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.$^{-1}$

and $\omega''e = 1006$ cm.$^{-1}$, and the triplet separations, it appears that *the new system must involve at least one* $^3\Pi$ *state of the normal* TiO *molecule*. It seems likely that the lower level of the transition is the known $X^3\Pi$ state, and that this is actually the ground state of the molecule. The upper level might be a singlet level (intercombination system) or a previously unobserved triplet level. The latter case is the more probable, and the weakness of the system in emission might be explained if the absorption took place to, say, a $^3\Sigma$ level situated above another $^3\Sigma$ level lying so low that the corresponding bands have wave-lengths too long to have been observed up to now.

The plates used in this investigation were taken with the 200-inch and 100-inch reflectors at the Mount Wilson and Palomar observatories and were made available by the kindness of Drs Bowen and Merrill. The work was supported in part from funds granted to the Ohio State University by the Research Foundation for aid in fundamental research.

19. SUR LA TEMPERATURE DES ETOILES R ET N

Par R. Bouigue

Des mesures spectrophotométriques effectuées aux Observatoires de Haute Provence et de Toulouse ont permis d'établir une relation entre l'intensité des raies D du sodium et la température de vibration déduite des quatre séquences suivantes: séquences +4 et +5 pour CN (syst. rouge) et séquences −1 et −2 pour C^2 (syst. de Swan). Ces deux quantités et la considération de l'intensité de la bande 6260 A. constituent trois critères de classification situés dans une zone spectrale relativement étroite (5400–6800 A.) et toujours observable, ces critères montrent que la classe des étoiles carbonnées se divise en trois sous-classes distinctes qui se raccordent aux environs de C 6.

20. THE VIOLET AND ULTRA-VIOLET REGIONS OF THE SPECTRA OF THE N-TYPE STARS

By P Swings, A. McKellar and K. N. Rao

Introduction

The violet and ultra-violet regions of the spectra of the cool carbon stars are notoriously difficult to photograph. This is so particularly for the late N-type stars with which the present paper deals. The spectra of R-type and early N-type stars can be photographed down to λ3500 by exposures several times as long as for M-type stars of comparable class. However, the later N-type spectra fall so rapidly in intensity from λ4400 and so even more extremely from λ4100 to shorter wave-lengths that the spectra of the brightest stars have not been recorded below λ3900.

The earlier investigators (e.g. Shane, 1920) were well aware that the extreme decrease in intensity toward the violet was much more than expected from a source at the temperature indicated for late N-type stars, but observations did not reveal the source of opacity. In 1947 Shajn and Struve photographed the spectrum of UU Aur (N 3) to about λ3900 and by comparing it with an M-type spectrum advanced reasons for supposing the source of extra opacity in the violet and ultra-violet to be at least partly molecular absorptions.

In 1948 McKellar described a survey of the spectra of several N-type stars in the λ4000 region, and noted that a well-marked group of absorption bands occurred in the spectrum of Y CVn. The strongest band was at λ4053, and the group was tentatively identified with the λ4050 group first produced in the laboratory by Herzberg and long known in emission in cometary spectra.

To digress for a moment on the subject of the λ4050 bands, when they were produced in the laboratory in 1942, there appeared good reasons for attributing them to CH_2.