Meetings

Ordinary Meeting and Christmas Lecture, 2005 December 17

held at The English Heritage Lecture Theatre, 23 Savile Row, London W1

Richard Miles, *President*
Ron Johnson, Hazel Collett and Nick James, *Secretaries*

The President opened the second meeting of the 116th session, reporting with sadness the death of Dr Andy Hollis, who had been Director of the Asteroids and Remote Planets Section until only a few months earlier. Born in Cambridge in 1947, Dr Hollis had first joined the Association at the age of 14, later becoming Director of the then Terrestrial Planets Section's Minor Planets Group in 1984. He had remained at its helm for the next 20 years, seeing it through its transition to a separate Section in its own right, and later changing to its present name. He had surely been one of the Association's most skilful observers, in recognition of which he was awarded the Merlin Medal in 1992; of such quality were his observations that he was able to use them in a thesis on the evolution of asteroids when the Open University had first begun to offer PhD courses, culminating in his receipt of one of the University's first doctorates. His year-long battle with cancer, and longer struggle with multiple sclerosis, had sadly come to an end on November 21. Members stood for a moment's silence.

The President then invited Mrs Hazel Collett to read the minutes of the previous meeting, which were approved by members and duly signed. Mr Ron Johnson, Business Secretary, announced that no presents had been received. Dr Miles reported that 80 new members were proposed for election, and put to members the election of those 112 who had been proposed at the previous meeting; these being accepted, he declared them elected, and invited any newcomers to introduce themselves to him during the interval. Mr Nick James, Papers Secretary, said that at the two meetings of Council since the previous Ordinary Meeting, two papers had been approved for publication in the *Journal*:

> *The retrofocally corrected apochromatic dialyte refracting telescope*, by John Wall & Peter Wise;
> *Noctilucent cloud over Britain and western Europe, 1998–2000*, by David Gavine.

Dr Miles said that the next meeting would be the second in the Association's series of *Back To Basics* workshops, to be held on January 21 at the University of Kent in Canterbury. The next Ordinary Meeting, featuring talks by Chris Lintott, Martin Mobberley and Doug Ellison, would follow on January 25, at a new venue within Guy's Hospital; the present venue, home to the Association for many years in its present and previous incarnations as the English Heritage Lecture Theatre and the Scientific Societies' Lecture Theatre respectively, was soon, sadly, to be demolished.

The President then introduced the evening's first speaker, Prof Don Kurtz. Academically most notable as the discoverer of a new class of rapidly pulsating A-type stars, Prof Kurtz had started his career with a doctorate from the University of Texas, after which he had passed two decades working at the University of Cape Town. He now held a chair in the Centre for Astrophysics of the University of Central Lancashire. This afternoon, he would be presenting the Association's Christmas Lecture, on the measurement of time.

It's about time

Prof Kurtz opened by listing a series of questions. What *was* time? We liked to think of it as a line – a river flowing from past to future – but how accurate was that image? Did the past have any real existence beyond our perception of its having once been? Was time travel possible? Such were not questions that he or anyone else could answer; the nature of time was an unsolved philosophical puzzle. In the fifth century, St Augustine had observed: 'What, then, is time? If no one asks me, I know what it is. If I wish to explain what it is to him who asks me, I do not know.' Meanwhile a modern dictionary offered only that 'time' was a 'measured or measurable duration', while 'duration' was the 'time in which a thing lasts' – a circular definition. And so, in this talk, he would leave such matters aside, addressing instead the measurement of time.

Many of the units used to measure time – days, months and years – had roots in simple astronomical observations. Others, such as weeks, had semi-astronomical origins, while some – hours, minutes and seconds – had no astronomical roots except as manmade divisions of the duration of a day, Prof Kurtz explained.

The day, to which he turned first, would be known to many as the time taken for the Earth to complete one full rotation about its axis. But this was not *quite* true. In that time, the Earth travelled a little way in its orbit around the Sun – about a degree. Thus, from one noon to the next, the Earth would have to turn a little more than once – by ~361°, in fact – to catch up with the movement of the Sun along the ecliptic. In other words, what was commonly called a 'day', the interval between noons – the *solar day*, was a little longer than the time taken for the Earth to rotate once on its axis, and likewise the stars once about the heavens – the *sidereal day*. In the time taken for the Earth to complete an orbit of the Sun – a year – the number of elapsed solar days would be one fewer than the number of sidereal days.

