Sagittarius

The Newsletter of the Astronomy Section of La Société Guernesiaise

July – September 2011

Forthcoming Events

Perseids BBQ

Observatory: 12th August: 7.30 pm

Public Open Evenings

(now Thursdays)

28th July: 9.00 pm

4th August: 9.00 pm

11th August: 8.30 pm

18th August: 8.30 pm

25th August: 8.30 pm

1st September: 8.30 pm

New format will be that Public Open Evenings will be on a Thursday evening and will comprise a talk or film show, with a clear night for observation being a bonus!

In addition, the Section meets at the Observatory every Tuesday evening, and Friday if clear for observing.

Inside

Inserts

Star chart

Sunset, sunrise, moonset and moonrise times

Letter from the Secretary.

Debby Quertier has been our Secretary for the past 13 years. We have seen many changes during her time of office, ranging from the purchase of new telescopes to the complete renovation of our meeting room. Debby's knowledge of the night sky is legendary and she easily held the interest of everyone during our open evenings. We all agree that Debby has done a wonderful job and all with a minimum of fuss.

So with that background, I have taken over as Secretary knowing that I have a very difficult act to follow.

We have over fifty members in our group who pay subscriptions every year and receive the Sagittarius newsletter. A healthy 10-12 people regularly meet on a Tuesday evening but there is always room for more. I am in favour of everyone getting from the Section exactly what they wish, but my only concern is that many do not come along because they do not know what to expect. We meet every Tuesday from 8 pm onwards and we would be very happy to meet you, talk to you and have you join us for a cup of coffee or tea. So why not give me a call or e-mail.

Our first Open Evening this year was on Thursday May 26th when we tried something different. It was cloudy and we could not use the telescopes but we showed them to our Guests and then had an evening of talks, slide shows and general discussion. It went very well and the same format will be used for future Open Evenings (on selected Thursdays) with clear skies a bonus!

We plan to have occasional talks at the Observatory this year, one of us speaking followed by questions and (hopefully) answers. If anyone would like to know in advance of these evenings, (always on a Tuesday), perhaps you could give me your e-mail or telephone number.

Finally, I am always open to suggestions for improving the running of the Section for its members, or just to talk about any aspect of our interest in Astronomy. I do not want anyone to feel left out.

Frank Dowding
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Tel. 255215

Energy from Nuclear Fusion

'The Sun shines and warms and lights us and we have no curiosity to know why this is so.' While this observation by Ralph Waldo Emerson is probably true in general, it is fortunate that there are many exceptions, when a sense of curiosity about the Sun, and indeed about many other wonders in the world about us,

has led enquiring minds to make scientific progress.
One question that the curious might ask about the Sun is, 'How does it get its energy?' There were two early suggestions put forward to account for the Sun's energy source. Perhaps radioactive processes supplied the energy, as they apparently did in heating the core of the Earth? It was known, however, that the Sun, which was believed to have condensed from a cloud of gas consisting mainly of hydrogen and helium, contained insufficient amounts of the heavy elements that tend to undergo radioactive processes. The other suggestion, made by Lord Kelvin in about 1860, was that the steady contraction under its own gravity of the mass of material that formed the Sun, could supply the energy, essentially translating gravitational energy into the energy of radiation. It could be calculated, from the estimated mass and radius of the Sun, that enough energy could have been generated in this way to sustain it at its present luminosity for about 20 million years. Unfortunately, it was known from geological studies that the Earth, and the Solar System including the Sun itself, must be greater than a billion years old. The situation at the beginning of the twentieth century was consequently that some other explanation had to be found.

