TRANSIT

The June 2014 Newsletter of

Cleveland & Darlington Astronomical Society

FINAL MEETING OF THE SEASON – NB CHANGE OF VENUE!

Friday 13 June 2014, at 7.30 pm

AGM followed by a social evening (*see Editorial below*)

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Next season's meeting schedule will be sent out during the summer, with the first meeting planned for Friday 12 September

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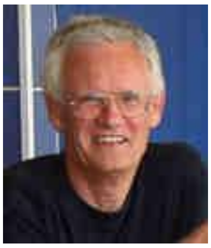
Editorial

Rod Cuff



Firstly, a warm welcome to **new members** Marcin Odziomek and Richard Robinson. We hope you enjoy and get a lot out of your time in CaDAS.

Your committee has decided to organise something different from previous years for our **AGM/meeting** this month. Those of you receiving this by email will already know the details, but they're repeated after the end of this editorial.

This month's *Transit* contains some fine Solar System images, not only from the prolific **Keith Johnson** but also from **Dr David Weldrake**, a local lad and ex-CaDAS member made astrogood in Australia. Dave wrote an absorbing series of articles back in 2009 about his life as a professional astronomer, and it's great to know that he's still producing quality material from the sky, even if no longer for money! Amateurs can still collaborate effectively with professional astronomers, so I thought you might be interested to know the current results of such a collaboration concerning Jupiter, reported here in a BAA bulletin.

Finally, **Ray Brown** has written what I think is the best yet of his articles on physical topics connected with our science – it's always fascinating to reflect that the very small (quantum effects, the behaviour of sub-atomic particles) is the progenitor of the very large (stars, supernovae, the formation of most elements). **John Crowther** and **Neil Haggath** round us off with a couple of quizzes.

Two personal items, if I may. Some readers will know that for about a decade I've been doing one or more distance-learning courses in astronomy each year, mostly from the University of Central Lancashire but occasionally from Jodrell Bank (no longer available) and the Open University. I eventually realised this could lead to a BSc in Astronomy, and I set myself onto that track.

However, I've become unhappy with the course content and administration during the last couple of years, and have now decided not to go any further. Nevertheless, I've clocked up the equivalent of two full years of a degree course, and so am eligible for the **Diploma in Astronomy** (universities tend to give Certificates after one year, Diplomas after two). And so, later this month, I shall actually have a worthwhile formal academic qualification in astronomy. My old dad, who first started my interest with his copy of Fred Hoyle's *The Nature of the Universe*, would have been delighted.

The second item is that this is my last issue as *Transit*'s editor. The past five years have been very enjoyable for me, and through the magazine I've got much more involved with CaDAS that I ever was in the previous five. I want to thank all the contributors who have been so generous with their time and expertise in supplying scientific and historical articles, observing notes, tutorial guides, reviews, quizzes, humour, tailpieces, photographs, drawings and letters, and in Andy Fleming's case guest-editing several issues. I've tried to make *Transit* almost wholly a CaDAS-generated magazine, with very little material taken from the internet, and that's only been possible with willing (and often prolific) contributors from amongst its readers. Alas, there are sadly few such people – more contributors wanted, please…

Gratefully welcoming any such will be the **new editor of Transit**. Subject to approval at the AGM, I'm delighted to say that **Jon Mathieson** has volunteered to take on the post of Communications & Information Secretary, which includes being editor. Heartfelt thanks, Jon, for ensuring the continuity of issues and stepping up to the plate – I hope you enjoy it as much as I've done.

Jon has time to get his feet under the table, as *Transit* is now taking its summer break. Please let him have any material for the next issue by **mid-August**. His communications details are as follows:

Jon.Mathieson@jonm.net, mobile 07545 641 287. 12 Rushmere, Marton, Middlesbrough TS8 9XL

Best wishes – *Rod* (rodcuff@sfep.net)

AGM and social evening

The last meeting of the season on **Friday 13 June**, our Annual General Meeting and social evening, will be held not in the rather confined interior of the Planetarium but instead in the capacious and friendly surroundings of the ***Hamilton Russell Arms*** in the nearby village of **Thorpe Thewles** (if coming from the south, turn left into the village off the A177 exactly opposite where you would have turned right to get to the Planetarium). We hope as many members as possible will come along to both AGM and social evening (in the bar at the rear of the pub).

The AGM will start at 7.30 pm, and will probably take no more than half an hour. If partners or other non-CaDAS members care to sit in on the AGM, they will be warmly welcome, but of course only CaDAS members will be able to vote. The *provisional* agenda is as follows:

1. Chairman's welcome and opening remarks
2. Apologies for absence
3. Acceptance of the Minutes of the 2013 AGM
4. Chairman's report: CaDAS and TASC
5. General Secretary's report
6. Treasurer's report and financial statement
7. Election of Officers and Committee Members
    - Chairman
    - Treasurer
    - Programme Secretary
    - Information and Communications Secretary
    - General Secretary
    - Four General Members
8. Membership Fees
9. Any Other Business
10. Chairman's closure of the Annual General Meeting

At about 8.15 pm, the unserious part of the evening will get going with a **(free) cold buffet**. Again, partners and other family members are warmly invited to the social evening, but will be asked to pay around £7 to cover food and entertainment unless they are CaDAS members in their own right.

Later there will be a few **competitions**, including a quiz, to be unveiled on the night … There Will Be Prizes, including a £25 food voucher generously donated by the manager of the *Hamilton Russell Arms.*

There will also be a **raffle** for CaDAS funds, and we would very much appreciate members offering items to be raffled. **If you have an item you'd like to donate for this**, could I ask you, please, to drop me a quick email or phone message as soon as possible so that we can draw up a list of prizes to be won, and also to bring your donation to the pub on the night? We would be very appreciative of any tempting item that you are kind enough to donate – and of course it needn't have anything to do with astronomy at all!

