Meetings

Ordinary Meeting, 2012 November 17

held at the Royal Astronomical Society, Burlington House, Piccadilly, London W1

Prof Bill Leatherbarrow, *President*
Hazel Collett, Dr Richard Miles *(Acting)* **& Nick James,** *Secretaries*

Professor Leatherbarrow welcomed members to the second Ordinary Meeting of the 123rd session of the Association. The minutes of the previous meeting had been displayed, and were approved by the audience and signed by the President. The names of three proposed new members were displayed in the office for members' inspection, and 38 members proposed at the last meeting had been elected by Council that morning. The audience approved their election. Prof Leatherbarrow urged any new members present in the audience to introduce themselves to him later during the tea break.

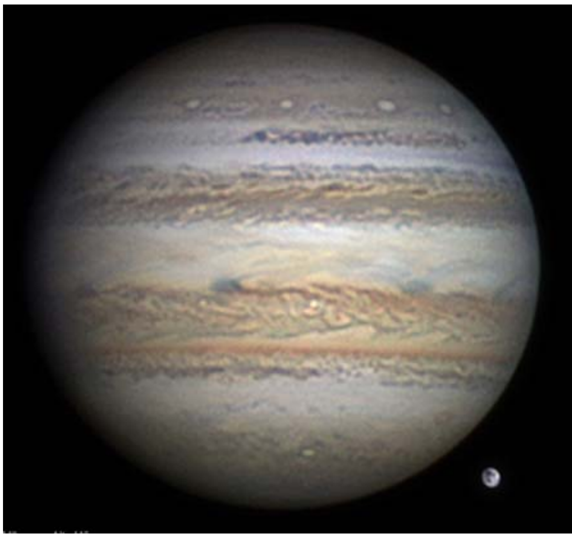
Prof Leatherbarrow then reminded members that the next meeting of the Association would be on Saturday December 15 at the same venue, when the Christmas Lecture would be given by Dr Paul Abel. He also said that the BBC would be airing a series of *Stargazing Live* transmissions on 2013 January 8–10, and that the BAA would again be joining forces with the Baker Street Irregular Astronomers to stage public observing from Regents Park: details and times to be confirmed later.

The President then introduced the first speaker of the afternoon, Dr John Rogers, who as Director of the Association's Jupiter Section since 1988 was well known to the membership having published widely, authored a standard work on the planet Jupiter and set the work of the Section on a firmly scientific basis during his first quarter-century in the post.

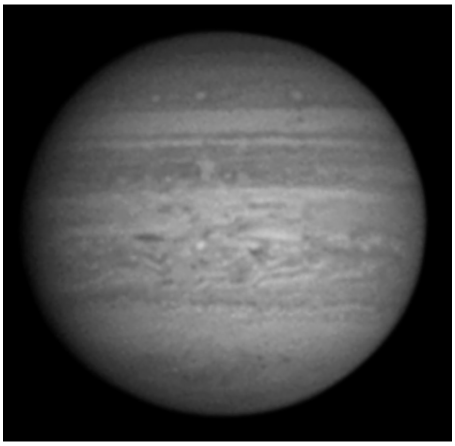
The new climatic upheaval on Jupiter

Dr Rogers began his talk by commenting that it had been a very exciting year on Jupiter, involving changes in the South Equatorial Belt (SEB), North Temperate Belt (NTB) and in particular the North Equatorial Belt (NEB), which in 2012 had seen its first full-scale revival in living memory. He described the cyclic nature of SEB and NTB revivals, pointing out that the events seen in 1990 and 1993 were also seen again in 2007 and 2010 whereas recent activity in the NEB was very unusual. Such behaviour involving initial narrowing then widening of the NEB had been witnessed by T. E. R. Phillips back in 1896–'97 and subsequently every 3 years or so by BAA observers until 1915.

