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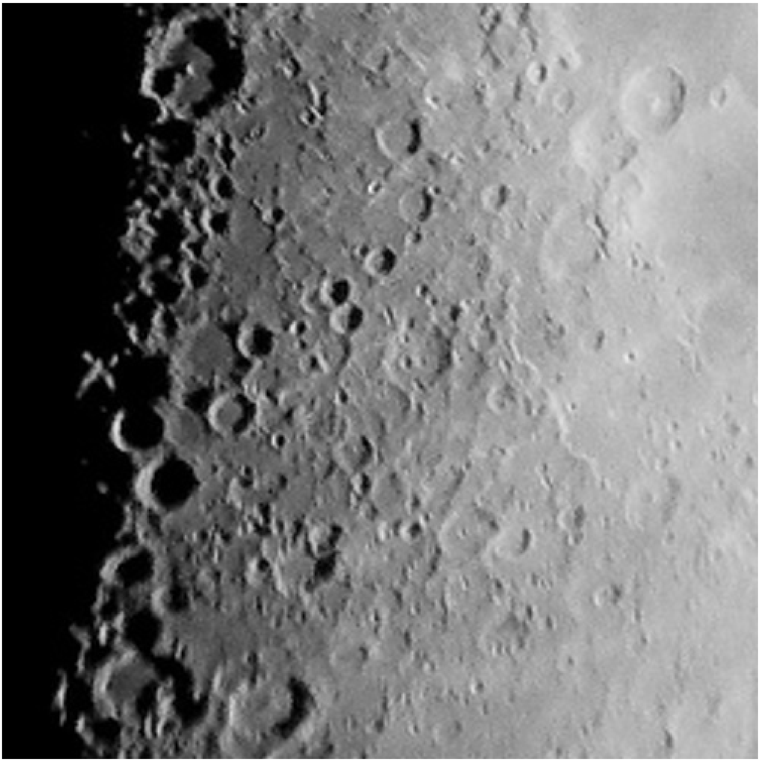


The Lunar X or Werner X – near the centre of the left edge – can be seen for only a few hours each month when the angle of illumination is just right. Photograph taken on 2010-03-24 by Carol Gentle.

Insights into gravitation on Earth

Last November, I described the calculations of the gravitational attraction to various bodies that are *not* spheres. The results were written as tables and diagrams, as no formulae can be derived for the complicated integrations involved. The sphere *also* needs a significant integration but by contrast, there is only one answer, the distance to the centre of the sphere; this is then used with Newton's third law to generate the gravitational pull.

However if one poses the question "What on earth affects our weight most?" the simple spherical form allows one to find out what affects us most (aside from the frivolous answer of "How much we eat!").

This shows the earth with normalised units. One cubic metre at the centre weighs comparatively little, but if it lies just 4 miles below your feet, it would have 1 million times more pull via the inverse square law. As 4 miles is about 6 km, there are another 12,000 half-metres to go before one is physically standing on it. This would involve multiplying by a further 144 million times!

This gives the impression that most of the pull comes from the vicinity of your feet! However, this cannot be true, or one would find oneself leaning sideways when next to a cliff. (In fact, one really is, but it can hardly be measured at all with the most sensitive instruments.) A better insight is obtained by doing a calculation on a smaller part of the earth.

This shows that half our weight comes from a sphere that just reaches the centre. As this is only one eighth of the earth's volume, it is apparent that the remaining 7/8 is rather ineffective in supplying the other half. This is made obvious by the addition of a second half-radius sphere below.

As its centre is three times further away than the upper sphere, it exerts one-ninth of its g, giving only a slight increase to 0.5555. As the total weight has now doubled, the centre of attraction – given by inserting the known mass and g into the inverse square law – moves noticeably down from the centre of the top sphere, to 0.67. This is exactly the same figure given for the calculation in *Journal 61* of a split mass in line with the observer. In that case, the mass size was not defined; indeed, it has no effect on the calculation as long as it remains a sphere.

Such a body when rotated through 90 degrees is only slightly more difficult to calculate.

