Ordinary Meeting, 2008 May 28

held at the Royal Astronomical Society, Burlington House, Piccadilly, London SE1

Roger Pickard, President

Ron Johnson, Hazel Collett and Nick James, Secretaries

The President opened the sixth meeting of the 118th Session and invited Mrs Hazel Collett, Meetings Secretary, to read the minutes of the previous meeting, which were approved by the audience and duly signed. The President announced that 8 new members were proposed for election, and put to members the election of the 12 new members who had been proposed at the previous meeting; these were approved and declared duly elected. Mr Nick James, Papers Secretary, reported that seven papers had been approved for publication in the *Journal*:

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The President announced that the next Ordinary Meeting would be held during the Association's annual Exhibition Meeting on Saturday June 28 at the National Space Centre in Leicester. He then introduced the evening's first speaker, Prof. Paul Hewitt of the Institute of Astronomy, Cambridge.

The New Generation of Gravitational Lens Surveys

Prof. Hewitt explained that the theme of his talk would be *dark matter* and *dark energy*. He added, however, that despite their surprisingly frequent mention in popular science, very little was actually known about the physical nature of either of them – hence the rather vague and non-descriptive names which they had been given. The only concrete things that could be said about either were descriptions of the observations which pointed to their existence, and these would be the subject of the remainder of the talk.

The speaker began his talk by showing a recent all-sky image of the radio emission called the *cosmic microwave background* (CMB) as observed by NASA's *WMAP* satellite, explaining that this radio radiation dated from when the Universe had been a mere 500,000 years old, and that it had been travelling through space ever since. Up until that time, termed the *epoch of recombination*, all of the material in the Universe had been at such high temperatures that all of the hydrogen – the bulk of the material in the early Universe – had been in a highly opaque ionised form – the same form which was present in the Sun today, and which made its disk opaque. At an age of 500,000 years, this hydrogen had cooled to below 6,000°C for the first time in its history and had been able to form into transparent neutral atoms, like those found in interstellar space today. Even today, 13 billion years later, if a radio telescope was pointed in any direction, and it looked beyond any foreground galaxies which might lie in its field of view, it saw a surface covering the whole sky at a distance of 13 billion light years, where the final emission of this ancient glowing ionised hydrogen could still be seen. This emission was the CMB – originally it had glowed red-hot at a similar temperature to the surface of the Sun, but now it had been heavily redshifted to radio wavelengths by the subsequent expansion of the Universe.

Prof. Hewitt explained that the CMB was of central importance to modern cosmology because it was rather like a photograph of the Universe as it had been in the distant past. Those parts of the sky where the CMB was brighter than average were understood to correspond to regions of the Universe which had had a slightly above-average density of hydrogen at the epoch of recombination; conversely, parts of the sky where the CMB was fainter were understood to correspond with regions of the Universe where the density of hydrogen had been lower. The picture presented in this fashion was of a remarkably smooth Universe: gas appeared to have been spread evenly throughout space at the epoch of recombination, and the formation of structures such as stars or galaxies appeared not yet to have happened. Prof. Hewitt added that this result was a little troublesome: several indicators of the ages of galaxies pointed to their being very old structures – nearly as old as the Universe itself – and so it seemed that they must have formed incredibly rapidly after the epoch of recombination.

The speaker went on to explain the relevance of this to dark matter. He explained that the small variations in density seen in the CMB were understood to have been subsequently amplified to form the structures seen in the Universe today. The enhanced inward gravitational pull of denser regions was understood to have pulled them together and caused them to collapse to form clusters of galaxies. He explained that as the two forces involved in this collapse – gravity pulling the material together and gas pressure pushing it apart – were both well understood, theoretical models could be run on supercomputers to see how the process depended upon the amount of mass in the Universe. The answer was that it seemed to do so very strongly, and so by comparing the structures seen in the Universe today with those seen in the CMB, and trying to build theoretical models to mimic both, it was possible to obtain a remarkably precise calculation of the mass of the Universe.