Fast forward to the present: Grischa Hahn, studying zonal wind speeds versus latitude from amateur images, has noted accelerations in the speed of atmospheric jet streams. In 2010–'11, both the NTB and the NEB developed super-fast drifts which, it was thought, might herald subsequent upheavals in these belts. Meanwhile in 2011–'12 the NEB narrowed to form a remarkably thin dark belt, having an appearance last seen in 1925. Then the possible start of an NEB revival was detected in 2012 March, when a spreading zone of disturbance appeared with two very dark spots on the NEB south edge. Then, on April 19 as the planet approached conjunction with the Sun, Manos Kardasis observing from Greece discovered an outbreak on the NTB, and was subsequently the first to image the planet after conjunction, obtaining an infrared (742nm) image on June 4. By mid-June, it was clear that both the NEB and NTB were highly disturbed and undergoing classic revivals.



Jupiter & Ganymede on 2012 August 10, 04:08UT. (Image by Damian Peach, as below). The NEB (just below the equator) is extremely turbulent, with new dark formations on its equatorial edge. The disturbance extends north to the southern NTB, which has revived as a dark orange belt. There are also pale coloured shadings in the Equatorial Zone.



Images of Jupiter by Damian Peach (Selsey, W. Sussex), with a Celestron C14 (355mm Schmidt-Cass.) Processing includes use of the *WinJUPOS* derotation function to compile images over 5 minutes [7 mins for the IR image]. *Left:* 2012 Feb 11, 17:13UT. Jupiter before the great northern upheaval. Note the narrow, quiet NEB (just below the equator, with two dark 'barges') and the faint NTB. *Right:* 2012 June 19, 06:22UT. A near-infrared (700nm) image taken 2 hours after sunrise, showing intense turbulence across the NEB to the NTB at the height of the upheaval.

The speaker then showed a comparison between the 2012 appearance and a map showing the NEB revival he had made from drawings by E. M. Antoniadi in 1893. He explained that convective outbreaks liberate energy that deposits into large eddies seen as ovals or barges along the edge of the reviving belt. Unusually, dark-grey spots appeared to turn into white ovals, a process not seen before and which he indicated may be associated with whitish cloud tops forming as the disturbance settled down.

John Rogers rounded off his presentation by saying that a successful prediction of the new outbreak of the NTB had been made based on the change in jet speeds and its apparent 5-year periodicity. Moreover, the narrowing and revival of the NEB had been seen for the first time since around 1926, all of which may indicate that Jupiter was adopting a similar behaviour to that observed a century ago.

Following questions and discussion, the meeting broke for tea.

Modelling the upper atmospheres and ionospheres of planets

Prof Leatherbarrow then introduced the second speaker, Prof Alan Aylward, recently retired from his post as head of the Atmospheric Physics Laboratory at University College London, to speak on 'Modelling the upper atmospheres and ionospheres of planets both inside and outside the solar system'.

Prof Aylward first acknowledged that advances in modelling had been the result of efforts by not only himself but also his many co-workers, the subject having begun after World War II when rockets able to probe the upper atmosphere became available for research. Early attempts to model the neutral upper atmosphere or thermosphere (100–400km altitude) were unsuccessful. In this region viscosity and temperature dominate over the Coriolis effect, with winds blowing from hot to cold.

Though the upper atmospheres of Venus and Mars could be modelled, the Earth's was more complicated. Charged particles, though only a small percentage of the thermosphere, play an important role, with ionisation greatest at about 350km in the F-layer.

Early history saw the Norwegian scientist Birkeland simulating aurorae in the laboratory using cathode rays, from which he postulated that fast electrons ejected from the Sun were attracted along magnetic field lines, thereby reaching the polar regions and producing auroral displays. In practice, ions form in the thermosphere and are constrained by magnetic field lines whereby the Earth's N–S dipole links the two hemispheres with O^+ being the dominant ion, while above 400km in the ionosphere H and He^+ ions are the most abundant. Spectra of aurorae largely comprise emission lines from N and O ions excited by various energetic particles entering the upper atmosphere. In this respect, Prof Aylward said that Birkeland had got it wrong in that electrons do not hit our atmosphere directly, but incoming electrons alter the degree of coupling, making the auroral zones expand or contract.

In practice a very complex mechanism operates and to model it is rather like weather forecasting. A lot of input data are needed for the analysis, and the atmosphere is divided into boxes, typically every 2° in latitude and 18° in longitude by 1 scale height in depth. For each box, equations for momentum and energy/temperature continuity are solved. He showed an example of the output of the modelling, pointing out how the solar wind opens magnetic field lines and shifts the auroral zones about 15° away from the magnetic poles.