During the early years of the new century, before the First World War, great discoveries in a hitherto unknown realm of physics were made. In 1897, the Cambridge physicist J J Thomson had shown by his discovery of the electron that the atom, previously believed to be the indivisible building-block of all matter, did in fact have an inner structure. An investigation of that inner structure was pursued by Rutherford and his research group at Manchester, in a series of experiments culminating in 1911 with the discovery of the atomic nucleus. A further discovery of great significance was also made by Rutherford and his group and was published in 1919, by which time Rutherford had moved to Cambridge. That discovery was the first observation in a laboratory experiment of a nuclear reaction, when nuclei of nitrogen, bombarded with alpha-particles from a radioactive source, produced nuclei of oxygen. (For centuries the 'philosopher's stone' which would magically transform one element into another – preferably a base metal into gold – had been sought: it turned out in this case to be the alpha-particle.) With that discovery nuclear physics could be said to have been born; it later proved to be highly relevant in the understanding of how energy-generating processes might occur in the Sun and other stars.

In 1920, Eddington suggested that energy might be produced in the synthesis of helium from hydrogen, with four nuclei of hydrogen somehow reacting to form one of helium. Following the invention by Aston of the mass spectrograph, by means of which nuclear mass could be measured with great accuracy, it could be shown that in this process of nucleosynthesis of helium from hydrogen there would be a minute loss of mass (about 0.8% of the total), the so-called 'mass defect' $\mathbf{\Delta m}$, with the result that the equivalent amount of energy, as given by Einstein's formula $(\mathbf{\Delta m})\mathbf{c}^2$, would be released. Eddington calculated from the mass of the Sun that it would contain enough hydrogen, the proposed nuclear 'fuel', to sustain its energy output by this means for about 15 billion years, that is for appreciably longer than its estimated lifetime. (It might be worth noting here that, in accordance with that calculation, the Sun should be losing 4 billion kilograms of its mass per second; but that at its estimated present age of 5 billion years, it would still have lost only 0.03% of its mass so far.)

In order to make further progress here, a number of terms used in nuclear physics have to be introduced: these are set out in the 'box' below.

Some basic terms in nuclear physics

The atomic nucleus, which has diameter only about ten millionths that of the atom, accounts (e.g. in the case of hydrogen) for about 99.9% of the total atomic mass. This tiny, massive nucleus is made up of elementary particles, the ***proton*** *and the* ***neutron****.*

The proton has positive electric charge and the number of protons in the nucleus, the ***atomic number****, is equal to the number of (negatively charged) electrons in the outer structure of the atom, so that the whole atom is electrically neutral. The* ***atomic numbe****r defines the identity of the atom, whether it is an atom of hydrogen, helium, carbon, oxygen etc.; it also determines the place of the element in the* ***Periodic Table****. The same number of electrons, as well as their arrangement in the atom, determines the chemical properties of that element, that is how it combines with other atoms to form molecules and chemical compounds.*

Within the nucleus itself, different numbers of neutrons, which do not have electric charge, can be accommodated, giving different ***isotopes*** *of the same element. The nucleus of the hydrogen atom is a single proton, but the addition of a neutron gives a* ***deuteron (D)****, and the addition of two neutrons gives a* ***triton (T)****. The corresponding atoms are* ***deuterium*** *and* ***tritium****, respectively. In the case of helium, with two protons in the nucleus, the isotopes* ***helium-3*** *(with one neutron) and* ***helium-4*** *(with two neutrons) play important roles in the solar nuclear fusion processes. In any nuclear reaction the particular isotope involved can be critical, because isotopes of the same element can have very different nuclear properties.*

Materials often exist in regions of high temperature and pressure, where the atomic structure has been broken down to form a ***plasma****, an electrically neutral state of matter composed of nuclei and electrons, which behaves almost as a gas of free particles.*

