Intrinsic Variables, Supernovae and the Thermal Limit

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1 Introduction

According to the Reciprocal System, the main energy generation process in stars is by way of *thermal destruction* of the atoms of the elements in the stellar core.

> "…both the thermal energy of the matter in the star and its ionization energy are space displacements, and when the total of these space displacements reaches equality with one of the rotational time displacements of an atom, the opposite displacements neutralize each other, and the rotation reverts to the linear basis. In other words, both the ionization and a portion of the matter of the atoms are converted into kinetic energy. …
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> "…Inasmuch as the entire structure … is fluid, the heavy elements make their way to the center. As the temperature in the central regions rises, successively lighter elements reach their destructive limits and are converted to energy."[1]

2 The Destructive Limit

The destructive limit T_d, that is, the temperature at which the neutralization of one of the two-dimensional displacements of the atom takes place can be worked out as follows. A temperature T in Kelvin, when expressed in the natural units is given by

$$\frac{T}{T_{nat}} \tag{1}$$

where T_{nat} is the natural unit of temperature in the time-space region (that is, the three-dimensional spatial reference frame) expressed in the conventional units[2] as

$$T_{nat} = 7.20423 \times 10^{12} K \tag{2}$$

Since speed displacement is the deviation of the speed from the natural datum—the natural datum in the universe of motion being unity—the space displacement corresponding to a temperature T is

$$\left(\frac{T}{T_{nat}}\right) - 1 \tag{3}$$

This, therefore, is the space displacement available per each rotational unit of the atom when it is at a temperature of T° Kelvin. If the net number of rotational units (the atomic number) of the atom is Z, the total space displacement available due to the thermal energy is

1 Larson, Dewey B., *The Universe of Motion*, North Pacific Publishers, Portland, Oregon, U. S. A., 1984, pp. 41-42.
2 Larson, Dewey B., *Basic Properties of Matter*, ISUS, Inc., Salt Lake City, Utah, 1988, p. 59.

$$Z\left(\left(\frac{T}{T_{nat}}\right)-1\right) \tag{4}$$

The temperature of the atom is a linear (vibratory) motion in the time-space region, while the rotational motion that constitutes the atom is in the time region (inside unit space). The total number of equipossible orientations for a unit of linear motion in the time-space region is shown to be eight.[3] As such, the portion of the space displacement of the temperature that becomes effective in the time region is

$$\frac{Z\left(\left(\frac{T}{T_{nat}}\right)-1\right)}{8} \tag{5}$$

Thermal destruction of the atom implies the neutralization of one of its two-dimensional time displacement units, since the basic rotation constituting an atom is two-dimensional. The one-dimensional equivalent of a two-dimensional displacement of magnitude n being $2\times n^2$, where the atomic displacements are a-b-c,[4] the time displacement units need to be neutralized would be either $2\times(a-1)^2$ or $2\times b^2$. Thus, we have at the destructive limit T_d,

$$2n^2=\frac{Z\left(\left(\frac{T_d}{T_{nat}}\right)-1\right)}{8} \tag{6}$$

where n is the larger of (a-1) and b.

$$n=max((a-1),b) \tag{7}$$

$$T_d=7.20423\times10^{12}\left(1+\frac{16n^2}{Z}\right) \tag{8}$$

It must be pointed out, at this juncture, that though the space displacement of the electric ionization does add to that of the thermal motion in neutralizing a unit of the magnetic time displacement of the atom, its contribution is comparatively small—amounting to not more than a fraction of a percent of the temperature displacement. Hence, no appreciable error will be introduced by dropping the ionization displacement from consideration at the present stage.

In Figure 1 are shown plotted the values of the thermal destructive limit of the elements against Z. As can be seen, this temperature increases as the atomic number decreases. But the most conspicuous feature of the curve is that, instead of being monotonous, it dips at several locations where there is a change in the displacement of the atom in one of the magnetic dimensions. These dips, occurring respectively at Z = 70, 27 and 6 are of paramount significance in determining the course of the stellar evolution as we will presently see.

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3 K.V.K. Nehru, "The Inter-regional Ratio," *Reciprocity* XIV (2-3), Winter 1985/86, p. 5.

