Sagittarius

The Newsletter of the Astronomy Section of La Société Guernesiaise

January – March 2008

Forthcoming Events

AGM

22nd January: 8.00 pm at the Observatory

WEA Course

Thursdays 8.00 pm at the Observatory

7th February – 14th March

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

The Mysterious Cosmic Rays

Cosmic radiation is not really radiation at all, in the sense that the word is normally used. In fact cosmic rays are particles, which continuously rain down upon the Earth from space, and which carry a total energy that is as much as that received in the form of starlight from all the stars visible in the heavens.

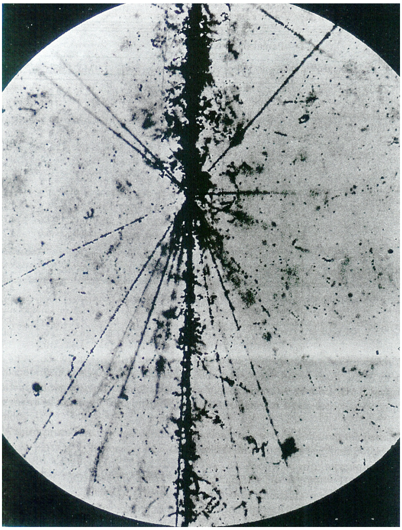
In astronomy the range over which observations can be made has over the past few decades broadened out from the visible region to the furthest extent of the spectrum. We are by now familiar with all the new branches of astronomy, from radio, through infrared and ultraviolet, to X and gamma-ray. All these branches of astronomy are concerned with electromagnetic radiation, of which the type we are most used to is light itself.

Observations with electromagnetic radiation do not, however, provide the only means by which we can learn about remote objects in the Universe. Particles can also carry information, so we should perhaps redefine astronomy as the collecting of all kinds of data from space. Cosmic radiation is just one field of research within the general subject sometimes called "particle astronomy". "Particle astrophysics", in which we seek to understand the basic physical processes that can account for the phenomena observed in particle astronomy, must surely be one of the most fascinating areas of modern research, relating as it does the infinitesimally small (particles and nuclei) to the almost unimaginably large (stars, galaxies and systems beyond).

It was realised quite early on in their investigation by astronomers that cosmic rays are charged particles: this could be deduced from the observation that, unlike electromagnetic radiation, they are deflected by the Earth's magnetic field. Unfortunately, this means that it is generally impossible to see exactly in which direction the source of the radiation lies; and indeed one of the main characteristics of the cosmic radiation is its isotropy, that is to say its equal intensity from all directions.

There are two types of cosmic radiation, the primary and the secondary. The secondary radiation consists of particles that have been produced in the Earth's atmosphere by the primary radiation as it comes in from space. This secondary radiation is of considerable historical interest because for many years the cosmic radiation was the only available source of high-energy particles for the experimental study of the basic constituents of matter. Particles of the primary cosmic radiation, interacting with the nuclei of atoms in the atmosphere, produce unstable particles such as mesons which, until just about fifty years ago, could not be produced by particle accelerators in Earth bound laboratories. Many discoveries about these fundamental particles of matter were made by detecting their production and interactions in devices such as cloud chambers, at the Earth's surface, and in photographic emulsions carried high into the atmosphere by helium filled balloons. But it is the primary radiation, before it is modified by interaction in the Earth's atmosphere, that is of greater interest to the astrophysicist.

What then are the primary cosmic rays? They are mainly atomic nuclei, of all different elements, which have somehow been accelerated to high energies. Most of these nuclei (about 80%) are protons, the nuclei of atoms of hydrogen, which is the most common element in the Universe. The relative proportion of the different nuclei in the radiation indicates that it represents a sample of material with composition similar to the "universal abundances" of elements found in the wider Universe. The differences in composition are just as interesting as the similarities, however, because these differences can be related to the past history of the radiation as it passes through the interstellar medium (ISM) en route from its source, wherever that may be, to the observer on Earth. It should be mentioned here that the primary radiation includes some fast electrons, and also some antiprotons at a very low flux level (only about five millionths of the number of protons).