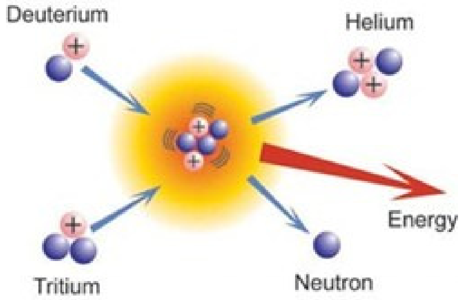
Following the work of Eddington, a further advance was made in 1927 by Atkinson and Houtermans: they realised that at the high temperature (about 10 million degrees Celsius) and high pressure (about 100 billion times atmospheric) believed to exist in the interior of the Sun, the hydrogen would form a plasma within which the mutual interaction of high energy protons (the nuclei of the plasma material) would lead to 'thermonuclear' reactions taking place. As considered by Bethe and by von Weizsacker independently in 1938 and 1939, the nucleosynthesis of helium from hydrogen could then proceed in several stages: first, a deuteron could be produced from two interacting protons; and then the deuteron could interact with another proton to give helium-3, which undergoes a further reaction to give helium-4, the final product. The rate of deuteron formation in the initial stage would be very slow indeed, however, with the probability of any given proton interacting in this way corresponding to just one interaction event in 14 billion years. The process proposed was nevertheless regarded as viable, because of the large number of protons in the solar interior, and because of the long time over which the plasma could be sustained at the required high temperature and pressure. As a result of this and other more recent research, it has been generally accepted that the nucleosyn thesis of helium from hydrogen is the process by which the Sun, and also other stars described by astronomers as being in the 'Main Sequence' class, derive their energy.

A most perceptive comment has been made, which is that it is the very slow rate at which the suggested initial phase of 'hydrogen burning' occurs that has enabled the Sun to produce energy over a sufficiently long time to allow the Earth to form, to cool and to act as host to the evolution of life to the level that we know.

For several decades during the late twentieth century it was an ambition, at that time seemingly impossible to achieve, to build a device in which nuclear fusion could be induced to take place and, as in the Sun, provide a source of energy. It was clear at the outset that any attempt to reproduce the particular nuclear processes believed to occur in the Sun would not be successful: the first stage, of deuteron formation, with its billion-year timescale, might be possible in the Sun, with its long lifetime, but not on Earth where, to be profitable, reactions that occur much faster would have to be employed.

Perhaps it might be possible to omit altogether the deuteron-production process, and instead start with pure deuterium as the 'fuel'? Deuterium occurs as a component of ordinary water, of which there is an abundance in the Earth's rivers and oceans. In a high-temperature plasma of deuterium, thermonuclear reactions between deuterons, the so-called 'D-D' reactions, should occur if the temperature were sufficiently high, more than 100 million degrees

Celsius. An alternative fuel could be a mixture of deuterium and tritium where, as could be seen from the basic nuclear data relating to the deuteron and triton, 'D-T' reactions (as shown in the illustration here) should be even more productive of energy. Tritium does not occur naturally, but can be produced by irradiation of the element lithium with neutrons.



Consideration of the essential nuclear physics therefore gave rise to much optimism as to the generation of energy from some suitable nuclear fusion process, and to the dream of obtaining an apparently unlimited supply of energy from readily available raw materials. The main practical difficulty then lay with the engineering, that is with the actual design and construction of a device that would translate the dream into reality.

