Ordinary Meeting, 2004 December 18

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

Tom Boles, President

Ron Johnson, Nick Hewitt and Nick James, Secretaries

The President opened the third Meeting of the 115th session, and invited Dr Nick Hewitt to read the minutes of the November Meeting, which were duly approved. Mr Boles announced that the names of 25 candidates for election to membership would be displayed in the Association's library, and the 24 candidates proposed at the previous meeting, finding the approval of the audience, were declared elected. The President invited any newcomers to introduce themselves to him later. Mr Nick James, papers secretary, announced that ??? papers had been accepted for Journal publication:

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It was announced that the next meeting would be on January 26 at the Geological Society, Burlington House, when the main speaker would be Dr David Boyd, speaking on *Clocking a Spinning White Dwarf*, followed by contributions by Martin Taylor, Peter Wise and Nick James. The President also wished to remind members of the forthcoming *Back to Basics* course, to be held in Chichester on January 29.

Before proceeding to the afternoon's talks, Mr Boles remarked that the meeting was taking place in the month of a significant historical anniversary, for at the meeting of 1934 October 28, seventy years previously, a bright youth, 11½ years of age, had been elected a member of the Association. At the time, this must have seemed no special occasion, but with time that bright youth was to work up through the ranks of the Association. He was to become the author of many books and a TV presenter. He would become famous around the globe. The youth was, of course, Sir Patrick Moore, and the President scarcely had to inform members of his presence at the Meeting, for few could have failed to notice the applause which had erupted some minutes earlier, upon his entry to the lecture theatre.

Almost exactly 20 years ago, Sir Patrick had held the Presidency of the Association; he had also held posts as Director of the Lunar and Venus sections at various times. In total, he had been a member of Council for no less than 40 years. He had been a prolific writer of papers for the Journal over the years: the President had to confess to having stopped counting at 200, though there were doubtless many more still. The first, on the subject of lunar craters, had been written at the age of a mere fourteen, and though it was so long ago, the President supposed a first paper was always one to be remembered. Perhaps his greatest contribution of all was through the interface he provided between the Association and the media. His popularisation of astronomy had brought in numerous youngsters, and Mr Boles remarked that it was a common observation that even many now-professional astronomers admitted that they had first been inspired into the field by Sir Patrick's work.

On behalf of the Officers, Council and Members of the Association, in recognition of all his many contributions, the President offered Sir Patrick his warmest congratulations on his 70th anniversary. In view of his lifelong passion for the observation of the Moon and planets, no gift seemed a more fitting memento than a brass-orrery, which, to great applause, Mr Boles presented to Sir Patrick.

Rising to his feet, with apologies that his mobility was not what it once was, Sir Patrick thanked all for this reception: the orrery would, he assured members, be a treasured possession. He remembered well the day, 70 years before, when he had, as an 11½-year-old, had to walk forward to shake hands with the then-President of the Association, and, incidentally, also then-Astronomer-Royal, Harold Spencer Jones. Reminiscing of some of the past members he had known over those 70-years, and some of the lighter moments he had shared with them, he remarked that the Association remained unchanged. Astronomy had moved on, but the Association had always moved with it. He always thought it important to remember that the Association was, above all else, the observers, and that through their work, it had played a tremendous part in astronomy, both in the UK and abroad, building up a great deal of interest in the field. He described the BAA as a cornerstone to astronomy, and he greatly regretted that it seemed unlikely to him that he would be able to attend any further London meetings. Finally, Sir Patrick wished to thank all for the kind invitation to such a reception in recognition of his anniversary. His speech was followed by prolonged applause, after which the President returned his own thanks to Sir Patrick for his very great effort to travel up from his Selsey home to attend the afternoon's meeting.

Mr Boles then proceeded to introduce the afternoon's first speaker, Prof David Hughes, who would be delivering the 2004 Christmas Lecture. Prof Hughes presently headed up a planetary sciences group at the University of Sheffield specialising in cometary research, and the President remarked that a casual search for his publications had brought up no less than 320 papers bearing his name. Given his active interest in the *Rosetta* mission, Mr

Boles supposed he would be kept busy until at least 2014, waiting for the return of data.