Turning to Venus to illustrate this further, here was an example where the distinction was greater. Having an orbital period of 224.70 days, and a rotational period of –243.01 days (the negative sign indicating its rotation to be in the opposite sense to the Earth's) the duration of its sidereal day exceeded that of its year; there were –0.92 sidereal days in each Venusian year. But was the same true of the duration of solar days? There being one fewer solar days than sidereal days in each year, the speaker calculated that there were –1.92 solar days in each Venusian year, and hence each lasted –117 Earth days; on Venus, as on Earth, the perceived day was shorter than the year. Though the stars took more than a year to complete each revolution around the sky, the Sun's drifting along the Venusian ecliptic sped it around the sky faster, to return to noon in under half the time.

Mercury was odder still. Orbiting close enough to the Sun to be locked into a gravitational resonance, there were exactly $^3/_2$ sidereal days in each Mercurian year, and thus exactly half a solar day in each year: on Mercury, each day lasted two years.

In conclusion, the length of the day was entirely astronomical in origin. By contrast, though, the starting point of each day – the time at which each gave way to the next – was arbitrary. Whilst the choice of midnight seemed so natural now as to go unquestioned, it was merely a convention adopted to avoid a change of date during working hours. This advantage being lost upon astronomers, it was unsurprising that a different convention had been adopted in the Julian Date system used for astronomical calculations, in which days started at noon. These conventions were by no means universal to other cultures: in the Swahili calendar, days started at sunrise, whilst in the Jewish calendar, at sunset.

The speaker added that the length of the day was not actually quite constant, because the Earth's rotation rate showed small fluctuations. For example, changing tides slightly altered its shape, and consequently its moment of inertia, and in turn its spin rate. The resulting change around its average period was ~1ms. Seasonal changes in wind patterns and ocean currents effected a somewhat larger variation of ~25ms. And the gradual orbital drift of the Moon away from the Earth was causing a deceleration which would continue until eventually, in the distant future, the length of the day would stabilise at about 40 hours. To account for this effect, there was an occasional need to insert *leap seconds* into the calendar, to keep solar time in synchrony with that measured by atomic clocks – a process called *intercalation*.

The modern division of the day into 24 hours had its roots in Babylonian culture, which had divided both day and night into twelve equal hours. Twelve had presumably seemed a good number on account of its ready divisibility. As the divisions between night and day were sunrise and sunset, the system's hours had been considerably longer on summer days as compared to winter days, but these variable-length hours had nonetheless remained in widespread use until the advent of mechanical clocks in the Middle Ages. The division of hours into sub-units of minutes and seconds was also Babylonian in origin, and once again, divisibility seemed to be the motivation in choosing the number of subunits, in this case 60.

Moving onto the week, here was a more arbitrary unit, no more than a convenient clustering of a few days. The need for such groupings seemed to be felt widely, if not quite universally; the Ancient Greek culture was one of few that appeared to have refrained. Early Roman civilisation had used eight-day weeks; the modern seven-day week seems likely to have been already well-embedded in the culture which wrote the Old Testament. It had later passed down through Jewish and Christian roots and, under Judeo-Christian influence, had been adopted by the Roman Empire in its latter years. Running from that time until the present, the seven-day weekly cycle of days was the longest contiguously running measure of time that would be mentioned in the talk.

The reasoning behind the choice of seven days for the duration of each week was not clear, though the speaker offered two theories, both astronomically based. Firstly, seven was the closest integral number of days to one quarter of the time between New Moons; second, more loosely, there were seven visible 'planets' in the sky, if the Sun and Moon were included, making it a 'favoured' number. Weight was added to the latter explanation by similarities between the names of the days and those of the planets, or of the gods who, in later cultures, superseded those associated with the planets in Roman times. The similarities of 'Saturday' to 'Saturn's Day', of 'Sunday' to 'Sun's Day', and of 'Monday' to 'Moon's Day' were clearest. But the name 'Tuesday' derived from 'Tiew's Day', Tiew being the Germanic god of war, Mars his Roman predecessor. 'Wednesday' derived from 'Woden's Day', 'Woden' being the Anglo-Saxon for 'violently insane leader', Mercury the Roman god of commerce and thievery. 'Thursday' derived from 'Thor's Day', Thor being the Norse God of Thunder, Jupiter his Roman predecessor. Finally, 'Friday' derived from 'Freya's Day', Freya being the Teutonic god of love and beauty, Venus his Roman predecessor. Similar patterns were observed in other European languages.

