Ordinary Meeting, 2002 November 30
held at the Scientific Societies' Lecture Theatre, 23 Savile Row, London W1

Guy Hurst, President

Ron Johnson, Nick Hewitt and Nick James, Secretaries

The President opened the second Ordinary Meeting of the 113th session. The minutes of the October meeting were read by Dr Hewitt and approved by the audience. Mr Johnson announced that there were no presents to announce. Mr Hurst stated that 26 new members had been proposed, and that their names would be displayed in the library. The members present approved the election of the 32 new members proposed at the previous meeting.

The President announced on behalf of Mr James, who was absent, that no papers had been approved by Council. Mr Hurst went on to comment upon a recent article[1] in the *Independent,* which had reported government plans to levy rent charges upon the occupants of New Burlington House. This would affect the Royal Astronomical Society, of which the Association is a sub-tenant. He informed members that Council were aware of this matter, however he did not wish to comment further in view of the likelihood of legal action. Members were assured that these proposals would not be realised for several years.

The next meeting would be at a new venue, the St Bride Institute on Fleet Street. Peter Hingley would be speaking on *Astronomers and Oddities - the RAS and its library*, and Prof Joseph Silk would speak on *The Big Bang*. The President regretted that the current meeting would be the last at Savile Row after 32 years. Dr Richard McKim had reliably informed him that the first meeting at this venue had been 1970 January 28th.

Mr Hurst then welcomed Prof Robert Hutchison to deliver the afternoon's first talk about meteorites. Prof Hutchison's highly respected work in this field had earned him the Gold Medal of the RAS in 2001.

What do Chondrite meteorites tell us about the origin of Solar System planets?

Prof Hutchison explained that looking at the Earth's crust was not a very useful way to investigate the formation of the Earth, since it was continuously evolving. For this reason, it was necessary to look elsewhere, and the analysis of meteors had proved particularly fruitful. When a meteor hits the Earth's atmosphere, it typically exceeds our escape velocity. The resultant friction generates a great deal of heat, and melts the surface layer of the object. The core remains very cold, however. The speaker explained that most meteors are categorised as chondrites. They are also labelled, usually with the name of the locality where they land, though in some cases only with a number. The latter is the case for oceanic meteors, for example.

The speaker went on to describe the technique of radioactive dating, which had first been accurately used by Clave Patterson in the 1950s. Two different isotopes of uranium decay to lead with different halflives, and thus by measuring the proportions of the various species in a sample, and comparing with the natural abundances, an age estimate can be made. Dating of basalt in the Earth's crust yielded an age of 4-5 billion years, in close correlation with data from meteors. Prof Hutchison discussed the typical microstructure of meteors, explaining that the mixture of species present indicated that the material forming the Earth had previously been processed in 35-40 separate stars.

Prof Hutchison then discussed a 31g object which had caused a great deal of debate around 1980. It appeared to be of Martian origin, although the suggestion of a sample escaping the Martian gravitational field and travelling to Earth appeared incredibly unlikely. The escape velocity of the Moon is considerably smaller than that of Mars, and its closer proximity suggested that if one meteor could travel from Mars, a very great number should have travelled from the Moon. This is not observed. Landing probes sent to Mars had shown that the Martian atmosphere matched gas samples in pockets of the meteor, showing that it was almost certainly of Martian origin.

The speaker proceeded to describe a 3.7 tonne meteor that had been found in western Australia by John Carlisle. Transporting it across the desert had proven a considerable challenge, with crowbars having to be lashed to the underside of a truck to support the weight. The team had had seventeen punctures on their 43km journey, and Prof Hutchison admired their resourcefulness.

Ratios of ^{27}Al and ^{26}Mg abundances in certain samples indicated an age of around 4570 million years, which led the speaker to suggest that such meteors had formed within 2 million years of the birth of the solar system. However, other evidence indicated that they had formed in the violent collision of two planetary bodies of considerable size, and Jupiter appeared to be the only planet fitting this criterion. Prof Hutchison postulated that this was evidence that Jupiter was present in the solar system within two million years of its formation. It seemed unlikely that such a vast body could grow in such a short time, so he argued that it may have been gravitationally captured by the Sun after its formation.

