Ordinary Meeting, 2005 May 25
held at The Geological Society, Burlington House, Piccadilly, London W1

Tom Boles, President

Ron Johnson, Nick Hewitt and Nick James, Secretaries

The President opened the seventh Meeting of the 115th Session and, after a brief safety announcement, invited Dr Nick Hewitt to read the minutes of the previous meeting. These met the approval of members and were duly signed. In the absence of a list, an unspecified number of new members were proposed for election; those 29 who had been proposed at the April meeting were approved by the audience and declared elected. Mr Nick James, Papers Secretary, announced that two papers had been approved by Council for publication in the Journal:

The Rev William Ludlam (1716-88) and the Cockfield Tower Ob… ??, by Martin Mobberley
Analysis of Venus Transit Images Obtained by Long Distance, Plane… ??, by ??? Airey

Mr Boles informed members that the next meeting would be the Exhibition Meeting, to be held at the Cavendish Laboratory in Cambridge on June 26, and which would include the presentation of the Association's annual awards. He then proceeded to welcome the evening's first speaker, Dr Andy Norton. A Senior Lecturer at the Open University, he specialised in X-ray astronomy; on this occasion he would be giving an insight into the physics of variable stars.

Outbursts, Orbits and Oscillations

Dr Norton subtitled the talk to come 'Time Domain Astrophysics: Compact Interacting Binary Systems and Extrasolar Planets', explaining that this concisely summarised it. 'Time domain astrophysics', he added, was the study of how the brightnesses of objects varied over time. Whereas some objects – nebulae and galaxies – could be resolved and imaged, many others, such as stars, could not, appearing only as points of light. While much could often be learnt from the spectra of their light, if time variations could be detected in their brightnesses, these could then provide valuable new insights into their nature.

Systems whose brightnesses varied dramatically invariably involved extreme physical conditions. To undergo variability on short timescales, they had to be physically compact: a well-tested physical law stated that no information could propagate faster than the velocity of light. For an object to flare significantly within a period of hours, the region of space powering this could not exceed a few light-hours across, otherwise its parts could not 'know' that each other were flaring, barring baroque explanations involving the intelligent prearrangement of such synchrony.

The speaker explained that it was thus understood that these systems were orbiting pairs of stars, one of which was gravitationally sucking gas from its companion's surface. If the former was particularly dense – one of the degenerate compact objects (COs) formed at the ends of the lives of stars, a *white dwarf*, *neutron star*, or *black hole* – then this gas could achieve tremendous temperatures as it collapsed down into the tiny space surrounding its attractor, thus generating a vast amount of light from a very compact volume of space. These were the 'Compact Interacting Binary Systems' of his subtitle.

With reference to the final part of his title, 'Extrasolar Planets', he explained that many of the techniques developed for studying variable stars had now been found to be of great value in searching for Earth-like planets around other stars; he would explain why at the end of the talk.

He explained that the transfer of mass in Compact Interacting Binary Systems could take place by one of two mechanisms. In the first scenario, the CO actively drew material from its companion: either the donor star was of low mass and its gas only weakly bound, or it orbited very close to its compact companion; in either case its outer layers might feel greater attraction to the CO than to the star of which it was part. The technical name for this was *Roche-lobe overflow*, the 'Roche-lobe' being the point in space between the two stars where their gravitational attractions exactly counterbalanced each other, and 'overflow' referring to the fact that in these systems, the donor star's gas extended beyond this point, such that its outer layers attracted towards the CO.

In the second scenario, the CO played a more passive rôle, and the donor star was at the opposite extreme of mass – a hot massive star, whose intense heat produced a substantial stellar wind. The orbiting CO would capture some of this wind without needing to actively strip material.

The speaker went on to describe the light-curve signatures characteristic of various types of system: objects containing each of the three types of CO had distinct behaviour, he explained. In most cases, the variability was most apparent at either optical and infrared wavelengths, or in X-rays. An animation of the X-ray sky over the four-year period 1996-2000, compiled by a team at MIT from the results of the *Rossi X-ray Timing Explorer* (RXTE) satellite, illustrated this. The brightest objects were almost exclusively accreting COs, and so the view appeared much more dynamic than its familiar visible counterpart.