Comets and their Exploration by Spacecraft

Prof Hughes first wished to thank the Association for inviting him to deliver the Christmas lecture. He recalled that he had started his career with an interest in meteors – tiny dust grains originally broken from the surfaces of comets, producing streaks of light across the sky upon impact with the atmosphere. With time his interests had moved from the dust grains to the comets themselves, but they illustrated a central theme of the talk to come: comets were dying objects, always getting smaller. The first part of the talk would be a general introduction to comets, followed by a discussion of space missions which had explored them, winding up with a discussion of unanswered questions. The speaker remarked that there was no shortage of these: he had thought of no less than fourteen embarrassingly simple questions which science had not yet succeeded in answering.

Observers had long been familiar with the fact that comets were surrounded by a coma, which had led to the idea, traceable back to Newtonian origin, that they comprised of a sublimating dirty snowball nucleus, though in modern times it had first come to widespread acceptance through the work of Fred Whipple. Another familiar fact was that comets evolved: as they approached the Sun, the rate at which material was lost changed rapidly. Using the familiar example of Halley's Comet, the speaker quantified this: at a distance of 3AU from the Sun, the nucleus was thought to lose an average of one molecule per square centimetre per second, yet at perihelion, 0.5AU from the Sun, it was thought to lose 11,000 molecules/cm^2/s. The speaker remarked that as well as ice, this also included rocky debris, the dust from which gave rise to both the Orionid and δ-Aquarid meteor showers.

Another familiar fact was that comets spent much of their lives in an inactive state: they generally only 'turned on' and acquired any noticeable coma at a distance of around 3AU from the Sun. Halley, presently at a similar distance to Neptune, was essentially indistinguishable from an asteroid, and would remain so until around 2061, when its 76-year periodic orbit would bring it back to perihelion. Between perihelia, it did nothing more interesting than follow an elliptical orbit described by Kepler's Three Laws. In the case of its latest return in 1985-6, the speaker recalled that a significant coma had first developed around 1985 November, as it passed the orbit of Mars. By the time it passed the Earth's orbit in early 1986, a full coma and tail had developed. The speaker had frequently been asked what colour comets were: the answer was much the same as that of the Sun, they merely scattered the Sun's rays. The ion tail itself had a rather bluer colouration as it was composed of ionised plasma, which, just as an electrical spark, radiated preferentially blue light.

It was also known that there were a large number of comets in the solar system, though no one knew quite how many. Furthermore, because they spent time both far from the Earth, and rather closer to it, the risk of one colliding with our planet was one to be monitored. Historically, it seemed probable that much of the water in the oceans had arrived in the impacts of comets.

Perhaps comets were the most beautiful of the naked eye offerings of the sky, and the speaker showed a few of his favourite images. These included an exceptional image of Halley, with, in the foreground, a burning dust grain from another comet in the form of a Quadrantid meteor. The speaker also showed an artistic photograph of Comet Bennett from Switzerland, just above the Moon-illuminated Jungfrau. Prof Hughes remarked that this particular comet appeared to have fragmented in 1974, and that this was not well understood. Little was known about the mass, composition, or mechanical strength of cometary nuclei, and so in turn, little was known about what was needed to break them apart. Presently, this seemed to happen entirely randomly. Finally, the speaker showed an image of a more recent comet, Hale-Bopp, a fine example where both dust and plasma tail clearly visible.

Given their aesthetic appeal, it was perhaps not surprising, then, that comets had attracted wide historical attention. Legend had it that Julius Caesar had been instructed by his wife not to attend Senate on that fateful Ides of March, because the appearance of Halley's Comet was a bad omen. The same comet appeared in the Bayeux Tapestry, prophesising the defeat of King Harold at Hastings. And the return of Halley in 1301 had inspired Giotto's *Adoration of the Magi* (1304-6), in which the Star of Bethlehem appeared as a comet.