This idea was backed up by considering the dynamics of the disc of material surrounding the Sun in the early solar system. Jupiter-sized objects would be most likely to form only in the inner regions of this disc, from material with low angular momentum. Such a theory was supported by observations of extra-solar planets, where it was found that the vast majority of Jupiter-sized objects were in close orbits to their parent star. It therefore seemed unlikely that Jupiter had formed in the solar system. Prof Hutchison also cited the 7.2° inclination of Jupiter's orbit to the solar rotation axis as evidence for an unusual history. He pointed out that the idea of the capture of such an object was not as ridiculous as it might appear, since free-floating Jupiter-sized objects had been detected in Orion. Finally, he speculated that the fluke capture of Jupiter 2 million years after the formation of the Sun might have made life possible on Earth. If this was the case, Prof Hutchison believed that whilst our solar system might not be unique, there could not be many other systems like it.

In response to a question as to whether any observable features on Jupiter would confirm the age difference, the speaker was sceptical. He pointed out that radioactive dating methods are typically accurate to within two million years, and this is equal to the predicted delay between the formation of the solar system and Jupiter's capture into it.

The President thanked Prof Hutchison for his comprehensive talk, before adjourning the meeting for tea. After the break, Dr Nick Hewitt made a presentation on behalf of the Association to Mr Colin Powell of the Royal Society of Chemistry. Mr Powell had given tremendous support to the organisation of meetings at Savile Row, for which Dr Hewitt was deeply grateful. The President then invited Mr Martin Mobberley to present his Sky Notes.

The December Sky

Mr Mobberley opened with a report of the occultation of a mag 5 star, HIP 19388, by minor planet 345 Tercidina on 2002 September 17. The speaker illustrated the location of amateurs who had contributed observations from across central Europe, and hailed it as the second most observed occultation of its kind – the first being a US event. These observations had placed more than 60 chords across the object, and refined its size to 99km by 93km. Mr Mobberley remarked that professionals would have been unable to obtain such accurate data without the use of a costly space probe.

During 2002, there had been an unusual clustering of four nova events in Sgr, one of which had peaked at mag 5. The speaker showed Mike Jäger’s images of the second event, V4742, which was tucked just south of the Trifid and Lagoon nebulae. The nova showed a striking red colour, and Maurice Gavin had reported spectral measurements of a strong Hα line. A light curve constructed by Guy Hurst showed a three magnitude fall within a few days of the peak at 8.5 around 17 September. The third Sgr event, V4743, had been discovered by Katsumi Haseda on September 20 at mag 5.

A GRB on the evening of October 4 had been the first ever to have been successfully observed by amateurs. The object, GRB021004, appeared beside the Eastern side of the square of Pegasus. Nick James had achieved the first amateur images at twilight, followed by numerous others. A robotic telescope had obtained images of the optical transient associated with the event within minutes of its discovery.

The speaker congratulated Mr Tom Boles on a spate of supernova discoveries, starting with 2002gc. Three further discoveries had come within a week, including 2002hl and 2002hm, which had received consecutive labels from the IAU. The absence of any further discoveries since November 7 was most disappointing, however! The hypernova 2002ap in M74 was still observable at mag 10.7 after 10 months.

Moving onto planetary observation, Mr Mobberley showed fantastic images by Ed Grafton from Houston and Damian Peach from Tenerife. A notable white spot in the South Temperate zone of Saturn had caught the attention of both on September 27. More generally, recent images had revealed a greenish tint to Saturn's southern polar region, and a greyish tint had also been reported in the A ring.

Recent images suggested Jupiter's Great Red Spot to be a little more orange than usual. An exquisite stacked image of the post-spot turbulence by Ed Grafton was of exceptional quality. The inclination of Jupiter's orbit was particularly favourable for so-called "Mutual Galilean Events" in the coming month. These are events where two moons occult one another. The speaker referred interested observers to a very complete article in the 2002 December *Sky and Telescope,*[2] and listed the observable UK events: Dec 16th, 2h07 – 2h13, Callistro totally occulting Io for 54 seconds; Dec 20th, 4h48 – 4h55, Europa eclipsing Io over a period of 112 seconds to a maximum of 59%; Dec 23rd, 0h15 – 1h18, Europa eclipsing Ganymede for 634 seconds to a maximum of 59%. There would also be occasions when two moons would cast simultaneous shadows onto the Jovian surface: Dec 17th, 2h02 – 2h17; Dec 24th, 3h55 – 4h53; Dec 31st 5h48 – dawn (7h29).