Letters

What is it?

from Pat Duggan

I've given up trying to find out something online about the object shown below, as I keep getting 'George Adams' and not 'George Inch'! Do you think anyone from CaDAS might be able to help? Here's the background.

My family had returned to their own distant homes after visiting me for Easter. I was looking for something to amuse myself with on the Bank Holiday Monday afternoon, and a massive car-boot sale in Stokesley seemed like a good place to start. I purchased from a 'strange object stall' something that looks like an old telescope, possibly incomplete.

I started to dismantle it with the idea of giving it a good clean and putting it back together again, but at every layer there seemed to be more 'bits' than I expected to find.Then the telephone rang and, in abandoning my task to answer it, I put some of the sections down in the wrong order and so was completely perplexed when I later returned to re-assemble my new 'toy'! I hope I've finally got it right, but the eyepiece remains insecure. It contains no less than five separate lenses of poor-quality glass.

The very clear inscription says: George Inch 62 Wapping London.

Please can anyone tell me what my £5 has bought?

Best wishes – Pat

Mallorca Residential School[1]

from Dr Johanna Jarvis

I would like to make you and your members aware of the exciting new Mallorca Residential School taking place this August/September. Details are below, and more information can be found on my website (also see below) and as an additional incentive any astronomy group with four or more members enrolling on the school will receive a 10% discount on the school fee.

[1] *[Until a few years ago, the Open University ran a course (SXR208) that sounds very similar to the School described here, with a couple of months of preparation work and self-education at home before going out to Mallorca for a truly excellent week's practical preparation, observation and data analysis. Students worked from early evening to dawn in teams of four at the Observatory, making use of their 12-inch Meade LX200 dome-housed telescopes and high-quality attached kit. And then crashed out in the daylight hours at the group's hotel near a beach. I went in 2007 and had THE most rewarding time. John McCue has been a tutor on the course several times too, and also speaks very warmly about it. – Ed.]*

Observe the night sky from the beautiful Mediterranean island of Mallorca as the culmination of a sex-week educational school.

The Mallorca Residential School commences with five weeks of home study at your own pace and concludes in five nights working at the well-equipped astronomical teaching observatory, Observatori Astronomic de Mallorca (OAM).

The objective of the school is to facilitate each participant's completion of four practical observing projects, collecting and analysing unique photometric and spectroscopic observations by which you will explore various aspects of the Universe we live in and thereby develop a wide variety of practical observing skills.

Beginning with the basics and addressing all of the background theoretical and practical knowledge needed for the projects, this school is appropriate for anyone wishing to extend their astronomical knowledge and skill set.

With much appreciation,

Dr Johanna F Jarvis FRAS
Astronomy Tuition
Communication & Consultancy

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OBSERVATION REPORTS AND PLANNING

Websites – June/July 2014

Here are some suggestions for websites that will highlight some of what to look out for in the night sky over the next couple of months. Saturn remains a superb object, and it's also a good time to track down the asteroids Ceres and Vesta, which now appear closer to each other in the sky than at any time since they were discovered nearly two centuries ago. To add to the Solar System gallery, a couple of comets should be easy targets for a 6-inch telescope. In the deep sky, plenty of globular clusters are on show.

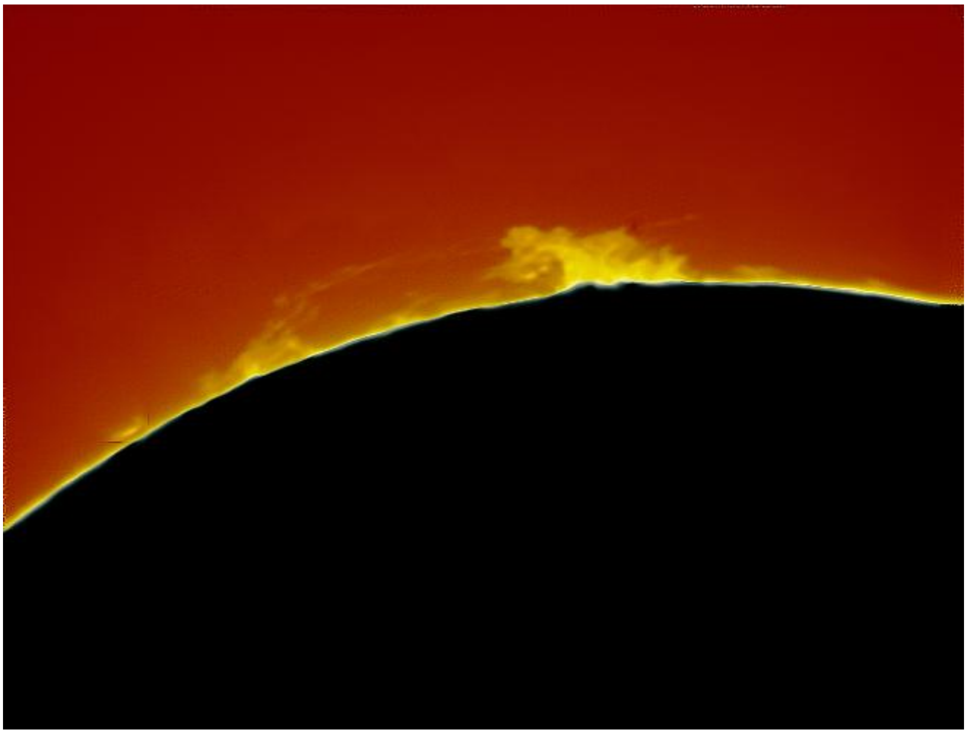
- **BAA Sky Notes** for June and July:
  http://britastro.org/skynotes_render/5552
- **HubbleSite**: a **video** of things to see each month (a transcript can be downloaded from the site as well):
  http://hubblesite.org/explore_astronomy/tonights_sky
- **Night Sky Info's** comprehensive coverage of the current night sky:
  www.nightskyinfo.com
- **Jodrell Bank Centre for Astrophysics** – The night sky:
  www.jodrellbank.manchester.ac.uk/astronomy/nightsky
- **Telescope House** monthly sky guide:
  http://tinyurl.com/pzzpmsx
- **Orion's** What's in the Sky this Month:
  www.telescope.com/content.jsp?pageName=In-the-Sky-this-Month
- **Society for Popular Astronomy's** What's Up for June 2014:
  www.popastro.com/youngstargazers/skyguide