The speaker proceeded to discuss their scientific investigation, starting with the work of Aristotle, who had believed comets to be atmospheric phenomena. His conviction that the heavens were unchanging was so firmly held, that he could not accept comets as a part of them. He suggested that earthquakes ejected gas, which rose up and ignited in the upper atmosphere. It seemed that his idea that comets were caused by natural disasters was later turned around: comets came to be seen as a warning of bad times to come.

Moving forward somewhat to the Newtonian era, it was Halley who had first shown that the elliptical orbits of Newton's Theory of Gravity extended to comets. Newton himself had later devised a mathematical technique for deriving five orbital parameters for a given comet, given three observations at different times and places. This was not quite complete, for comets had six parameters, and so Newton had had to assume all comets to follow parabolic orbits, with an eccentricity of unity. He had later passed this work onto Halley, who used it to undertake the painstaking work of finding the orbits of many comets, each taking several weeks. It was through this work that his suspicions had been aroused upon noticing amongst his catalogue three comets, in 1682, 1607 and 1531, each with a near-identical orbit, and each separated by around 76 years. The comet in question was the one now known as Halley's Comet, and it had been the first time that anyone had proposed that they might return periodically.

The speaker remarked that Hevelius had thought that comets were made of material ejected from the surfaces of planets, spun off rather like the hurling of a discus. The curvature of the subsequent trajectory would be determined by the speed of the ejection. By contrast, the opposite was now understood to be true: comets often added new material to planets. It was widely thought that Jupiter and Saturn both harboured rocky nuclei of around 10-20 Earth masses, each composed mostly of cometary material.

The process of this accretion could be illustrated with reference to another famous comet: Shoemaker-Levy 9, discovered by David Levy and Carolyn Shoemaker. At discovery in 1993, it had been observed to be in around 20 pieces, each orbiting Jupiter. A comet orbiting a planet was a rare find, though not unprecedented, the speaker added. Adding together the bits, it was thought to have originally been of around 1.5km diameter, and tracing the orbit back, it was found to have fragmented in 1992 upon a close encounter with Jupiter. Moreover, tracing the orbit forward, it was realised that it would collide with the surface of the planet upon its next return in 1994.

At this point, the speaker had to confess some embarrassment. Having calculated that 99.5% of the cometary material would be reduced to an atomic state upon impact, he had briefed the media that there would be little to see: it would sink into the planet like a stone into a pond. Thus he had been somewhat surprised, on the day of the impact, to hear reports of the large dark scars which were in fact seen. His mistake had been to overlook the 0.5% of the material which would not vanish!

The speaker went on to discuss space missions to comets, remarking that each had cost around half-a-billion pounds. The first, ESA's *Giotto* mission, had flown past Halley's Comet during its 1985/6 return. In preparing the mission, he recalled that it had been established that two observation windows were feasible, 1985 November or 1986 March. The latter had been selected simply on the grounds that time was in short supply, and it would give a few additional months for preparation. In essence, the plan had been to put Giotto on a trajectory which was close to the nucleus of Halley at a particular time, though at that time it would be hurtling past the comet at a relative velocity of 65km/s in a head-on collision. This had made photography somewhat challenging – the satellite was also spinning once every four seconds – and as any photographer knew, movement and rotation were best avoided when taking pictures.

The closest approach distance to the nucleus, 600km, had been selected deliberately: at this distance Giotto would collide with many of the dust grains surrounding the comet, and its chance of surviving the encounter was almost exactly 50%. Indeed the speaker recalled that a collision with one large grain had knocked Giotto severely off-course, but that this had been rectifiable.

Prof Hughes expressed some amusement that in their scheduling, some broadcasters had overlooked the 8-minute lag in transmissions from Giotto, and so images from the craft had arrived somewhat later than the media had anticipated. However, when they finally came, they had been the first ever taken of a cometary nucleus, and though some had described them as hideous – the speaker himself confessed the quality left something to be desired – they provided the first decisive evidence that Halley had a single solid nucleus. In addition, the speaker remarked upon the large number of craters apparent on the surface, appearing rather similar to the impact craters on the Moon, except that in this case the surface was far too young for these to have resulted from impacts. Many now believed comets to have a foam-like structure, outbursts being seen whenever the sublimation of snow opened up a new hole in the surface, suddenly revealing a vast area of fresh snow to solar radiation.