Damian Peach had recently turned his attention to Venus, in an attempt to image the mysterious Ashen Light. He hoped that three dimensional surface plots of his data would aid his quest, but he was without positive observation thus far.

Mr Mobberley opened his discussion of the comet scene with superb images of 2002 O4 (Hoenig) and 46P (Wirtanen) by Ed Grafton. The speaker illustrated the paths of 2001RX14 (LINEAR), which was expected to peak around mag 11; 2001HT50 (LINEAR-NEAT), which would pass through Hydra in December at around mag 12; 2002V1 (NEAT), which would brighten from mag 14 to 12 whilst passing through Aries in December; and finally 154P/Brewington which would brighten from mag 13 to mag 11 over the next three months. Currently in Aquarius, it would have a close encounter with the south-east limb of the square of Pegasus next February.

The speaker closed his summary with mention of the total solar eclipse of December 4, which would be visible across southern Africa and Australia. Many amateurs not present at the afternoon's meeting were preparing for this event, although totality would last only 26 seconds for Australian observers. Mr Mobberley then handed over to Neil Bone, who would summarise the results from the recent 2002 Leonid meteor shower.

Leonid Feedback

Mr Bone had received floods of observation reports since the shower of November 19. Weather had proved problematic for many observers, although those in Scotland and on the Chilterns had had a good view. In other areas, cloud and fog had hindered any form of observation. Preliminary reports suggested that the near-full Moon had limited observers to mag 4 at best.

Referring back to the Asher-McNaught models outlined in his preview at the previous meeting, the speaker suggested that the estimated 3h56 UT peak had come a little later than expected, just after 4h. Mr Bone pointed out that a 10-15 minute error in such predictions was to be expected, and they remain very accurate. At maximum, rates of around 15 meteors per minute had been reported. On average the meteors had been brighter than usual, although there had not been a significant excess of fireballs. One such event at 4h09 had caught the attention of a number of observers, however, and was reported to have left a 20-30 second trail.

Relatively few observations had been received for the 3h region of the distribution, although it appeared that rates had soared at around 3h45 before peaking at 1500 EZHR. On the tail of the distribution, rates had remained high at 4h30, and had reduced to 2-3 meteors per minute by 5h.

The speaker urged observers to take a look at the Geminid shower on December 14, which he believed to be the next best shower after the Leonids. The peak would be at 4h UT, although observation from 1h until dawn was recommended. Mr Bone believed that a good show would be guaranteed, since the shower had frequently reached 120 EZHR in recent years. It was undergoing a period of evolution, and good rates were to be expected for the next decade or so. Early morning observations were likely to be the most fruitful on this occasion due to the late-setting Moon.

Looking further ahead, the speaker also recommended observation of the Quadrantids, due to peak on the night of 2003 January 3-4. The radiant would be low at peak, although the activity might outstrip even the Perseids.

Following the applause for Mr Bone's thorough summary, the President welcomed Mr Jerry Workman to report on the progress of the Cassini mission to Saturn.

The Cassini Mission

Mr Workman believed many amateurs might be asking why there was a need to send a new probe to Saturn when amateurs such as Damian Peach were obtaining such superb observations from the Earth. He pointed out that the ring structure is the most eye-catching feature for amateurs. Early observations had recorded them as a triple planet, and they had first been correctly identified in 1655 by Huygens. Two decades later in 1675, Cassini resolved the planet sufficiently well to see a gap between two apparently separate rings – the gap we now call the *Cassini divide*. The Berlin observatory identified another sub-gap within the A ring in 1837, but it was decided that it was sufficiently hard to resolve that it did not warrant a further division.

In contrast, the Voyager missions had revealed unexpected character on the surface of the planet itself. Its tremendous size dominates the dynamics of its gaseous surface. There is little large scale structure comparable to the Great Red Spot on Jupiter, but there is rich fine structure, with an average wind velocity in excess of 1000mph. These are the fastest in the solar system, and their energy source remains a mystery.