However, a problem remained. The estimated ages of galaxies could not be reproduced by such models: the collapse of clumps after the epoch of recombination was too slow in the models for galaxies to be formed as rapidly as they seemed to have been in the Universe. The problem could be solved by the introduction of a new kind of material – dark matter – which did not absorb or emit any light. Models showed that the collapse of hydrogen gas into galaxy-like structures had been inhibited prior to the epoch of recombination. Any such collapse, in the process of increasing the density of this luminous ionised hydrogen, would have rapidly increased the corresponding brightness of the light it emitted. The intense radiation produced by the collapsing region would produce an outward force called *radiation pressure*, which would rapidly overcome the gravitational force causing it to collapse and cause the gas to disperse. After the epoch of reionisation, when the hydrogen gas had become transparent, it had been freed from radiation pressure, and become able for the first time to make significant progress towards collapsing into galaxies.

By contrast, dark matter, if it produced no light at all, would always have been free from radiation pressure, and could have begun collapsing immediately after the Big Bang. After the epoch of recombination, the hydrogen gas would then have fallen very rapidly into the regions where the dark matter had already begun collapsing at earlier times, explaining the very rapid way in which galaxies seemed to have formed.

Such models were now strongly favoured on account of their excellent reproduction of the kinds of structures seen in the Universe today, as well as the observed ages of galaxies. Comparing these models to the latest observations from the *WMAP* satellite, it had been concluded quite precisely that the Universe contained a mixture of 4% *baryonic* matter – all of the matter which made up everything we could see in the Universe – 26% *dark matter*, and 70% *dark energy*. The speaker explained that very little was known about this final term.

Prof. Hewitt granted the audience that they might feel some justifiable scepticism about these percentages, given that they seemed to be based upon little that observers could easily relate to. He went on, therefore, to describe some experiments which provided independent evidence for the existence of dark matter. The oldest of these involved studying the rotation of spiral galaxies such as the Andromeda Galaxy (M31), which could be thought of as spinning disks of gas and stars. When such galaxies lay in edge-on orientations, as M31 did, their rotation speeds could be measured quite easily by taking spectra of their stars and looking for a Doppler shift. Those stars which were being carried away from the Earth by the galaxy's rotational motion appeared redshifted, meanwhile stars on the other side of the galaxy, that were moving towards the Earth, appeared blueshifted by a corresponding amount. The magnitudes of these red- and blueshifts indicated the rotational speed of the galaxy.

For a galaxy to sustain any given rotation speed, theory said that the centrifugal forces on the stars needed to be exactly counterbalanced by the inward gravitational forces that they felt, otherwise they would either fly outwards, if the centrifugal force was greater, or sink inwards, if the gravitational force was greater. However, this was difficult to reconcile with observations. When the visible stars in galaxies such as M31 were counted, and a mass estimated for each star, it became clear that there was far too little mass present to keep the outer parts of the galaxy rotating at the speeds observed; it seemed a mystery why they didn't fly off into intergalactic space. Even if there were assumed to be some stars hidden behind dust clouds, it was hard to find enough mass. To avoid this fate, it was inferred that galaxies such as M31 must contain huge amounts of material – more than the total mass contained in all of their stars – in some invisible form, termed dark matter.

Further evidence for the existence of dark matter came from studies of *gravitational lenses*. The speaker explained that sometimes, when a very distant galaxy lay precisely behind another much nearer galaxy – or more normally, cluster of galaxies – the light rays from the distant galaxy were bent by the gravitational attraction of the nearer object as they skimmed past it. The effect was rather as if they had passed through a refracting telescope lens. The amount by which the rays were bent depended upon the mass of the nearer *lensing* object.

One key difference between telescope lenses and gravitational lenses was that whilst the former were carefully figured to produce focused images, the latter were less painstakingly constructed, and tended to produce multiple distorted images, often stretched out into arc-like shapes. Sometimes, if many images of the distant galaxy could be seen, it was possible to determine a significant amount of information about how the matter in the lensing object was distributed, but in most cases, it was only possible to determine the amount of mass in the lens.