In addition to imaging, Giotto had also collected dust grains from around the nucleus, and measured their mass distribution and chemical composition using a mass spectrometer. The speaker remarked that this hardware was very similar to that onboard *Rosetta*, due to arrive at comet 67P/Churyumov-Gerasimenko in 2014, however the latter would be able to gain samples from much closer to the nucleus as a result of actually being in orbit around it.

Reviewing other past space missions, the speaker remarked that three had successfully returned images of cometary nuclei: as already mentioned, Giotto had returned images of Halley in 1985 to a resolution of ~200 metres per pixel, but in addition, *Deep Space I* had imaged Comet Borelli in 2001 at a resolution of ~50 metres, and *Stardust* had visited Comet Wild II in 2004, taking images at a resolution of ~20 metres. The latter had also collected dust samples, to be returned to Earth on 2006 January 13, using a similar mechanism to that employed for the *Genesis* capsule: the samples would parachute down into the Utah desert, being caught by helicopter to prevent their impacting with the ground. In view of the failure of Genesis' parachutes, the speaker hoped for better luck this time around. Looking at past imaging performance, he remarked that a factor-of-ten increase in resolution had been achieved in a decade, and it was hoped Rosetta would achieve sub-millimetre resolution when its landing craft was deployed in 2014.

Presently, Rosetta was flying through the solar system towards its destination, having been launched on 2004 March 2. Its path would take it through three gravity-assist encounters with the Earth, and one with Mars, before arriving very close to 67P/Churyumov-Gerasimenko in 2014 May. At that time, in contrast with Giotto, it would also be in a very similar orbit to the comet, allowing an orbital insertion burn to be undertaken, putting it into an orbit around it. It would then follow the comet's nucleus as it approached perihelion in 2015 August. The speaker was hopeful that it would remain active for at least one-and-a-half of the comet's six-year orbits. Prof Hughes remarked that Rosetta had been little in the news in recent months: this was, he explained, simply because it was working nominally. All was going to plan, but as there was little data being returned in flight, there was little news to report.

Moving on to discuss unanswered questions, the speaker remarked that perhaps the most obvious was the mass of comets. The physical dimensions of cometary nuclei could be determined from the images taken by the aforementioned three spacecraft, but as little was known of their composition, so their physical density was also unknown. One might guess that since they were thought to contain a lot of ice, they would share a similar density. But ice was known to be a strong material, and by contrast, comets broke apart under the influence of quite weak gravitational encounters. It seemed possible they were more similar to snow, but in that case, the density would be a mere twelfth that of ice, and so already a factor of ten uncertainty could be seen to have crept into mass estimates. This was a question that Rosetta would answer immediately: as soon as it entered orbit around 67P/Churyumov-Gerasimenko, an orbital radius and period would be known, and from these, using Newton's Laws, the comet's mass could be derived. But by the same token, the speaker remarked that without knowing the mass of the body it was entering orbit around, there were big uncertainties as to what orbital insertion manoeuvre would be required: no one knew how easy it would be to enter orbit, without first knowing the mass of the comet.

Other missions, of interest in the nearer future, included NASA's *Deep Impact*, due to launch in 2005 January, to make a rendez-vous with 9P/Tempel I in 2005 July. It was to impact it with a 370kg projectile, at a collision velocity of 10km/s. The speaker remarked that the illuminated face of the comet was only 4km across, and so this shot required precision aim. NASA had confidently suggested that a crater of dimensions 100m across and 20m deep would result: a claim he viewed sceptically given the lack of data concerning the mechanical strength of the nucleus. The volume of the crater could be accurately estimated by calculating the energy released in the impact, and comparing with the sublimation energy per unit volume of water ice, but he thought it equally possible that the projectile might sink into the nucleus leaving behind it a 4-metre-wide tunnel. In any case, the results were keenly awaited.