4 Larson, Dewey B., *Nothing But Motion*, North Pacific Publishers, Portland, Oregon, 1979, p. 132.

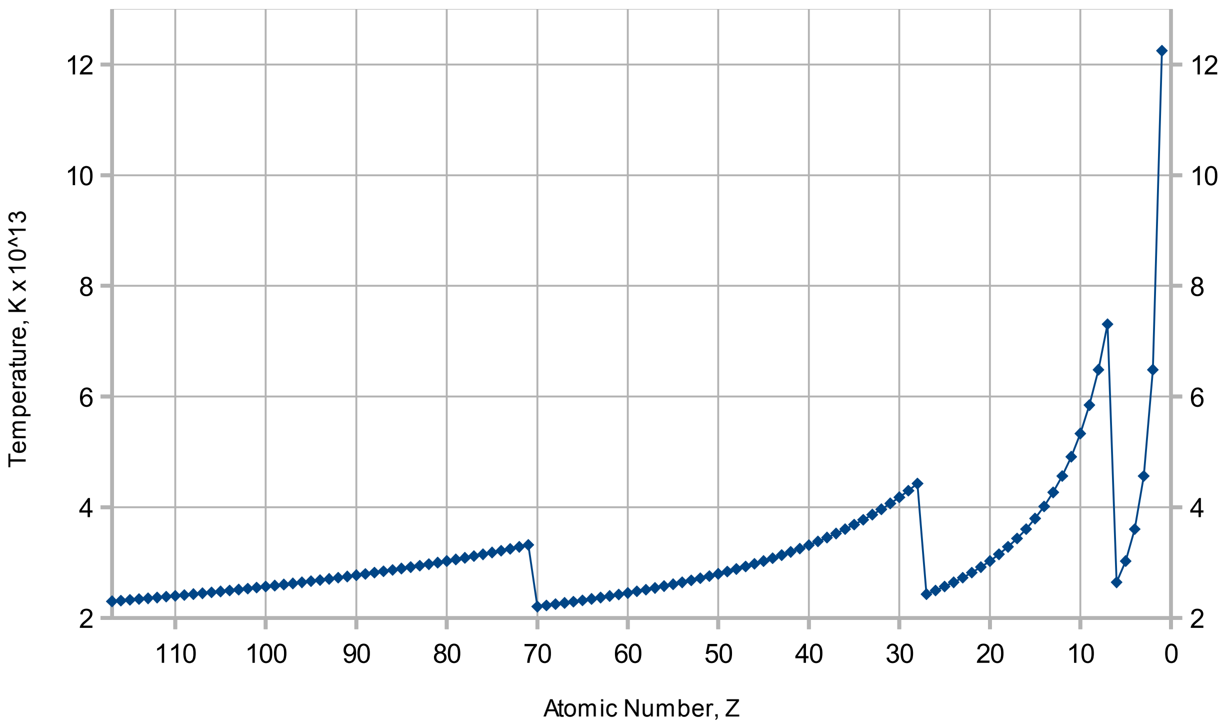

Figure 1: Destructive Limits of the Elements

3 The Intrinsic Variables

Under normal stellar conditions, where there is no severe large-scale turbulence, gravitational segregation of the elements according to their masses would take place, the heavier ones migrating toward the core. Taking this gravitational segregation into consideration, if we plot the thermal limit T_d of the material of the star at different radii we obtain a curve of the general nature shown in Figure 2. The distribution of the actual temperature T in the star at various radii is also shown plotted in the figure. We see at the center, P, that the temperature is the same as the destructive limit of the heaviest element present. As such, this element gets thermally neutralized to yield the energy output of the star. We shall refer to this process as the 'regular burning' in order to distinguish it from the 'secondary burning,' which we will presently explain.

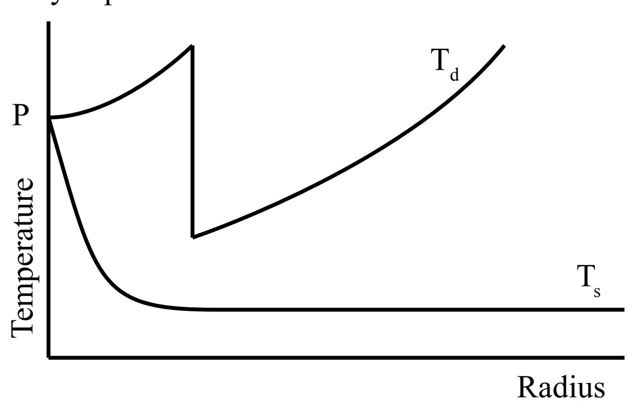

Figure 2: Regular Burning

As the element burning (that is, the thermal neutralization) continues, elements of lower Z (and with higher T_d) keep arriving at the center. At the same time the stellar temperature gradually keeps on rising so that each of these lower Z elements reaches the thermal limit successively at the center. Thus, the T_d versus radius curve goes on shifting horizontally to the left in the diagram, while the stellar temperature, T_s, versus radius curve gradually keeps on rising, signifying higher stellar temperatures, as evolution progresses. Eventually the group of elements with Z = 74 to 70 arrives near the center. The state of affairs is now as shown in Figure 3. It can be seen that the stellar temperature curve now begins to intersect the T_d curve at two points P and Q. Therefore we find that while principally elements 74 and 73 are burning at the center P, at a location Q slightly farther out, element 70 also arrives at its destructive limit. The consequent ignition of the element 70, however, upsets the prevenient equilibrium between the thermal and the gravitational forces, for three reasons.