Clearly gravitational lenses could provide valuable information about dark matter, since they provided another independent method for estimating the masses of galaxies. However, the speaker explained that until recently their usefulness had been restricted by the difficulties faced in finding significant numbers of lensed objects on the sky. Traditionally, search programmes for gravitational lenses had operated by compiling databases of galaxies which showed signs of being at very great distances. Optical images were then obtained for each object and checked for any unusual morphological features which might be attributed to lensing. Where such features were seen, their spectra needed to be obtained before they could be conclusively confirmed to be the result of gravitational lensing.

This was labour-intensive work. One of the most successful projects to have followed this strategy had been the *CLASS* survey, undertaken by the Jodrell Bank Observatory in collaboration with colleagues in Holland and the US. However, even this project had had a remarkably modest yield: after looking at over 11,000 objects over the past decade, it had discovered only 22 confirmed lenses. Part of the problem with these traditional surveys was that they surveyed *all* distant galaxies, each of which had a very small chance of being lensed. The speaker explained that modern surveys were trying to devise ways to predict which galaxies were most likely to be lensed, and to spend observing time on only the most promising targets.

The speaker closed by describing the *SLACS* survey, which was searching for lensed objects in the areas of sky around galaxies which were known to be very massive, and which were likely to be large enough to produce lensed images of any galaxies which lay behind them. Instead of looking for objects with unusual morphologies, which were often difficult to spot, the survey looked for evidence of lensing in the spectra of these galaxies. Normally, the spectra of massive galaxies were remarkably uniform, but galaxies whose light was entangled with that of lensed images of more distant objects had an assortment of unusual features added to their spectra.

Once a database of massive galaxies with strange spectra had been compiled, these objects were imaged by the *Hubble Space Telescope* (HST)'s *Advanced Camera for Surveys* (ACS) to search for unusual morphologies to clinch the case. This search strategy was still labour-intensive – taking spectra of galaxies was a slow process – but it was aided by the work of the pre-existing *Sloan Digital Sky Survey* (SDSS), which had been operating a dedicated 2.5-m telescope in New Mexico for the past eight years. One of the SDSS's principal activities was taking spectra and images of distant galaxies, and it was releasing all of its data into the public domain. To date, it had obtained spectra for 1.3 million galaxies. Using this data, the *SLACS* survey had been able to find several hundred lenses, at a rate of several tens for every night of dedicated observing time required. In due course, this huge new sample of gravitational lenses would provide substantial new insights into the amount of dark matter in galaxies and its distribution within them.

Following the applause for Prof. Hewitt's talk, the President introduced the evening's second speaker, Dr Carolin Crawford, from the X-ray Astronomy Group of the Institute of Astronomy, Cambridge.

An Introduction to X-ray Astronomy

Dr Crawford opened by explaining that X-rays were a form of light which resided outside the visible part of the electromagnetic spectrum, having wavelengths of hundreds to thousands of times shorter than those of visible light, between 10 and 0.005 nm. Their existence had been known about since 1895, when Wilhelm Röntgen, a German physicist, had discovered that some cathode ray tubes emitted an unfamiliar kind of radiation, to which he had given the name *X-rays*, using the mathematical notation *x* to indicate something unknown. Röntgen had gone on to pioneer the medical applications of X-rays for which they were still best known today.

The speaker explained, however, that the way in which X-rays were used in medicine differed from how astronomers studied them in one important respect. Almost invariably, astronomers looking at the X-ray sky were interested in the objects which were *emitting* the X-rays; in medicine, by contrast, well understood X-ray sources were used, and it was the *absorption* of their X-rays by bone which was interesting.

Dr Crawford went on to explain that the appearance of the sky in X-rays was profoundly different from the familiar view seen in visible light. This could be understood by considering the kinds of sources which produced visible light and X-rays. Most of the visible light in the Universe emanated from hot objects such as the surfaces of stars, which glowed red-hot at temperatures of a few thousand degrees, or planets and nebulae which reflected light from nearby stars. To emit at X-ray wavelengths, objects had to be much hotter than this, reaching temperatures of tens of millions of degrees, found only in the most violent of astronomical environments.