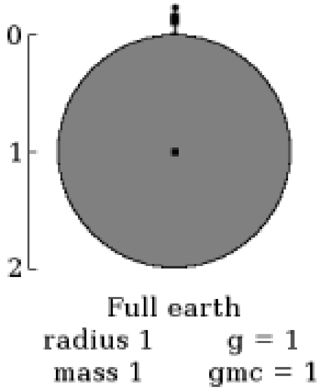


Fig. 1.

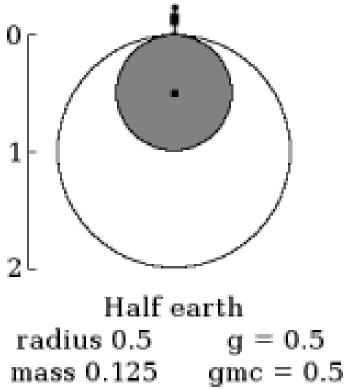


Fig. 2.

The unit of length is the earth's radius (about 4000 miles). The units of mass and gravity g are also the earth's mass and gravity. Gravity is then mass divided by the square of the radius $g = M/R^2$ *and the distance to the gravitational mass centre is* $R = \sqrt{g/M}$.

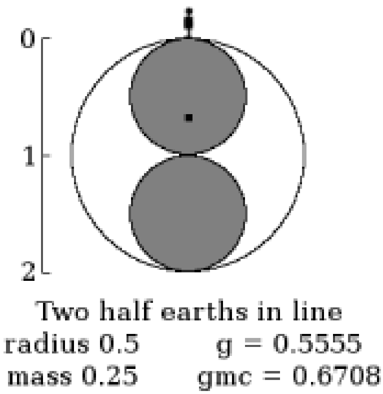


Fig. 3.

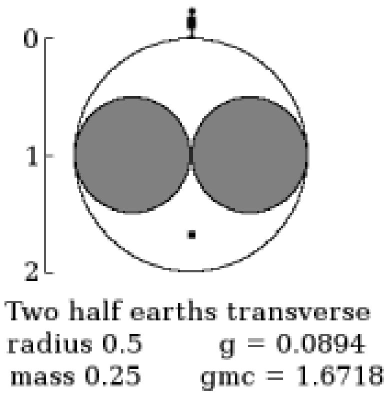


Fig. 4.

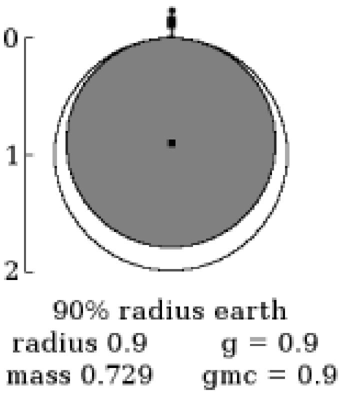


Fig. 5.

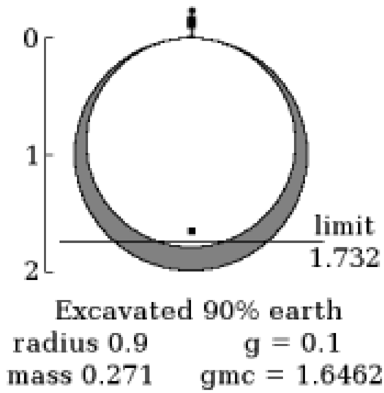


Fig. 6.

$$\sqrt{(1-r^3)/(1-r)} = \sqrt{1+r+r^2}$$

In addition to the downward displacement of the centres, one has to allow for the lengthening of the hypotenuse and the cosine reduction due the angle of the vector away from the vertical. The result is to move the gravity mass-centre noticeably below the line joining the centres.

Finally, a sphere approaching the full size of the earth gives some interesting results.

72% of the full earth's mass is sufficient to produce $0.9g$ and the remaining 28% would produce the other 10%. The mass still operates from its centre, but consider the "excavated" situation of Fig. 6.