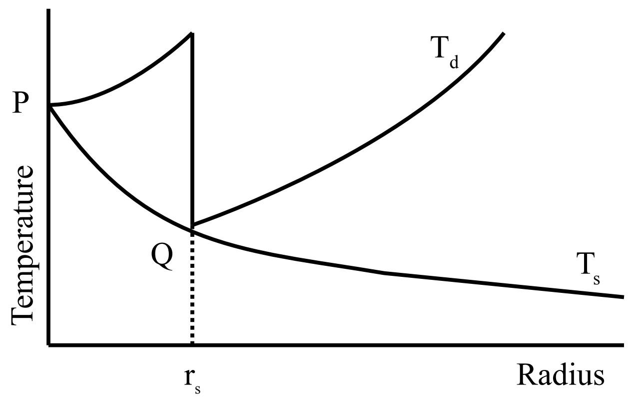

Figure 3: Onset of Secondary Burning

Firstly, the element 70 is relatively more plentiful compared to the elements of higher Z and thus a potentially larger energy source is switched on, and switched on suddenly, in addition to the existing source. This new source we shall refer to as the ‘secondary source.’ Secondly, this happens not quite at the center (where the regular source has been operating) but at a slightly larger radius r_s (see Figure 3), which we shall call the ‘secondary burning radius,’ where there was no energy generation previously. Thirdly, the extent of the spherical area at radius r_s, where the thermal limit of the secondary fuel is reached, is comparatively larger than that available to the regular fuel at the center, and in consequence the proportion of the secondary fuel that is ignited is very much more.

The additional energy thus released causes an expansion of the star. This drops the stellar temperature and acts as a negative feedback, shutting off the new energy source. Subsequent contraction repeats the cycle and we have the phenomenon of the *intrinsic variable*. In fact, the Cepheids could be identified as the stars burning elements around the Ytterbium-dip at Z = 70 (Figure 1).

Larson proposes,[5] in the context of the Reciprocal System, that in the regular course of the energy generation process, with elements of lower atomic numbers successively arriving at the center to be neutralized, the appearance of an element like Lead (Pb) with comparatively higher than normal abundance initiates the variability cycle. This might well be one of the causes of the variability and the long period variables seem to fall into this category. However, as the stellar mass (and consequently its temperature) increases, the ratio of the additional energy produced to the total stored energy decreases. As such, the variations become damped out and unobservable. In the case of the higher temperature stars, therefore, the principal cause for the variability could be attributed to the Yb-dip as explained in the foregoing.

5 Larson, Dewey B., *The Universe of Motion*, *op. cit.*, pp. 61-63.

The phenomenon of the intrinsic variable occurs whenever there is a cyclic upsurge in the energy production. This also happens when the central temperature of a gravitationally contracting aggregate first reaches the destructive limit of the heaviest element present there. In fact, Larson identifies this category of stars as the long period variables.[5]

4 The Main Sequence Stars

The phenomenon of the variable luminosity manifests only in case the accretion rate is high and the star follows the path AC shown in the Color-Magnitude diagram (Figure 6) in *Universe of Motion*.[6] The story of a main sequence star, with about the same surface temperature as that of the variable is somewhat different. This is primarily because when the stellar temperature arrives at the Yb-dip, the temperature gradients in the variable and the main sequence star are markedly different. In the variable, the Yb-dip occurs much farther from the core as compared with the main sequence star. As shown in Figure 4 (a) and (b) the temperature gradient in the core is much steeper in the main sequence star.