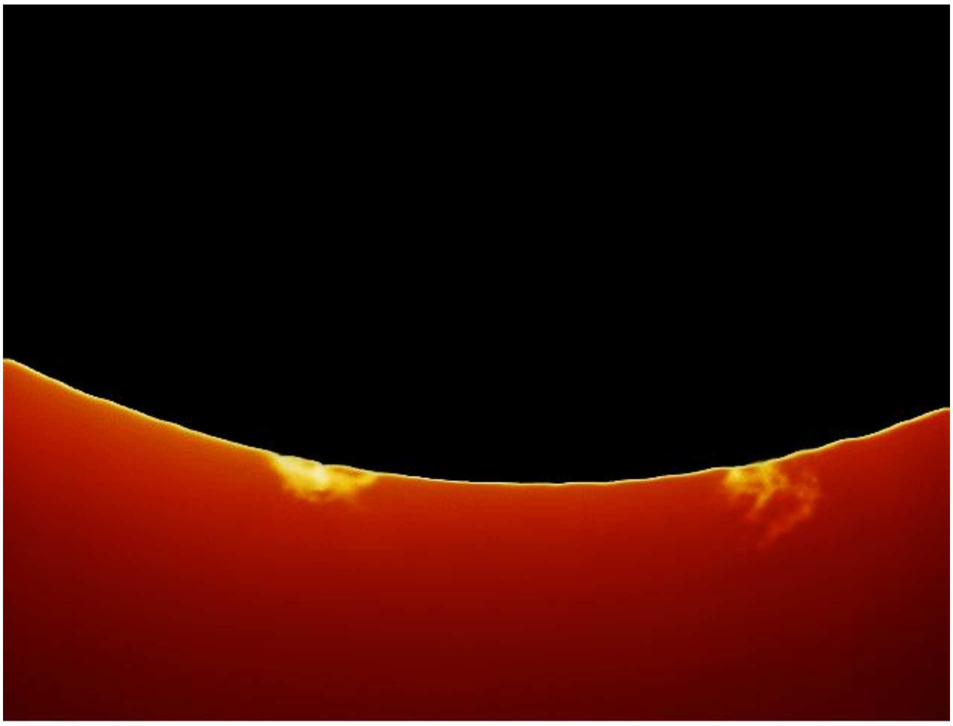
Solar images from 17 and 31 May 2014

Keith Johnson

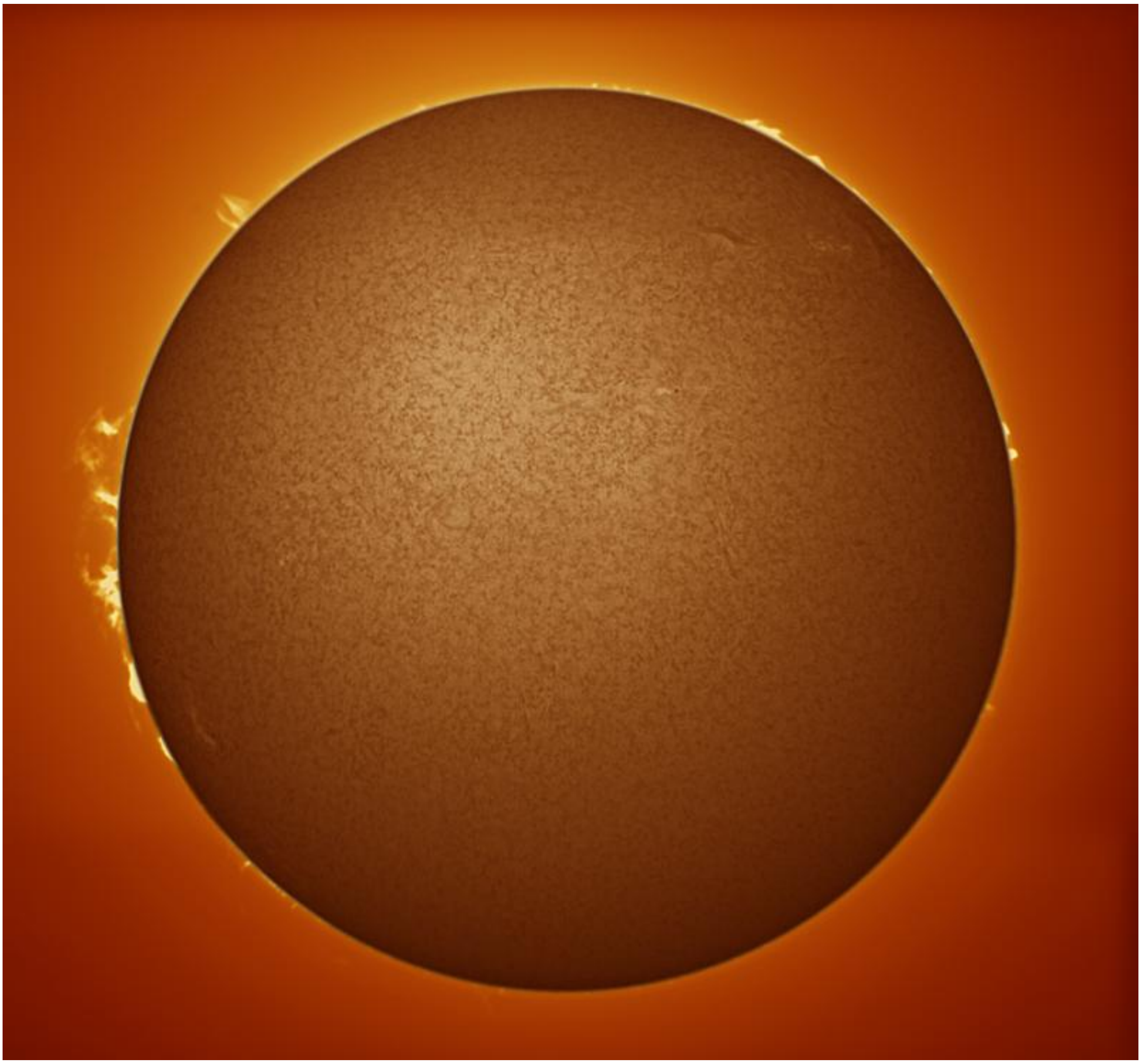
On 17 May some clear spells gave me the opportunity to try out the Lunt Hα telescope, using a 2.5× Powermate, EQ6 Pro mount and DMK 21AU618.AS camera. The first two images below concentrate on the prominences that were visible that day.

