THE RV TAURI VARIABLES

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RV Tauri stars are yellow supergiant variables with light curves that have alternating deep and shallow minima. The amplitudes of light variations are on the order of 1.5 to 2.5 magnitudes, with occasional rises that exceed these limits. The periods, defined as the interval between two deep minima are 50 to 100 days. Many show long period changes of 500 to 9000 days in their mean magnitudes (Kameny, 1956). The light curves do not repeat at each cycle. Occasionally there may be irregularities in the light curve, or absence of the scheduled minima, or an exchange of deep and shallow minima. It has been noticed that the maximum following a deep minimum is usually brighter than the preceding few maxima.

Variables of the RV Tauri type are divided into two groups based upon the mean brightness of their light curves:

RVa: Variables whose mean magnitude is essentially constant. Example: R Scuti.

RVb: Variables for which the mean brightness varies over a period of time. Examples: RV Tauri, SX Centauri.

These variables are of F, G, and K spectral types, and of luminosity Class I. The light variations are correlated with the spectra in that the spectrum is earliest at maximum, and latest at minimum, as is the case with many of the long period variables. The phase of spectral variations somewhat precedes that of the light variations.

One of the peculiarities in the spectra of some of these stars is the appearance of TiO absorption bands at deep minima, or even at both minima. This may be due to changes of temperature in their atmospheres. The spectra of many RV Tauri variables show bright lines of hydrogen that are usually shifted toward the violet at times of rise from minimum, and high dispersion spectra show that the strong metallic absorption lines are doubled at or near maximum. The radial velocities are of the order of 40 km/sec. with the radial velocity curve lagging slightly behind the light curve. Some of the variables (AC Her, U Mon, R Sct) with double lines show discontinuous velocity curves (Abt, 1953).

Preston et al. (1963) have divided the RV Tauri stars into three groups spectroscopically:

RVA: Variables of G and K spectral class with TiO bands at deep minima.

RVB: Variables with peculiar spectra, with hydrogen lines corresponding to F and G spectral classes, Ca II lines corresponding to earlier types, and with strong CN and CH bands at minimum.

RVC: Variables with spectra that resemble those of the RVB group but with the CN and CH lines either weak or absent.

The above classification is suggestive of an evolutionary trend.

However, no definite evidence has as yet been obtained to prove this point.

The known RV Tauri variables are distributed within a radius of 3000 parsecs of the sun. Being too distant, accurate parallaxes have not been determined. These variables are mostly concentrated toward the galactic center, with apparent groupings near Ophiuchus, Aquila, and Gemini, at galactic longitudes of 30°, 40°, and 180°, respectively (Kameny, 1956) and with suspected clumpings at 60° and 75° (Stothers, 1964). RV Tauri variables occur both as field stars and as members of globular clusters. At maximum they are the brightest members of the clusters and are located near the centers of the clusters. From the distances of the clusters in which they occur, their absolute visual magnitudes have been determined to be of the order of -5 to -4 (Kameny, 1956), thus making them intrinsically the brightest stars in the Galaxy. The masses of these variables are between 20 and 50 solar masses, and their radii are about 100 solar radii (Kameny, 1956).

Although cluster and field RV Tauri variables are basically alike, those in the clusters have shorter periods with amplitudes of about 2 magnitudes, while the others have larger amplitudes (Stothers, 1964). Also those in the clusters are slightly bluer (Kameny, 1956), and belong to the RVC group, with higher radial velocities than the field variables.

Kinematically these variables are not homogeneous. The RVA group resembles an intermediate disk population (Joy, 1952); the RVB group appears to be related to the disk; and the RVC group suggests a halo population (Stothers, 1964). Thus they seem to form an intermediate subsystem between the disk population (Population I) and the halo population (Population II) (Perepelkina, 1950).

Several pulsation theories have been proposed to explain the light and spectral variations, peculiarities, and radial velocity curves. Observations of Gehrz and Woolf (1970) show that these variables have the largest known infrared emission, which peaks at about 8.4 microns. It has been hypothesized that matter ejected by shock waves condenses and forms solids in a cool circumstellar shell of about 25 stellar radii. Serkowski's (1970) observations of large and variable polarization on some of these stars seem to present additional evidence of non-spherical oscillations and the presence of a dust shell around these stars. However, some characteristics, such as the alternating minima, uniform maxima, and certain "persistent regularities" (Wenzel, 1961, Preston et al., 1963) suggest the possibility of a binary hypothesis for these variables.

Although the RV Tauri stars are very luminous, only 105 of them are known in the Galaxy (Kukarkin et al., 1969-71), thus indicating that they are extremely scarce. Their infrequency might be attributed to the rarity of their physical structure, such as their very large mass, and to their critical evolution, where the narrow point of instability that they cross might be of very short duration. To help solve the mystery of why they are rare, further work to determine more and better light curves (particularly for long period variations), and more radial velocities are essential. More detailed spectroscopic studies at high dispersions are also needed.

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