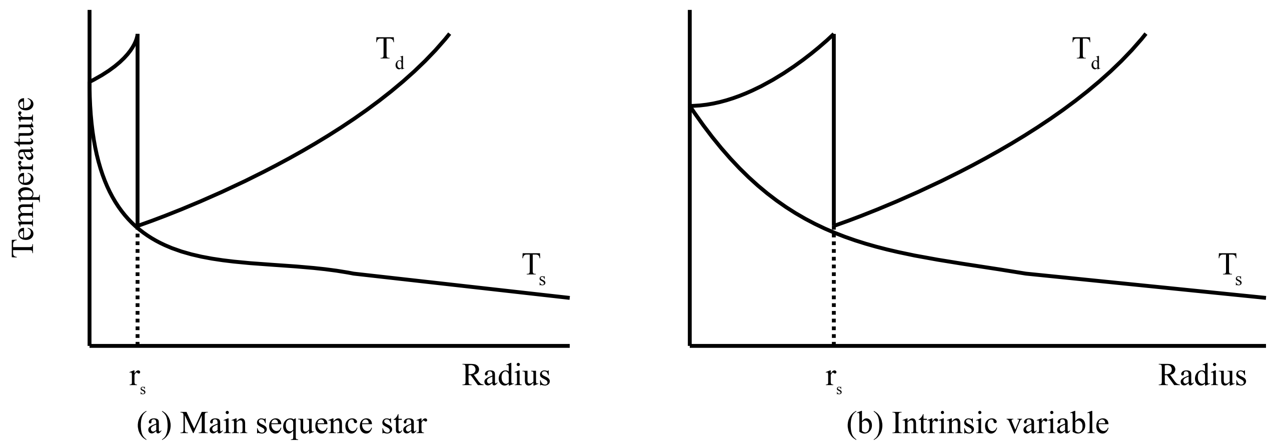

Figure 4: Effect of Temperature Gradient on the Dip

If dZ is the difference between the atomic number of the element currently burning at the center and that of the new arrival (the secondary source), the effect of the steep temperature gradient is to keep dZ to a small value (1 or 2). Therefore no marked difference in the magnitude of energy generation will result by the initiation of the secondary burning. Whatever little difference is there is successfully damped out by the larger heat capacity and the larger mass of the overlying material (in view of the smaller secondary burning radius r_s). Consequently the main sequence star of comparable surface temperature passes less conspicuously than the variable through this T_d dip. In the case of the variable the dZ is larger (4 or 5) (see Figure 4 (b)), which results in considerable amount of secondary energy production.

5 The Type I Supernova

As the element-burning continues and the Cobalt-dip (at Z = 27) arrives at the core while element 31 or 30 is burning at the center, a spectacularly different result ensues. Firstly, the secondary source triggered suddenly is proportionately very large—not just three or four times the regular, as in the case of the Yb-dip, but nearly a hundredfold bigger—owing to the much greater relative abundance of the Cobalt-group of elements. Secondly, because of the large size of the dip in T_d at Z = 27, the secondary

6 *Ibid.*, Figure 6, p. 64.

burning radius is appreciably large. As such, a large number of elements (with Z between 32 and 27), and in quantities more plentiful than the regular fuel now burning at the center, are present within the sphere of radius r_s, waiting to be ignited but for their higher destructive temperatures.

The initial spate of the secondary energy released by the onset of the thermal destruction of Cobalt at the radius r_s does two things on the one hand, it causes the expansion of the overlying material and results in a drop in the temperature, which thereby acts as a negative feedback switching off the Cobalt ignition. On the other hand, it compresses the material inside the radius r_s. This sudden implosion raises the temperature in the region sharply and brings all the high-T_d material within the radius r_s catastrophically to its destructive limit. Consequently, a pilot explosion takes place in the core, liberating considerably large quantities of energy—greater nearly by a magnitude or two than was being released hitherto—in a short interval. This acts as a positive feedback and retriggers the burning of the Cobalt-Iron group of materials at the radius r_s at a substantially high rate. This high rate of temperature rise raises the temperature of a large portion of the Cobalt-group well above its destructive limit, culminating in the supernova explosion before the negative feedback of the drop in temperature owing to the expansion of the outer layers has time to operate. In fact, if the star is quite large, a few outer luminosity pulsations may be apparent before the core explodes activating the final cataclysm of the Cobalt explosion.

As Larson points out,[7] the supernova explosion disperses the major portion of the Cobalt-group out into space before it had a chance to get destroyed in the event. Hence their cosmic abundance keeps on building up unlike that of the other elements of higher Z. The elements of Z = 28 through 30, which are inside the secondary burning radius, and are involved in the pilot explosion, also seem to share this good fortune to a limited degree by virtue of their higher destructive limits.

6 Conclusions

Highlighting the effect of the T_d dip on stellar evolution we summarize:

1. In the course of the regular burning in stellar core, the element that reaches the thermal limit next in the succession is that with dZ = 1 or 2. The effect of the dip is to activate a source with dZ = 4 or 5, with the concomitant larger difference between the relative abundances of the regular and the secondary energy sources. This is one of the causes of the variable luminosity.
2. The secondary energy source thus activated by the dip is an extra source, operating in addition to the regular source existing at the center.
3. The secondary source is located not at the center but at a larger radius called the secondary burning radius.
4. The long-period variables could be identified as the stars burning element Lead (Z = 82) at the center or the ones that just started their energy production by thermal neutralization while the Cepheids the ones passing the Ytterbium-dip (Z = 70).
5. The Type I supernova explosion is the result of the Cobalt-dip (Z = 27) reaching the stellar core.

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7 *Ibid.*, p. 50.