He turned first to *classical novae*, objects which flared over a period of days, later decaying back to normality over tens of days, before repeating the process on a timescale theorised to be ~10,000 years, though tricky to confirm observationally. This behaviour resulted from the accretion of hydrogen gas onto a white dwarf – an object of a little less than 1.4 times the mass of the Sun, but comparable size to the Earth. It was thought that as the accreted gas accumulated on the white dwarf's surface, its pressure built up, until reaching a critical point where nuclear fusion became possible, whereupon it burnt explosively to form helium, producing the observed flare.

Another type of variable star, *X-ray bursters*, produced quite different light-curves, but from a very similar process. They produced rapid bursts of X-rays, lasting only a few seconds, but repeating every few hours; a famous example was Cygnus X-2. These flares resulted from the same thermonuclear explosions as those of classical novae, but here the hydrogen was not accreting onto a white dwarf, rather an even denser neutron star – an object of between 1.4 and 2.5 times the mass of the Sun, yet compressed to so great a density that it was contained within a mere 10 km radius. The process was entirely analogous, but the timescale more rapid because of the smaller central attractor.

Other objects seemed not to fall into either of these classes, however. Among them were *dwarf novae*, observed to flare periodically on a timescale of days or weeks. The variability of these was believed to arise from a quite distinct mechanism. Whenever material was drawn onto a CO, it was thought to form a disc-like structure, called an *accretion disc*, as it spiralled inward towards it captor. In dwarf novae, it was thought that the flaring was caused not on the attractor's surface, but by an instability in the disc itself.

At the onset of accretion, material would begin building up in the disc: the rate of gas entering it would exceed the rate of its delivery onto the white dwarf's surface. As the density of the disc rose, so too would its temperature, eventually exceeding the ionisation temperature of hydrogen, around 4,000°C, whereupon it would suddenly glow brightly and become opaque. The viscosity of this plasma would be much greater than that of the neutral gas from which it had formed, and consequently the disc would rapidly collapse onto its attractor. As its density now became much lower, it would cool and return to a neutral state, ready for the cycle to recommence.

As with classical novae, directly comparable but observationally quite distinct, neutron star systems were also found. These, called *soft X-ray transients*, the term 'soft' referring here to the low-energy X-rays which they emitted, were among the most dramatically variable systems in the Universe, producing vast flares of X-rays lasting for several months, recurring every few years. As with X-ray bursters, the mechanism behind their variability was essentially identical to that of their white-dwarf-containing counterparts, but taking place on a different scale.

Dr Norton then went on to describe some of the other objects found in the zoo of variable stars. He turned first to *intermediate polar* systems, a class of *cataclysmic variable* stars – this being a collective term for all variable stars containing white dwarfs. These, he explained, could be recognised by their characteristic variability on both short – perhaps 15-minute – time-scales, and over much longer periods. Using the light-curve of AO Piscium as an example, he showed how it pulsed periodically at quite precise 15-minute intervals, and how the brightnesses of these spikes was modulated on a timescale of hours, once again, with quite precise period.

He used these systems to introduce one of the most powerful tools of time domain astrophysics: Fourier transform time series analysis. Any plot of how some measured quantity varied over time could be decomposed into a sum of sine waves of different frequencies; by plotting the amplitudes of these as a function of their frequency, one could obtain a *frequency spectrum* – a map of the timescales on which that quantity varied. Applying this to AO Piscium, he showed that it allowed the intermediate polar's modulation to be characterised much more precisely: the frequency spectrum showed two sharp peaks, one representing 805-second periodicity, and the other 3.59-hour periodicity. Other peaks, at exact multiples, or *harmonics*, of these frequencies could be ignored: they resulted from the object's light-curve not exactly matching the sine waves used to construct the spectrum, instead having some more complicated waveform of matching period. He showed how, now that the system's period was so precisely determined, its light-curve could be *folded* onto it, and data from many periods combined to give an accurate profile of the waveform.

The speaker explained that this dual-period behaviour was believed to arise from the accretion of material onto a white dwarf with a strong magnetic field. Whilst magnetism would not affect neutral infalling matter, it would exert a force on ionised material, allowing it to move freely only along the field's direction. This was relevant because, as the accreted material spiralled inwards, the originally neutral gas would heat up and ionise. Suddenly it would become funnelled by the magnetic field, allowing it only to travel in one direction. Now, the star's magnetic field would resemble that of the Earth, emanating vertically from its surface at two magnetic poles, before turning parallel to its surface and connecting around to the opposite pole. This configuration would prevent material from accreting onto its magnetic equator, where the field lay parallel to the star's surface, rendering downward motion impossible. Accretion would, however, be possible at the magnetic poles, where the field was vertical. Thus, its magnetic poles would glow much more brilliantly than the rest of its surface.