This now operates from much further down, at 1.65 earth radius. It does *not*, however, tend to the centre of gravity, even when the excavation is increased to the full earth. From the formula in the figure it can be seen that $1-r$ (for g) divides into $1-r^3$ for the mass, to give $1+r+r^2$. As r tends to unity this goes to 3, so the mass centre never goes below $\sqrt{3}$ in this "wine glass" shape. So one is not attracted to the "wine", but to a point in the "glass" 1.73 radii below the top. :-)

This feature arises from the fact that though there is decreasing mass in the upper sides; the inverse square law there is exerting its strong influence, even allowing for the cosine reduction. This is unlike the situation where the full body is distanced from the measuring point.

Graham Clarke

NASA honours Edinburgh astronomer

NASA's Exceptional Technology Achievement Medal is awarded to individuals for technology contributions achieved in one of the following areas: early technology development significantly contributing to NASA's mission, exemplary collaborative effort in achieving significant technology transfer, or exceptional utilisation of a NASA-developed technology resulting in a significant commercial application. These are the highest awards given by NASA. This medal has now been awarded to the late Dr Tim Hawarden for his pioneering work on passive radiative cooling of infrared space telescopes.

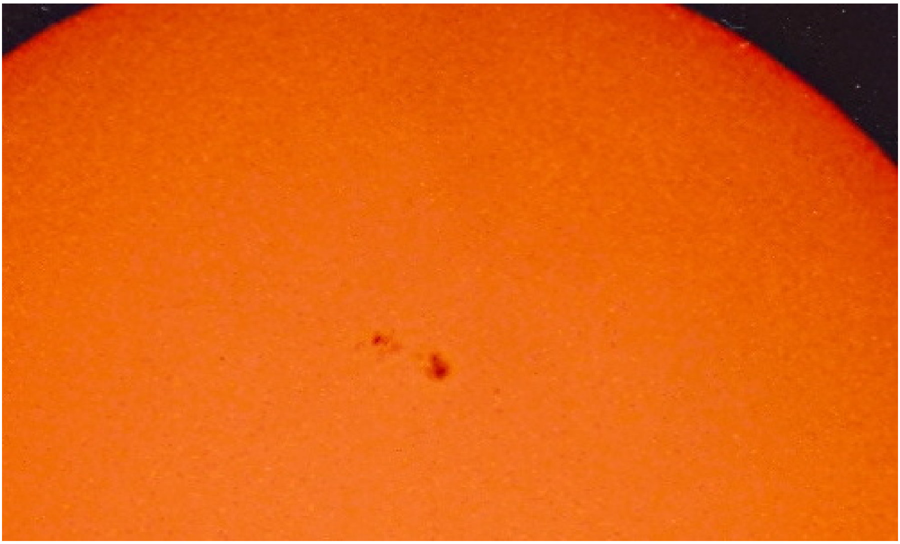
Hawarden graduated from the University of Natal in 1966 with a BSc in physics and applied mathematics, followed by an MSc and PhD in astronomy from the University of Cape Town in 1970 and 1975 resp. Having worked at the Royal Observatory at the Cape and the South African Astronomical Observatory, he moved to the UK Schmidt Telescope in Australia. From there he went on to the Royal Observatory Edinburgh, where he would work for the UKIRT infrared telescope in Hawaii, as head of the Edinburgh UKIRT unit, as support astronomer in Hawaii, as project scientist for the UKIRT Upgrades Programme, and back to Hawaii as head of UKIRT Development. In 2001, he finally returned to Edinburgh to work on the next generation of ground-based telescopes like the E-ELT (European Extremely Large Telescope). Hawarden retired in 2006 and died in 2009, only a few months before the NASA award was made.

