



WAS NEWS

Monthly Newsletter of the Worthing Astronomical Society

www.was.org.uk



Number 191

ALMANAC

All times U.T.

November 2005

November / December

LUNAR

November	Date	Time	Rise	Set
New moon	2 nd	01.25	07.33	16.18
First Quarter	9 th	01.57	14.10	23.33
Full Moon	16 th	00.58	15.52	08.08
Last Quarter	23 rd	22.11	22.56	13.17
December				
New moon	1 st	15.01	07.59	15.10
First Quarter	8 th	09.36	12.45	** **
Full Moon	15 th	16.16	15.01	08.25
Last Quarter	23 rd	19.36	** **	11.54
New moon	31 st	03.12	09.11	15.51

EARTH

November	Sunrise	Sunset
2 nd	06.56	16.31
9 th	07.08	16.20
16 th	07.20	16.10
23 rd	07.32	16.01
December		
1 st	07.44	15.55
8 th	07.53	15.52
15 th	08.00	15.51
23 rd	08.05	15.54
31 st	08.06	16.01

PLANETS (As at November 23rd)

Planet	Constellation	Rises	Sets	Mag.
Mercury	Scorpius	07.48	16.14	-0.5
Unfavourable				
Venus	Sagittarius	11.26	18.45	-4.6
Evening object in the west				
Mars	Aries	14.59	05.45	-1.9
Visible most of night				
Jupiter	Virgo	05.09	15.08	-1.7
Morning object				
Saturn	Cancer	21.08	12.25	+0.2
Evening object				
Uranus	Aquarius	13.12	23.41	+5.8
Evening object in the south west				
Neptune	Capricornus	12.23	21.39	+7.9
Evening object in the southwest				
Pluto	Serpens cauda	08.42	18.06	+14.0
Unfavourable				

PHENOMENA

Day	Hour	Phenomenon
November		
7 th	8	Mars at opposition
14 th	6	Mercury at stationary point
15 th	5	Mars 3° S. of moon
16 th	00	Uranus at stationary point
22 nd	05	Saturn 3° N. of moon
22 nd	09	Saturn at stationary point
24 th	16	Mercury in inferior conjunction
29 th	06	Jupiter 3° N. of moon
30 th	15	Mercury 6° N. of moon
December		
4 th	02	Mercury at stationary point
4 th	19	Venus 2° N. of moon
9 th	13	Venus at greatest brilliancy
10 th	04	Mars at stationary point
12 th	05	Mars 1° S. of moon
12 th	13	Mercury at greatest elongation (W. 21°)
16 th	04	Pluto in conjunction

Minima of Algol

November	24 th	04.30	27 th	01.18	29 th	22.06		
December	2 nd	19.00	14 th	06.12	17 th	03.00	19 th	23.54

Lunar Occultation's Times as at Old W.A.S. Observatory

Date	U.T.	S.A.O. No	Mag	Phase
Nov				
10 th	h. m. s.			
10 th	17.46.55	165346	8.5	Diss
10 th	20.14.56	165396	8.9	Diss
10 th	20.29.13	165395	8.5	Diss
10 th	23.04.32	146446	7.8	Diss
11 th	19.53.05	146906	8.5	Diss
11 th	20.39.15	146910	8.5	Diss
11 th	20.15.17	146924	9.0	Diss
12 th	20.14.26	109323	8.3	Diss
12 th	20.18.49	109315	6.6	Diss
12 th	21.02.44	109348	7.4	Diss
12 th	22.05.49	109355	7.3	Diss
12 th	22.33.22	109370	8.3	Diss
12 th	23.26.17	109396	8.4	Diss
12 th	23.58.00	109392	7.9	Diss
17 th	20.08.30	76945	7.6	Reapp
18 th	19.30.10	77837	6.1	Reapp
19 th	03.19.23	78154	8.4	Reapp
19 th	04.29.31	78191	7.6	Reapp
19 th	21.06.49	78968	7.2	Reapp
20 th	01.40.01	79127	8.6	Reapp
20 th	03.31.29	79710	6.4	Reapp
20 th	23.43.00	79855	8.1	Reapp
20 th	23.45.43	79861	5.9	Reapp
21 st	00.30.59	79869	6.2	Reapp
Dec				
5 th	17.26.34	189703	7.9	Diss
6 th	18.09.11	164641	8.6	Diss
6 th	18.39.13	164657	7.5	Diss
6 th	18.40.58	164637	7.5	Diss
7 th	17.17.29	165218	7.8	Diss
7 th	17.37.57	165220	8.7	Diss
7 th	18.31.01	165233	6.8	Diss
7 th	21.40.32	165285	6.7	Diss
9 th	16.41.11	109135	7.9	Diss
9 th	18.21.43	109160	9.0	Diss
9 th	18.33.18	109156	9.1	Diss
9 th	20.05.15	109178	8.8	Diss
9 th	20.16.15	109182	7.8	Diss
9 th	21.20.46	109192	5.8	Diss
9 th	21.32.04	109200	8.4	Diss
9 th	22.34.33	109222	8.9	Diss
10 th	18.11.18	109713	8.6	Diss
10 th	19.02.48	109719	8.7	Diss
10 th	21.19.56	109759	8.6	Diss
10 th	22.27.19	109777	8.9	Diss
10 th	23.09.49	109784	8.9	Diss
10 th	23.20.55	109789	8.2	Diss
11 th	18.10.49	92748	8.3	Diss
11 th	20.28.50	92777	8.7	Diss
11 th	21.54.24	92786	8.8	Diss
11 th	22.17.39	92797	7.9	Diss
11 th	22.27.09	92800	8.7	Diss
11 th	22.30.46	92799	8.8	Diss
12 th	22.55.39	93221	7.6	Diss
13 th	19.15.59	76215	5.5	Diss
18 th	20.21.44	80196	7.7	Reapp
18 th	20.22.25	80195	7.9	Reapp
19 th	22.52.16	98518	9.0	Reapp

