Stars Assembly

I'd like to talk today about stars. For objects that are a very long way away, we know a surprising amount about other stars. We know their age, how fast they are travelling, what elements they are made of, where they are in their life cycle and even whether or not they have planets of their own.

For example, our own star is called the Sun. It is 4 ½ billion years old and is a fairly unremarkable example of a yellow dwarf star. The sun's core is quite hot: 15 million Celsius. It is orbited by eight planets (Pluto was down-graded in 2006), at least five dwarf planets, tens of thousands of asteroids and up to 3 trillion comets and icy bodies. This is all run-of-the-mill.

But when it comes to other suns, there have been some amazing breakthroughs in astrophysics in the last month. Scientists have used orbiting telescopes - the Hubble and the Spitzer Space Telescope - to gaze as far as we can into space. Because light takes time to travel through space, if we look at an object five light years away, we are seeing that object as it was five years ago. This means that when you look up at the night sky, you aren't seeing a single object – you are looking at a patchwork quilt of stars, each of which is shining with light sent from many different times in the past.

The universe you see when you look up at night came into being 13.8 billion years ago in the Big Bang. The idea of the Big Bang is literally beyond the human brain to grasp. Terry Pratchett, the writer, came closest to capturing its strangeness in his phrase, 'In the beginning there was nothing, then it exploded.' After an initial flash, in which all the matter of the universe was compressed into an unimaginably small space, the universe went through a period known as the cosmic dark ages. The latest information tells us that 250 to 350 million years after the Big Bang, the first stars emerged, bringing light to the cosmos.

Thanks to the latest research, we can now see those stars. If we train our telescopes about 13½ billion light years away, we can see the same distance back in time. The space telescopes capture a blurry image. It is a view from close to the beginning of the Universe. The blob is one of the first galaxies. We are actually seeing stars just 500 million years or so after the Big Bang. It is so distant that, even seen through the world's most powerful telescopes, it appears pixelated. Astronomers have worked out when these first stars began shining. They say that this period, known as the "cosmic dawn," occurred between 250 to 350 million years after the Big Bang.

As I said earlier, our own sun is pretty normal, and ignited nine billion years after those first stars. There is another star, relatively local at just 200 light year's distance, near the constellation Libra, that is much more extraordinary. We usually label stars with a boring numerical descriptor – in this case HD 140283. But this star has another, better, name: The Methuselah Star.

The first thing that makes the Methuselah Star standout is its speed. It is racing through what is now the Milky Way galaxy at speeds vastly greater than any other star. The incredible speed it has achieved can only be explained by one thing. This star does not come from our galaxy. It is a relic, a survivor from a dwarf galaxy that was swallowed up by the Milky Way in the very earliest years of our galaxy's life. That event took place 12 billion years ago. But the Methuselah Star is even older than that.

It is one of the oldest things we've ever observed. Early estimates of its age were in the ballpark of 16 billion years old. The most modern estimate of its age is 14 ½ billion years old, plus or minus about 800 million years. That's old. But there's an even bigger problem. We know, with a high degree of accuracy, how old the universe is. We know that the universe is 13.8billion years old, plus or minus 21million years. What! How could a star be older than the universe it is in?

That's how the star got its name – it is named for Methuselah, a biblical patriarch who is reported to have lived 969 years.

Does this mean that we've got the age of the universe wrong? No. We are confident we've got that right. Does this mean there was no Big Bang? No. We can see the remnants of that explosion everywhere in the night sky, as background radiation. Could the star have travelled from another universe? Not unless you believe in lunatic science fiction.

What the star is made of gives us a clue. Stars fall into different types, but they can all be grouped into three different populations of stars, crudely defined by the amount of metal in them. Our own Sun is a Population I star, with about 1% of heavier elements like carbon, iron and nickel.

The Methuselah Star is a Population II star, with considerably lower amounts of these elements. Population II stars were born from the ashes of the first stars, called Population III, which contained only hydrogen and helium.

The three distinct classes of stars began their lives in different eras of the universe. Shortly after the Big Bang, the universe was made up of hydrogen and helium. The ratio was about 92% hydrogen and 8% helium.

Population III stars began to shine very early on in the life of the universe. Physics tells us that they were huge and hot and they burned through their fuel in a cosmological blink of an eye, converting hydrogen and helium into heavier elements. These stellar monsters then exploded, mixing some of these heavier elements into the cosmos.

Population II stars formed a little later, but still very early in the history of the universe. Their original ingredients were still sparse in heavy elements, especially iron. Then these Population II stars went through the stellar life cycle and some exploded as supernovae. This spilled yet more heavier elements through the universe. The most common elements, like carbon and oxygen, are created in the cores of most stars, fused from lighter elements like hydrogen and helium. Heavier elements, like iron, are only formed in the most massive stars which end their lives in supernova explosions. Any element heavier than iron is only born in the extreme conditions of the supernova explosion itself.

So, our Sun and all the planets condensed out of gas clouds enriched with elements from the death throes of early Population II stars. You, the calcium in your bones and the iron in your blood are only possible because of the life cycles of distant stars, over billions of years.

So, how do we solve the problem of the age of the Methuselah Star? Let's go back to that uncertainty about dating the star and the universe itself. The star's age is somewhere between 15.26 billion and 13.66 billion years old. The age of the universe is between 13.821 billion and 13.779 billion.

So, the two ages can be compatible, within the margin of error. But it means that the Methuselah Star began to shine within a few 100 million years of the start of the universe.

There is no question that the Methuselah star is old – indeed it is the oldest star in the universe for which there is a fairly precise estimate of its age. It is a cosmic curiosity – a living fossil of the types of stars formed when the universe was still new.

And it reminds us where we all came from - drifting clouds of heavier elements, forged in the death explosions of great suns. In the Tempest, Shakespeare wrote: 'We are such stuff as dreams are made on, and our little life is rounded with a sleep.' A modern physicist might reply 'We are such stuff as stars are made on, and our little life is rounded with future suns.'

A final thought. All of these numbers seem vast. To creatures who would be lucky to live a hundred years, these time scales of billions of years is unimaginably daunting. But prepare to be daunted yet further. The age of the universe is just under 14 billion years. That seems like a long time. But cosmologists speculate that the universe will exist in the form that we know it for at least 100 trillion years. That means that so far we have only had 0.014% of the whole life of the universe. We are in fact at the very start of all things. From that perspective we are newborns, living in a newborn universe. Perhaps that's why we haven't found any aliens – perhaps we are the first.

In which case there's a pristine universe out there for our species to explore and we have a duty to set the tone for the various species who will come after us.