The collision of a cosmic ray iron nucleus with a nucleus of a nuclear emulsion. (From CF Powell, PH Fowler and DH Perkins (1959). *The study of elementary particles by the photographic method,* page 95. Oxford: Pergamon Press.)

So where do the cosmic rays come from? It is perhaps natural for us to look to the Sun, which produces many of the already known types of radiation, as a possible source. That the Sun is indeed a source of energetic charged particles is shown in a most dramatic way by the events on Earth that follow solar flares: at times of enhanced solar activity (also indicated by the greater number of visible sunspots) there can be severe disruption of radio communication and the production of extensive aurorae in the polar regions. The energetic charged particles responsible for these occasional but spectacular events can be regarded as the Sun's contribution to the cosmic radiation.

Particles (mostly protons and electrons) are also emitted continuously by the Sun in its generally quiet state, when it is not undergoing periods of spasmodic activity: these particles make up the "solar wind", which is emitted through "coronal holes" in the corona, the outermost region of the solar atmosphere, which consists of plasma at a temperature of several million degrees Celsius. At such a high temperature, the protons and electrons have sufficient energy to escape the gravitational field of the Sun, so that they are emitted into space together with other forms of radiation. The solar wind blows, at a rate determined by the general level of solar activity, from the Sun and outwards to the farthest reaches of the heliosphere, which is the spherical region of space over which the Sun exerts its influence, and which has a radius of at least 40 AU, where 1 AU (the Astronomical Unit) is the Earth - Sun distance.

Apart from the rare solar-flare events, the general flux of the cosmic radiation that we observe on Earth is strongly correlated with the level of solar activity, as indicated by sunspot number: each follows closely the eleven-year solar cycle. The remarkable fact, however, is that the cosmic-ray flux is less, not greater, at times of greater solar activity, a situation described as an "inverse correlation". The explanation of this inverse correlation seems to be that the cosmic radiation in general comes from outside the solar system, and that the solar wind in one way actually impedes it in its passage to Earth. This solar modulation of the cosmic radiation probably results from the interaction of the radiation with complex magnetic field regions within the solar system, which themselves are affected by the variable solar-wind current. We conclude, therefore, that although the cosmic radiation is greatly dependent upon the Sun, its actual source must lie elsewhere.

An important clue to the origin of the cosmic rays is given by their composition, as expressed in terms of the relative number of nuclei of the different elements. As mentioned earlier, the composition of the radiation that we observe is its original composition as modified by its passage through the interstellar medium. Interaction of heavy cosmic-ray nuclei with the nuclei in the ISM can result in nuclear fragmentation, and the consequent production of light elements such as lithium, beryllium and boron (just below helium in the Periodic Table of the elements) which, being highly reactive, are not normally found in appreciable quantities in nature, for example in the bodies of the solar system. A calculation based on the relatively large number of these light nuclei in the cosmic rays, together with the estimated density of the ISM (about one atom per cubic centimetre), enables an important conclusion to be drawn: this is that the cosmic radiation that we observe has travelled, between its source and the Earth, a distance about thirty times the diameter of the Galaxy, and that this journey has taken the radiation about ten million years. If we assume the cosmic radiation as observed from Earth to be a fair sample of the radiation in general then a plausible explanation for these findings is that the cosmic rays originate within our Galaxy, but after emission from their source follow lengthy and tangled paths through the ISM, as they move under the strong influence of the magnetic fields that they encounter there. This process of diffusion of the radiation allows it to permeate the whole of the disc of the Galaxy, but with some particles (which tend to be the more energetic ones) eventually leaking out into the Galactic halo and sometimes further, into intergalactic space. This whole picture has been described as the "leaky box model" for the cosmic radiation.