However, such environments did exist. The prime examples were the neighbourhoods of black holes and neutron stars. Compact objects such as these often attracted a flow of gravitationally-captured matter from their surroundings, which was compressed to high densities and elevated to tremendous temperatures by friction as it was funnelled down onto their tiny central cores. Other examples included shock fronts and blast waves, such as were found around the remnants of historic supernova explosions, and in places where massive stars produced powerful solar winds which collided with the interstellar medium.

The speaker went on to illustrate these ideas by comparing corresponding images of the familiar area of sky around the constellation of Orion, as seen in visible light and X-rays (see Fig. 1). In the visible light image, the most brilliant object was the Moon, lying in Taurus, but it was hardly distinct at all in X-rays. Dr Crawford explained that though the Moon did reflect solar X-rays, the Sun was not an especially bright source of them. The neutron star at the centre of the Crab Nebula (M1) was, by contrast, one of the brightest objects in the X-ray image, despite its meagre sixteenth-magnitude optical appearance. The stars of Orion's belt and the Orion Nebula (M42) were bright in both images: these were young stars, and their strong solar winds produced powerful shock fronts around the stars, where they collided with interstellar gas. Neither Rigel nor Betelgeuse were visible in X-rays: these were old and relatively tranquil stars. A curious case was that of Sirius, which *was* visible in both images, despite being an old star. Dr Crawford explained that a compact eighth-magnitude white dwarf star, Sirius B, orbited around its better-known companion at a distance of 3–11", and although the white dwarf was almost invisible at optical wavelengths against the glare of Sirius, it was almost entirely responsible for the pair's X-ray brightness.

[Figure 1: The constellation of Orion, as seen in X-rays (left) and visible light (right). The Moon is visible in the

top-centre of the optical image.
Images available for download from: http://www.mpe-garching.mpg.de/background-picture.html (Image credit: Max-Planck Institute; included on images)]

Turning to discuss the practicalities of observing in X-rays, the speaker explained that the Earth's atmosphere was highly absorbent at X-ray wavelengths – a good thing for life on Earth, given the propensity of X-rays for causing cell mutations – and so it was necessary to observe from altitudes of at least 80 km. The earliest X-ray telescopes, flown soon after the end of the Second World War, had used balloons and German V2 rockets to reach such altitudes, and had identified the Sun as a source of weak X-ray emission. More recently, a series of space-based observatories had been flown, including *Einstein* (NASA, 1978–1981), *ROSAT* (ESA, 1990–1999) and *ASCA* (Japanese, 1993–2000). Two were currently operational: *Chandra* (NASA, 1999–) – the X-ray counterpart of the *Hubble Space Telescope* in NASA's *Great Observatories* programme – and *XMM-Newton* (ESA, 1999–).

Getting above the Earth's atmosphere, however, was not the only challenge of X-ray astronomy. Conventional mirrors could not be used to focus such short-wavelength light. To understand this, it was useful to think of X-rays as particles, photons, rather than as waves. At these short wavelengths, each photon of X-ray light carried so much energy that it could be compared to a bullet. Conventional telescope mirrors tended to absorb them in preference to reflecting them. However, just as bullets could be made to ricochet off surfaces at shallow angles of incidence, so too could X-rays. By designing a telescope where light could be brought to a focus whilst only ever grazing mirrors at shallow angles, it was possible to focus even X-rays. This meant, however, that each mirror could only collect light from a very small area of aperture, since it was turned almost edge-on to the incoming radiation, and so, in practice, many concentric ring-shaped mirrors with a common focus were nested within one another to build up an adequate collecting area (see Fig. 2).

[Figure 2: Schematic diagram of the optics of *Chandra*. The primary and secondary reflective surfaces are orientated in concentric rings, such that X-rays make grazing incidences with them.
Image available for download from: http://chandra.harvard.edu/graphics/resources/illustrations/cxcmirrors.jpg (Image credit: NASA / Chandra Science Center)]

The need to minimise the deflection of the X-rays by the mirrors gave rise to another problem: the focal lengths of these telescopes needed to be long. *Chandra* had an aperture diameter of 1.2 m and a focal length of 10 m; meanwhile *XMM-Newton*'s three separate telescopes had a maximum aperture diameter of 70 cm and focal length of 7.5 m. These giant optical systems were at the limit of what it was physically possible to launch into space, and it was likely that future telescopes would be launched into space piecewise and assembled in orbit.