AVI captures were with Lucam Recorder professional, and alignment and stacking with AutoStakkert! II. Other processing was carried out with Adobe Photoshop CS2.





On the last day of the month I was able to capture a detailed image of the Sun as a whole (shown below), again with some good prominences on view. This used the same telescope and mount as earlier in the month, but this time with a ZWO ASI120MC USBII camera. I took two video sequences with exposure set to capture the main disk, and a further two concentrating on the prominences. The sequences were stacked into four images using Registax v6, then combined into a single image and adjusted using Adobe Photoshop CS2.



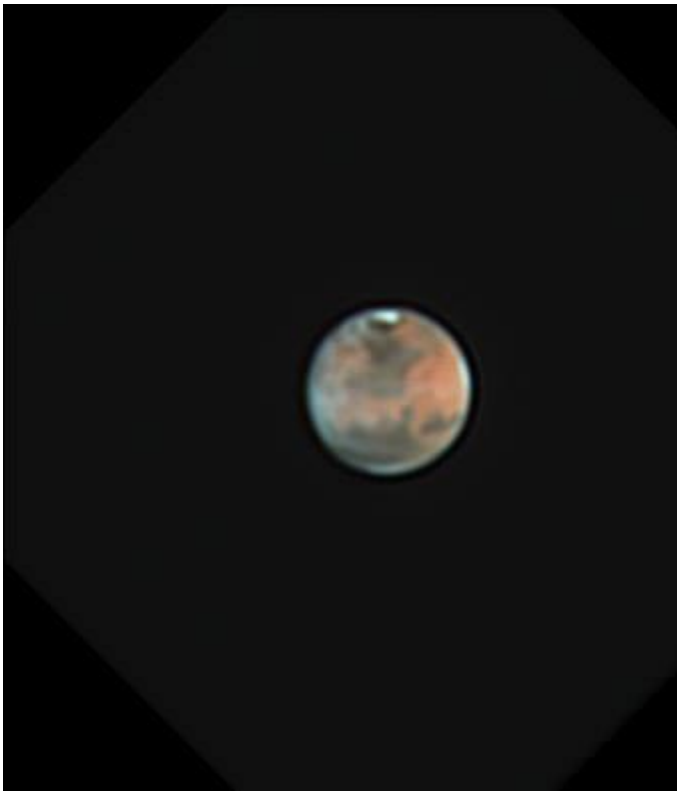
Photographing Saturn and Mars

Dave Weldrake

I hope you're all doing well in the UK[2]. Thanks for regularly sending *Transit* and other CaDAS news over to me – it's great to keep up with what's going on over there. I have a couple of submissions for the magazine if that's OK[3] – images of Saturn and Mars that I took with my new planetary camera.

Both pictures were taken on 1 May with a Takahashi TOA130 refractor and ZWO ASI120MM camera with LRGB filters. Mars shows lots of cloud and even a polar vortex cloud right next to the polar cap.

I hope to send in a few more pics as I learn how to get the most out of the new setup.



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[2] *[Here's a potted biog for Dave, taken from* Transit *of August 2009:*

> David Weldrake first joined CaDAS as a young teenager in 1992. He was an active observer in the society, often using its observatory, until he moved to Australia in 2001 to study for his Astrophysics PhD at Mount Stromlo Observatory.
>
> Since graduating in 2005 he has been employed as a postdoctoral researcher (in the detection and study of transiting exoplanets) at the Max-Planck Institute for Astronomy in Heidelberg, Germany, and the Harvard–Smithsonian Center for Astrophysics in Boston, USA.
>
> In early 2009 he moved back to Australia permanently, still spending his free time observing, only now with an upside-down Orion.

