Ordinary Meeting, 2007 November 24
held at the Mermaid Conference Centre, Blackfriars, London SE1

Roger Pickard, President

Ron Johnson, Hazel Collett and Nick James, Secretaries

The President opened the second meeting of the 118th Session and invited Mrs Hazel Collett, Meetings Secretary, to read the minutes of the previous meeting, which were approved by the audience and duly signed. The President announced that 60 new members were proposed for election, and put to members the election of those 11 new members who had been proposed at the previous meeting; they were approved and declared duly elected.

In the absence of the Papers Secretary, Mr Ron Johnson, Business Secretary, announced that two papers had been approved for publication in the *Journal*:

The Influence of Jupiter's South Equitorial Disturbance on Jet Stream Speed, by John Rogers
The Leonid Meteor Shower in 2001, by Neil Bone
[??? check that these titles are correct]

The President announced that the next Ordinary Meeting would be the Christmas Meeting, to be held on Saturday December 15 at 2.30pm at the present venue. Before then, the Webb Deep-Sky Society would be holding their Annual Meeting on December 1 in Cambridge. The next in the Association's series of Back to Basics workshops would be held in Clanfield, Hampshire, on 2008 January 12. The President then proceeded to introduce the afternoon's first speaker, Prof. Richard Harrison, head of both the Space Physics Division and the Solar Physics Group of the Rutherford Appleton Laboratory in Didcot, Oxfordshire.

The STEREO Mission

Prof. Harrison opened by remarking that the Sun was unusual among astronomical objects in the degree to which its three-dimensional structure could be readily appreciated. Whereas the surfaces of the planets appeared largely two-dimensional, and our view of galaxies was even more restricted – their orientations did not appear to change from one century to the next – movies of the solar atmosphere revealed a writhing dynamic sea of super-imposed structures which had self-evident three-dimensional depth.

The diffuse uppermost layers of the solar atmosphere, its *corona*, were usually observed using a *coronagraph* – a kind of telescope designed especially for the purpose, which had an occulting plate obscuring the central solar disk to stop its light from entering the optics, allowing features which were normally lost in the Sun's glare to be resolved. Images from such telescopes revealed that the Sun's surface occasionally underwent massive explosions, blowing large pockets of gas outwards into the solar system; these so-called *coronal mass ejections* (CMEs) were the most powerful explosions to take place anywhere in the solar system.

Prof. Harrison explained that these events were not merely scientific curiosities. When they were directed towards the Earth, and our planet was consequently impacted a few days later by the ejected material, the result was a so-called *geomagnetic storm*. Often such storms were benign, and merely resulted in an auroral display triggered by the impact of high-velocity ionised solar wind particles with the upper atmosphere. Occasionally, however, they could be more harmful. Space-based electronic circuits could be damaged by exposure to ionised particles, and several satellites had been lost as a result of such damage. The varying magnetic fields associated with such storms could generate power surges in long-distance telecommunications and power lines, potentially triggering wide-scale electrical blackouts.

Turning to outline the recent history of solar observation, the speaker explained that there had been many space-based solar observatories active over the past decade. To summarise their work, he showed a view of an active region of the Sun's surface undergoing a CME, as seen at a wavelength of 195 Å (far-UV). This image indicated the region to be incredibly hot; emission at 195 Å was produced by highly ionised iron atoms which could only be formed at temperatures of several tens of millions of °C. For comparison, most of the Sun's surface was at a temperature of only a few thousand °C. The speaker also pointed out that the 195-Å emission was concentrated into loop-like structures and explained that this provided compelling evidence for strong magnetic fields in the vicinity of active regions on the Sun's surface.

