The H-R Diagram and the Life of a Star

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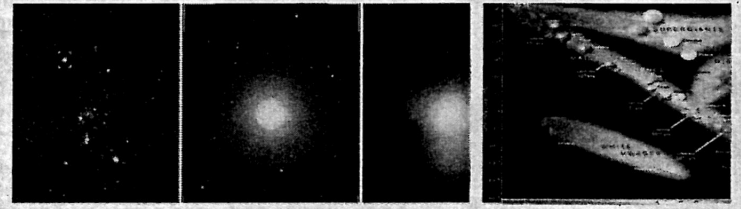

From left: Star Betelgeuse with a computer image; a typical H-R diagram.

Imagine an extraterrestrial (ET) visits the Earth and finds us humans as the dominant species. The ET wants to know how a human being is born, what is its growth pattern, how long it lives and finally, how does it die. There are two options to find the answers to these questions. The direct option is to identify one human being and follow its life-story from the maternity home to the morgue. This will take a long time, naturally and beyond telling in detail what happened to the identified being, it cannot give a general picture. That can be obtained from the second option, namely to look at a large group of humans and see what variety exists therein. For example, after examining all people, the ET will find some young ones, some middle aged adults and some senior citizens. Although not initially, but after a careful physical examination, the ET will be able to correlate external physical characteristics with the age of the humans being.

A similar situation exists vis-a-vis stars. When following the life cycle of a star, it is not a practical proposition to examine a single star all through its life. Rather, one should examine stars in a large group to check their physical characteristics. We would then find clues to how stars evolve. A very useful tool for this investigation is in the form of a diagram first drawn by two astronomers independently. The Hertzsprung-Russell diagram or simply the H-R diagram owes its origin to Ejnar Hertzprung and Henry Norris Russell. The basic idea was first used by Hertzprung in 1909 while Russell took it further in 1913.

What is the H-R diagram about? On a graph paper, it plots the surface temperature of the star on the horizontal axis while on the vertical axis, it plots its luminosity that is, the amount of radiation emitted by the star per second. The Sun's luminosity, for example, is nearly 400 billion, billion megawatts. The stars in a cluster will appear as points in the diagram. As seen in the figure, a large fraction of the stars are distributed in a band extending from the bottom right hand corner to the top left hand corner. The former stars are reddish in appearance while the latter are blue. In fact, physics of light tells us that the seven rainbow colours can be related to the ambient temperature, with blue stars being the hottest and red ones, the coolest. This band is called the main sequence. Our Sun appears on it approximately midway, corresponding to its yellowish appearance.

Some H-R diagrams have fewer stars on the main sequence and more on a spur emerging from it to the right. This spur is called the red giant branch, as the stars seen there are reddish and vastly inflated compared to the main sequence stars. Betelgeuse for example is a giant star with a radius 1,800 times that of the Sun. Further, as seen in the figure, there is a third category of stars the so-called white dwarfs with radii no more than a percent of the Sun's radius. These lie in a small band below the main sequence.

The H-R diagram carries a lot of information about star systems and by clever application of physics, we can understand why a particular star lies at a particular spot in the diagram. From there, it is another step to link these stages to a chronological sequence. Thus, we can argue that a star begins life on the main sequence and then moves on to the giant branch and then evolves further into states rather critically dependent on how massive the star is. The middle part of the last century led to a very good understanding of stars, starting with their position on the H-R diagram.

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Astrophysicist Jayant Narlikar and theoretical physicist Thanu Padmanabhan will contribute to DNA's special series through 2009, designated the International Year of Astronomy.

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