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Publisher's version / Version de l'éditeur:
https://doi.org/10.4224/23000142
Skygazing: Astronomy through the seasons, 2014-03-04

GRAVITY'S OTHER ROLE

Ken Tapping, 4th March, 2014

All of us must have seen building sites covered with a metre or more of soil or rubble, and then left for a year or more. One reason this is done is to use the weight of that material to squeeze down and consolidate the ground underneath. This illustrates the “other” important role played by gravity in the universe. In addition to keeping everything orbiting in the right place, it holds everything together and makes building things like stars possible. Without gravity there would be no stars, no light, and no planets to depend on them.

Planets and stars are huge spheres of material, held together by the particles in them attracting all the other particles. The weight of the overlying material compresses the material in their cores. In the case of our Earth, the pressure makes the Earth's inner core behave like a solid; in the outer core the pressure is less, and the material is molten. Gravity has an even more important role in stars. As in the case of planets, gravity holds them together, but in addition, it makes stars shine.

Around a century ago, scientists realized that the largest concentrations of energy lie in atoms, and even more, in the particles from which they are made. One way to access that energy continues to be to find large, unstable atoms like uranium and plutonium, and put them in an environment where they are even more unstable, so that they come apart, producing heat, radiation and assorted radioactive waste products. We depend upon this process, known as nuclear fission, operated under controlled conditions, to produce electricity.

Another process is to encourage small atoms, like hydrogen, to combine into bigger atoms, liberating energy at the same time. We call this process “nuclear fusion”. The problem is that to make this happen requires making that hydrogen very hot and intensely compressied. Here on Earth we have managed to make this work in a completely uncontrolled fashion, in bombs, but we have still not found a way to do this continuously under control, in power stations. However, stars do this very well, using the compression method we see in action on building sites. Mother Nature just piles a lot of material on top and lets gravity do the work.

A star forms by lots of cosmic material, mainly hydrogen, collapsing together under its own gravity. The impacts and compression make the core very hot and dense. Eventually it gets hot enough for nuclear fusion to start. The tendency for the core to be blown apart by this release of energy is stopped by the sheer weight of the overlying material. Moreover, the process is self regulating. If energy output falls, the star collapses a bit, increasing the compression and temperature, making the energy output rise again. On the other hand, if energy output rises, the increasing pressure in the core makes the star expand, cooling it and relieving the pressure, making the energy output fall. In stars like the Sun, the process works very precisely, so that its energy output is so constant we need very precise instruments to measure any changes.

This is not the case for all stars. Some ageing stars have their output vary irregularly over periods of years. Some other giant stars oscillate in brightness by 50% or more over days or so. It turns out the time taken for some types of these stars to complete an energy variation cycle is directly related to their energy output. That means we can estimate how intrinsically bright these stars are, measure how bright they look and calculate how far away they are. Known as Cepheid variables, after delta cephei, the first star of this type to be discovered, these stars have become of crucial importance in measuring cosmic distances.

Jupiter dominates the southern sky overnight. Mars rises about 10pm, and Saturn at midnight. Venus rises around 5am. On 8 March, the Moon reaches First Quarter, and also reaches its highest point in the sky.

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