5.0: Moving Through Time Introduction

It is often said that telescopes are time machines, showing us views of the Universe from earlier times as we study more distant objects. Yet the objects themselves also age.

Stars and galaxies are born, evolve and die, but with lifetimes that are so long, we can only study snapshots that (in almost all cases) seem unchanging. In this chapter, we examine several techniques for determining the ages and lifetimes of stars and then see how the Universe and its constituents evolve through cosmic time.

Video Transcript

The Life Cycle of Stars

Away out there in space there's huge clouds of dust and gas and if one of those clouds of dust and gas is massive enough, it's own gravity causes it to start to collapse so it folds in on itself towards the center of that cloud. t gets denser and denser and hotter and hotter and eventually, the particles of that the gas and the dust are made of are brought so close together that they start to stick together. They start to fuse. That's the energy source of a star. The star switches on and begins to shine. Inside every newborn star, hydrogen atoms are fused together to make helium. This process is called fusion, and it creates the energy of every star. What happens to a star during the rest of its life depends on how massive it is at its birth.

A star like the sun is in a delicate balance between gravity which wants to make the star collapse in on itself and the pressure that pushes outward that comes from the energy produced in these fusion reactions at its core. At some point in the future, the hydrogen runs out. At that point, the core of the star will start to collapse in on itself under its own weight it gets denser, it gets hotter until the point where you can actually start to use the helium atoms themselves as the fuel for the fusion pushing helium atoms together, making carbon and oxygen the next heavier elements on the periodic table. As the star begins to fuse helium, it creates more energy and that causes the outer layers of the star to expand.

One day, our sun will grow so large it will swallow up the inner planets of the solar system out as far as the Earth! It will become a red giant. For the sun, this will be the beginning of the end what happens is that the outer layers of the star get farther and farther from the middle. The force of gravity that they feel is getting weaker, and, actually, the star loses hold of its outer atmosphere. Its outer atmosphere drifts off out into space. It expands to become a planetary nebula. And they're some of the most beautiful objects in the universe. Once the outer layers have drifted away, all that is left of the star is its core. A white dwarf star is the dead, remnant core of a star like the sun at the end of its life It's something that might weight as much as 1/2 the mass of the Sun but it's only about the size of the Earth, so it's an incredibly dense object. It's dead, there's no nuclear fusion going on any more, it's incredibly hot but then over millions of years, it will gradually cool down to become a black dwarf.

Some stars, however, are much more massive than the sun and they lead very different lives. They are able to fuse heavier and heavier elements inside their core the star gets bigger and bigger some grow up to 1000 times the size of our sun until it has fused elements all the way up to iron and once we've formed an iron core, there's no more energy that can be got from fusion that core collapses the rest of the star starts to collapse in after it but then it bounces off. There's a huge shock wave. And in just a second: BANG! The outer parts of the star are blasted off in to space in a huge super-nova explosion! These super-nova

explosions are so powerful that when one of these stars explodes it can actually outshine the whole galaxy of which is part (a galaxy of maybe a 100,000 million stars).

For these super giant stars all that is left is a super dense core known as a neutron star an object that can have a mass greater than our sun but be less than 20 kilometers across but for the most massive stars of all we think, that when the core collapses the gravity is so strong, it becomes a black hole from which not even light can escape so stars are actually the places in the universe where the elements are created.

After the Big Bang, our universe contained only hydrogen and helium. All the other, heavier elements were therefore fused inside stars. The amazing thing is that virtually everything you see around you was made inside a star billions of years ago before the sun and planets were formed and when that star died and blasted its guts out into space that formed the raw materials from which our sun the planet earth and indeed ourselves were made and, ultimately, that's one of the major reasons I think understanding stars is crucial, because its actually telling us where we came from.
