Iron

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IRON

Ken Tapping, 10th May, 2016

When we look at something made out of iron, such as a nail, we are looking at something that played a role in the death of a star. Moreover, the iron helped trigger the catastrophe by being stable.

There are two ways we can make energy using atoms. We can take large, marginally-stable atoms like uranium, which contain a lot of energy, and prod them into breaking up into smaller atoms containing less energy. The excess energy is emitted and is available for us to use. This process is called nuclear fission. It is used in nuclear power plants. The other way starts with the smallest atoms, like hydrogen. If we compress and heat these atoms, they will combine to form larger atoms, which contain less energy. As before, the excess energy is emitted. This process is called nuclear fusion. Since light elements are far more common than heavy ones, we would really like to use fusion for energy production, but as yet have not managed to make a fusion power station that makes more energy than it uses to operate.

If large atoms can lose energy to make more stable, smaller atoms, and small atoms can lose energy by combining to make larger ones, then somewhere in the middle must be atoms that are low energy, and don't want to break up or combine. This makes them extremely stable and unusable as sources of energy. These atoms are those of iron and its immediate relatives. This makes iron important in the death of stars.

Stars form from the collapse of cosmic gas clouds, which are mainly made up of hydrogen. As the hydrogen in the core of the embryo star gets increasingly compressed by the weight of the overlying material, it gets hotter. When it reaches a temperature of between 10 and 20 million degrees, nuclear fusion starts, with hydrogen atoms combining to make helium. Eventually, when the star starts to run out of hydrogen, the core collapses a bit, gets hotter and helium atoms start to combine to make heavier atoms, like carbon and nitrogen. Then, as time passes, the star resorts to fusing heavier and heavier atoms. However, each step releases less energy. Helium fusion releases far less energy than hydrogen fusion, so when we get to elements like phosphorus or silicon, the energy yields are lower still, meaning the energy crises turn up more and more frequently, eventually on a daily basis. The situation is exacerbated by the loss of energy due to neutrinos, which radiate off into space. As the temperature in the core rises, the rate at which these particles steal the star's energy increases rapidly. The last energy source, silicon, lasts about a day; the eventual end product is iron.

Iron is the most stable element, and will not yield energy by fission of fusion. The star has now exhausted all sources of energy and in in desperate straits. With no energy source, it starts to collapse, the core temperature rockets, leading to even higher energy losses due to neutrinos.

The pressure holding up the star's material vanishes, and the star collapses. The infalling material can reach a good fraction of the speed of light. The crunch of material in the centre of the star releases a lot of energy, driving many different nuclear fusion reactions that absorb energy. It is at this point that elements heavier than iron, such as copper, gold, silver, platinum, lead and uranium are produced. The collapsing material rebounds and is thrown off into space at high speed, in one of the biggest explosions known to occur in the universe. The new elements, together with all the other products of the star's energy production, including iron, become mixed with the clouds of cosmic gas and dust, and become available for making new stars, planets, and nails.

Jupiter is high in the south after sunset. Mars and Saturn, rise around 11pm. Mars is the brighter of the two and will be at its closest to Earth on the 30th. The Moon will reach First Quarter on the 13th.

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