The speaker noted in passing that these were not the only appearances of the names of the planets in the etymologies of English words. For example, 'saturnine' – meaning 'sluggish' – derived from Saturn's slow crawl along the ecliptic, whilst 'mercurial' – meaning 'lively' – derived from Mercury's flighty movement. Others, 'jovial' and 'martial' among them, derived from the planets' associations with deities.

Turning now to larger units of time – months and years – Prof Kurtz explained that whilst these were commonly said to equal the orbital periods of the Moon around the Earth and of the Earth around the Sun, as with the unit of the day, such definitions were approximate, not exact. In the case of the lunar month, the reason was very similar: the period between New Moons was extended because on each orbit, the Sun had moved some distance in its annual path along the ecliptic, and so before returning to solar conjunction, the Moon had to traverse more than one revolution around the celestial sphere to catch up with the Sun. In consequence, whilst the Moon's orbital period was 27.32 days, New Moons were separated by 29.53 days.

The reason in the case of the year was due to a different phenomenon. The *tropical year* – that which the seasons followed – was the period of the oscillation of the Sun's declination between the two tropics. This closely, but not quite, matched the orbital period of the Earth around the Sun – 365.2564 days. The discrepancy arose in consequence of the Earth's non-spherical shape, with a bulging equator. The Sun exerted a fractionally stronger gravitational pull upon the equatorial bulge which faced it, and as the Earth spun, the effect of this pull was entirely analogous to the effect of gravity on a tilted gyroscope. It pulled the 23°.5 inclination of the Earth's rotation axis, and the celestial north pole with it, in gradual circles around the ecliptic north pole, an effect termed the *precession of the equinoxes*. Every 20 millennia, one rotation was completed, and the number of elapsed tropical years consequently exceeded the number of the Earth's orbits by one. The resulting length of each tropical year was 365.2422 days.

Owing to the inconveniently non-integer number of lunar months in each year – 12.37 – most cultures, including our own, had replaced lunar months with arbitrary divisions of the solar year. This practice was not universal, however. In the opposite extreme, the Islamic calendar was entirely lunar, a new year beginning upon every twelfth New Moon, after only 354–5 days. Hence its months did not keep step with the seasons, and for this reason the dates of the festival month of Ramadan differed from year to year with respect to our calendar.

The Hebrew (Jewish) calendar adopted a luni-solar approach, taking advantage of the closeness of the duration of 235 lunar months to that of 19 solar years – a similarity accurate to within 0.002% and known since antiquity, termed the 19-year *Metonic Cycle*. Lunar months were used, and a new year started after every twelfth, except in seven 'leap-years' out of every 19, when the final month, Adar, was repeated as a 'leap-month'. In consequence the months could both remain lunar and also be in good synchrony with the seasons.

The origin of our own system of months could be traced back to the Roman Republican calendar, used throughout the Roman Empire until the Julian reform of 46 BC. Twelve months, some of 29 days and others of 31 days, added up to a total of 355 days in each year. To prevent the seasons from drifting by ten days each year, an extra 27-day month was intercalated into approximately every third year, between February 23 and 24. This system had a number of disadvantages, arising largely because leap months were not inserted systematically into every third year, but rather determined by pontifices, often at short notice. Poor communications meant that much of the Empire was often unaware of these decisions, and additionally, at times of domestic crisis, leap years were often overlooked, and the seasons thus allowed to drift.