A few years after that, Dave decided to change careers away from professional astronomy, but he is still an active and enthusiastic amateur observer and astrophotographer. – Ed.]

[3] *[Sigh – as if it wouldn't be … – Ed.]*

Jupiter's Great Red Spot: a pro-am collaborative project

BAA bulletin

[On 19 May John Rogers, Director of the British Astronomical Association's Jupiter Section, sent out the following bulletin, likely to be of interest to anyone who has been looking at or imaging Jupiter recently. – Ed.]

Observers have noticed that one feature of Jupiter this apparition has been the small size, and strong reddish colour, of the Great Red Spot. Not only has its long-term shrinkage proceeded so it is smaller than ever before; we have also found that its internal rotation has speeded up. We measured the internal circulation of the GRS on images taken by many amateur observers in 2014 Jan. and found a rotation period of only 3.6 days, shorter than any previous ground-based measurement, and evidence that the wind speed may also have increased. All this has happened just as an intense outbreak of spots on the adjacent eastward jetstream has been interacting with the GRS, suggesting a possible physical link. Our report was posted at www.britastro.org/jupiter/2013_14reports.htm [Report no.7] and http://alpo-j.asahikawa-med.ac.jp/kk14/j140406s.htm and has been covered in news items at:

www.skyandtelescope.com/astronomy-news/observing-news/jupiters-great-red-spot/

www.universetoday.com/108257/will-jupiters-great-red-spot-turn-into-a-wee-red-dot/

Acting on this evidence, Dr Amy Simon and colleagues got time at short notice for the Hubble Space Telescope to image the GRS on April 21. A press release with the first colour image is at http://hubblesite.org/newscenter/archive/releases/solar-system/2014/24/.

The Hubble images, taken ~10 hours apart, are now being used to investigate the GRS rotation and its interaction with the jetstream spots, in the hope of finding out why the GRS is shrinking and what drives its winds. Through this project, we hope that amateur observations may lead to a significant advance in understanding Jupiter's atmospheric dynamics.

GENERAL ARTICLES

Pressing matters

Ray Brown

Pressure is a term we frequently encounter in various contexts, such as in weather forecasts. The scientific definition of pressure is the force acting upon unit area of surface. So the pressure exerted on the ground by the foot of an elephant is less than that due to the stiletto heel of a shoe worn by even the most petite woman; the much smaller area of the heel more than compensates for the lower weight of the woman. In that example the force is gravitational: the attraction of both elephant and woman by the mass of the Earth. However, pressure can be associated with any force acting orthogonally on an area of matter.

You will recall that Newton's Second Law is written as

$$F = m \times a$$

where a is the acceleration of a fixed mass m when acted on by a force F.

A particular example is that the **weight** w of an object is given by its mass multiplied by the acceleration g of any freely falling object (on Earth, g = 9.8 m s^{-2}):

$$W = m \times g$$

Momentum p is defined as the product of mass m and velocity v:

$$p = m \times v$$

Acceleration, of course, means the rate of change of **velocity** with time t, so the force acting on a fixed mass is equal to the rate of change of its momentum caused by the force. More generally, **force** corresponds to the rate of change of momentum, even when the change arises from a change in m as well as a change in v.

In short: $F = \mathrm{d}p/\mathrm{d}t = \mathrm{d}(mv)/\mathrm{d}t$

Air pressure is familiar to us. Although it varies a little with the weather, atmospheric pressure at sea level (1 **bar**, or about 15 psi or 10 tons per square metre) is large enough to allow aircraft to fly. When we inflate a tyre, we increase the pressure within it. Incidentally, if we use a simple hand- or foot-pump, we can feel that the pump becomes warmer because, by compressing the air, we are doing work on it, which is a way of increasing the energy of the air molecules and thereby their temperature. Conversely, the air released when we open a tyre valve is noticeably cold because it is losing energy in pushing back the surrounding atmosphere.

The tyre pressure is the force applied by the air within it to unit area of the tyre wall. Similarly, atmospheric pressure (about 10^5 Pascals or 10^5 N m^{-2}) is the force (in Newtons N) being applied to every square metre of your body, your house and every other object exposed to the air. That pressure is equal to the gravitational pressure arising from the weight of the atmosphere above us, but the force on us is caused by air molecules changing momentum when they rebound from collisions with us. They change momentum because on rebound they reverse direction (from v being positive to being negative or *vice versa*). When we increase a tyre pressure, we are cramming more air molecules into it and so there will be proportionately more molecular collisions with the tyre wall every second. Robert Boyle found experimentally that the volume V and pressure P of a fixed mass of any gas at a fixed temperature can be expressed by the law named after him:

$$PV = \text{constant}$$

Clearly this result has a simple theoretical basis in terms of molecular momentum.

Air has mass and is subject to gravitational force, so air pressure decreases with increasing altitude because, at higher altitudes, there is less air at still higher altitudes weighing down on it. Likewise, the water pressure in the oceans increases rapidly as we go to depths but, whereas at an altitude of 20,000 feet (the highest habitable elevation on Earth) air pressure has fallen only to about one half of its value at sea level, by contrast in water you only have to descend 10 metres below the surface for the hydrostatic pressure to become equal to the atmospheric pressure, so bringing the total pressure there to 2 bar. The contrast arises because air at sea level is roughly 850 times less dense than water, so the weight of a much thicker layer above is required to produce the same compressive force. However, as liquids are much less compressible than gases, the density of water in the deepest ocean trench is only increased by some 5% despite the pressure there being more than 1000 atmospheres. The pressure in the core of Earth is estimated to be over 3×10^6 bar.