Dr Hawarden also worked on the Infrared Space Observatory (ISO). Later, he was the instigator of passive radiation cooling. "This was breakthrough stuff and although Tim met initial severe resistance from the engineering establishment, typically he persevered and showed through detailed calculation that his ideas were sound. He soon gathered a strong following from fellow astronomers and eventually this idea was accepted and widely adopted. Tim's legacy can be seen in missions as diverse as the Herschel Telescope, launched in June 2009, through to the James Webb Space Telescope, the Hubble successor to be launched in 2014." [1]

1. Ian Robson (2009). "Dr Tim Hawarden". Obituary.
   http://www.roe.ac.uk/roe/staff/tgh/index.html
2. "Posthumous award from NASA". ROE press release, 2010-05-12.
   http://www.roe.ac.uk/whatsnew/index.html

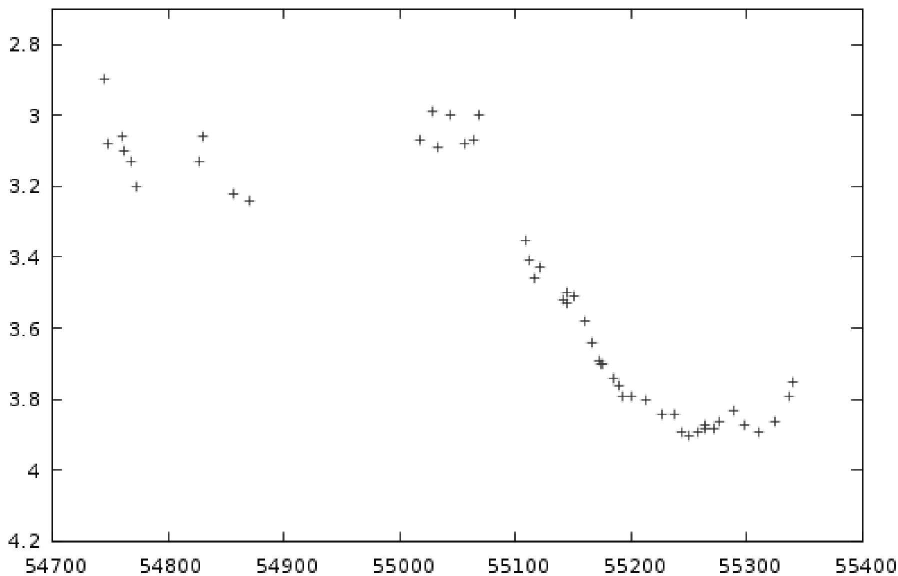
Horst Meyerdierks

Martin Allan took this picture of the Sun on 2010-03-14, when it showed one of the more complex sunspot groups of recent years. He took a 1/250 s exposure with a digital SLR through a 5 in. refractor (1180 mm focal length) with a solar filter.



David Small took this 180° panorama of noctilucent cloud on 2010-06-20/21 at about 01:00 UT.

Horst's light curve of ε Aur. See text on the following pages.



Recent observations

Sun

Horst Meyerdierks takes an image of the Sun whenever possible and averages his spot counts in 30-day intervals. He reports the following R numbers (number of spots plus ten times the number of spot groups):

2008-10-01 / 2008-10-30	2.8	2009-07-28 / 2009-08-26	0.0
2008-10-31 / 2008-11-29	5.9	2009-08-27 / 2009-09-25	3.8
2008-11-30 / 2008-12-29	0.0	2009-09-26 / 2009-10-25	1.5
2008-12-30 / 2009-01-28	0.0	2009-10-26 / 2009-11-24	4.3
2009-01-29 / 2009-02-27	1.8	2009-11-25 / 2009-12-24	7.4
2009-02-28 / 2009-03-29	0.9	2009-12-25 / 2010-01-23	13.7
2009-03-30 / 2009-04-28	0.0	2010-01-24 / 2010-02-22	15.8
2009-04-29 / 2009-05-28	0.8	2010-02-23 / 2010-03-24	19.0
2009-05-29 / 2009-06-27	3.6	2010-03-25 / 2010-04-23	9.1
2009-06-28 / 2009-07-27	5.0	2010-04-24 / 2010-05-23	2.8

Noctilucent cloud

In 2009, Horst set up a digital SLR with a controlling laptop to take pictures of any NLC that might show. The camera was located at the Royal Observatory, but in 2010, the scaffolding for repair of the Observatory's copper domes gets in the way. Horst has teamed up with David Small to run the camera from David's kitchen window in the Borders.

