# 3. ON RW AURIGAE TYPE STARS AND RELATED TYPES

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First of all it will be necessary to say a few words on terminology. Different names are now in use either for the same group of variables or for different variants of a rather heterogeneous class. Let me list the following:

| | |
|---|---|
| RW Aurigae stars, | Orion type variables, |
| RR Tauri stars, | Nova-like variables, |
| T Tauri stars, | Main sequence variables. |
| Nebular type variables, | |

The first three names, using the designation of a prototype star, have been formed in analogy to other classes of variables such as the Mira, Algol, RV Tauri, $\delta$ Cephei, and RR Lyrae stars. The name T Tauri stars, however, which was introduced by Joy, points to certain properties of the spectra and therefore does not include all objects which might be assigned to the class on the basis of photometric behaviour. Furthermore, T Tauri is photometrically not characteristic of the class. According to Ludendorff, the star is similar to R Coronae Borealis, the changes generally being rather slow. This conclusion is supported by the light curves given by Esch and Losinsky. At my request, Mr Ahnert has estimated T Tauri on all sky patrol and other plates available at the Sonneberg Observatory, and has found the variations from about 1930 up to the present time to be in agreement with the statements mentioned above, with one exception: in September 1934, the variable showed rapid changes of range about 0·6 magnitude. This fact indicates that T Tauri really belongs to the RW Aurigae class, but is far from being a typical member.

Before we can come to a decision as to the best designation, we must examine this class of variables as a whole.

(1) *Photometric properties.* A typical RW Aurigae star is a variable having rapid non-periodic changes whose range is from 1 to 4 magnitudes. The variations may be either continuous or interrupted by short or long intervals of practically constant light. Quasi-periodic fluctuations are not excluded, but are not an essential feature. This behaviour is typical of the



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class, but there are many variants that have small ranges, relatively slow variations, Algol-like minima occurring at irregular intervals, or behaviour reminiscent of the U Geminorum stars. T Tauri represents an extreme sub-type that generally has slow variations and that only rarely shows rapid changes. It can be seen that the light curves exhibit a large diversity.

(2) *Spectral properties.* In the 1948 *General Catalogue of Variable Stars*, there are 150 stars classified as of the RW Aurigae or Orion types, including those whose assignment of type is followed by a question mark. For no more than twenty-five of these stars is the spectral type given. The distribution is as follows.

| RW and RW? stars | | Ori and Ori? stars | |
|---|---|---|---|
| G0 to G5 | 11 | B2 | 1 |
| K5 | 1 | A0 to A2 | 3 |
| M | 1 | F0 to F5 | 2 |
| Pec | 1 | G5 | 1 |
| | | K | 4 |

On the basis of this distribution scheme, the typical RW Aurigae stars are seen to have a rather small range of spectral class; the typical spectral type is dG5e, in contrast to the Orion stars which have a large range in type. Beside these two groups, there is at least one other, represented by the emission-line variables in the Taurus clouds, the characteristic spectral type of which is dKe, thus indicating an association with the flare stars. But it seems that the distribution of energy in the continua of these stars is not that of a genuine dK-type star, for investigations by Goetz and Wenzel at Sonneberg Observatory and by Haro at the Tonantzintla Observatory reveal an excess of blue light. Probably emission lines are a typical feature of the RW Aurigae and Orion variables, but there is no narrow correlation with the type of light variation, because T Tauri has a typical RW Aurigae-like spectrum without being a typical variable of this type.