Despite the immense amount that could be learnt from such images, all past observations had been made either from the ground or from satellites in Earth orbit, and here lay a significant weakness in them. They had all been made from the vicinity of the Earth, from which vantage point it was easiest to see those ejection events which were directed at 90° to the Earth–Sun line and which, being directed in the plane of the sky, appeared with good angular separation from the Sun. Any events which had been directed towards the Earth would most likely not have been recorded in these observations at all: they would have appeared to have been coming directly out of the solar disk, and would have been lost in its glare. However, it was these events which were arguably the most important to observe, because they were the progenitors of geomagnetic storms, and needed to be measured in order to better quantify how the magnitudes of events on the solar surface corresponded to measurable effects on Earth.

The *STEREO* mission had been designed to overcome this limitation. It consisted of two nearly identical spacecraft, both roughly following the Earth's orbit around the Sun. The first – labelled 'A' for 'Ahead' – lay slightly inside the Earth's orbit and moved a little faster than the Earth, drifting ahead of it at a rate of 22°/yr. The second – labelled 'B' for 'Behind' – lay slightly outside the Earth's orbit and moved slower than the Earth, drifting behind it at the same rate. An observer on the Sun would see the two satellites each moving away from the Earth at the same rate of 22°/yr, but in opposite directions.

The two spacecraft had been launched on 2006 October 25 aboard a single Delta II rocket, and had commenced scientific operations in 2007 April. At the time of the meeting, they had drifted to distances of around 20.5° ahead and behind the Earth respectively. They had already captured images of several CMEs travelling towards the Earth, and together they had been able to produce a three-dimensional mapping of each event, since they had yielded simultaneous images from two widely-separated vantage points. The power of *STEREO* in this regard would grow in coming months as the two spacecraft moved further apart.

Although the *STEREO* spacecraft were nominally solar physics observatories, the speaker added that the optimisation of their coronagraphs for picking out faint CMEs had also made them exceptionally good at imaging other diffuse astronomical objects. In the background of all *STEREO* images, the Milky Way and nearby galaxies stood out especially prominently. The view of Mercury was also rather appealing: the whole of its 88-day orbit was contained within the coronagraphs' field-of-view, and so unbroken movies of its orbital passage could be obtained. The speaker presented a puzzle to the audience: astute observers would notice that Mercury appeared to be circling the Sun's north pole in the wrong direction in these images – counter-clockwise. He went on to explain that Mercury appeared brightest when in full phase, on the far side of its orbit, and faintest when on the near side of its orbit. The eye was tricked into inverting the orbit by assuming that Mercury was brightest when nearest to the observer.

Prof. Harrison continued on this theme by showing some of the earliest images captured by *STEREO*. Prominent features in these included the highly-structured curving tail of Comet McNaught, which appeared rich with ray-like striations. The speaker explained that whilst the *STEREO* science team was composed exclusively of solar physicists and had not itself been able to analyse these images, all *STEREO* data was freely available on the web, and comet observers had taken an interest in this data. It had thus turned out that, rather surprisingly, the first scientific paper produced by *STEREO*'s flight had been about Comet McNaught.

Looking ahead, cometary imaging would undoubtedly continue to form a substantial auxiliary part of *STEREO*'s science programme. The *LASCO* coronagraph aboard its forerunner, the *SOHO* satellite, had discovered in excess of 1,000 new comets since starting scientific operations in 1996 – mostly so-called *sungrazing* comets, which brightened substantially as they made close approaches to the Sun's surface. *STEREO* would likewise be a powerful tool for comet discovery, with the advantage over *SOHO* of having binocular vision, allowing instantaneous three-dimensional positions to be obtained for comet nuclei, and much more rapid determinations of their orbital elements as a result.

The speaker added that most of *SOHO*'s discoveries had been made by amateur comet hunters; the most dedicated among them had developed an exceptionally good sense for picking out faint objects from noise. They would be encouraged to continue their good work using *STEREO*, and the speaker envisaged that their dominance of the art would continue: the *STEREO* team would make all of their images publicly available on the web. Prof. Harrison welcomed any members who were interested in becoming involved to visit the *STEREO* website[1].