In 2009, after a false start with a webcam, the camera missed the first few NLC sightings at the end of May. In June about half the nights, and in July virtually all nights, showed NLC. There were no sightings in August. The 2010 NLC season started later, this camera had no sightings in May, and the first NLC only on 11/12 June.

Full reports and imagery are at http://www.chiandh.me.uk/p/Noctilucent_cloud.

ε Aurigae

Horst also collects photometry of the 27-year period eclipsing binary ε Aur with a dSLR. The light curve shown runs from 2008-10 to 2010-05 and shows "unfiltered" magnitudes; they are filtered by the green filters of the dSLR, but not corrected for the difference to a proper V filter. Each of the more recent data points is the result of ten raw-format images that contain the variable and the comparison star η Aur. The early data, covering the 2008/2009 autumn and winter, are not as good, because only four raw images were used. The group of data in summer 2009, just before the main decline in brightness, were extracted from noctilucent cloud photographs in JPG format. The JPG data format is unsuitable and the low position of Auriga on the northern horizon does not help the quality of these data.

Although you couldn't really tell from these data, there are brightness variations outside the eclipse. The decline to eclipse began in August or September 2009. By January 2010, the decline began to level off. The last two points may indicate a brightening, or they may just be an effect of the comparison star sitting a few degrees lower and closer to the horizon.

Society news

At most Ordinary Meetings, Alan Pickup gives a presentation about the sky in the forthcoming month, usually including snippets of recent news in the fields of observational astronomy and spaceflight.

Following the Annual General Meeting on 2010-03-26, the outgoing President gave a presentation on noctilucent cloud. On 2010-05-07, Ross McLure reported on the search for the highest redshift galaxies in the universe, which we see at a time close to when the first stars formed and re-ionised the hydrogen gas of the universe. On 2010-06-04, Alistair Glasse reported on the James Webb Space Telescope, which is to replace the Hubble Space Telescope. The JWST will work in the infrared instead of HST's instruments for visible and UV light.

The re-formed imaging group held further meetings in March and April; it will meet again from September onwards. The group has a Flickr group at http://www.flickr.com/groups/aseimaginggroup, which is used to share images amongst the group, with Society members and with the public. Among the results are images of Venus and Mercury, of Mars and Praësepe, and of the International Space Station and Iridium flares.

The Annual General Meeting elected the following Council of the Society, which took office on 2010-04-01:

- President: David Small
- Vice-Presidents: Iain McEachran, Rachel Thomas
- Secretary: Graham Rule
- Treasurer: Alan Ellis
- Councillors: Vincent Balfour, Daniel Gallacher, Frank Howie, Horst Meyerdierks, Peter Mulholland, Kenneth Thomas

Forthcoming events

2010-07-02	20:00 AUC	**Dr Christiane Helling**, University of St Andrews *Making extraterrestrial jewellery*
2010-08-07		**Possible excursion to Kellie Castle** (members only, event remains to be confirmed)
2010-09-10	20:00 AUC	**Dr Martin Hendry**, University of Glasgow *Gravitational wave astronomy: Opening a new window on the universe*
2010-09	JGVH	**Imaging group** (the group should resume monthly meetings in September, dates and venue to be confirmed)
2010-10-01	20:00 AUC	**Ordinary Meeting** (speaker and subject to be confirmed)
2010-11-05	20:00 AUC	**Ordinary Meeting** (speaker and subject to be confirmed)

AUC:

Augustine Church Centre,
41 George IV Bridge, Edinburgh, EH1 1EL.

JGVH:

Juniper Green Village Hall,
Barberton Avenue, Juniper Green, EH14 5DU.

PLDS:

Dark Site near Pearie Law, 4 km south of West Calder,
NT 003 579, $\lambda = -3^\circ 35' 28''$, $\phi = +55^\circ 48' 17''$.

Our meetings are open to the public, unless otherwise stated. We are always happy to see new faces. Ordinary meetings take place at 20:00 (Civil Time), usually in the Augustine Church Centre on the first Friday of the month. Any changes to our meeting arrangements will be put on our website http://www.astronomyedinburgh.org

Contents of this issue

About the ASE Journal

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