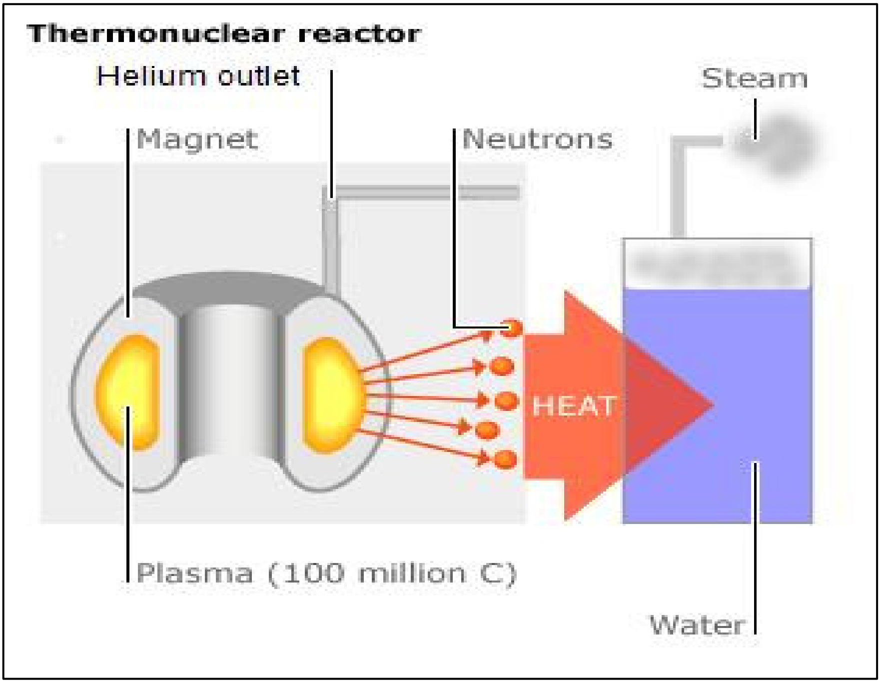
Plasmas of high temperature and density are difficult to contain, with the further problem that contact of a hot plasma with the walls of its containing vessel lead immediately to its cooling. The idea of magnetic confinement, which might be possible for a plasma of electrically charged particles (nuclei and electrons), therefore seemed to be an alternative: it should be possible for a carefully contoured magnetic field to confine such a plasma to a space where, in suitable conditions, thermonuclear reactions could take place. Different shapes of 'magnetic bottle' were devised, in a variety of experiments. Eventually, the preferred type of plasma container that emerged was the hollow, doughnut-shaped vessel, or 'torus', sometimes referred to by the Russian term 'tokamak'.

The breakeven point for any thermonuclear fusion device is reached when the energy produced in the plasma by fusion, during the time over which the hot plasma can be contained, is equal to the energy required to produce the plasma in the first place. There is a mathematical formula that can be derived, which includes the three key plasma parameters of temperature, density and confinement time, and which expresses this criterion precisely. The aim of any fusion device is to attain critical values of all three of these parameters, if possible simultaneously.

The most successful thermonuclear fusion device to have been built so far is JET (Joint European Torus) which is situated at Culham, near Abingdon in Oxfordshire, and which has been in operation since 1983. JET was initially operated with a pure deuterium plasma heated by several million amperes of current, from the mains electricity supply, to a temperature of 50 million degrees Celsius. One remarkable achievement of JET has been to attain an ultimate plasma temperature of 300 million degrees, which is about twenty times the estimated temperature at the centre of the Sun; but the required values of the three plasma parameters could not be achieved all at once in the same experiment. In 1991, with tritium injected into the deuterium plasma, JET was able to produce 1.7 megawatts of fusion power for about two seconds and, to quote an official report published subsequently, 'This was the first time that a significant amount of fusion power had been generated in a magnetic confinement device'.

JET is essentially an experimental device designed to study the production of plasmas suitable for a nuclear fusion reactor; it is not itself a reactor from which energy could be extracted for industrial or commercial use. In 2006, the decision was taken to build an experimental reactor called ITER (International Thermonuclear Experimental Reactor). The ITER project is the result of an ambitious scientific collaboration between a number of technologically advanced nations, and its construction at Cadarache, near Marseilles, is due to be completed within the next ten years.

One objective of ITER, as it has been at JET since about 1995, is to study the 'self-heating' of the contained plasma by energetic nuclei created as by-products of the fusion process. At ITER an additional feature will be a 'blanket', a solid wall shaped around the plasma-containment vessel and designed to degrade neutrons also



produced in the fusion process: the neutrons heat the blanket, from which energy could in principle be extracted. In any future full-scale reactor (as shown in the illustration above), energy would be extracted by means of a 'heat-exchanger', producing steam to drive a turbine for electricity generation, as in a conventionally fuelled power station. The ITER neutrons also interact with lithium incorporated into the material of the blanket, to produce tritium which, if 'distilled out', contributes towards replenishing the supply of reactor fuel.

ITER should have the capacity to produce 500 megawatts of fusion power which, with an input of 50 megawatts, would represent an impressive power 'gain'.

There is little doubt that nuclear fusion processes in the interior of the Sun provide the heat and light energy which sustains life on Earth. It would indeed be a great achievement if similar fusion processes could, by means of modern technology, be employed to generate energy, using fuel that is both abundant and easily accessible. The basic physics of nuclear fusion is well understood, but it requires engineering genius to translate this dream into reality.