Following the applause for Prof. Harrison's talk, the meeting broke for tea. The President then welcomed the afternoon's second speaker, Dr David Berghmans, from the Solar Influences Data analysis Center (SIDC) of the Royal Observatory of Belgium.

The History of the Sunspot Index

Dr Berghmans explained that whereas the previous talk had described efforts to understand the Sun's present behaviour, his would look at how historical records, and in particular sunspot counts, could be used to infer how it had behaved over the past few hundred years. He explained that sunspots were cool regions on the face of the Sun, which appeared as dark blemishes. They were understood to be magnetic in origin, forming in places where the Sun's magnetic field had locally grown so strong that it disrupted the normal convectional flow of the solar atmosphere.

Sunspot activity showed variability on many timescales. Individual spots, typically similar in size to the Earth, were transient phenomena which lasted for only a few days. The statistical average number of sunspots visible followed a regular 11-year cycle, decreasing to almost zero between cycles. On still longer timescales, the number of sunspots visible in each cycle showed substantial variation, following consistent trends over periods of centuries. At the time of the meeting, the Sun was almost completely devoid of sunspots because sunspot cycle 23 – the 23rd 11-year cycle since the 1755-1766 cycle – had just drawn to a close, and the first spots of the new cycle were not expected to be seen until early 2008.

The speaker explained that trends in sunspot numbers were rather more than simply curiosities for solar observers; they affected a surprisingly broad range of sciences. Experience showed that they were correlated with many other aspects of the Sun's behaviour, and through the constant streaming of the solar wind out through the solar system, this in turn affected the Earth's atmosphere. To illustrate his point, the speaker showed a plot of the quantity of a radioactive isotope of carbon, ^{14}C, found in ancient organic remains as a function of their age, and compared it to a plot of historical sunspot counts over the same period. It was apparent that the two were highly correlated: those organic samples which dated from periods of weak solar activity contained consistently more ^{14}C than those dating from other periods. The speaker explained that the production of ^{14}C in body tissue was usually triggered by cosmic ray impacts, and that the Earth's magnetosphere seemed to perform much better as a shield against cosmic rays when it was being bombarded by a strong solar wind.

As a second illustration, he added that the Little Ice Age (LIA) of the 18th century was widely linked by climatologists to the lull in solar activity which had been observed at around the same time – the Maunder Minimum. Their supposition was that the Sun had been fractionally less luminous during this period. Understanding such connections between solar activity and our climate would be a vital step in distinguishing between the topical issues of man-made versus natural global warming.

Turning to the history of sunspot observation, Dr Berghmans explained that it was not possible to date the earliest observations of sunspots. In misty conditions, when the Sun's disk was sufficiently dimmed by the atmosphere, it was possible to see large sunspots even with the naked eye, and so their existence seemed to have been recognised since prehistoric times. It was also impossible to name the first astronomer to have begun systematic counts, although it was clear that by the early 17th century, Galileo, Christoph Sheiner, Thomas Harriot, and David and Johannes Fabricius had all begun keeping records. However, these first efforts at counting sunspots had not lasted long. Within a few years, the Maunder Minimum had begun, sunspots had almost completely disappeared from the Sun's face, and inevitably, interest in them had waned – a situation which had prevailed right through until the early 18th century. The speaker stressed, however, that it would be unfounded to suggest that this so-called 'minimum' was merely the result of a lack of observations. Johannes Hevelius and John Flamsteed, amongst others, had occasionally recorded small sunspots during this period, and would surely also have recorded larger spots if they had been present.

