they are anomalously weak in the spectrum of the titanium arc. The measurements of the present plates of R Hya and R Leo have permitted a vibrational analysis of these band groups. They, together with weaker sequences near 5600 A. and 6500 A., form a system which is identical with that which Coheur produced at Liège by exploding thin wires of titanium. From the vibrational constants, $\omega'e = 876{\cdot}6$ cm.$^{-1}$