Dr Crawford then turned to review how a variety of objects appeared in X-rays. The Sun had been the first astronomical source of X-rays to be discovered, although it was in fact a comparatively weak source. Its face, being at a temperature of only a few thousand degrees, did not produce X-rays at all. The solar corona, especially around active regions of the Sun's surface, reached much higher temperatures than the surface itself, because of its continual bombardment by the solar wind, and was entirely responsible for the few X-rays that the Sun did emit. Likewise, most other middle-aged stars produced a meagre display of X-rays.

Turning to the Orion Nebula (M42), the speaker remarked that the diffuse nebulosity for which it was best known in optical images was absent from X-ray images. This was produced by gas and dust at temperatures of only a few hundreds of degrees. But the Trapezium star cluster – the central cluster of hot young stars embedded in the nebulosity in optical images – was clearly apparent in X-rays. The solar winds produced by these young stars were strong enough to shock the surrounding gas such that it became a much stronger source of X-rays than the Sun's corona.

Turning to another, nearer star-forming region, and zooming in to show how a single young star appeared, the speaker showed an image of DG Tau – a star of similar mass to the Sun, but only a million years old. It was thought to still be in the process of contracting and collapsing to form a main-sequence star. Two X-ray-bright jets were clearly visible on either side of the central source, each extending to about 700 AU from the central star. The speaker remarked that the more distant of the two jets appeared anomalously faint and explained that this seemed to provide evidence for the presence of a proto-planetary disc, or proplyd, of solid material around the star, absorbing the X-rays from the jet behind it. This disc might in time evolve into a solar system of planets like our own, and the speaker remarked that if, as was widely believed, all young stars went through a phase of being prodigious sources of X-rays, it was intriguing to consider what effect that might have on young solar systems.

X-rays were also produced by supernova remnants, and these appeared as more extended sources than young stars. In the case of the remnant of *Tycho's Supernova* (see Fig. 3), which exploded in 1572, a circular bubble of X-ray emission could be seen, and the speaker explained that this appeared to be emanating from the material which had been thrown out into space by the supernova explosion. The fact that this material was still, 430 years after the explosion, producing X-rays was evidence that it still remained at a temperature of tens of millions of degrees. The emission had a mossy texture, which the speaker explained to show that the gas was highly turbulent. Around the sharply defined outer edge of the bubble could be seen a narrow line of high-energy X-ray emission, where the blast wave from the supernova explosion was still expanding outwards into the interstellar medium around it. The speaker showed images of other supernova remnants, including the Crab Nebula (M1), which had exploded in 1054, and Cassiopeia A, which had exploded around 300 years ago but seemed not to have been observed at the time. These showed similar X-ray morphologies, and the speaker explained that these images formed a useful evolutionary sequence: it would be a long wait before any one of these supernova remnants aged appreciably, but by comparing them, some grasp of their life cycle could be obtained.

[Figure 3: The remnant of SN 1572 (Tycho's supernova) as seen by *Chandra*. Low-energy X-rays are shown in red, and high-energy X-rays are shown in blue. In the centre, a bubble of mottled low-energy emission arises from hot debris from the supernova explosion. Around this, there is a thin shell of much higher energy X-ray emission, 20 light-years (9 arc-minutes) across, attributed to the shock front where the blast wave from the supernova hits the interstellar medium.
Image available for download from: http://upload.wikimedia.org/wikipedia/commons/1/14/Tycho-supernova-xray.jpg (Image credit: NASA / Chandra Science Center)]

Dr Crawford added, however, that in recent months a supernova remnant by the name of G1.9+0.3 had made headlines[1] because a pair of images taken in 1985 and 2007 *had* revealed compelling evidence for its evolution over the intervening years. A comparison of the two images showed that its shock wave had been perceptably larger in 2005 as compared to 1982; it seemed to have expanded noticeably between the observations. From this, the remnant was inferred to be a very young object, and by calculating the rate of the observed expansion, it was possible to conclude with confidence that the supernova was expanding outwards at a rate of 5% of the speed of light, and had exploded around 140 years ago. The lack of 19th century observations of this supernova going off could probably be explained by its location, close to the centre of our galaxy. The amount of gas and dust along our line of sight to the remnant's core was likely to have hidden even an object as bright as a supernova from view.