Depth (ft)	Pressure (psia:atm)	Pound-force per square foot area
- 53,900 ft	1.47 psia : 0.1 atm	211
- 38,400 ft	2.54 psia : 0.2 atm	365
- 18,000 ft	7.35 psia : 0.5 atm	1,058
0 ft - sea level	14.7 psia : 1.0 atm	2,117
33 ft	29.4 psia : 2.0 atm	4,234
66 ft	44.1 psia : 3.0 atm	6,350
99 ft	58.8 psia : 4.0 atm	8,467
132 ft	73.5 psia : 5.0 atm	10,584
165 ft	88.2 psia : 6.0 atm	12,701

All types of particle that possess momentum can exert pressure. Although the so-called rest mass of a **photon** is zero, it nevertheless does have momentum p given by **de Broglie's equation**

$$p = h/\lambda \qquad (1)$$

λ is the wavelength of the electromagnetic radiation carried by the photon and h is **Planck's constant** (= 6.626×10^{-34} J s), which is one of the fundamental constants of physics and is the constant of proportionality relating the frequency ν of an electromagnetic radiation to the energy E of the photon associated with it:

$$E = h\nu \qquad (2)$$

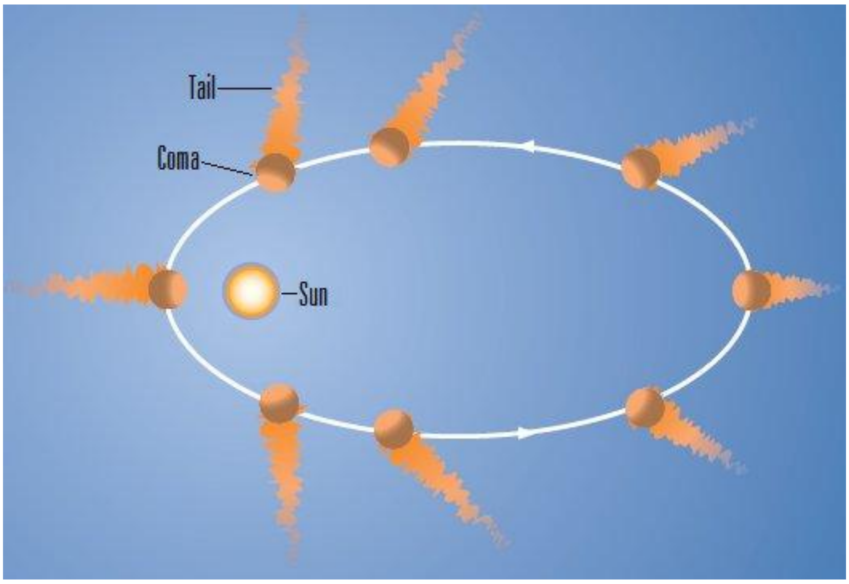
The speed of light c is the product of the wavelength and the number of waves per second:

$$c = \lambda\nu \qquad (3)$$

So the energy and momentum of a photon are related by

$$E = pc \qquad (4)$$

Johannes Kepler first proposed the concept of **radiation pressure** in order to explain why the tail of a comet always points away from the Sun.



Radiation pressure is an all-important factor in cosmology. When a proto-star begins to form from extremely cold molecular clouds as a result of gravitational attractions amongst (mainly hydrogen) molecules drawing them closer together, the pressure within it rises as what was previously almost a vacuum is transformed into a gas. The gas pressure will be greatest at the centre of the proto-star. The compression causes the **gravitational potential energy** to be converted to **kinetic energy** of the molecules, with a resulting rise in temperature of the proto-star. Above 3000K, hydrogen molecules increasingly dissociate to hydrogen *atoms*. These in turn gradually ionise above 10,000K to form a **plasma** of protons and electrons.

In a plasma, as in a metal, the conduction electrons are no longer bound to and associated with any particular ion and so are able to move freely and to respond to electric fields. But electrons are subject to **Pauli's Exclusion Principle**, which requires electrons to be distinguishable from one another. As this can no longer be achieved by identifying each electron with its own proton 'address', then the electrons must all occupy different energy levels. This fact, known as **electron degeneracy**, only has significant consequences at extreme pressures and densities, as we shall see later.

The contraction of the proto-star and its temperature rise become arrested by two effects: both the mounting internal pressure and, increasingly, **radiation pressure**. All matter emits electromagnetic radiation. The intensity and frequency distribution of radiation emitted by a model 'black body' varies with temperature. With increasing absolute temperature T, the **excitance** (total power emitted by unit area of the black body) M increases dramatically according to **Stefan's Law**

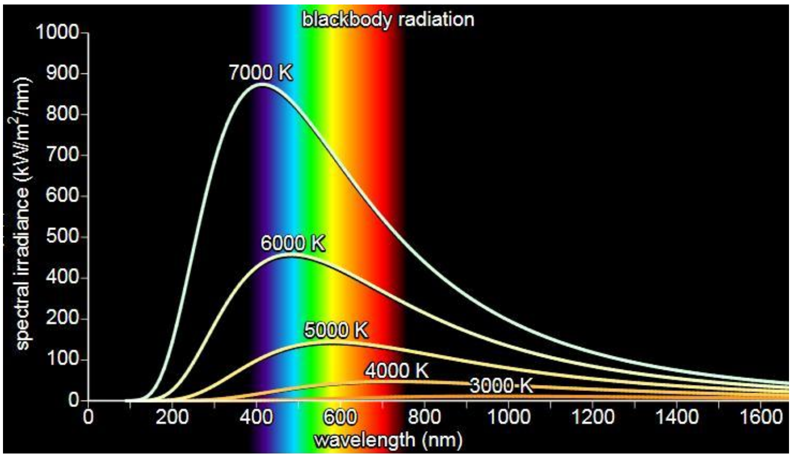
$$M = \text{constant} \times T^4 \qquad (5)$$

and the distribution favours higher frequencies (i.e. lower wavelengths λ), expressed approximately by **Wien's Displacement Law**

$$T\lambda_{max} \approx \text{constant} \qquad (6)$$

where λ_{max} is the wavelength at which energy is radiated most intensely.