In recent decades, the construction of thermonuclear devices has made substantial progress in that direction; this had led to a great sense of optimism that nuclear fusion should be able to provide industrial levels of sustainable power, not just yet perhaps, but certainly in the foreseeable future.

David Falla

A Close Moon

The Moon's orbit is complex. Basically it orbits the Earth in an ellipse, of which the Earth is at one focus. The Moon's average distance from the Earth is 384,400 km, but it normally varies from 363,296 km (perigee) to 405,504 km (apogee).

However, the eccentricity of its orbit changes depending on its relationship with the Sun. When the long axis of the ellipse lines up with the Sun, which it does every 206 days, the ellipse is stretched by the Sun's gravitational pull, and its eccentricity increases. This results in a lunar perigee less than average, and an apogee greater than average. So its distance can be anything from 356,371 km to 406,720 km, a variation of over 14%.

Every 18 years the shortest lunar perigee coincides with the Full Moon. This happened on 19 March 2011, when its distance was just 356,577 km. Dubbed a "supermoon" it appeared larger than usual, and presented a good photo opportunity as it rose above the eastern horizon.

I took photographs with a tripod-mounted camera with a 1000 mm focal length lens, and one is shown on the right in the accompanying picture. I used similar equipment to photograph the rising Moon on 30 August 2007, and this appears as the left image. The difference between the two horizontal diameters is some 10%. The horizontal diameters were measured because atmospheric refraction affects the vertical diameters, especially when the Moon is near the horizon.

David Le Conte

For further information see *Mathematical Astronomy Morsels* by Jean Meeus (Willman-Bell Inc., 1997), chapters 2 and 3.

Geoff Falla's regular roundup of articles from popular Astronomy and Space Journals

Star Clusters. A set of three articles focusing on the different kinds of star clusters; the open clusters - often large groups of the more newly-formed stars, having condensed out of a gas cloud; the globular star clusters surrounding our Milky Way galaxy, but also seen forming in collisions between other galaxies, and super-size clusters containing many of the most massive stars. (Astronomy Now, April 2011)

Identifying Earth-like Exoplanet atmospheres. There is now strong evidence that terrestrial-type planets are more common in our galaxy than gas giants. Red dwarf stars are found to be more common than Sun-like stars; a habitable zone around these stars will be relatively close - so there is a much better chance of observing planetary transits, and analysing the atmospheres of these planets. (Astronomy, April 2011)

Iceland's Dramatic Auroral Displays. Iceland is best known for its volcanism and the night sky's "northern lights". Situated in the most active part of the Earth's northern auroral ring, Iceland has some of the best auroral displays to be seen anywhere, with the displays visible on most nights of the year. (Astronomy, April 2011)

First Man in Space - 50th Anniversary. Marking the 50th anniversary of Yuri Gagarin's epic space flight on April 12th 1961, when he achieved the first manned orbital flight around the Earth, and a few months later made visits to London and Manchester. (Sky at Night, April 2011)

The Hunt for Galaxy X. Ripple disturbances of hydrogen gas density in the outer disc of our Milky Way has shown that this must have been caused by a dwarf galaxy passing through the system at some time in the past. The search is now on to identify this dwarf galaxy, which it is estimated would be the third largest satellite galaxy after the Large and Small Magellanic Clouds. (Sky at Night, April 2011)

Spinning Hearts of Darkness. It has been found that most galaxies have supermassive black holes at their cores, with the spin rate of a black hole being a key factor in the release of energy. A black hole also determines how large a galaxy becomes, but because Earth's atmosphere blocks the high energy X-ray emissions, most of the survey work is from orbiting telescopes. (Sky and Telescope, May 2011)

The First Stars and Quasars. The universe is now becoming understood more clearly, that after the big bang which produced the observed microwave background radiation, there was a dark period before further ionization was involved in forming the first stars and black holes, and leading to the modern universe. (Sky and Telescope, May 2011)

