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1 Mar 2009

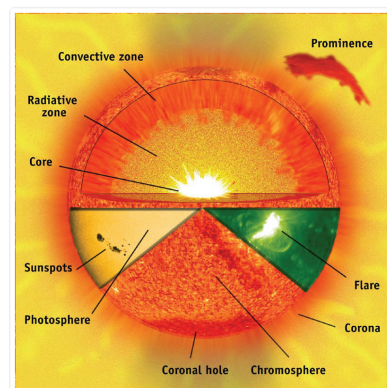
Wouldn't it be fascinating to know what it's actually like inside a star? After reading this you'll have an idea about the life of a star and how it shines. Why stars appear different colours is addressed, along with measuring stars' vibrations and techniques to "look into" our Sun and other stars. Astronomers don't have all the answers though, and this feature finishes with some questions that hopefully one day we will be able to crack!

The Ins and Outs of a Star

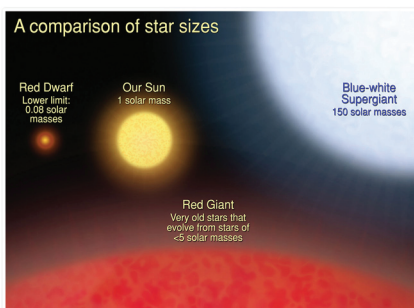
Wouldn't it be cool to know what it is like inside a star? Actually it is very hot in there, a few million degrees, and matter is in an interesting state. At these temperatures it is not solid, not liquid and not a gas, but a plasma: the fourth state of matter! In this article I will explain what we know about the inner structures and lives of stars, and how we can look "inside" them.

The evolution of a star has something in common with humans. A star is born, matures, ages and dies. It is not born from seeds or eggs, as we see for animals or people, but from a dust cloud. This cloud becomes denser and hotter over time, as gravity pulls all the dust particles together. At a certain point when this cloud is both dense and hot enough it becomes plasma and starts fusing hydrogen to helium. This produces a lot of energy and the star starts to shine.

Around the core, which is the engine of the star and where the fusion takes place, is a large atmosphere of gas. It consists of different layers, like our own planet's atmosphere, and in the different layers there can be greatly varying conditions. It can be very turbulent; a convective zone, or very calm; a radiative zone. This has an influence on the energy flowing from the core to the surface where we see it shining. These layers change over time, as the star gets older.



Our Sun is a more interesting place than many realise!
Image credit: SOHO (ESA & NASA).



We think of our Sun as being gigantic and it is, but compared so some other types of star, it's quite tiny!
Image credit: NASA, ESA and A. Feild (STScI).

Red hot!

The colour of a star depends on the temperature of its surface. When very hot it is white, and when slightly cooler it appears blue, yellow, orange and red. You can see a similar example of this yourself when you burn a candle. Close to the wick where it is hottest it is white and further outward the colours change from blue to yellow, orange and red.

Our Sun is a mature yellow star and it will remain like this for another four billion years. Sometime after, it will run out of hydrogen, its fuel. This will not be the end of our star, but it will require a new fuel source. This will be helium, the ashes of the first burning process. However, before it can use helium the core of the star must grow hotter still. So the core becomes even more heated and dense for the star's "second burning life", but the star is now old and this cannot continue. Our Sun will just die quietly when it has burned all its helium, but heavier stars die in explosions like fireworks!

Good vibrations

Now we know a little bit about a star's life, it is time to explain how we can look into a star. Actually it is done the same way that we look inside the Earth. For instance when there is an earthquake, the Earth shakes, but not all material inside the Earth responds in the same way, and due to this difference we can derive what type of material is present in a certain place. For example, you can hear the difference in material when you induce vibrations upon it by knocking on a wooden, metal or glass door. We use this same technique on stars.



The vibrations of the Sun, our closest star have been measured for many years now. This is done in two ways: by measuring tiny variations in the brightness of the star and by measuring the surface moving up and down.

You can probably imagine that it's possible to measure something getting brighter and dimmer, but recording the surface going up and down without standing on it? Well, we use the Doppler shift to measure this. Everyone notices the Doppler shift as an ambulance approaches. As it moves towards the listener they hear a higher tone, and once it moves away, a lower tone. Astronomers observe the "higher and lower tones" of light coming from a star, and in this way can measure the stellar surface going up and down.

Key questions

These measurements are the first very important step. Once aware of the periods between the different vibrations it's possible to derive the structure inside the star. Different vibrations might reflect at different depths within the star and can tell us what is happening in that layer. Other vibrations go even deeper, to the star's core and can tell us what it is like in there. So we may find answers to some of the following questions:



The frequency of waves from both an ambulance's siren and the Sun change depending on direction. This is the Doppler effect.

How large is the core exactly?

How large are the turbulent or quiet layers above the core?

Do these rotate in the same directions and with the same speed as the outside layers?

What happens at interfaces between different layers?

We have learnt much from our Sun, and we are using this new knowledge to make discoveries about other stars.



Stars come in a variety of colours, which tell us about their temperature. Blue-white stars, like Sirius shown in this artist's impression, are among the hottest.
Image credit: NASA, ESA and G. Bacon (STScI).

This feature article was written as part of the Cosmic Diary Cornerstone project for the International Year of Astronomy 2009. To find out more, check out www.cosmicdiary.org and www.astronomy2009.org.