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DIM STARS LAST LONGEST

Ken Tapping, 28th June, 2016

Stars are really interesting things. They provide heat and light, making life possible on our world, and probably other worlds too. In making that heat and light, they also produce as waste products the elements needed to make worlds and living creatures. That's how we got from a universe that was once almost entirely made up of hydrogen gas to the universe we live in and see around us today.

Even the most casual look at the night sky shows that some stars look a lot brighter than others. They are also different. Stars differ in apparent brightness because some are much closer to us than others, and also because some are intrinsically much brighter than others. We describe the total energy output from stars in terms of luminosity. We say the Sun has a luminosity of 1, so a star with a luminosity of 100 radiates 100 times as much energy as the Sun.

If we know the distance of a star and measure how bright it looks in the sky, we can calculate its luminosity. By carefully measuring its colour, we can estimate its temperature. Just knowing these two numbers for a star tells us a lot. In the early 20th Century, two astronomers: Danish astronomer Ejnar Hertzsprung and American astronomer Henry Norris Russell, working totally independently, plotted the luminosities of hundreds of stars against their temperatures. What they found was really intriguing. Most of the stars by far fell onto a band extending from the top left (bright, hot) of the diagram to the bottom right (dim, cool). That band is now known as the "Main Sequence.

Stars drop onto the Main Sequence soon after they are born, at a location depending on their mass, stay there for most of their lives, shining fairly steadily, and then move off it when they get old and start to run out of fuel. In human terms a star's life is something like growing up to age 25 in the first two or three years of life, and then aging slowly so that after 80 years of life your physical age is around 30, and then going downhill rapidly.

Stars shine because the weight of overlying material compresses and heats their cores to the point where nuclear fusion occurs. A high-mass star will have a more highly-compressed core, while the compression in a low mass star will be much less. The rate of energy production is extremely sensitive to this. A star with twice the mass of the Sun will produce energy at about 16 times the rate. The Sun will sit on the Main Sequence, providing us with a fairly steady supply of heat and light for roughly 8 billion years. A two solar mass star will only be able to do this for one billion years. If our Earth were orbiting such a star, things would have ended for the Earth while the most advanced living creatures were still single-celled things living in the sea. A ten solar mass star will radiate energy at roughly 10,000 times the rate the Sun does, and will be in trouble in less than ten million years. So there is really not much point in looking for complex life forms on planets orbiting stars two or more times the Sun's mass.

A star half the Sun's mass will spend eight times longer on the Main Sequence than the Sun does, giving lots of time for life to appear on its planets. Even less massive, red dwarf stars are so stingy with their energy production they might last as long as the universe. Dim stars last longest.

For any star there is a "Goldilocks Zone": the range of distances where planets would have the right temperatures for life. For a dim star, that zone lies close to the star and is narrow, reducing the chance of planets being in it. For bright stars the zone is more distant and broader. Stars like the Sun are a compromise between long life and a Goldilocks Zone big enough to contain planets.

Jupiter is descending in the west, and Mars and Saturn lie in the southern sky. Mars is the bright one; Saturn is fainter and to Mars' left. The Moon will be New on the 4th.

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