New Insight on the Sun. After a year in orbit around the Sun, studying it in detail, NASA's Solar Dynamics Observatory has given astronomers the ability to understand how the Sun's magnetic field drives solar activity. Three instruments are being used to obtain information from below the Sun's surface and out to the very hot solar corona.
(Astronomy, May 2011)

When the next Asteroid strikes. Plans which are now in operation with the Spaceguard Survey, started in 1998, to identify most of the substantial asteroids in near-Earth orbits which may be a future danger to the planet. Asteroids of less than 100 feet diameter would not cause widespread damage, but anything larger than a kilometre would need a spacecraft mission to remove it, or divert it onto a different path.
(Astronomy, May 2011)

The Ten Greatest Astronomical Discoveries. The greatest astronomical discoveries of all time; some dating back several centuries, such as our Sun-centred model of the solar system, and gravitational theory, with others of much more recent origin: the discovery of the cosmic microwave background supporting the big bang start of the universe, and the current breakthrough in discovering that many of the stars around us also have planets in orbit. (Sky at Night, May 2011)

Variable Stars. The varying luminosity of many stars - some pulsating with different periods ranging from days to years in some cases, while the brightness of other stars can vary because of eclipsing companion stars or more dramatic reasons. (Astronomy Now, May 2011)

A Search for Vulcanoids. It was once thought, from occasional claims, that there could be another small planet between Mercury and the Sun. The existence of such a planet - which was given the name Vulcan, has never been confirmed, but it is now thought likely that small asteroids may be located in that region, and a search has been started to find them. (Astronomy Now, May 2011)

Mercury Orbit mission - First Image. The Messenger spacecraft has obtained the first image of a previously unseen part of Mercury, showing a crate red surface, including a prominent rayed crater named Debussy (rather like the ray system around the lunar crater Tycho) and a small crater with unusual dark rays. (Astronomy and Space, June 2011)

The Invisible Force of Gravity. Although a weak force, gravity apparently controls the movement of planets, other major processes in our own galaxy, and in all of the galaxies beyond. Gravitational lensing, the bending of light by massive objects, is useful in studying some of the most distant galaxies, and there is now a search to identify gravitational waves which it is thought must exist. (Astronomy Now, June 2011)

In Search of the First Stars. The Hubble Space Telescope has been able to obtain images of stars and galaxies much farther away in space and back in time than previous telescopes could achieve. Now with images coming from an estimated 95 per cent of that distance back to the original 'big bang', it is expected that the new James Webb Space Telescope now being built will halve the remaining gap back to the start of the universe. (Astronomy, June 2011)

BAA meeting in Jersey

The 2011 Autumn Weekend Meeting of the British Astronomical Association is being held at the Radisson Blu Waterfront Hotel, St. Helier, Jersey, from 2 to 4 September, with the majority of talks being on the Saturday. It promises to be an interesting programme. Speakers include Mike Maunder (before Saturday lunch) and David Le Conte (after lunch).

Details and a booking form are enclosed with this newsletter. They are also available on the BAA website at http://britastro.org/baa/.

Obituary:

Les Curtis (1947-2011)

I was shocked to hear of the sudden death of Astronomy Section member Les Curtis on 26 March, at the age of just 63. Les was a well-respected dentist, but he was also a man of many interests. I knew him primarily through La Société Guernesiaise, where he was a keen student of marine biology. He served on the Société Council. He was not an active member of the Astronomy Section, but he clearly had a peripheral interest in the subject; we did see him at the Observatory occasionally and he often attended lectures. He was also a keen singer - we sat next to each other in the basses of the 2010 Liberation Day *Guernsey Sings* performance.

His death was totally unexpected. He had been attending a marine biology course in England when he suffered a massive heart attack in his hotel room. I shall miss the friendly smile which he always had, and his readiness for a chat. I represented the Section at his funeral in a packed St Andrew's Church, at which the Bailiff read a lesson. Les is survived by his wife, Diana, two daughters and two grandchildren.

David Le Conte

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