Prof Kurtz explained that in 46 BC, the situation had grown so bad that the official date of the vernal equinox, March 25, differed from that of the astronomical equinox by three months. Julius Caesar employed an Alexandrian astronomer by the name of Sosigenes to revise the calendar. Knowing the year to have 365¼ days, Sosigenes had revised the lengths of the months to a total of 365 days, and suggested that a leap day be added into every fourth year. In practice, this was added after February 23, where the leap months had been inserted in the previous system. Additionally, 67 intercalary days were inserted into the year 46 BC to resynchronise the astronomical vernal equinox with March 25. On account of its long length, this year became known as the *Year of Confusion*.

The confusion was not entirely over, however. Firstly, in the years immediately following Caesar's death, the system of leap years seemed not to be fully understood; leap days were inserted into every third year for the following 36 years, later corrected by the omission of leap years. More seriously, the length of the tropical year was not exactly 365¼ days, but in fact 365.2422 days. Though a difference of only 11 minutes and 14 seconds, the effect accumulated over time. By AD 325, when the Catholic Church convened the First Council of Nicaea to determine how the date of Easter was to relate to that of the vernal equinox, this date had already drifted by four days to March 21.

By the 15th century, the astronomical vernal equinox had shifted to March 11 – a matter of concern to Pope Sixtus IV, as the date of the Easter feast was now uncertain. In 1472, he employed the astronomer Johann Müller to investigate, but the work came to a halt when Müller was assassinated in 1476. The matter then had to wait until the Council of Trent, which in 1563 approved a plan to reform the calendar and return the vernal equinox to that date upon which it had fallen at the time of Council of Nicaea – March 21. This plan finally reached fruition under the papacy of Gregory XIII, who employed to the task first the astronomer Ghiraldi, and then, after he died in 1576, Christopher Clavius, who saw it to its completion.

Clavius' solution was to propose that century years should be excluded from being leap years, except for those divisible by 400. This scheme yielded an average year length of 365.2425 days – 26 seconds too long, an error of one day in every 3,300 years. This error remains in our calendar to this day, but is actually comparable in magnitude to the long-term variability in the Earth's rotation period discussed earlier. To fulfil the Council of Trent's desire to return the vernal equinox to March 21, Gregory XIII additionally declared that the day following 1582 October 5 would be called October 15. This decree was followed throughout the Catholic world, but not by Protestant countries, England among them.

The transition to the Gregorian calendar was not made in England and its colonies until 1752, by which time the calendar had drifted by a further day. And so, Parliament decreed that 1752 September 2 would be followed by September 14. At the same time, the official start of the year was moved from Lady Day, March 25, where it had been up until this time, to January 1. Bankers however, refused to pay their taxes until a full year had elapsed, which was not until 1753 April 5, giving rise to the apparently strange date for the start of the modern tax year. Many countries in the Orthodox world did not adopt the Gregorian reform until later still – in Russia not until the October Revolution of 1918, and in Greece not until 1923.

Following the applause for Prof Kurtz's talk, the President invited questions. Roger Dymock asked, in view of recent media reports on the effect of climate change on ocean currents, whether this would alter the rotation rate of the Earth and thus the length of the day. The speaker replied that this was an interesting question, but not a straightforward one to answer, as the currents would flow in different directions at different depths. He was not aware of any studies of the matter. Another member asked whether the speaker thought it likely that astronomical time would switch from solar to atomic time; the speaker replied that he thought it likely that this transition would be made within the next decade. Finally, a member asked why 'leap'-days were so-called when they were in fact quite the opposite; the speaker remarked that this, too, was a good question – he supposed that 'intercalated day' seemed a bit too much of a mouthful.

Dr Miles thanked Prof Kurtz for his excellent address, remarking that the making of calendars was one field where astronomy had very real practical uses. The meeting then broke for tea, after which Mr Rod Jenkins was invited to speak on a seasonally topical subject.

The Star of Bethlehem

Mr Jenkins explained that his research into the Star of Bethlehem had started in response to his frustration at the apparent lack of any widely accepted studies in the literature of whether the 'star' could be explained astronomically. He felt many of the existing studies to be rather unscientific in nature.

Setting the scene, he explained that only one source described the apparition of the star: the Gospel according to St Matthew (2:1-11). The other Gospels lacked any mention of the star, as did all known contemporary historical records. Furthermore, there was some vagueness about the exact translation of this one source from its original Greek: the description of a 'star in the East' could also refer to a 'star at its helical rising' – the day of the year upon which it, rising four minutes earlier each day, first became visible in dawn twilight.