The short timescale pulsing of intermediate polars could be explained by a misalignment of the star's magnetic field with its rotation axis; generally these lay in different directions. Thus, as the star rotated, its bright magnetic poles would periodically rotate past our line of sight, giving rise to the observed pulses. The longer timescale modulation, for example, the 3.59-hour period of AO Piscium, could be attributed to the orbital period of the white dwarf around its donor companion, the clarity of our line of sight changing, depending upon the orientation of the two stars. In some cases, AO Piscium being one, brief eclipses were seen during this cycle, suggesting that the white dwarf passed behind its companion.

Turning to one final type of variable star, Dr Norton moved onto *X-ray pulsars*; as with all the preceeding cataclysmic variables, intermediate polars were not without neutron-star-based counterparts. He reminded members that ordinary *pulsars* were stars which emitted radio pulses at precise time intervals, attributed to beams of radio radiation emanating from a neutron star's magnetic poles, turning periodically past our line of sight as the star rotated. X-ray pulsars were similar, only the pulses were seen in X-rays, and were attributed to the accretion of material down onto these poles.

The speaker's final topic was how the study of variable stars had led to the development of a new technique for detecting planets around other stars. Previously, searches had focussed upon looking for small motions of stars induced by the gravitational pull of orbiting planets; he reminded members that planets did not strictly circle their Suns, but rather both planet and Sun circled their common centre of mass, it was just that, as the Sun was so much heavier, its motion was comparatively tiny. Thus, planet-bearing stars could be identified by the characteristic swaying back and forth of their Doppler shifts. To date, over 120 planets had been discovered by this route, but most were so-called '*Hot Jupiters*', large planets in close orbits (within 1 AU) around their parent stars, which produced the largest, most-easily detectable, stellar motions.

Another route was to look for the small diminutions in stars' intensities which might result from planets transiting across their faces. This method would be considerably more sensitive to Earth-like planets, and had already borne fruits, making its maiden discovery in 2001, in the form of a planet around HD209458, found by the *Hubble Space Telescope*; five other discoveries had since been made. The light-curves of these transits needed careful scrutiny to distinguish them from variable stars, but they had a characteristic U-shape: flat throughout the transit, with limb-darkening at either end.

Dr Norton then went on to describe the *SuperWASP* project, which hoped to use images from dedicated wide-field cameras to detect an estimated 1,000 new planets over the coming five years, working on the basis that one in every thousand main-sequence stars was expected to show a transit every ~4 days. The methodology was simple: as much of the sky as possible would be imaged each night, and photometry performed on every star; a light-curve would be constructed for each, looking for the characteristic signature of a transit. The *Liverpool Telescope* would perform spectral follow-up observations on any potential discoveries, seeking to confirm them by the traditional Doppler shift method.

The project would consist of two observatories: one in the northern hemisphere, amongst the *Isaac Newton Group* (ING) of telescopes in La Palma, the other in the southern hemisphere, in Sutherland, South Africa. Each would have eight cameras on a robotic mount, with slightly offset 7.8° fields. The lenses were off-the-shelf *Canon* stock, with 200-mm focal length and 11.1-cm aperture (f/1.8), connected to 2048 × 2048 CCD arrays. He recalled with amusement the setback that the project had faced when, partway through construction, Canon had discontinued their chosen model of lens; after the initial frustration, it had proved to be a blessing in disguise when cheap stock became available on *eBay*, though claiming expenses for this purchase had initially raised a few eyebrows.

It was reported that SuperWASP's northern observatory in La Palma had operated manned for 80 nights between April 2004 and the following autumn, surveying 7% of the sky each night using five cameras. It would eventually be fully robotic, and image the entirety of the visible sky at least once per night. The first 80-night run had produced 4 Tb of data; this eventual set-up would generate 10 Tb/yr, and so a well-automated pipeline would be required to process this volume of data. The flat-field calibration, aperture photometry, and construction and analysis of light-curves, would all be fully-automated.