Prof Aylward then moved on to discuss the upper atmospheres of Jupiter, Saturn, Titan and Triton: the latter two being simpler owing to the absence of any magnetic field. Infrared studies of the Jovian auroral ovals indicated a chemistry dominated by H_2 being ionised to form H_3^+, and UCL scientists were first to prove this, demonstrating the near-perfect fit between calculated spectra of H_3^+ and the observed emission spectra. He showed how the very sharp emission lines enable Doppler motion within the auroral ovals to be mapped.

Bright spots within the ovals arise when ionised particles from Jupiter's moon Io strike the upper atmosphere. Since these ions are trapped by the giant planet's intense magnetic field lines, they are forced to rotate rapidly rather like on a race track. Saturn, he said, was very different being somewhat intermediate between the Earth and Jupiter, with the satellite Enceladus injecting water vapour and other molecules into the Saturnian upper atmosphere.

Prof Aylward believed that the discovery of extrasolar planets in recent years had been a defining moment for atmospheric modelling. Gas giants have been found orbiting much closer to their parent star than does say Jupiter – can a Jupiter-size planet orbiting 51 Pegasi at a distance of 0.05AU hold on to its atmosphere? In general models showed that H_3^+ ions can participate in a self-cooling mechanism, and such atmospheres might be stable.

Transit observations of HD 209458b have revealed the presence of methane, water vapour, carbon monoxide and a connected plume of hydrogen, *i.e.* significant loss of material. Koskinen *et al.* (2007)[1] had shown that cooling by H_3^+ ions functions down to about 0.16AU, but closer than that the atmosphere heats up, expands and material is stripped away.

Prof Aylward went on to contrast this with the properties of extrasolar planet HD 17156b, which is in a highly eccentric orbit passing in and out of a potentially unstable region. Here, simulations by Prof Aylward and his colleagues (Koskinen *et al.* 2009)[2] showed that the atmosphere tends to remain stable when close to its star, although its actual behaviour depends on the amount of atomic hydrogen in the thermosphere. The speaker explained that future modelling would examine other planets, especially terrestrial analogues, including some of those recently discovered from the *Kepler* space observatory.

The President thanked Prof Aylward for his talk and after a number of questions from the audience, invited the final speaker, Bob Marriott, to present the current Sky Notes. Opening his talk, Mr Marriott said that last Wednesday's total solar eclipse, which began one hour after sunrise on November 14 as seen from Cairns, Australia, was unusual in that the shadow track had then crossed the International Date Line so that the eclipse finished at sunset on November 13 local time!

He then treated the members to some fine auroral images including a panoramic view taken by Graeme Whipps, Scotland on 2012 October 8 (sent by Ken Kennedy) and an image taken by Glyn Marsh from the Isle of Man.

Mr Marriott then mentioned Rob McNaught, who had travelled to Australia as a BAA member during the 1980s hoping to stay there long enough to see Halley's Comet, but is yet to return to the UK, having in the meantime discovered a great number of comets, the latest of which (C/2012 T4) was announced on October 16.

He then described the current visibility of the planets, noting an unusually close appulse of Saturn and Venus visible before sunrise on November 26 & 27 with Mercury also not far distant. The maximum of the Leonids meteor shower was due that evening, and the December Geminids had now overtaken the Perseids as the best shower of the year. To close, he suggested that now was a favourable time for observers to try to detect Sirius B visually, despite its being 16,000 times fainter than Sirius A.

Following applause for Bob Marriott's entertaining presentation, Prof Leatherbarrow adjourned the meeting until Saturday December 15 in the same hall, the occasion of the Christmas Lecture.

Richard Miles

1 Koskinen T. T., Aylward A. D. & Miller S., 'A stability limit for the atmospheres of giant extrasolar planets', *Nature* **450**, 845–848 (2007)

2 Koskinen T. T., Aylward A. D. & Miller S., 'The upper atmosphere of HD17156b', *ApJ.* **693**, 868–885 (2009)