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EVAPORATING STARS

Ken Tapping, 8th November, 2016

The Sun is evaporating. Material from its surface is constantly flowing off into space at hundreds or even thousands of kilometres a second. We call this the “solar wind”. Sometimes the wind is a “breeze”, sometimes it is a gale, and sometimes dense blobs of solar material come at us at even higher speeds – solar storms. This is not unique to the Sun, all stars do it: some more, some less.

Stars are balls of very hot gas with nuclear fusion producing energy deep inside. The form of a star is the result of a delicate balance between two forces: the radiation flowing outwards and trying to push the star apart, and its gravity, pulling inwards and holding the star together. If the radiation starts to win, the star swells, the pressure in the middle reduces, and the fusion process slows, producing less energy, and the star shrinks again. If the energy production slackens off, the outward pressure drops, gravity takes over and compresses the core, causing fusion reactor to increase output. This feedback process works really well for most stars, like the Sun, stabilizing the star for billions of years. In some stars the process oscillates, making the stars pulsate.

However the situation is complicated by the presence of another important ingredient, magnetic fields. All stars pick up some magnetism in the material from which they form. This acts as a “seed” for a dynamo inside the star, driven by flows of very hot material. Huge electric currents are generated, which in turn give rise to intense magnetic fields. Telescopes designed to observe the Sun (Don’t try this yourself unless you have both the knowledge and the right equipment. You can irreparably damage your eyes, even in a fraction of a second) show the Sun’s surface to resemble a pile carpet with lots of fibres and loops. Magnetic fields give stars this complex structure. Otherwise they would look exactly as we would expect a ball of hot gas to look – like a fuzzy blob.

Around the “surface” of the Sun the density of material drops and the temperature rockets from several thousand degrees to over a million degrees. The pressure is such that gravity cannot hold this hot material back, and it flows off into space as a wind. In stars like the Sun, the rate at which material is lost into the wind is tiny.

However, things can change, dramatically. As a star ages, its core gets filled with waste products from nuclear fusion. Energy production happens on the surface of this lump of nuclear waste. The zone of energy production is bigger than it was and not as deeply buried in the star, and the increased radiation pressure pushes the star’s material outwards, making the star swell into a red giant star. This will happen to the Sun in 2 or 3 billion years. The Earth might end up inside!

With the star so much bigger, the material extends out to where gravity is too weak to hold it back, and the rate at which material is lost into the wind goes up hugely. Hiccups in energy production can happen in ageing stars. These can provide enough kick for great chunks of the outermost material to get blown off in great sneezes. Radiation from the star may make this material glow. These glowing clouds were first spotted by 18th Century astronomers. Through their small telescopes they looked like little glowing discs, rather like planets, which got them called “planetary nebulae”.

More modern telescopes, such as the Hubble Space Telescope, reveal planetary nebulae to be among the most beautiful things in the sky. They can look like flowers, rings, helices, a lemon slice, a cat’s eye, a butterfly, or other things, glowing in different colours. We’re not in any hurry to see what sort of planetary nebula the Sun will produce.

Venus is very low in the sunset glow. Mars is low in the south in the evening. Jupiter shines in the southeast before dawn. The Moon will reach First Quarter on the 7th.

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