Both these laws can be derived from Max Planck's distribution law of energy intensity vs λ.



The graph above shows how, with rising temperature, the total energy emitted (the area under each curve) increases and the distribution moves to shorter wavelengths.

Equation (4) shows that energy E can be regarded as a surrogate for momentum p. So we can expect p, and therefore radiation pressure, to increase with T^4.

(Incidentally, the electromagnetic energy from the Sun incident on each square meter of the equator [**solar insolation**] at midday at the equinox is about 1.05 kilowatt. Using equation (4) and taking $c = 3 \times 10^8$ m s^{-2}, we calculate the radiation pressure to be 3.5×10^{-6} N m^{-2} if all the radiation is absorbed and 7.0×10^{-6} N m^{-2} if it is reflected. See http://pveducation.org/pvcdrom/properties-of-sunlight/calculation-of-solar-insolation.)

Although the plasma within the proto-star may not conform exactly to the model of a black body, its qualitative behaviour can be regarded as much the same. The essential point is that electromagnetic radiation is emitted as photons, which are both much more numerous and more energetic with increasing temperature.

So, with rising temperature both the momenta of the photons and their intensity increase. These photons eventually collide with and are either absorbed by or reflected by other matter, so exerting pressure on them. Recoil of the matter that emits the radiation also implies a momentum change. The highest temperature and density of the proto-star are at its centre, so the net forces due to radiation pressure are outwards. In this way the tendency towards compression driven by gravitational attraction is counterbalanced by the pressure that drives expansion.

The mass of the proto-star determines the state at which the balance occurs. For very small proto-stars the balance of forces occurs at temperatures lower than the 15 million degrees needed for hydrogen fusion to take place, and a humble brown dwarf is the end result. More massive proto-stars develop into stars. Readers will be familiar with the fact that the more massive the star, the further it can proceed through the successive stages of forming heavier elements. Lighter elements become exhausted as fuels for fusion in the core. They can no longer contribute to the radiation pressure, so further gravitational contraction takes place until the temperature rises sufficiently for the next fusion process to begin.

Medium-sized stars cannot progress beyond the 'triple-alpha process' and so can form no elements heavier than carbon and oxygen. As fusion reactions in the core close down, further gravitational collapse occurs until the density rises to the point where *none* of the electrons is any longer associated with any particular nucleus. This is an extreme case of electron degeneracy, as it involves *all* the electrons, not merely the valence electrons of parent ions. However, much more importantly, the electrons have been forced into close proximity with one another. The density of a white dwarf is about a million times that of tap water. **Heisenberg's Uncertainty Principle** predicts that, when the position of a particle such as an electron is closely known, its momentum cannot be precisely defined and so it can assume extreme values. This quantum effect produces an **electron degeneracy pressure** which is temperature-independent and so persists as the dying star cools. These facts put a limit on the extent of compression that is possible in white dwarf stars, where again we find that gravitational forces are counterbalanced against an internal pressure.

However, if the star still retains more mass than the **Chandrasekhar limit** (about 1.4 solar masses), the **Fermi energy** (corresponding to the last-filled energy state at T = 0 K) is so high that it becomes possible to absorb the electrons *into* the nuclei, so converting protons into neutrons. The star is tending to become a soup of neutrons. Electron degeneracy pressure has been insufficient to prevent further shrinkage. This can lead to a supernova, but if the residue is still above the Chandrasekar limit then a neutron star will form, in which it is the degeneracy pressure of the *neutrons* that arrests further collapse.

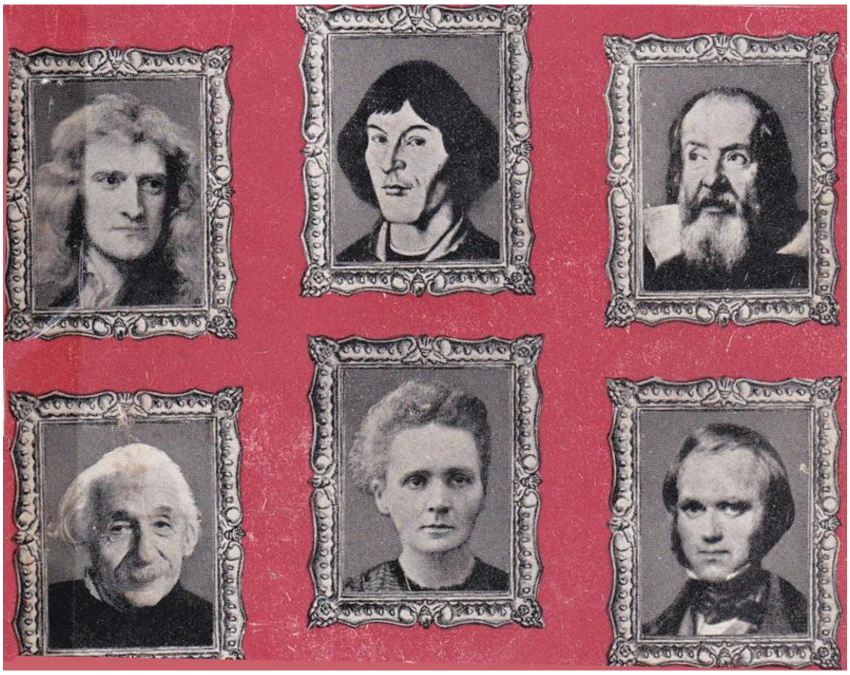
For stars that *still* have at least 3 × the solar mass, even neutron degeneracy pressure cannot halt their final compression towards a black hole.