To close, Dr Norton added that a lot of valuable data would come out of SuperWASP quite apart from extrasolar planet detections: it would detect anything in the range mag 6-16 which varied, providing an extensive survey of variable stars, as well as detecting novae, supernovae and near-Earth asteroids.

Following the applause for Dr Norton's talk, the President congratulated him on providing such a clear explanation of the complex taxonomy of variable stars. Mr Nick James asked how well SuperWASP's pipeline was working, remarking that historically such automation had tended to sound the death knell for amateur work. The speaker replied that the construction of light-curves was working well; none of the light-curves in his talk had been touched up. By contrast, the classification of objects was not yet automated, and was done by eye at present.

Mr Mark Armstrong asked what discoveries had been made in SuperWASP's first run. The speaker reported that several hundred new variable stars had been identified, but no extrasolar planets discovered. Mr Maurice Gavin asked what colour pass-band it used. The speaker replied that it sought to capture as much light as possible, and so imaged in white light.

The President then proceeded to welcome the evening's next speaker, Mr Martin Mobberley, to present his Sky Notes.

The May Sky

Mr Mobberley opened by remarking that despite solar minimum being near, images of the Sun (from appropriately filtered instruments) still showed some substantial features; he showed a large sunspot group imaged by Nigel Bryant on April 30, and a prominence caught by Maurice Gavin on May 15 with his 40 mm *Coronado PST*. Then, turning to the UK supernova patrol scene, he reported that the recent lull still continued, and that, after a complete lack of discoveries this month, the UK total still stood at 170.

He next reported that radio galaxy 3C 454.3, lying just west of the Square of Pegasus, ~3° north-west of Markab, had, on May 9, been detected in an unprecedented outburst from its normally tranquil state, reaching mag 11.9 in the red-band, and 12.5 in the V-band. It was believed to be a *blazer* – an active galaxy viewed down the direction of one of its jets – an identification supported by observations of nearby knots of material which, due to an effect most apparent in blazers called *relativistic beaming*, appeared as if they were travelling at 14 times the speed of light.

There were still no visually observable comets: 2004 Q2 (Machholz) remained the brightest northern object at mag 9, still circumpolar in Canes Venatici, where it would remain until sinking southward into Boötes in mid-July. On June 9 it would pass within 30' of the tight spirals of M94, when the Moon would be a favourable three days old; the speaker thought this might make a photogenic conjunction. 161P/Hartley-IRAS was in Pisces at mag 12 and brightening; it would pass into Andromeda on June 6, Perseus 11 days later, and then Cassiopeia on June 27, perhaps reaching mag 9 by that time.

Mr Mobberley mentioned two recent comet discoveries; firstly, P/2005 JQ5 (Catalina), found by the *Catalina Survey* on May 6. Its unusual designation resulted from its having originally appeared asteroidal in its discovery images. At mag 14, it was now showing cometary features, and might approach mag 12 by late June. In eastern Virgo at present, it would track westward and pass into Leo on June 19. The other discovery, 2005 K1, had been found by Brian Skiff at the Lowell Observatory using the 59 cm LONEOS Schmidt telescope. Presently at mag 17 in Draconis, it had originally been thought that it might brighten substantially, but refined orbital parameters placed its perihelion at a distant 4 AU from the Sun. It was reported to have a 12" coma, and 90" tail.

9P/Tempel 1 lay in Virgo, heading southward and brightening at mag 11; the speaker reminded members that it might flare substantially on July 4 after NASA's *Deep Impact* collided it with a 370-kg impactor, but that a clear southern horizon would be needed to see it: its unfavourable position placed it to set into the evening twilight shortly after the Sun on the following days. 21P/Giacobini-Zinner, at mag 11, was soon to pass from Andromeda into Pisces, but was fast heading eastward into dawn twilight.

Minor planets *Ceres* and *Pallas* had both recently passed their oppositions, on May 11 and April 27 respectively. Both had reached nearly mag 7, becoming easy binocular targets. Mentioning two occultations which had taken place in the last week, the speaker reported that 7 Iris' occultation of HIP 83097 on May 22 was not thought to have produced any observations, thick cloud covering most of its path. That of mag 11.4 star TYC 6238-01428-1 by 168 Sibylla on May 20 had met better weather, and, from the three observations of which he was so far aware, he showed the three resulting chords which constrained its size. It was placed at around 95 × 160 km, if an elliptical shape was assumed.