Another proposed mission, though sadly scrapped due to budget constraints, was the *Comet Rendez-vous Asteroid Flyby* (CRAF) mission, which had planned to project a dart-shaped spacecraft into the nucleus of a comet. It had been hoped that an antenna on the back end would be left protruding from the surface of the nucleus to return data. However, the speaker had thought this an exceptionally challenging proposal, given the lack of information about the material into which it would be impacting, since the dart might either disappear completely into the nucleus, or else rebound from the surface. Nonetheless, it would have been an interesting experiment.

A more complete review of Prof Hughes' excellent discussion of the outstanding questions of cometary astronomy can be found in his own paper on the subject, to be published in a future issue of this Journal.

Following the applause for the speaker's excellent lecture, a member of the audience asked whether there had been any attempt to measure the mass of the three comet nuclei which spacecraft had encountered at close range, since in each case there would have been a small trajectory change as a result of the nucleus' gravitational pull, and this might have been measurable. The speaker said that he was not aware of any such work, and thought that if such a technique had successfully obtained a mass estimate, it would have been headline news. The Meeting then broke for tea, after which the President welcomed Mr Martin Mobberley to present his Sky Notes.

The December Sky

Mr Mobberley opened by expressing his very great honour to be presenting his Sky Notes this month in the presence of Sir Patrick Moore. As this was the last instalment of the year, he would follow his convention of opening with a round-up of the year's highlights. There had been 43 comet discoveries to date, including 15 by LINEAR, and a further 6 LINEAR co-discoveries. NEAT had contributed 5 discoveries. Though the competition was stiff, amateurs still had a chance, and there had been three such discoveries in 2004, by Bradfield, Machholz and Tucker. Mr Jonathan Shanklin interjected that a 44th comet had recently been announced.

Moving on to novae, the speaker reported that there had been six galactic events discovered in 2004, if one included Liller's October 28 event, which had strictly been in the nearby Large Magellanic Cloud. However, none of these had been particularly spectacular in the northern hemisphere. A total of 205 supernovae had been discovered, the LOSS search of the Lick Observatory being the most prolific discoverer with 80 events. However, the Association's Tom Boles and Mark Armstrong had the second and third greatest numbers of discoveries, with 22 and 15 respectively. Ron Arbour, also BAA, had made four discoveries. Mr Mobberley paused to reflect that given the UK skies, and the automated nature of the Lick search programme, British amateurs were doing astoundingly well.

Looking ahead, the speaker recommended observation of the Quadrantid meteor shower between 2005 January 1-6, expected to peak before dawn on January 3. Unfortunately the last-quarter Moon would interfere on this occasion, and whilst stressing he did not mean to put anyone off, Mr Mobberley added that he could only recall ever once seeing a single Quadrantid, though the shower had produced surprises on past occasions. On the same night, January 3, observers on the England/Scotland border would see a grazing lunar occultation of mag 3.9 star η-Virginis at 00h20 UT, at an altitude of 8° above the Eastern horizon. The speaker remarked that he normally ignored events so low in the sky, but given the brightness of the star in question, he thought this would be readily observable given a suitable site. London observers would see a near miss.

The speaker explained that his round-up of supernova discoveries would be exceptionally quick this month: there were no new UK discoveries, as there had been few breaks in the cloud. A new mag 7.6 nova had been discovered in Puppis by Tago and Sakurai on November 20, though it was now fading, and expected to plummet to mag 16 in the near future. Although it had been at the very southern limit of the UK-observable sky, the speaker showed an image successfully obtained in Chelmsford by Nick James at 03h17 on 2004 November 27 to prove that observation had been possible.

Moving onto comets, the next promising prospect was not far away in the form of C/2004 Q2 Machholz. Presently tracking northwards through Eridanus, and passing into Taurus on December 27, it was expected to peak at around mag 3-4 a week into January. Closest approach, at a distance of 0.35AU, would be on January 6, and it would pass around a degree to the west of the Pleiades the following night. The phase of the Moon was favourable, with New Moon on January 10 offering the chance of dark skies. On January 10/11 it would move through into Perseus, and on into Casseopeia on 26/27, fading to fifth magnitude by the end of the month.