In the early 18th century, after the end of the Maunder Minimum, professional interest in sunspots had remained rather limited: the perception had broadly been that they were inconsequential curiosities. It was therefore not surprising that the first person to have compiled consistent counts over a long enough period to notice that they followed an 11-year cycle had not been a professional, but an Austrian amateur, Samuel Heinrich Schwabe. Even Schwabe, an apothecary by trade, had not been especially interested in the spots themselves: he had been searching for transits of a hypothetical planet called *Vulcan*, which had been thought at the time to lie in a close orbit about the Sun, inside the orbit of Mercury. Vulcan's existence had been proposed to explain the strange non-elliptical orbit of Mercury, which seemed to defy Kepler's Laws, but which could be perfectly explained by the gravitational influence of another nearby planet. Searching for transits had seemed to Schwabe the easiest way to detect a planet which might lie so close to the sun that it was always hidden in twilight.

In light of this, Schwabe had compiled 17 years of sunspot observations by 1843, at which point he had accumulated enough data to note with confidence that sunspot numbers seemed to have changed markedly over his years of recording them, apparently following an 11-year cycle. Soon after, others had noted that this period corresponded rather precisely with the appearance of aurorae, and professional interest had begun to be pricked. Dr Bergmans added that Schwabe had, of course, been disappointed in his search for Vulcan; in fact Mercury's strange orbit had remained unexplained until the formulation of Einstein's General Theory of Relativity in 1915, although similar observations of non-ellipticity in Uranus' orbit had led to the discovery of Neptune in 1846.

The era of professional sunspot observation had dawned, and in 1849, Johannes Rudolph Wolf, a Swiss professional, had begun to collate historical sunspot observations into a systematic catalogue, with the hope of constructing from them a consistent measure of past sunspot activity. To this end, he had defined the *Wolf Number*, N_W, as:

$$N_W = k(10N_G + N_S)$$

where N_G was the number of sunspot groups visible and N_S was the number of large sunspots visible. The scaling constant k had been introduced to compensate for the inferiority of the telescopes used in historical observations as compared to Wolf's own, which would lead to their having shown fewer small sunspots. To continue his catalogue into the present, he had added his own observations, setting $k = 1$ for these. Seeking to minimise the methodological difference between new and old observations, he had, in addition to this rescaling, also opted not to include the very smallest spots – which would not have been seen by historical telescopes – in his own counts. The work of making these daily observations had been taken over by the Zürich Observatory upon its foundation in 1864, when Wolf had been appointed its inaugural Director.

Reflecting on Wolf's work, the speaker explained that whilst the Wolf Number seemed at first sight to be an entirely arbitrary formula, it was possible to see how it had been motivated. Typically, $N_S \approx 10N_G$, and so the formula gave approximately equal weight to numbers of individual sunspots versus numbers of sunspot groups as two measures of solar activity. He added that it was Wolf's insight in devising an objective counting scheme which was retrospectively extensible right back to the earliest systematic counts which gave the modern *International Relative Sunspot Number*, R_i, still based upon Wolf's metric, its unique value. It was the only measure of solar activity which could be traced back consistently to the early 18th century.

Since Wolf's time, the counting scheme had undergone various modernisations. After Wolf's retirement as Director of the Zürich Observatory in 1882, his successor, Alfred Wolfer, had decided that future counts should include all visible spots. The exclusion of small spots had been, in Wolfer's view, subjective, as there had been no well-defined threshold size. To highlight this break away from Wolf's methodology, the new counts had been renamed the *Zürich Sunspot Number*, N_Z, but in order to place them on a consistent scale with the Wolf Number, the scaling factor in Wolf's metric had been set to $k = 0.8$ for all new observations, accounting for the inclusion of more sunspots in the new counts.

Wolfer had also built up a network of around 30 stations, spread across Europe and Asia, each making their own counts to supplement those made from the single Zürich observatory used by Wolf. Though this had been a labour-intensive development – counts now needed to be collated from many widely-spread observatories – it had meant that observations could be made even during periods of poor seeing, cloud cover, or even night-time in Zürich. This step was now understood to have halved the uncertainty in the resulting sunspot counts.