The speaker went on to remark that at the centre of each of the supernova remnants shown could be seen a bright point source of X-rays, marking the position of the dense neutron star which had been left behind by the core of the star which had undergone the supernova explosion. In the case of the Crab Nebula (M1), the neutron star was sufficiently close that *Chandra* could resolve detail in its accretion disc (see Fig. 4) and show the jets emerging from its two poles. It appeared rather similar to the proplyds already mentioned, but this time much more violent.

[Figure 4: The pulsar at the centre of the Crab Nebula (M1), as seen by *Chandra*. The accretion disc is clearly visible, measuring around 2 pc across. Jets are seen to emerge from the disc's poles.
Image available for download from: http://science.nasa.gov/chandra/images/CRAB_1200dpi.jpg (Image credit: NASA / Chandra Science Center)]

Moving on to larger objects – collections of stars – Dr Crawford showed a series of images of nearby globular clusters, remarking that although a few point sources could be seen in X-rays, far fewer stars were visible than in optical light. These clusters were old – there was no ongoing star formation in them – and as old stars did not produce many X-rays, it was only old compact objects such as neutron stars – deceased members of the cluster – which could be seen in the X-ray image. This made the X-ray view of globular clusters highly complimentary to the optical view: it showed the population of stars which were no longer shining in visible light.

Images of nearby spiral galaxies such as the Andromeda Galaxy (M31) and the Whirlpool Galaxy (M51) likewise showed the distribution of neutron stars through each galaxy, revealing a dense conglomeration of them close to each galactic centre, with the remainder of the population spread along the spiral arms. The nebulae in these galaxies were invisible, and the young stars within these sites of ongoing star formation comparatively faint. However, a faint hazy puddle of X-ray emission was apparent around the centre of each galaxy, which the speaker attributed to hot gas given off by numerous past supernova explosions in each galaxy's bulge. Much brighter sources of X-rays were galaxies which had *active galactic nuclei* (AGNs) – black holes of several million times the mass of the Sun accompanied by similarly huge accretion discs – at their centres: Centaurus A (NGC 5128) was a prime example.

To close, Dr Crawford explained that the puddles of X-ray emission seen around the centres of galaxies were not the only diffuse X-ray sources. Around the galaxy clusters in Virgo and Coma, puddles measuring nearly 3° across could be seen, and other, more distant, galaxy clusters were accompanied by similar, smaller halos. The familiar optical images of these clusters revealed that they typically contained hundreds to thousands of galaxies, spread over tens of millions of light years, but the X-ray emission showed that there was also some smooth distribution of material in between the galaxies – an *intergalactic medium*. The significance of its X-ray emission was that for the first time, the amount of gas lying in the vast spaces between galaxies could be estimated, and surprisingly, it seemed that there was ten times as much invisible gas between galaxies as there was within them. This gas was understood to have reached temperatures of tens of millions of degrees in the process of falling in towards the immense gravitational attraction of the galaxy cluster, and hence to have become a source of X-rays.

Following the applause, the President invited Mr Guy Hurst to present this month's Sky Notes.

The May Sky

Mr Hurst remarked that May and June were never good months for observers on account of their having such short hours of darkness, and so he opened with an update on NASA's *Phoenix* and *Mars Reconnaissance Orbiter* (MRO) missions to Mars. *Phoenix* had landed successfully on Mars' north polar plane three days earlier, on 2008 May 25 at around 23:45 UT. A few images of the landing site had already appeared on the NASA website, but analysis of them was clearly at an early stage. The speaker explained that the orbit of *MRO* had been adjusted in the past few days to place it close to *Phoenix*'s landing site at the time of its descent. Consequently, it had been able to use its *HiRISE* camera to obtain a series of high-resolution images of *Phoenix*'s entry into the Martian atmosphere. NASA's press releases were advertising these images as the first ever taken by one spacecraft of another's landing. More importantly, images of the deployment of *Phoenix*'s parachutes would provide valuable feedback for the design of future missions.