Another of the 2004 amateur discoveries, Q1 (Tucker), would be in Andromeda for the next month, remaining close to mag 13, meanwhile Comet 78P/Gehrels, presently in Aries, would pass into Taurus in mid-January, tracking slowly eastwards through the constellation for three months at around mag 11, and passing close by Aldebaran in mid-March. An exciting prospect for the spring was 2003 T4 (LINEAR), passing from Hercules into Lyra around New Year, and perhaps brightening to mag 9 by the end of January. Looking ahead, it might brighten to mag 7 by early March, at which time it would be in Delphinus, heading towards perihelion at a distance of 0.85AU from the Sun on April 3. 32P/Comas Sola, in Aries until late March and fading, had now reached mag 11 and was essentially a CCD object, though likely to remain at mag 12 for the next few months.

With reference to the previous speaker, Mr Mobberley showed where in the sky to find 9P/Tempel, the comet which *Deep Impact* would be impacting next July. Brightening to around mag 15 by mid-January, and mag 9.5 by mid-June, whilst remaining in Virgo throughout, it would regrettably be too far south for UK observation by the time of impact.

Moving onto the planetary scene, the speaker reported that Saturn was now in Gemini, transiting at 2am, and so was up for most of the night. The northern hemisphere was slowly emerging from below the rings, and a selection of images from the Association’s planetary imagers, including Dave Tyler, Damian Peach, and the speaker himself, were shown.

Members were reminded that before the next meeting, the *Huygens* probe would be released from the *Cassini* spacecraft, in orbit around Saturn, and would descend into the atmosphere of Saturn’s moon Titan. The separation of the probe had been scheduled for 02h00 UT on Christmas Day, a time and date which the speaker thought sounded familiar from a certain recent Mars mission. Descent into Titan’s atmosphere would take place on January 14, and hence it was possible that there might be images from the surface before the next meeting – if so, these would be the first such images from any moon in the solar system other than our own. Whether Huygens would land unscathed on the surface depended upon whether the probe survived impact, which in turn depended upon what material the surface was composed of – it was not presently known even whether to expect solid or liquid, as all images taken by spacecraft passing Titan had revealed nothing other than thick atmospheric clouds.

Jupiter was now in Virgo, transiting at 7am, and so was easily observable in the pre-dawn sky. Dr John Rogers, director of the Jupiter Section, had informed the speaker that the north equatorial belt (NEB) was very broad following a typical broadening event in 2004, and it was expected that dark ‘barges’ and bright ‘portholes’ would develop in the belt in the following year. The northern tropical belt (NTB) was still absent, and the southern tropical belt (STB) only present at some longitudes, such as those following the Great Red Spot, at System II longitude 100°. The speaker wished to draw members’ attention to a forthcoming double Jovian Moon Shadow event on 2005 January 16, between 03h08 UT and 04h48 UT, at an altitude of ~30° in the UK, when both Io and Ganymede’s shadows would be visible on the planet’s disk.

On December 7, there had been a lunar occultation of Jupiter, though not visible from the UK as first contact was at 09h15 UT. However, Don Parker had returned a fine sequence of images of the ingress half of the occultation from Florida. Mr Mobberley wished to pass on Mr Parker’s kindest regards to Sir Patrick Moore on the occasion of this significant anniversary.

To close, the speaker mentioned two asteroids which might be visible in the near future, firstly 3200 Phaethon, the progenitor to the Geminid meteor shower which had been on display in the days running up to the meeting. It would be around mag 15 in the Perseus/Pisces region throughout December, making closest approach at 0.61AU on December 22. 433 Eros, the asteroid which the *NEAR* spacecraft had imaged at close range and landed upon in

2001, would make closest approach next April, and although its distance would be 0.39AU, its physical size, 33×13×13km, would make it quite bright. Sadly, it would be at southerly declinations at this time, and so the best UK observing prospect would be in January, when Eros would be mag 11 as it plunged southwards. Finally, the speaker remarked that Hind's Variable Nebula in Taurus had been reported bright, and might be visible in 10-inch instruments. The reason for the brightening was uncertain, though thought to be connected with nearby variable star T-Tauri, 1' away.