Historical scholarship widely dated the nativity itself to 7–5 BC and the writing of St Matthew's Gospel to AD 85–90. Consequently, it was widely agreed that the text was unlikely to have been written by the actual Apostle Matthew, and in all probability the events described had preceded the lifespan of its true author.

The speaker then began looking for possible explanations of the 'star'. Rejecting miracles, for the purposes of the argument, as untestable and unscientific, he began looking for astronomical events. Starting with planetary conjunctions, he could find three, in 523, 146 and 7BC, to within 65, 10 and 58 arcminutes respectively. All would have been trivially naked eye resolvable, and whilst some argued the third to explain the star, 58' was quite a large arc. One would have to ask why, if the Magi had set out upon seeing this 'star', they had not set out in 146BC instead; attempts to explain this rapidly grew too baroque for plausibility.

Alternative astronomical explanations included an apparition of Comet Halley in 12BC. Elsewhere, the appearance of a nova and a comet in 5–4BC were recorded – possibly confused accounts of a single event – but these seemed far too commonplace events to trigger such an extraordinary response.

Mr Jenkins argued the Gospel account, then, to be fictitious, and presented an alternative explanation of it. He noted that several sources, including Pliny the Elder, recorded a procession led by Tiridates, King of Armenia, travelling to pay homage to Nero, the Roman Emperor, in AD66. This coincided with an apparition of Comet Halley, whose circumstances would have matched those described by Matthew. Moreover, it was documented that Tiridates had returned home by a different route, as Matthew described the Magi to do. The speaker conjectured that the Gospel's author may have been inspired by accounts of this journey; he perhaps had such faith in the Old Testament prophesies that the appearance of a new star would herald the birth of the Messiah, that he was left in no doubt as to its having happened, and so had set it down as historical fact.

A full account of Mr Jenkins' research can be found in his paper on the subject.[1] Following the applause for Mr Jenkins' thought-provoking talk, the President invited Mr Martin Mobberley to conclude the meeting with his regular Sky Notes.

The December sky

Mr Mobberley opened his final Sky Notes of 2005 with a review of the year's celestial events. Turning first to comets, 51 had been discovered to date since January 1, excluding the Sun-grazing discoveries of the SOHO satellite. Two had been amateur discoveries: 2005 T5 and 2005 N1, by Broughton and Juels–Holvercem respectively. LINEAR, once the bane of amateur patrollers, had recorded a mere eight discoveries, and NEAT a near-insignificant two; both were overtaken by the 22 discoveries of the Catalina Sky Survey's 68cm Schmidt.

Over 330 supernovae had been discovered thus far in 2005, including over 130 by the Sloan Digital Sky Survey (SDSS) and over 65 by the Lick Observatory Sky Survey (LOSS). UK amateurs were still finding events as well – a total of 14 over the year – eleven by Tom Boles, two by Mark Armstrong, and one by Ron Arbour; the UK tally of amateur discoveries now stood at a once-unimaginable 176. Nine galactic novae had been recorded, as well as one – Nova Liller – in the nearby Large Magellanic Cloud.

On October 3, an annular solar eclipse was visible across Portugal, Spain and northern Africa; a partial eclipse to a maximum of 66% was seen from London. Galleries of images by Nick James from Valencia and Pete Lawrence from Madrid were shown, and Mr Mobberley dwelled briefly upon Lawrence's images of third contact to demonstrate how the shape of the Baily's Beads as they appeared matched that predicted from lunar topography.

Turning to the present sky, the speaker remarked upon his frustration at the lack of cometary visitors. Perhaps the best prospect was 29P/Schwassmann–Wachmann, which in coming months would appear to be casting a 4° circle around Hamal. Though typically a meagre mag ~16, its occasional outbursts often reached mag ~12. 2005 E2 (McNaught), near Nashira in Capricornus at present, was brightening towards perihelion on February 23, and might reach mag 10, but was sinking into evening twilight, already visible at an altitude of only 15° in true darkness. Perhaps the best CCD target of the winter would be 2005 B1 (Christensen) at mag 14, presently around a degree south of Rastaban in Draco, which would spend the coming months tracking eastward toward Cygnus.