After this time, the Zürich Sunspot Number had continued to be compiled in essentially the same way for almost a century, until 1980, when the Zürich Observatory had controversially decided to abandon sunspot counting altogether, under pressure from its parent institution, Zürich's Federal Institute of Technology (ETH). There had been numerous reasons for this decision. Sunspot counting was costly, labour-intensive work, and whilst it was valuable for posterity, funding councils tended to favour more glamorous or groundbreaking projects. In addition, the site of the Zürich Observatory was no longer ideal for the purpose: what had once been the outskirts of Zürich was now surrounded by the city, and its sky visibility and seeing conditions had deteriorated.

But perhaps most importantly, several rival measures of solar activity had grown into widespread use by 1980. During World War II, the American military had started their own sunspot count – the *American Relative Sunspot Number*, R_a – realising the value of sunspot counts for forecasting radio propagation conditions, but lacking easy communications links with Switzerland. Ever since 1945, the American Association of Variable Star Observers (AAVSO) had continued to compile these counts. Another easily obtainable estimate of solar activity came in the form of the Sun's 10.7 cm radio flux, which correlated well with N_Z.

After much debate, it had been agreed that the Zürich Observatory would cease compiling the Zürich Sunspot Number, but would strive to find another institution to take over the work, which was willing to retain the old methodology as closely as possible. It was agreed that the name of the sunspot count would, from 1980, be changed to the *International Relative Sunspot Number*, R_i, to reflect its geographical move. The Royal Observatory of Belgium in Brussels had agreed to become the sunspot count's new home, and over the course of 1980-1, the *Sunspot Index Data Center* (SIDC) had been formed there, later to be renamed in 2000 the *Solar Influences Data analysis Center*, to reflect its widening rôle in monitoring space weather.

Whilst remaining loyal to the methodology formerly used at Zürich, the SIDC had sought to modernise its procedures. The handling of data reports was now largely computerised, and this had allowed for an expansion of the number of its stations from 30 to a present figure of nearly 80. These were still heavily concentrated in Europe and Asia – at a recent count, 71% had been in Europe – but there were now a handful of stations in the Americas.

The speaker closed with an invitation for members to help the SIDC by considering becoming a station in their network. The SIDC's newly computerised analysis system could take data from new stations with no extra work, and amateur astronomers were warmly encouraged to get involved. More details could be found on the centre's website[2].

Following the applause for Dr Berghmans' talk, the President invited the Director of the Association's Solar Section, Lyn Smith, to give an update on the section's activity.

Solar Section Update

Ms Smith reported that the Sun had been very inactive over the past few months. With the exception of a brief resurgence in May and June, sunspot counts had been declining throughout 2007, and were now very close to zero.

In September, the Sun's face had gone for 22 days without showing any sunspots– from 6th to 27th – and although a few small sunspot groups had been seen in the following week, these had been followed by another draught, this time lasting for 29 days – from October 9 to November 5. The speaker pointed out that whilst these spotless spells were long, they were far from being record-breakers; in 1913, for example, the Sun had gone for 92 days without showing any sunspots.

This period of quiescence had not been entirely unexpected, and it could be simply explained: sunspot cycle 23 had now ended and the new cycle had not yet begun. The first sunspots of cycle 24 might appear at any time, although the latest predictions from NASA were that they would not appear until 2008 March.

The speaker went on to report that whilst the Sun's face had little to show in white light at present, it remained active when viewed through Hα or Calcium K-line filters. Even at this time of solar minimum, observers using such filters were reporting several prominences on the solar limb each month.

The speaker closed by reporting that the section was developing a computerised observation filing system which would allow its members to report sunspot counts electronically via the BAA website. The section had been actively liasing with the preceding speaker to learn from the SIDC's experiences of setting up such systems. She then handed over to the section's Assistant Director, Mr Tony Broxton.