Following applause, the President proceeded to welcome the next speaker, Dr John Mason.

Kepler's Supernova of 1604

Dr Mason remarked that in contrast with the extragalactic supernova discoveries mentioned by the previous speaker, supernova explosions actually within our own Galaxy were very rare. Indeed, none had been observed in living memory: the last had happened over 300 years previously. The present talk would be concerned with one particular such supernova which had burst into prominence in Orphiuchus on 1604 October 9, now known as *Kepler's Supernova* for reasons to be discussed in due course. It had been lost to twilight on November 6, but had still been easily observable when it re-emerged in 1605 January.

The speaker remarked that the astronomers of the time were particularly lucky: this was the second Galactic supernova to have burst into prominence in only 32 years. It was perhaps a little regrettable that the telescope was not to be used for astronomy until 1609, just too late for these two events, and that there had only been one Galactic supernova in the 400 years since then.

The speaker emphasised that despite its name, Kepler had not been the first to observe the supernova: the first recorded observations were by Italian observers, Altobelli in Verona, Clavius in Rome and Capra and Marius in Padua. However, he could be fairly confident that it had been observed on the first night of its prominence, as by a fortuitous coincidence there was a conjunction of the planets Mars, Jupiter and Saturn in the sky at the time. The supernova itself had appeared right among the planets, peaking at mag –3, in excess of the brightness of Jupiter, and so would have been particularly conspicuous in an area of the sky where many were looking.

Kepler himself had been in Prague at the time, serving as a Court Astronomer, but only came to hear of the event through the reports of a local weatherman, Brunowski. Even after hearing such reports, cloudy skies prevented him from making any immediate observations of his own, and it was seven whole days before he saw the new 'star' for himself. His name would come to be attached to it as a result of his writing a book, *De Stella Nova*, published in 1606, in which he wrote up all of his extensive observations.

Dr Mason proceeded to list all of the Galactic supernovae of the past 1000 years: six in total. The first, in 1006 in Lupus had shone at a brilliant mag –9, and must have been a truly spectacular sight, though not visible from the UK. In 1054, Chinese astronomers had recorded a supernova in Lyra at around mag –5, the remnant of which was now visible as the famous Crab Nebula, whilst a century later in 1181, a somewhat fainter mag –1 event had been observed in Casseopeia. The next two events had happened only 32 years apart: a mag –4 event in Casseopeia in 1572, followed by Kepler's supernova of 1604, mag –3 in Orphiochus. The most recent event had been very much fainter at sixth magnitude, and whilst historical records seemed ambiguous as to whether it had been in 1667 or in 1680, the remnant had now been detected in the form of the radio source Casseopeia A. Indeed, in all six cases, some form of remnant of the explosion, often in the form of an expanding shell of gas, had now been identified.

Looking through this list, the speaker remarked that three of the six events had been in Casseopeia. He was not sure whether this was mere luck, or whether there was reason to think future events might also be more likely to happen in this part of the sky. The speaker went on to remind members that there were two distinct types of supernovae: core collapse events, and so-called 'Type-Ia' supernovae. In the former case, the inner core of a massive star collapsed in upon itself to form a neutron star in a massive explosion. The latter case resulted when a compact white dwarf star was in a binary system with another more normal star, and accreted gas from the surface of its companion. As this happened, the mass of the white dwarf would gradually increase, but when it exceeded a mass limit of 1.4 times the mass of the Sun, called the Chandrasekhar limit, it could no longer support itself against its own gravity. The result was a monumental explosion, ripping through the white dwarf and completely destroying it, and often ripping apart its companion as well. Dr Mason remarked that one way in which to distinguish the two classes of events was that core-collapse events always left a neutron star or pulsar remnant, whereas Type-Ia events completely destroyed the progenitor star. In both cases, however, a remnant taking the form of a shell of shocked gas could often be seen expanding away from the explosion.