Mr Mobberley moved next to the planets, and first to Mars, presently drifting through Aries, and due to pass into Taurus in the second week of February. A sizeable dust storm had blown up in mid-October, but alas it had been mostly unobservable from the UK – the similarity of Mars' rotation period to our own meant that on several consecutive nights the affected region had been turned to the Earth only in UK daytime; US observers, by contrast, had had a fine view. The storm appeared to have started around October 17 in the vicinity of *Chryse*, before spreading northward to fill *Valles Marineris* a couple of days later and flowing over *Mare Erythraeum* shortly thereafter, later surrounding *Solis Lacus*. It appeared to subside towards the end of the month.

Saturn was well placed in Cancer at present, visible for much of the night. In Spring 2003, its rings had reached their 15-yearly maximum inclination to the Earth, providing a good view of Saturn's south pole, and the southern face of its rings. Its northern polar region was entirely concealed behind the rings, only re-emerging in late 2004.

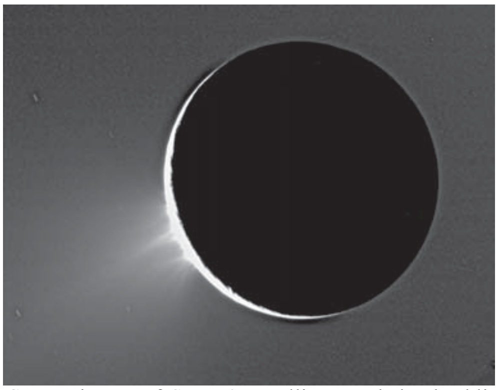
Dave Tyler's recent images of the surface revealed a white spot at system III longitude 118° in the southern polar region; it was unusual to see such a feature so high in latitude. However, even observers without the resolution to pick this out might be interested by a photographic opportunity coming up around February 5, when Saturn would skirt within 30' of the Beehive Cluster (M44). Around 2005 September 15 it had previously skirted ~1° from this cluster; this pass, in retrograde motion, would be closer.

The *Cassini* space probe was still returning stunning images, all of which were available on the mission website; Mr Mobberley picked a few of his personal favourites to show. Images of Hyperion from *Cassini*'s close pass of September 26 revealed a strange world, pummelled with impact craters, giving an appearance which the speaker compared to that of a bath sponge. One huge impact crater appeared to dominate nearly three-quarters of its face. On September 16, the spacecraft had seen Dione partially occult Tethys – an eye-catching meeting of worlds.

Enceladus had attracted much interest in recent weeks. A fountain-like spray of material was seen emanating from the southern polar region, towering at least 300km in altitude; it had been suggested that the source might be geysers erupting from pressurised reservoirs of liquid water beneath the surface. On November 26/27, *Cassini* had had the opportunity to view this curious moon occult the Sun, and the resulting backlit conditions were ideal for imaging this vapour plume in scattered sunlight.

Moving on to Venus, the phase was presently 19% and its diameter 47"; towards Christmas the crescent would narrow to 11% but enlarge to 53" diameter. Recently there had been some debate as to whether it was possible to photograph a shadow cast by Venus; the speaker showed several images by Pete Richard and Douglas Lawrence from Selsey which proved beyond doubt that it could be done. Finally among the planets, Jupiter was now only just observable before sunrise, but would soon be visible earlier in the night.

From January 1–6, the Quadrantid meteor shower would be active, peaking at around 17h00 UT on January 3, making the night of January 3/4 likely to yield the highest rate, perhaps reaching ZHR 100. The Moon would be a favourable four days old.



Cassini image of Saturn's satellite Enceladus backlit by the Sun, showing pressurised jets erupting from the surface.

Two asteroids were singled out for mention: firstly 3 Juno, which had passed opposition on December 12, and was around mag 7.6 in Orion. The second, 4 Vesta, would reach opposition on January 5, and was around mag 6.2 in Gemini. Less readily observable was 25143 Itokawa, a 600m-long rock whose appearance was compared to that of a gherkin, which had been visited by the Japanese *Hayabusa* probe in November. To obtain surface samples, the asteroid was impacted with a series of 5gm metal balls at 300 m/s,