



NRC Publications Archive Archives des publications du CNRC

How do stars work?

Tapping, Ken

This publication could be one of several versions: author's original, accepted manuscript or the publisher's version. / La version de cette publication peut être l'une des suivantes : la version prépublication de l'auteur, la version acceptée du manuscrit ou la version de l'éditeur.

For the publisher's version, please access the DOI link below. / Pour consulter la version de l'éditeur, utilisez le lien DOI ci-dessous.

Publisher's version / Version de l'éditeur:

<https://doi.org/10.4224/23000217>

Skygazing: Astronomy through the seasons, 2015-02-03

NRC Publications Record / Notice d'Archives des publications de CNRC:

<https://nrc-publications.canada.ca/eng/view/object/?id=ae4972b4-8cdd-477c-ac86-f75a457cdef3>

<https://publications-cnrc.canada.ca/fra/voir/objet/?id=ae4972b4-8cdd-477c-ac86-f75a457cdef3>

Access and use of this website and the material on it are subject to the Terms and Conditions set forth at

<https://nrc-publications.canada.ca/eng/copyright>

READ THESE TERMS AND CONDITIONS CAREFULLY BEFORE USING THIS WEBSITE.

L'accès à ce site Web et l'utilisation de son contenu sont assujettis aux conditions présentées dans le site

<https://publications-cnrc.canada.ca/fra/droits>

LISEZ CES CONDITIONS ATTENTIVEMENT AVANT D'UTILISER CE SITE WEB.

Questions? Contact the NRC Publications Archive team at

PublicationsArchive-ArchivesPublications@nrc-cnrc.gc.ca. If you wish to email the authors directly, please see the first page of the publication for their contact information.

Vous avez des questions? Nous pouvons vous aider. Pour communiquer directement avec un auteur, consultez la première page de la revue dans laquelle son article a été publié afin de trouver ses coordonnées. Si vous n'arrivez pas à les repérer, communiquez avec nous à PublicationsArchive-ArchivesPublications@nrc-cnrc.gc.ca.



HOW DO STARS WORK?

Ken Tapping, 3rd February, 2015

If you hold a square metre of black card so that it faces the Sun on a very clear day, you will catch about 1.4 kilowatts of energy. The Earth orbits the Sun at a distance of 150 million kilometres. The Sun radiates energy in all directions, and if we imagine the Sun to be surrounded by a sphere of black card with a radius of 150 million kilometres, with each square metre catching 1.4 kilowatts, we can calculate the Sun's total energy output. It is a staggering 3 with twenty three zeroes after it kilowatts. In addition, since life appeared on our planet about 3.5 billion years ago, we can assume the Sun's energy output must have been maintained at least that long and cannot have hugely changed between then and now.

Until the 20th Century we did not know much about the potential of nuclear energy, so scientists were really puzzled about where the Sun gets its energy from. The Sun is about 1.5 million kilometres in diameter. If we had a big ball of coal that size, and assuming there is oxygen out there so that it could burn, it would go out after a million years or so. Obviously coal is not the answer, and burning any other fossil fuel would not make that big a difference. Another suggestion came from the knowledge that compressing a gas makes it hot. So could the Sun's energy come from its gradual shrinkage under its own gravity?

When a star forms from the collapse of a gas and dust cloud, it does initially get very hot from the energy released by additional material dropping on it, and with the increasing compression as the amount of overlying material grows. However, mature stars do not have material falling on them; they are usually ejecting material as stellar winds – the solar wind in the case of the Sun. Subsequent shrinkage will not provide heat for very long, only about ten million years. It took nuclear science to provide the answer. Stars like the Sun are powered by nuclear fusion: the combination of lighter atoms like hydrogen into heavier ones.

We have been experimenting with nuclear fusion for years. If we could crack this problem we would no longer have problems with energy supplies. However, compressing ionized hydrogen or deuterium in a laboratory device is very difficult. Controlling the material is orders of magnitude harder than finding and grabbing a bar of soap that has been in a hot bath for a few minutes. So far we have only managed small amounts of nuclear fusion in a totally uncontrolled fashion, in hydrogen bombs. How can stars manage so easily what we are still not able to do?

The recipe is simple. Collapse a small cosmic cloud, which is mostly hydrogen to form a small ball. Now allow more hydrogen to fall on top. The infalling material makes the ball get hotter, and its growing weight increasingly compresses and heats the centre of the growing ball. When its temperature reaches 10-15 million degrees nuclear fusion starts. We might expect this to cause a enormous explosion. However, the energy release causes the gas ball – now a new-born star – to expand, which reduces the density in the core and slows down the rate of nuclear fusion. This process acts as a regulator, controlling the rate at which energy is produced. Most stars have it right, and the process keeps energy production fairly constant for billions of years. There are some stars where the regulation process oscillates, causing the star to vary dramatically in brightness. In other cases the regulation process completely breaks down and destroys the star. Obviously Mother Nature got it right for the Sun, otherwise we would not be here to consider the problem.

Venus is conspicuous low in the southwest after sunset. Mars lies a few degrees to its left and a bit higher. Jupiter dominates the southern sky overnight and Saturn rises around 3am. The Moon will be Full on the 3rd and Last Quarter on the 11th.

Ken Tapping is an astronomer with the National Research Council's Dominion Radio Astrophysical Observatory, Penticton, BC, V2A 6J9.

Tel (250) 497-2300, Fax (250) 497-2355

E-mail: ken.tapping@nrc-cnrc.gc.ca