Iron

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IRON

Ken Tapping, 10th October, 2017

Iron is important stuff. Our way of life depends on it. It is involved in some way in almost everything we make, and it is a key element in our body chemistry. Actually it is even more important than that. The fact our planet exists and that the materials of life are out there in the interstellar gas and dust clouds are all thanks to the nature of iron.

As far as we have been able to deduce, no iron existed at the beginning of the universe, and the Big Bang never made any. All the iron around us and in our bodies was produced in the cores of ageing stars. Paradoxically, if it were not for the extraordinary stability of iron atoms, they, along with all the other elements needed for making planets and living things, might have remained locked away inside stars – unavailable.

The nuclear power stations currently in use employ nuclear fission – breaking big atoms into smaller ones – to produce energy. We mine rare, unstable atoms such as uranium, and exploit that instability, encouraging them to break into smaller, more stable atoms. Stars work the other way. They form from the collapse of huge cosmic clouds of mainly hydrogen. This is the very simplest atom, consisting of one proton and one electron, compared with uranium's 92 electrons, 92 protons and 143 neutrons. The hydrogen in stars' cores is compressed and heated by the weight of the overlying material, until nuclear fusion starts. In this process, four atoms of hydrogen (4 protons and 4 electrons) coalesce into one atom of helium (2 electrons, 2 protons and 2 neutrons). Two protons from the hydrogen are converted into neutrons and everything left over is radiated as energy, making the star shine.

When a star starts to run out of hydrogen in its core, it shrinks a bit, causing the pressure and temperature to go up until the helium starts to fuse into larger atoms, such as carbon, nitrogen and oxygen. If a star is large enough to achieve sufficiently high pressures and temperatures in its core, it can go on, fusing lighter elements into heavier ones. However, this is a process of diminishing returns. Each additional fusion process yields less energy. With less energy release potential, these atoms are more stable. A handful of soil, with little energy release potential, is highly stable. A handful of gunpowder, with a large energy release potential is far less stable.

If from the hydrogen end, increasingly large atoms are more stable, and from the uranium end, smaller atoms are more stable, there should be an element in the middle whose atoms are the most stable. That atom is iron. Making bigger or smaller atoms out of iron atoms requires energy.

This means trouble for stars. During their lives they have been obtaining energy by fusing smaller atoms into larger ones, until the waste product is iron. At this point energy production stops. The core cools, the pressure drops and the star starts to shrink. This sends the pressure and temperature up again, but the iron is unaffected. As the temperature rises, an increasing flood of particles known as neutrinos is produced, sucking more energy out of the core. The shrinkage continues and the temperature eventually rises to the point where the iron becomes unstable, turning back into helium and lighter elements, and sucking out all the energy produced by fusing them into iron. This dramatically cools the star's core, removing the pressure holding up the star's outer layers. They collapse, generating a nuclear explosion that blows the star apart. The explosion provides the energy to make those elements with larger atoms than iron. All this stuff is ejected into space, where it becomes available for making planets and people….thanks to the stability of iron.

Saturn lies low in the southwest. Brilliant Venus lies close to Mars in the dawn glow. The Moon will reach Last Quarter on the 12th.

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