(3) *Relation to Interstellar Matter.* An outstanding feature is the association of RW Aurigae stars with bright or dark nebulae, well-known examples being T Tauri and R Monocerotis. On the other hand, there are equally typical members that have no appreciable relationship with nebular matter, as, for example, RW Aurigae. Statistically the situation is contradictory. In an investigation which I made some years ago, I found a good correlation of the locations of the bright RW Aurigae variables with interstellar clouds but a surprisingly poor correlation for the faint ones, especially in the Taurus cloud. (The dKe stars found later are not included in this remark.) The explanation seems to be the following: two distinct maxima of frequency with apparent magnitude are shown by variables of



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this region, and if one tentatively assumes an absolute magnitude of +5 for all the stars, then two groups at distances of about 80 and of about 400 parsecs are indicated. The members of the first group might be regarded as foreground stars projected on the clouds, while the second group is formed by distant stars visible in the windows between the clouds. This interpretation is not in favour of the existence of a uniform physical association. In my opinion the distribution over the sky of the isolated RW Aurigae variables found up to the present time is primarily a result of the method of search, and therefore is not suitable for the study of the spatial distribution on a large scale. But it must be emphasized that the existence of real associations of main sequence variables and their association with nebular matter is beyond doubt. Indeed they seem to be of a different kind than the pretended Taurus association. I would mention the Orion association, the group around S Monocerotis, the group in Corona Austrina, and the association of dKe-type stars in the western part of the Taurus clouds.

Scrutinizing these results, one gets the impression that the problem is a rather complicated one. There are at least three groups of stars whose relationship is probable although not immediately obvious:

(*a*) Genuine isolated RW Aurigae stars and members of closely related subtypes,

(*b*) variables in close association with nebulae,

(*c*) isolated stars whose relationship to Group (*a*) is rather highly probable.

It is very difficult to define the limits of this last group, for there are some rather heterogeneous objects that may have to be included, such as type Be variables like $\gamma$ Cassiopeiae, and stars like V Sagittae and EM Cygni that are now regarded as old novae. The situation is complicated the more since no clear separation is possible between the three groups. The first impression is that Groups (*a*) and (*b*) are, although related, nevertheless of a different kind. But entering into the details one finds in Group (*b*) genuine RW Aurigae stars as well as Orion variables that are isolated from nebulosity, and thus obviously belong to Group (*a*). In this connexion, SX Phoenicis may be mentioned. It is a variable with an extremely short period and strong variations of the light curve. It also seems to be a main sequence star, and not a normal cluster type variable. Further possible members are the novae of different types, and the U Geminorum stars and related variables, which in the Hertzsprung-Russell diagram have positions below the main sequence.

The most important problem to be solved is that of the separation and



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relationship of the different groups, especially the isolated RW Aurigae stars and the Orion type variables. The problem involves both their physical condition and their position in space. Are they objects of different properties and cosmic significance, or are they related in the same way as are the RR Lyrae stars in globular clusters and those in the general galactic space? It might be suggested that nebular regions may be the place where such stars develop and from which they originate, so that the isolated stars are to be regarded as emigrated objects. One of the means of separating the groups is the determination of spectral types and luminosity classes. A beginning has been made by the work of Herbig at Lick Observatory.

A general aspect of the problem in its present state is that the observational material is by far too limited. This is true not only for the spectroscopic information, as mentioned above, but also for the photometric data. Very much work is required in the future to provide better information on the light curves of this most complicated group of stars, where every individual seems to represent a sub-type of its own, and where only very long and condensed series of observations are able to reveal the details. During my recent stay in South-West Africa, I availed myself of the excellent climate of that country by observing some RW Aurigae stars of different sub-types, but only collaboration on a large scale can lead to complete success, even for a single star.

Returning to the question of terminology I make the following proposal: the general heading of *main sequence variables* includes all the objects mentioned in this report, and is in agreement with the classification scheme given by Schneller in *Geschichte und Literatur II*, **3**, p.v. The discrimination of sub-classes depends primarily upon photometric properties so long as spectral types are not available to a large extent. So we may follow the present usage of the *General Catalogue*, where the main classes are *Novae*, *U Geminorum stars*, and *RW Aurigae stars*. One small change might be proposed: all stars of related properties not showing the typical characteristics of the RW Aurigae class ought to be named *RW Aurigae-similar*, abbreviated RWs, without the introduction of further details. Only future work will show whether or not well-defined sub-types exist.



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