The Voyager probes had also overturned our previous picture of the rings. For example, it revealed that the Cassini divide was an area of low density, not a complete gap. It revealed that there are actually over 4000 closely-packed rings, not just four large structures as had previously been thought. The rings were believed to be composed of water ice and small pieces of rock, which ranged from the size of a sugar-lump to that of the lecture theatre. We had learnt from Voyager that rings are not the rare phenomenon once thought, but in fact all four gas giants exhibit them to some extent. Both Neptune and Jupiter have faint structures around them.

Further out in the Saturn system, the moons had produced numerous puzzles when Voyager resolved the first surface detail ever seen on them. Firstly, Mimas' landscape was dominated by an 80-mile crater. This was indicative of a particularly violent history, as the formation of such a crater in an object of 240-mile diameter would have brought it close to total destruction. The central peak of the impact crater rose several miles out of the surface.

In contrast, Enceladus had a bright surface of water ice which was virtually uncratered. This begged the question of where the craters had gone. The speaker favoured the explanation that vulcanism had eroded such features, although a more subtle alternative was that tidal gravitational forces on the moon from Saturn might heat it and cause surface melt. The liquid would flow up through cracks in the surface before resolidifying as a smooth top layer. A few fractures in the surface supported this idea of past breaking and rebonding, but were not sufficient to convince the speaker.

Mr Workman moved onto Diomine, which is believed to be composed of an inner rock core, surrounded by water ice. Overall the moon is rather lightweight – only twice the density of water. A curious feature of the surface is a number of white wisps and speckles, centred around the crater Amata. It is believed that the impact that created Amata also blew a large amount of liquid water melt off the surface. This subsequently resolidified in the vacuum of space before returning to the surface. Similar wisps are also seen on Rhea, a moon which the Cassini probe would spend some time imaging. It was the aim of the Cassini probe to orbit within the system for four years, rather than just fly past the system, as the Voyager probes had done.

Moving onto Iapetus, the speaker described a feature observed as long ago as 1671 by Cassini. The moon's two hemispheres have spectacularly different colourings. Furthermore, Voyager found that the shape of Iapetus is remarkably irregular for such a large object. Some people had proposed that a dark tar-like substance had oozed up through the surface, whilst others believed it had been accreted from elsewhere. The speaker favoured the opinion that the material had come from Phoebus, although the colour of the dark material on Iapetus did not quite match the hue of Phoebus.

Finally, the speaker described the moon commonly thought of as the king of Saturn's moons: Titan. The atmosphere is 94% nitrogen, and it appeared likely that the surface was liquid ethane or methane. Conditions in the atmosphere were ideal for liquification of such hydrocarbons. Infrared HST images hinted that light-coloured regions might be continents of solid hydrocarbon, although this remained an area of active research.

The Cassini mission would be in two-parts: there would be an orbiter and the Huygens landing probe, which would be destined for the atmosphere of Titan. The orbiter was exceptionally large – as high as a single-storey building – and weighing six tonnes. Sadly an atmospheric probe had not been included due to space constraints. Cassini had been launched in 1997 as a NASA/European collaboration. A recent encounter with Jupiter had been used to test the camera, which appeared to be working well. It would finally reach Saturn in 2004 July.

The first priority would be to obtain a stable orbit. Then, in 2005 January, the Huygens probe would be released into the atmosphere of Titan, marking the start of scientific investigation. A slight technical hitch had recently been identified with Huygens, although engineers were confident that the control software could be suitably modified. It was hoped that after penetrating the atmosphere, the probe would continue to function for around half an hour on the surface, and take two or three images of the landing site. A particularly interesting question would be whether Huygens would splat down or splash down on Titan.

It was hoped that the orbiter would complete around 80 orbits of Saturn, half of which would be close passes of Titan. A few questions of interest included the nature of the magnetic field, the composition of the ring particles, the atmospheric composition, as well as the many puzzling features of the moons. Between 2005 and 2008 around eight billion images would be taken. Depending upon the status of the mission in 2008, it could potentially extend until 2010.