Jupiter, in Virgo, now transited at 9pm BST. Imaging maestro Dave Tyler had been observing it as early as possible in the evening to catch it at its highest in the sky; some of his finest results had come with the Sun only 1-2° below the horizon. A montage by John Rogers of many of the presently observable spots was displayed, special mention being given to a jetstream spot in the northern Southern Tropical Belt, which had approached the Great Red Spot (GRS), becoming irresolvably close to it. Later, there had been signs of a new feature within the GRS. A gallery of some of Mr Tyler's finest results followed.

Saturn's apparition was now past its prime, it now transiting at 4.30pm BST and setting just after midnight. The speaker displayed some recent highlights from *Cassini*, including a series of images of the F ring as *Prometheus*, one of its two shepherd moons, skirted its inner edge; it could be seen to visibly kink in the moon's wake. Mars was now rising at 2.30pm BST, in dawn twilight, but would soon be visible earlier in the night, its disk due to reach nearly 20" in the autumn, and its declination a UK-favourable +15°, exceeding +20° in early 2006.

Mr Mobberley closed with a slideshow of images by Damian Peach, who had recently returned from a 21-day trip to the steady skies of Barbados with his *Celestron* 9.25". Mr Peach had had clear skies on 19 of those nights, though he had found that they could yield to rainstorms with astonishing speed, making it vital to have rain covers close at hand at all times. He reported that the seeing had frequently reached Pickering 9-10 – so fine that after stacking and enhancing his best frames, he had found that features on 0”4 scales could often be seen, surpassing the instrument’s 0”5 diffraction limit. A series of astounding lunar images was followed by a preview of his planetary images – the speaker explained that much was yet to come, as Mr Peach had returned with 400 Gb of images, and the task of processing them all would take some time to complete. Among his early results, features on Mars’ disk had been remarkably well resolved, despite its diameter having been a mere 6”6 at the time of imaging. Mr Mobberley promised that the slideshow would continue next month, with the latest fruits of Mr Peach’s massive image processing task.

After the applause for Mr Mobberley’s summary, the President welcomed the evening’s final speaker, Dr Jeremy Shears.

CCD Observations from the Bunbury Observatory

Upon his return to the UK in 2004 January, after several years abroad, the time had seemed ripe to realise his long-held dream of setting up a fixed observatory, Dr Shears explained. This talk would recount the experiences of his first year as a newcomer to the art of CCD astronomy. He recalled with amusement the reaction of his estate agent when first told that minimal light pollution was to be a major requirement in his choice of home, and, when a house in the town of Bunbury, 15 miles south of Chester, had been chosen, the surreal scene as the postman had had to weave a path through the morning traffic of the narrow local roads with his seven-foot dome.

For his primary telescope, he had chosen a *Takahashi FS102*, a 102-mm apochromatic refractor with 820-mm focal length: he had acquired something of an affection for them whilst travelling the Far East, where their portability was highly valued. His CCD observations were made with a *Starlight Xpress MX716* CCD array, a *Skysensor 2000* goto unit providing good tracking. He anticipated that some might greet his choice of instrument with surprise: he had been in part curious himself to question whether it was possible to achieve scientifically useful results with a mere four-inch aperture. He left that question to the audience, and continued with his account.

Over the past year, he had made observations on 88 nights, around 25%. His imaging methodology, he explained, had rapidly settled upon a standard technique of taking one-minute exposures of all objects, and stacking them where longer effective exposures were required. He controlled the CCD array and performed basic calibration using *AstroArt III*; post-processing was done in *Adobe Photoshop*. Proceeding to show a gallery of the fruits of his deep-sky imaging efforts, he commented how well the wide field of the Takahashi framed the *Dumbbell Nebula* in its star-field. The *Veil*, the *Cocoon* and the *Crescent*: all were imaged with similar fidelity. *Stephan’s Quintet* was reason for a brief pause; the speaker remarked that capturing it had long been a dream: its association with the Redshift Controversy had caught his imagination.

Turning to comets, he remarked upon the fine examples which had graced the sky of late. In late summer, while imaging the fine tail of 2001 Q4, perhaps the most magnificent of all, he had discovered the technique of stacking his one-minute exposures not on stars, but rather on the cometary nucleus: while this did produce star trails, the resolution of the tail was greatly enhanced. Other comets had produced quite different shows – 2003 K4 with its stubby tail in June, and 2004 T4 with its diffuse coma in December. Machholz had provided perhaps some of his most stunning images, in early 2004, though its tail was much too large to fit into a CCD frame.

