



## Why is the night sky dark?

**The fact that it is dark at night tells us something about the universe, says S.Ananthanarayanan.**

The reason that it is so bright during the day is obviously that we are lit by the sun, which is only 8 light minutes away.

**The nearest star is far away**

In comparison, the nearest star, Proxima Centauris, is 4.3 light years away. There are 525,600 minutes in a year and 2,260,080 minutes in 4.3 years. That makes the nearest star 282,510 times more distant than the sun.

**What does it mean to be 282,510 times as far away? If the sun and the earth were a dot one millimeter in diameter, then Alpha Centauri would be a similar dot about 300 metres away.**

The intensity of light reduces according to the square of the distance. That is to say, an object that is twice as far away will appear not just half as bright, but will have only one fourth the brightness. Alpha Centauri is thus 7,981,100,100, or nearly 8 billion times less bright than the sun, when seen

from the earth. If there were a planet like the earth going around Alpha Centauri, our sun would also appear like a dim star to astronomers on that planet.

### **Should the night be brighter?**

For all the distance, there are so many stars that it can be argued that the night sky should be brighter. One way to explain why it is not is to say most the stars are many times more distant, and apart, than Alpha Centauri from the earth. But this fact alone is not a satisfactory explanation, because, if we consider such huge distances, there are also so many more stars that shine, albeit dimly, in such a large expanse. It can be worked out that if we take the universe to have infinite dimensions, then the total intensity of light reaching the earth would also be infinite!

Even without mathematics, we can imagine that if the universe were infinite, then in the space between any two stars, there would always be another star, and between any two such far away stars, there would again be another even farther-away star, and so on. The complete sky would thus be covered with stars, however dim, and 'night' would be so bright that the sun, during the day, may not make much of a difference! And if the night were bright like that, we would never see the stars!

### **The finite universe**

This was the reason that the notion of the universe being infinite was given up. Instead, it was construed that the farthest stars that we can see, around 15 billion light years, are at the edge of the universe. But then there is a question of why such a finite universe does not fall into itself, by gravity. Scientists have proposed a number of theories, including some that propose a form of matter that has repulsive gravity, unlike ordinary matter, which has normal gravity, which makes things attract.

Much clarity about the universe came from a method of finding out the speed of a distant star, by looking at the colours in the light it emitted. This method relies on the fact that the frequency of waves depends on the speed of the object that emits them. We may have all noticed that the whistle of a railway engine speeding towards us is *shrill*, but it changes to *deep* when the engine goes past and starts moving away from us. This is because sound waves get compressed and are of shorter wavelength when the source is coming towards us but get stretched and are of longer wavelength when the source is moving away. In the same way, when a star is speeding away from us, the characteristic colours that it emits get shifted to longer wavelengths, or to the 'red side'.

Another useful discovery was a way of estimating the distance a star by measuring the luminosity of nearby stars, of a variety called *variable stars*. It has been found that in stars like this, which have a regular cycle of waxing and waning, the time they take for a cycle is an indicator of their actual luminosity. Arriving at the real luminosity like this and then comparing with the brightness with which we actually see them provides a

measure of how far away the stars are. This is like knowing how loud a gunshot, or a bugle call, should sound and then estimating distance from how loud it actually sounds.

These 2 methods - of finding out the speed of a star and also its distance - led to startling discovery that the farthest stars are moving away at speeds that increase as they get further away! This suggested an 'expanding' universe. Expansion of the universe could offset the force of gravity that would otherwise draw the universe in. The idea has grown into the theory of the 'Big Bang' at the start of it all and is the dominant theory of the origin of the universe.