The actual source of the cosmic rays in the Galaxy is a matter on which there has been much speculation. The currently favoured theory of their origin is that the cosmic rays come mainly from supernovae. There are two kinds of supernova, usually referred to as Type I and Type II. Supernovae of Type II, which are the relevant ones here, are produced by highly luminous massive stars which, like most types of star, evolve by generating energy and at the same time creating complex nuclei (that is, nuclei heavier than hydrogen) through the various processes of nucleosynthesis. When the star reaches the stage at which it can no longer gain energy from nucleosynthesis - at which point of its evolution nuclei up to the element iron have been created - it can no longer support itself against the inexorable inward force of gravity, and so collapses upon itself catastrophically. The resulting explosive disintegration of the star, which is observed by astronomers as a supernova, produces an expanding nebula of gaseous debris, the supernova remnant (SNR), of which conspicuous examples are the Crab Nebula (M1 in Messier's Catalogue) and also SNR 1987A, observed in the Large Magellanic Cloud.

As well as the SNR, there is a further product of the supernova event and that is the compact neutron star that is formed at its centre. The plasma atmosphere of the neutron star, which has a strong magnetic field that has been greatly amplified by the compression of the plasma into the small volume of the neutron star's "atmosphere" (a few kilometres in extent), is also rotating: the result is a pulsar, from which beams of radio and other radiation are emitted as the neutron star spins; like the rotating beam of a lighthouse, these beams give rise to a series of regular pulses (flashes) by which the pulsar can be identified. Astrophysicists who work in the field of magnetohydrodynamics have suggested that in pulsars there exist just the right conditions for the acceleration of particles (nuclei) up to very great energies; and that these particles could then be emitted into the space within the Galaxy as the cosmic rays. It is only fair to add, however, that the exact mechanism for the particle-acceleration process is not entirely clear. In the words of one writer of a recent book on the cosmic radiation, "The ingredients are there, one might say, but the recipe evades us".

While we still have incomplete knowledge of the exact production process for the cosmic rays, the supernova theory of origin has received support from a rather unsuspected quarter. If the cosmic rays have only a certain lifetime in the Galaxy before they leak out, as previously described, then the escaping cosmic rays represent a constant loss of energy from the Galaxy. It has been estimated that a supernova occurs, somewhere in the Galaxy, about once every fifty years, and that at that rate supernovae would be able to supply just about enough energy in the form of cosmic radiation to compensate for that loss and thereby retain the energy balance.

One outstanding problem concerns the origin of the cosmic rays with the very highest energies, that is the ultra-high-energy cosmic rays (UHCRs), which cannot normally be confined within the Galaxy. Some idea of the energy carried by these UHCRs can be conveyed by the fact that the energy of a single one would be sufficient to raise the temperature of a cubic centimetre of water from near freezing right up to boiling point. However, the flux of cosmic rays falls off appreciably with energy, so cosmic rays of the highest known energies are very rare indeed: they arrive at the Earth at a rate of only a few per square metre per year.

The UHCRs that we observe could have come from other galaxies external to our own. Just as cosmic rays of the highest energies cannot be confined to our own Galaxy, so we could perhaps be the observers of similar cosmic rays that have leaked out of other galaxies, and which would preferentially be those that are also of high energy. The UHCRs do show a slight tendency to arrive from the direction of the Virgo cluster of galaxies, which contains the active galaxy M87.

Finally, a topical reference can be made to some recent cosmic-ray research, in relation to current concerns about global climate. Cosmic rays, and indeed all fast charged particles, cause ionisation of atoms in the atmosphere; this means that they leave a trail of ions on which water vapour can condense, as shown in laboratory studies with that old fashioned but most useful device in particle physics, the cloud chamber. There could be a connection, therefore, between cloud production and the flux of cosmic rays which, as previously mentioned, follows the solar cycle. Perhaps cosmic radiation could provide at least part of the explanation for the link that has been suggested to exist between solar activity and the climate that we experience on Earth.