Schwassmann-Wachmann 1 was a comet which had long intrigued him: quite apart from the impracticalities of its name, the widespread publication of its ephemeris seemed unjustified for so faint an object. Its regular outbursts to mag 11 seemed to provide the explanation, and he proceeded to tell the tale of his own observations. In early September, it had taken a rather uninspiring, faint and diffuse appearance. Eleven days later, the view had been completely changed: it had appeared much brighter, almost stellar in appearance. Over the following week, a diffuse coma had gradually appeared.

Supernovae had also caught Dr Shears’ attention: initially he had set out only to image 2004dj in NGC 2403 after hearing of its discovery in 2004 July, but, having obtained images, he had become curious to try photometry. Pleased with his first results, he had continued to monitor it from early 2004 September through until April, when it had faded below mag 15.7, and reliable photometry had proved impossible. He had also been able to monitor 2004et, discovered by Doug Rich in the sweeping photogenic spirals of NGC 6946 on 2004 September 17, for eight months.

His successes with supernova photometry had spurred him to try variable stars, and it was to these that he finally turned. He had observed two types of objects for the Variable Star Section: undertaking time-resolved photometry of those known to be in outburst, and periodically monitoring others for the *Recurrent Objects Programme*, checking them for outbursts, with a detection limit of mag ~17.5. The latter search had yielded one discovery: an outburst of dwarf nova CG Draconis to mag 15.6 on April 9. He remarked that, in view of the first talk, this search might soon be obsolete, but Dr Norton, in the audience, remarked that SuperWASP’s detection limit would be an inferior mag 16.

Dr Shears displayed several light-curves that he had produced, remarking how easy it had proven to be. Having obtained a series of images, he had imported them into the *AIP4Win*[1] software package, which could perform aperture photometry on them all in a single operation. One of his earliest successes had been with dwarf nova V1113 Cyg, whose light-curve he had studied with the *Peranso*[2] Fourier analysis tool, identifying a 111-minute period. This was within 3% of its published *superhump* period – that of variability attributed to precession of its accretion disc. Whilst not new science, this demonstrated the accuracy of which his set-up was capable.

The speaker closed with the light-curves of several further variable stars, most notably Bernhard 1, a newly discovered dwarf nova in Camelopardalis, identified from plate archives. An outburst had been detected on March 16, and he had had an opportunity to study it on March 19 between 19h30 and 23h29 UT, during which time he had captured three complete superhump cycles, his observations suggesting an unusually short 81-minute period, varying between mag 11.7 and 12.0. On March 25 he had observed quite different behaviour: rapid flickering with its brightness changing by up to 0.5 magnitudes within minutes. After initially doubting his observations, then finding re-reduction to effect no change, he had discovered that others had noted the same phenomenon.

He noted with awe the work of Mr Gary Poyner, who had made visual observations over a 24-minute period, estimating its magnitude every 10 seconds. Known as an observer *par excellence*, Poyner had reported variations by almost a whole magnitude, though the speaker was unsurprised by his decision not to continue any longer. A very mysterious star, members were urged to watch it as and when it was next active.

The speaker wished to leave with two thoughts. Firstly, to urge all deep sky enthusiasts to consider making variable star observations: he pointed out that many variable stars on the Recurrent Objects patrol list shared fields with deep sky wonders, not to mention active galaxies, which were themselves deep sky objects in the truest sense. Secondly, he left members with his opening question of whether science was possible with a four-inch aperture; he wasn’t yet sure himself, but felt he had certainly come close. He finally thanked everyone within the Association who had made his steep learning curve of the past year such an enjoyable experience.

After the applause for Dr Shears’ inspiring account, Mr Mark Armstrong asked what colour filters he had used in his photometry. Dr Shears replied none: he had tried using a V-band filter, but it had reduced his limiting magnitude by 1-2, severely restricting the science that could be achieved. With so small an aperture, he needed all the photons he could get.

Expressing his personal congratulations to Dr Shears on his fine work, the President then adjourned the meeting until June 25 at the Cavendish Laboratory in Cambridge.

Dominic Ford

References

[1] Berry, R. and Burnell, J., *The Handbook of Astronomical Image Processing*, Willmann-Bell (2000)
[2] http://www.peranso.com