Continuing on the theme of *MRO*'s recent observations, Mr Hurst added that it had flown close by Phobos, the larger of Mars' two moons, on 2008 March 23, and had used its *HiRISE* camera to obtain a pair of images at distances of 6,800 and 5,800 km from the moon's surface. He explained that both Phobos and its smaller neighbour Deimos were widely thought, based upon their small sizes and unusual compositions, to be asteroids which had been captured by Mars' gravitational field from the neighbouring asteroid belt which lay between Mars and Jupiter. *MRO*'s images showed the large Stickney impact crater on Phobos' surface, together with a striking series of grooves which covered almost half of the moon's surface and appeared to radiate outwards from a point close to, but not quite aligned with, the centre of Stickney.

Turning to discuss prospects for observing the planets, the speaker mentioned that over the past few days Mars had been in conjunction with the Beehive Cluster (M44); it had made its closest approach on the evening of May 22–23 at a distance of around 15' from the centre of the cluster, skimming among its outer members. This had been a challenge to observe, given the difference in brightness between Mars and M44, and although the speaker had seen some amateur images from abroad, noone in the audience had observed it. A much easier conjunction to observe had been the occultation of half of the Pleiades (M45) by the Moon on May 6. Mercury had also been nearby at the time, lying a mere 6° away. The speaker noted that this conjunction had been very widely photographed, and many novice astrophotographers had even managed to get images without using tripods.

Moving out to the gas giants, the speaker reported that Jupiter was now rising at 11pm UT, having emerged from its solar conjunction of late 2007 December, and would reach opposition on 2008 July 9. John Rogers, Director of the Jupiter Section, was reporting that early observations from the new apparition were showing that the large-scale turbulence and storms which had plagued the planet for the past two years were continuing. A small new red anticyclonic oval in the South Tropical Zone, dubbed the *Baby Red Spot*, was heading for a conjunction with the Great Red Spot in late June or early July. It was uncertain whether the two spots would pass one another or merge. At around the same time, another prominent red anticyclonic oval, Oval BA, itself dubbed the *Little Red Spot*, would be at a similar longitude but lying a few degrees to the south.

Saturn was also visible in the evening sky at present, setting at 1am UT; it had passed opposition on February 24. Amateur planetary imagers were currently interested in two prominent white spots visible in the planet's South Tropical Zone, which could be seen visually and photographically through telescopes of 20-cm aperture and larger.

Mr Hurst then moved on to congratulate Mr Peter Birtwhistle upon the discovery of his 100th asteroid, 2008 GE3, on April 7. The speaker noted that this object's magnitude had been a mere 20.7 at discovery; the rise of efficient robotised minor planet surveys had meant that amateurs needed to be able to catch asteroids at such faint magnitudes in order to beat the competition. The discovery of 100 objects was surely a testament to Mr Birtwhistle's dedication to the task. The speaker noted that Mr Birtwhistle's tally of asteroid discoveries might soon overtake the tallies of amateur supernova hunters. He noted, however, that new asteroid discoveries needed follow-up observations over longer timescales than new supernovae. Before an asteroid could be confirmed and numbered as a new minor planet, a secure orbit needed to be determined for it, based upon observations from several oppositions. Of Mr Birtwhistle's 100 discoveries, to date only 9 had become numbered minor planets. Of the rest, 50 had been observed at multiple oppositions and were expected to receive numbers soon, while the remaining 41 had only been observed at one opposition.

The speaker closed with a review of the comets in the sky at present. None were especially bright, although he drew attention to comet 2007 W1 (Boattini), which had recently outburst to mag 6.3, around two magnitudes brighter than had been expected. Lying in Puppis, it was not visible from the UK at present, but it would be more favourably situated in July and August. On August 1 it would pass close by π Ari, and then, after sweeping north through Aries in August, it would pass Hamal at the end of the month. If it remained in outburst, it could be expected to be around mag 8/9 during this period, and so within range of binoculars.

Following the applause, the President adjourned the meeting until Saturday June 28.

Dominic Ford

References

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[1] http://www.nrao.edu/pr/2008/youngsnr/