David Falla

Astronomical Events in 2008

This year we can look forward to a morning total eclipse of the Moon, a minor partial solar eclipse, and an occultation of Venus.

PLANETS

The dates of maximum elongations of **Mercury** are as follows. It can usually be seen about ten days before and after these dates. The best dates to observe it in the evening will be the last two weeks of January, and the first three weeks of May, and in the morning the last two weeks of October.

22 January	Evening
03 March	Morning
14 May	Evening
01 July	Morning
11 September	Evening
22 October	Morning

Venus, which has been a brilliant object in the pre-dawn sky for the last few months, will soon be lost from view. It will not re-appear until September, when it will be the 'Evening Star' low in the west until the end of the year. It will be occulted on 01 December (for details, see under the heading "Occultations and conjunctions", below.)

After its opposition in December 2007, **Mars** disappears in early 2008, not to be seen again for the rest of the year.

Jupiter appears in the dawn sky in February, and remains low in Sagittarius for the rest of the year. It reaches opposition on 09 July, and then becomes visible in the evening, never reaching much of an altitude. As usual, there will be transit and occultation events involving Jupiter's moons, details of which can be found on the Sky and Telescope web site, or simulated on software such as Starry Night.

Saturn, reaches opposition in Leo on 24 February, and remains visible in the evening until the middle of the year. It reappears in the morning sky in October.

Uranus is at opposition in Aquarius on 13 September at magnitude 6, and **Neptune** is at opposition in Capricornus on 15 August at magnitude 8.

DWARF PLANETS

Pluto reaches opposition in Sagittarius on 20 June at magnitude 14. **Ceres** does not reach opposition this year. **Eris**, at magnitude 19, is beyond the capabilities of most amateur telescopes.

ASTEROIDS

The brightest asteroid, **Vesta**, reaches opposition on 30 October in Cetus at magnitude 6.

ECLIPSES

There will be a total, although non-central **eclipse of the Moon on 21 February**. It will start entering the penumbra at 00.35 am, and the umbra at 01.43 am. Totality will last from

03.00 am to 03.51 am, with mid-eclipse being at 03.26 am. The Moon will have left the umbra by 05.09 am, and the penumbra by 06.17 am. All times are in Universal Time (UT). It will be in Leo during this eclipse, and should be a fine sight, being close to Saturn and Regulus.

On **01 August there will be a partial solar eclipse**, from 09.35 am to 10.53 am. Maximum eclipse of 22% will be at 10.13 am. Times are in BST.

On 16 August there is a partial lunar eclipse, from just after moonrise, at 8.35 pm, to 11.44 pm BST. Maximum eclipse is at 10.09 pm, when 81% of the Moon will be in the Earth's shadow.

OCCULTATIONS AND CONJUNCTIONS

Venus will be occulted by the unlit side of the Moon from 3.43 pm on 01 December (in daylight), re-appearing from the crescent-lit side of the Moon an hour after sunset, at 5.17 pm. During this occultation Jupiter will be just two degrees away, so it should be worth watching.

On 13 December, from 9.03 pm to 10.05 pm the third magnitude epsilon Geminorum will be occulted by the Moon.

Mercury will be within half a degree of the Moon after sunset on 09 January. On 01 February Venus and Jupiter will be about half a degree apart. On the evening of 12 March, and again on the morning of 20 September, the Moon will pass close to the Pleiades. Mars and the Moon will be close together on 10 May. Mars and Saturn will be within a degree of each other on the evening of 10 July. On the evening of 13 August Venus and Saturn are within half a degree. Two days later, on 15 August, it is Mercury's turn to be close to Saturn, and on 20 August Mercury is within a degree of Venus. On 12 September Mars is half a degree from Venus.