Mr Broxton reported that he was currently working on a complete rewrite of the *Solar Section Observers' Handbook*. He explained that his aim was to develop it into a manual which could be readily understood, even by readers who came to it with very little previous experience. The new version would start at a basic level and contain minimal mathematical content, yet it would work right through to a point where the reader could make scientifically useful observations and return them to the section. A publication date in early 2008 was planned, and its release would be advertised in magazines and at astronomy fairs with the hope of its reaching those who might previously have been rather daunted at the idea of joining the BAA.

Following the applause for Ms Smith's and Mr Broxton's reports, the President introduced the afternoon's final speaker, Mr Jonathan Shanklin, to present a brief report on the appearance of Comet McNaught.

Update on Comet 17P/Holmes

Mr Shanklin explained that the story of Comet 17P/Holmes went back to the earliest days of the BAA: its discoverer, Edwin Holmes, had been among the Association's founder members, and its discovery had come a mere two years after the Association's foundation. According to Holmes' records, on 1892 November 6, at the end of an evening's observing, he had directed his telescope towards M31, whereupon he had noticed an unexpected new object nearby. In time, this had been verified to be a new comet, lying in a short-period 6.9-year orbit. Since it had never been seen previously, and there had been no evidence for any recent change in its orbit, it had seemed certain that it must have outburst prodigiously to have appeared so suddenly. The speaker noted that he was uncertain of the exact location of Holmes' observing site, except that it was somewhere in London; he hoped that further research might throw light on this.

Two months later, in 1893 January, the comet had undergone a second, albeit less dramatic, outburst, attaining a peak brightness of mag 6. But, after fading for a second time, it had returned to a quiescent state, becoming a faint object which had brightened no further than to around mag 16 at each perihelion. It had continued in this way for over a century, until 2007 October 23-24, when it had again shown a very rapid brightening, suddenly becoming easily visible to the naked eye. The rapidity of this outburst had been quite staggering: the comet's magnitude had risen from 17 to 3 – a one million-fold increase in its luminosity – in less than 24 hours. The parallels between the 1892 and 2007 outbursts also seemed striking; the speaker even remarked that the position of the comet in the sky had been almost identical on both occasions, although this was almost certainly a coincidence.

Turning to describe observations of the latest outburst, Mr Shanklin explained that immediately after its appearance, the comet had appeared point-like or stellar; some observers had even mistaken it for a new nova. Within hours, however, it had grown in size and developed a remarkable disk-like morphology which had appeared rather like a planetary nebula. Over time, a diffuse outer halo and an inner condensation had become distinct. Initially no tail had been visible, although the leading edge of the disk had gradually grown to be much more sharply defined than its trailing edge, suggesting that a modest tail was present.

Mr Shanklin explained that the cause of the outburst remained poorly understood. It seemed clear that there had been a sudden and explosive ejection of a cloud of solid dust particles from the surface of the comet's nucleus. These particles were now spreading out in all directions to fill a spherical volume, and the comet's disk-like morphology was thought to result from the reflection of sunlight from them. Its light curve supported this interpretation: its magnitude was declining as an inverse-square law, as would be expected for a steadily expanding cloud of reflecting dust particles. The velocity with which these dust particles had been thrown out from the nucleus could be easily inferred from the observed expansion rate of the coma, and the answer produced was around 500 m/s. Here lay the puzzle: considerable explosive force would be required to eject so much dust at such a speed, and it was unclear what could have triggered such a sudden and violent explosion to take place across the whole surface of a comet.

The speaker closed by reporting that the comet was very well positioned for observation from the UK, and it would remain so for the next few months. It lay close to the zenith at midnight, which was ideal for telescopic observers, though rather uncomfortable for binocular users. If its light curve continued in its present decline, it would remain bright for some weeks to come, sinking below mag 6 in 2008 February. However, given its current rate of expansion, it was likely to become very large and diffuse by this time, and it would probably disappear into the sky background much sooner.

Following the applause for Mr Shanklin's report, the President adjourned the meeting until 2.30pm on December 15 at the present venue.

Dominic Ford

References

[1] http://stereo.rl.ac.uk/
[2] http://sidc.oma.be/