The President thanked Mr Workman for his detailed report of an enthralling subject, before welcoming the afternoon's final speaker, Mr Chris Lintott, to speak about recent developments in cosmology.

The Age of Precision Cosmology?

Mr Lintott opened by expressing his honour to be the final speaker at the Savile Row venue. He believed that in recent years humanity had reached a consistent and plausible cosmological model for the first time, and this explained the title of his talk.

Historically, philosophers had preferred the idea of an infinite static universe, in accordance with the cosmological principle that neither our position nor time in the universe is special. This was believed primarily out of modesty, but it had numerous problems. In both classical and general relativistic physics, such a model turned out to be unstable to small perturbations from uniformity, as was pointed out by Richard Bentley as early as 1691, in correspondence with Newton. Furthermore, the blazing sky paradox – often falsely attributed to Olbers – showed that the sky in such a universe would be as bright as the Sun in all directions, since every line of sight would eventually end on the surface of a star. Such was Einstein's faith in this cosmology that when he discovered its incompatibility with general relativity in 1917, he introduced the famous cosmological constant Λ to counteract the instability.

In 1929, however, Hubble published the remarkable observation that distant galaxies were receding from us. From this it was inferred that the universe was expanding. An obvious question to ask in light of this observed expansion was at what time, if we extrapolate back, did all points in space coincide? For the first time, we have scientific evidence that the universe may have started at some finite time in the past, in a giant primordial explosion.

Mathematically, such expansion was explained within the framework of general relativity by Friedmann. He constructed a model whereby the universe emerged from a primordial "Big Bang", and then expanded to a maximum size, before recollapsing in a "Big Crunch". It was later shown that two further possible models were a universe which tended asymptotically to a maximum size, or one which continued to expand for eternity.

When confronted with this evidence, Einstein retracted Λ, branding it as the “biggest blunder of his life”. Some believe that the idea of such a constant was a “fudge factor”, whilst others point out that it arises naturally as a constant of integration in relativity and hence discarding it was perhaps rather rash.

The Friedmann models were resisted by some, including most notably Sir Fred Hoyle, who proposed a steady-state model in which new galaxies formed in the voids between pre-existing ones as the universe expanded. Such models were largely discredited in 1967, however, with the discovery of the Cosmic Microwave Background Radiation (CMBR) by Penzias and Wilson of Bell Labs. This radiation is near equal in all directions, which implies it is not associated with either our solar system or indeed the Milky Way. Instead, it is believed to have formed and filled the universe when it was 500,000 years old, at a time known as recombination. It has the characteristic spectrum of a body cooling and expanding, as a big-bang universe would have been.

In recent years, observation of the CMBR by observatories including the COBE satellite had shown several surprising features, including a striking uniformity to one part in a hundred thousand. Calculations show that regions of the CMBR separated by more than a degree or so would not have had time to have any influence over one another between the big bang and the epoch of recombination. The global uniformity is therefore surprising: how do the various regions know how to make themselves similar to one another? This philosophical issue has led cosmologists to favour an idea known as inflation – a rapid period of expansion immediately after the Big Bang. This allows the various regions of the CMBR time to synchronise themselves.

The speaker finally discussed the distance-ladder method of estimating the distance of objects to ever-increasing redshifts. He pointed out that the use of Type Ia supernovae as standard candles had produced evidence suggestive that the outer regions of the universe were expanding more slowly than predicted by Hubble expansion. This supported a non-zero cosmological constant, and reopened the debate as to whether Λ was a necessary component of our cosmological models. Such a constant could be interpreted as an intrinsic energy of empty space (vacuum), which led particle physicists to attribute it to quantum fluctuations associated with the creation of pairs of particles and anti-particles. However such an association resulted in estimates of Λ which were 10^{120} times greater than the maximum limit allowed by astronomical observation.

The speaker closed by expressing his interest in hearing the resolution of this inconsistency. The President thanked Mr Lintott for his enlightening talk, before adjourning the meeting until 2003 January 4 at the St Bride Institute on Fleet Street.

Dominic Ford

1 - *The Independent*, 2002 November 25, 3.
2 - *Sky and Telescope*, **104**, 6, 100 (2002).