METEORS

The **Quadrantids** peak on the night of 05/06 January, almost coinciding with New Moon, and so will be very favourable. The rest of the year does not bode so well, however. The **Perseids** peak on the night of 11/12 August, but the Moon, at age 12 days, will badly affect observations of them. The **Leonids** too will be washed out with a 19-day-old Moon on 12 November, and the fact that the short peak occurs at midday. And the Geminids, peaking on 13 December, will be affected by a Full Moon.

COMETS

Comet Holmes, which unexpectedly flared up to 3rd magnitude in Perseus in October 2007, may still be visible at the beginning of 2008. **Comet Tuttle** may well be a binocular or naked-eye object low in the south in early January, disappearing southward by the end of the month. **Comet Boethin** may reach 7th magnitude in the evening in December. For more details of visible comets see the British Astronomical Association Comet Section web page. It is, of course, ever possible that a new comet may make an unexpected bright appearance.

EQUINOXES AND SOLSTICES

The following are the dates and times of the equinoxes and solstices in 2008:

Vernal Equinox	20 March	05.48 UT
Summer Solstice	21 June	00.59 BST
Autumnal Equinox	22 September	16.44 BST
Winter Solstice	21 December	12.03 UT

SATELLITES

The International Space Station is regularly visible from Guernsey. Also of interest are flashes from the Iridium satellites, and periodic launches of the Space Shuttle. Many other, fainter, satellites appear every night. Details of the times and directions of visibility can be obtained from the Heavens-Above web site.

WEA COURSE

The Astronomy Section is running its annual six-week "Star Gazing" course at the Observatory in February and March. Enrolment is through the Workers Education Association. As always, it is already fully subscribed.

OPEN DAYS

The Observatory will be open again for a number of Tuesday evenings during the year. Details are included with and are usually repeated in Sagittarius.

David Le Conte

References

SkyMap Pro and *Starry Night Pro* software
RAS diary
BAA Comet Section
FAS Astro Calendar 2007/2008

CALENDAR OF ASTRONOMICAL EVENTS

Month	Date	Time	Event
January		All night	Comet Holmes
January			Comet Tuttle
January	05/06		Quadrantid meteor shower
January	09	Evening	Mercury and Moon conjunction
January	22	Evening	Mercury maximum elongation
February	01	Evening	Venus and Jupiter conjunction
February	07	20.00 UT	WEA course starts
February	20/21	01.43	Total eclipse of the Moon
February	24		Saturn at opposition
March	03	Morning	Mercury maximum elongation
March	12	Evening	Moon and Pleiades conjunction
March	13	20.00 UT	WEA course ends
March	20	05.48 UT	Vernal Equinox
March	30	01.00 UT	BST starts
May	10	Evening	Mars and Moon conjunction
May	14	Evening	Mercury maximum elongation
June	20		Pluto at opposition
June	21	00.59 BST	Summer Solstice

July	01	Morning	Mercury maximum elongation
July	09		Jupiter at opposition
July	10	Evening	Mars and Saturn conjunction
August	01	09.35 BST	Partial eclipse of the Sun
August	11/12		Perseid meteor shower
August	13	Evening	Venus and Saturn conjunction
August	15	Evening	Mercury and Saturn conjunction
August	15		Neptune at opposition
August	16	20.35 BST	Partial eclipse of the Moon
August	20	Evening	Mercury and Venus conjunction
September	11	Evening	Mercury maximum elongation
September	12	Evening	Mars and Venus conjunction
September	13		Uranus at opposition
September	20	Morning	Moon and Pleaides conjunction
September	22	16.44 BST	Autumnal Equinox
October	22	Morning	Mercury maximum elongation
October	26	02.00 BST	BST ends
October	30		Vesta at opposition
November	17		Leonid meteor shower
December		Evening	Comet Boethin
December	01	15.43 UT	Occultation of Venus
December	13	21.03 UT	Occultation of epsilon Geminorum
December	13		Geminid meteor shower
December	21	12.03 UT	Winter Solstice