An easier quiz?

John Crowther

Here's a short picture quiz I came across recently that might be a little easier than the questions in Neil's quiz below! The answers are upside down on the last page. Who are these scientists? And can you fit the life dates to the images?

1564–1642	1867–1934	1879–1955
1473–1543	1809–1882	1642–1727



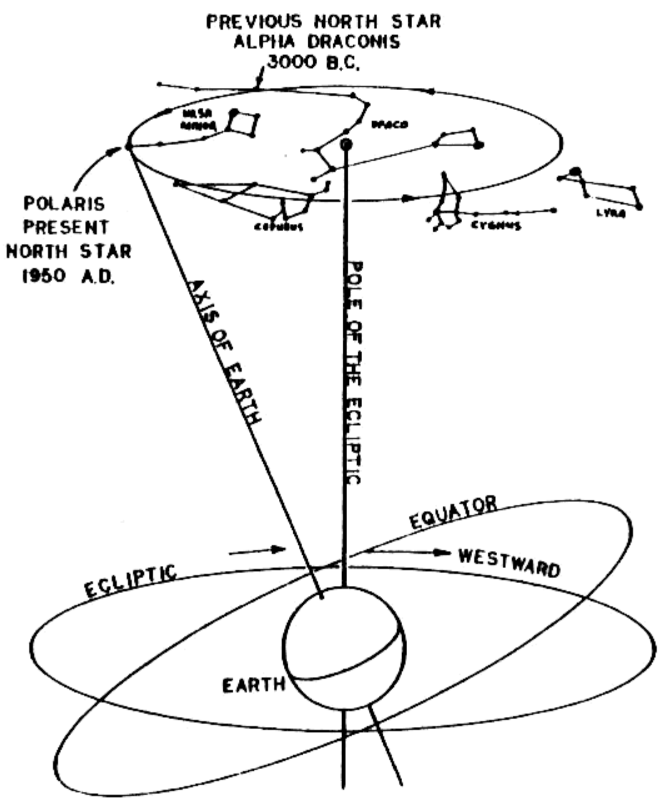
Answers to May's quiz

Every answer starts with the letter P, except for the 'Q' question 11.

1. The eighth brightest star. **Procyon (Alpha Canis Minoris).**
2. The second asteroid to be discovered. **Pallas**.
3. The first space probe to fly by Jupiter. **Pioneer 10, in 1973.**
4. The constellation in which the First Point of Aries is situated. **Pisces!**
5. His ratio forms the mathematical basis of the stellar magnitude scale. **Norman Pogson.**
6. The answer to Question 4 is a consequence of this phenomenon. **Precession.**
7. For a binary star, the closest point in the secondary’s orbit to the primary. **Periastron.**
8. Henrietta Leavitt’s vitally important discovery. **The Period–Luminosity Relationship for Cepheid variable stars – which proved to be a vital tool for measuring the distances of nearby galaxies.**
9. Two astronomer brothers, both long associated with Harvard College Observatory. **The Pickering brothers – Edward Charles (1846–1919) and William Henry (1858–1938).**
10. An amateur astronomer who made a historic observation on Christmas Day 1758. (And give yourself a bonus point if you can spell his name!) **Johann Palitzsch. He was the first person to recover Halley’s Comet, at its first predicted return.**
11. A meteor shower named after a non-existent constellation. **Quadrantids – named after the obsolete constellation Quadrans Muralis.**

Elaboration of Questions 4 and 6:

'First Point of Aries' is an old-fashioned name for the vernal equinox. It comes from – though I hate to mention *that* word – astrology; the astrological 'signs' of the Zodiac are equal 30° sectors of the ecliptic, measured from the vernal equinox. They were named, about 2500 years ago, after the constellations with which they roughly coincided. Owing to precession, the equinox moves with respect to the constellations, so the 'signs' no longer coincide with the constellations of the same names; they are displaced by roughly one constellation. Hence the 'First Point of Aries' is now in Pisces!



June's quiz

Every answer starts with the letter R. The questions are in very rough order of increasing difficulty.

1. The first American woman to go into space.
2. The common name of Alpha Herculis.
3. A large emission nebula in Monoceros, composed of NGC2237, 2238 and 2239.
4. The term used to describe Solar System bodies that orbit in the 'wrong' direction.
5. An amateur astronomer who built the world's biggest telescope in 1845.
6. 'The Father of Modern Astrophysics'.
7. The layer of loose pulverised material that covers the surface of the Moon.
8. The Hubble Space Telescope uses this type of optics, a variation on the Cassegrain design.
9. A 17th-century astronomer who established the naming conventions for lunar features, which we are stuck with to this day.
10. The closest distance at which a satellite can orbit a planet, without being torn apart by tidal forces.

Answers to John Crowther's picture quiz

From top left, clockwise:

Isaac Newton (1642–1727)

Galileo Galilei (1564–1642)

Marie Curie (1867–1934)

Nicolaus Copernicus (1473–1543)

Albert Einstein (1879–1955)

Charles Darwin (1809–1882)