The speaker explained that it was fairly certain that the events of 1006 and 1572 had been Type-Ia events: amongst other evidence, no remnant pulsar had been seen in either case. In the latter case, Dr Mason remarked upon a star by the name of Tycho-G, seen within the expanding shell remnant of the supernova by the Hubble Space Telescope (HST) and Chandra X-ray Observatory, apparently moving at a speed of around three-times that of other nearby stars. It was thought that this was the original binary companion star to the progenitor white dwarf, which had been given a 'kick' by the blast wave from the explosion.

In contrast, a pulsar was clearly visible in the Crab Nebula remnant of the 1054 event, and similarly for the 1181 supernova remnant: both optical and X-ray observations revealed a rapidly pulsating source at the centre. In the case of the 1667/1680 event, no pulsar had been detected within the remnant Casseopeia A, though Chandra images had recently revealed what appeared to be a radio-quiet neutron star. The speaker said it was not fully understood why a neutron star should sometimes be radio quiet, however some had constructed theoretical models of how the star's magnetic field might bring about such behaviour, and it was now widely accepted that this neutron star was the remnant of a core-collapse supernova.

Returning to Kepler's supernova, Dr Mason closed by remarking that this was the only one of the Galactic events listed earlier for which the question of whether it was Type-Ia or core-collapse remained open. After the event, Kepler had made detailed brightness observations until it had eventually faded out of sight on 1605 October 8, and he had published these in his book. In 1924, Walter Baade had used these observations to reconstruct the light-curve of the event as accurately as possible, and had found that the shape of the resultant curve resembled a typical Type-Ia event. However, over the years, many had discredited Baade's methodology, and support had tended to switch towards a core-collapse explanation. But now, recent images from a range of observatories at a range of wavelengths – the Very Large Array (VLA) in the radio, the Spitzer Space Telescope in the infrared, the HST in the optical, and Chandra in X-rays – all failed to show any sign of a pulsar at the centre. In addition, spectral observations of the remnant matched more closely the chemical composition that might be expected after a Type-Ia event – poorer in heavier elements than a core-collapse remnant.

The speaker remarked that many of the historical Galactic supernovae must have been amazingly eye-catching events, and he hoped the wait for another would not be a long one. Following the applause for Dr Mason's talk, Mr Boles introduced the afternoon's final talk, to be presented by Messrs Martin Mobberley and Ken Goward.

The Bury St Edmunds Athenaeum

Mr Mobberley remarked that the Bury St Edmunds Athenaeum was a place which he had been interested in for many years, ever since a school visit to an observatory situated in the roof of its building in his teens. However, though he had long wanted to find out the history of the telescope, he had only recently had the opportunity to do the necessary research. First founded in 1674, the history of the Athenaeum – its name simply referring to an academic institution – was relatively well established, but the speaker had been frustrated that even local historians seemed to know remarkably little about the observatory itself. It was probably nineteenth century, they told him, and the construction might, rumour had it, have been influenced by an Astronomer Royal. But that was all he could uncover. Consulting newspapers of the time in the records office also proved remarkably unproductive: there was simply an insurmountable volume of material to look through without more specific information as to the date of its construction.

However, communication with Ken Goward, chairman of the Society for the History of Astronomy, had given him a lead: Sir George Airy had mentioned in his autobiography that he had given a talk at the Athenaeum in 1858 October, chaired by Revd. Lord Arthur Hervey. From this date, Mr Mobberley had been able to find articles in archived copies of the local newspaper of the time detailing the talk in question, apparently an immensely popular spectacle. Furthermore, with the help of Dr Allan Chapman, a longtime friend of Mr Goward, the speaker had been able to locate a collection of Airy's subsequent correspondence with Hervey, held in the collection of the Bodleian Library in Oxford. Amongst this collection were found design sketches of a telescope by a certain William Simms, bearing a striking resemblance to the present-day instrument, and which Airy had apparently sent to Hervey with a recommendation that it would be a well-suited instrument, should the Athenaeum wish to install an observatory.

A full account of Mr Mobberley's research can be found in his paper on the subject, on page ???.

Following the applause, the President adjourned the Meeting until January 26 at the Geological Society, Burlington House.

Dominic Ford