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

Taking Science back to the Moon. In the next ten years or so there is planned to be a return of manned flights to the Moon, using a new rocket booster. This is to be named the Ares V, which will carry the Orion spacecraft. The far side of the Moon will be an ideal site for a radio telescope, free of radio interference from Earth. It will also be possible to test the theory of gravity with precise measurements, and to assemble new infrared and optical telescopes. (Sky and Telescope, October 2007)

Spotting Sputniks. Since the launch, on October 4th, 1957, of the first artificial satellite - the Russian Sputnik 1, a great many satellites have been launched for different purposes. A guide to observing satellites, including the Iridium "flare" satellites which can become very bright indeed, usually for just a few seconds, and the largest orbiting craft of all - the International Space Station. (Sky and Telescope, October 2007)

Dawn - the Asteroid Explorer. NASA's Dawn mission, the first exploration of the asteroid belt, was launched in September, and is planned to orbit Vesta in four years time, and Ceres in 2015, so that the structure and geology of these early

solar system bodies can be studied in detail.
(Astronomy & Space, October 2007)

Fifty Years of the Space Age. The most important achievements and crucial moments in the first 50 years of the space age; including a profile article about Sergei Korolev - the man who masterminded the launch of Sputnik 1 in 1957, also the first manned orbital flight in April 1961, and other major achievements before the USA succeeded with its own space programme and manned Apollo moon flights. (Sky at Night, October 2007)

The Seven Wonders of the Universe. A selection of six wonders of the Universe, including one in our own solar system - can you guess which one? With an opportunity also given to choose the seventh one.
(Astronomy Now, November 2007)

All about Astronomy Societies. A set of articles focusing on astronomical societies in the UK, with at least 180 local societies at present. A listing and map of the society locations (including the Channel Islands) with advice and how to create a website for those societies which do not already have one. (Astronomy Now, November 2007)

Destination Mars. The next stage in the exploration of Mars will come in May, when the Phoenix spacecraft is due to land in an area of the planet's Arctic region. It is planned to excavate ice and soil samples for detailed analysis. (Sky and Telescope, November 2007)

Astronomer Percival Lowell's "Canals" of Mars. The story of Lowell's 1907 expedition from his observatory base at Flagstaff, Arizona, to the even better viewing conditions of the Chilean Andes in the quest to obtain better photographic evidence of the Martian "canals", or channels thought to have been seen on the planet's surface. (Sky and Telescope, November 2007.)

Cassini-Huygens Mission Summary. The largest and most complex spacecraft ever built, the Cassini-Huygens mission arrived at Saturn in 2004 to begin a study of the planet and its moons. A summary of the main findings including the most important part of the mission - to discover more about Saturn's moon Titan, and to land the Huygens probe on its surface. (Astronomy & Space, December 2007) .

Mars at Opposition. A set of articles focusing on Mars at opposition on Christmas Eve, when for a month or so the planet will be high up in the southern part of our sky in the evenings, and giving a very good opportunity for observing details on its surface. Also an account of astronomer William Herschel's pioneering observations of Mars in the 18th century, the possibility of life of some kind there, and the “dance of the planets”, - how planetary orbits relate to how we see an apparently changing path of Mars. (Astronomy Now, December 2007)

Comet Holmes. One of the best and most unusual of comets seen in recent years, Comet Holmes increased suddenly and unexpectedly in brightness in early November to become visible to the naked eye. Telescope viewing and photos revealed a large circular coma surrounding the bright central part of its nucleus. (Astronomy Now, December 2007)

Sky Watch 2008. A monthly plan for observing the night sky, illustrated with photographic representations and star maps, and showing the positions of planets during the year. Also some useful tips for observing some of the most interesting objects. (Sky and Telescope - Skywatch, 2008)

Subscriptions for 2008: Please note that these are now due.

Families/Couples: £10
Individuals: £6
OAP / Juniors: £3

Email Address: It would be helpful if email addresses could be supplied on membership renewal forms as email provides a convenient means of notifying members of events between editions of Sagittarius.

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