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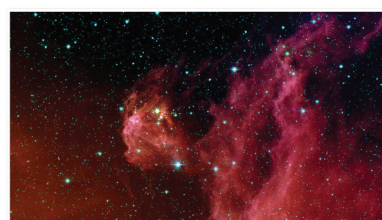
A researcher at the Spanish Space Agency, David has published over 80 scientific papers and has used many of the world's most powerful telescopes. He believes that outreach activities help the public understand how important science is.

Like humans and other animals, stars have a life cycle. But how are they “born”? Why do they form in the way that they do, and how does this influence their lives? How important is gravity, or what they are made of, or where they are created? Until relatively recently these were questions it seemed we had little hope of answering, but thanks to modern scientific technology and techniques, the secrets of stars can be revealed to all.

Why star formation?

When I was very young, not even 12, I watched a documentary. It really made an impact on me. Its name was “Michelangelo: The Last Giant”, by the well-known director Tom Priestley. Actually, I barely remember anything at all but it left a feeling which still today, almost thirty years later, remains with me. It made me wonder about the world, but also sparked a desire: I wanted to be like him, to do as many things as Michelangelo Buonarroti achieved.

Later I realised that I should keep my education as broad as possible, becoming a good professional in the area of my choosing but also learning about other fields. In any case, for my profession I never had any doubt: it would be astrophysics. Looking back, I believe I knew my work would be in stellar astronomy.



Barnard 30, a dark cloud located at 400 parsecs in Orion's Head.
Image credit: NASA/JPL-Caltech/D. Barrado y Navascués (LAEFF-INTA).

Galaxies caught my eye; cosmology my imagination. But... I felt some kind of closeness with the stars, perhaps induced by too much science-fiction. I wanted to navigate the stellar oceans, even if I only could with my mind. In the end this is just what I do: try to learn how stars are born, what their properties are and how they evolve.



A cartoon with the initial steps of the collapse and fragmentation of a molecular cloud.
Image credit: Department of Astronomy of the Cornell University.

Life cycles

Like humans and other animals, stars have a life cycle. They are born in large groups, cohorts which might include dozens, hundreds or even thousands of stars. In a sense they are like multiple twins. However, they might be very different to each other since the basic stellar property, mass, can vary. Some stars are similar to our own Sun, or even much bigger, as large as one hundred times as in the case of Eta Carinae, a stellar behemoth. But most stars are much less massive than the Sun, on average about half its mass. And it is this that basically defines its fate, its internal structure, its external properties, how long its life is going to be, and its end: grandiose in the case of very massive star, more humble for Sun-type stars. But even in this last case the end can be spectacular, since they produce beautiful planetary nebulae. As for the least massive stars, they are so spartan in the amount of energy they produce they are essentially eternal, since they will last billions or trillions of years.

This is because stars release energy which is primarily produced by nuclear reactions in their interior. During most of their life they fuse the simplest atomic element, hydrogen, into the second most basic, helium. But the rate of production depends essentially on the stellar mass: the bigger the star the larger the production, since the star needs to stop gravitational forces which push all the mass towards the centre. This is achieved by producing energy and heating the interior.



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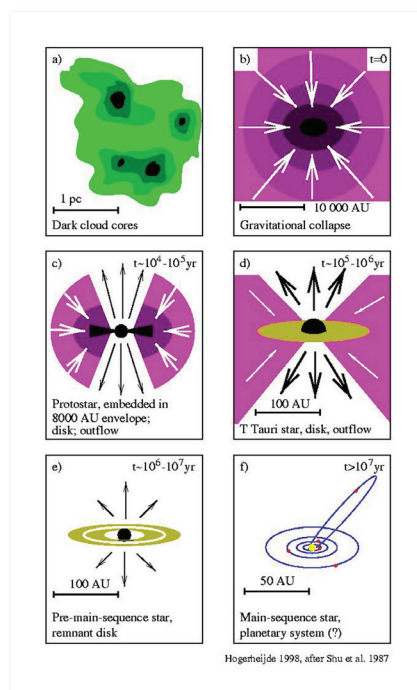
Burning questions

But then the questions remain: how stars are formed? Why do they have different masses? The answers are, at the same time, very easy and so complex that we do not completely understand all the details. However, we have a nice (albeit incomplete) picture about the process although but much research remains to be done.

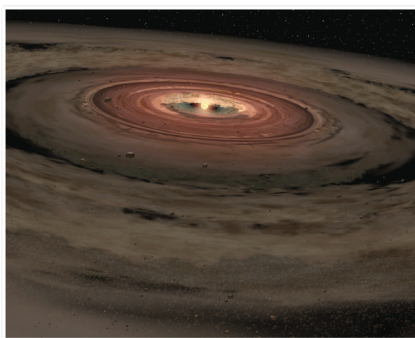
We know that new generations of stars are born in the huge molecular clouds randomly distributed across the Milky Way, our own galaxy. To be more specific, they are normally located close to its equator; the galactic plane. These clouds are made of very cold gas and dust. The density (amount of matter in a given volume) can be so low that if we could think of it as empty. But it is not.

Sometimes these clouds are affected by nearby events. It might be the gravitational interaction with another massive cloud just passing by. Or the disruption created by the spiral arms of the Galaxy. Or perhaps the shock generated by a nearby supernova. Whatever the reason, the cold cloud starts to collapse. The material becomes denser and hotter and breaks up its gigantic substructures, much larger than our own Solar System. The inner part is much hotter and denser than the rest but we cannot see it because the outer layers have become so opaque that visible light cannot cross it. We have a protostellar core, which eventually will evolve into a real star.

These cores will go on with their own collapse, converting part of gravitational energy into heat, as on a smaller scale we convert the potential energy of water in a dam into movement and electricity. Eventually they will become so hot and dense that the first nuclear reactions will take place in the interior. Some matter falls onto the star, but a fraction of it settles on a circumstellar disk. This also interacts with the central star, and beautiful and interesting phenomena can be produced out of these processes: powerful outflows of material; changes in the luminosity of the star; an evolution in the properties of the disk, which might eventually produce a planetary system...



Another cartoon, displaying different phases of the initial stellar evolution: from the collapse of the proto star to the creation of a planetary system, including the formation of a circumstellar disk and outflows.
Image credit: F. Hogerheijde.



This artist's concept shows a star surrounded by a swirling disk of planet-building circumstellar dust.
Image credit: NASA/JPL-Caltech/T. Pyle (SSC).

More to come

I will describe in this blog all the related phenomena, current discoveries, the techniques astrophysicist use and the implications in different contexts. I will also provide some historic and cultural perspective by talking about the past: about astronomy and science in general, but also about the human endeavour. Please, join me in this fascinating trip.

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.