Editors Note

I find it rather ironic that here I am editing a Newsletter about, amongst other things – rockets and yet they're the very things that are keeping seven month old assistant Was News Editor awake!!

Is there a Bonfire night equivalent of 'Humbug'?

Don't be such a grump instructs Mrs Was News Editor passing me a sparkler, have a jacket spud.....

With that thought in mind, I bid you all enjoy this month's edition!

Rob

Dates for your Diary

New Year Social

Graham Boots

Our New Year Social will be held on Wednesday the 11th January 2006.

Please let me know if you are able to organize any games or puzzles; or any other kind of contribution. I feel in recent years our New Year social has been well attended and more enjoyable so lets see if we can build on past achievements. We could do with some new ideas too.

If you can help I look forward to hearing from you.
(01903 505346)

Reports

WAS 40th Anniversary Event?

Jan Young, Linda Storey, Nick Quinn,
Wendy Dunkerley

On Saturday 22nd October 2005, thirty one members and guests of WAS attended a special show at the South Downs Planetarium to celebrate the 40th anniversary of the founding of the society. Dr John Mason gave a talk/show on events that were taking place in 1965 including a view of the night sky, as it was that night.

After the show members gathered in the Waterside pub to chat and partake in the liquid refreshments served there.

A very enjoyable evening and thanks to everyone who came along.

Observing Report.

Alex Vincent

Since the observatory closed on October 29 2004, I ran the observers nights at our Hill Barn observing site every clear Friday during the session November 2004 to April 2005. Unfortunately these were poorly attended with only a few members coming along.

Objects observed were the Moon, Jupiter, Saturn, Venus and several deep sky objects like M31, Orion Nebula, Pleiades, Beehive cluster etc. On November 19 there was a Leonid watch where a few meteors were seen.

The Geminid watch on December 13 was clouded out. Also observed in early 2005 was the naked eye Comet Machholz.

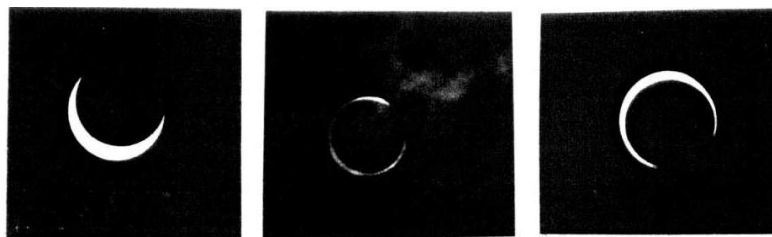
My last observer's night was a Perseid watch on August 12 at our Ferring Beach observing site. This was also poorly attended with only four attending. We saw a total of 18 meteors of which 11 were Perseids.

I undertook photography at most of these nights including the comet. The eclipsing binary star "Algol" the last object I photographed (at minimum) at the old observatory and also the last on my observers nights.

Annular Solar Eclipse.

Alex Vincent

On October 3 2005 there was an annular eclipse of the Sun visible across Spain and Africa. This eclipse was 65% partial from Worthing, where it was clear. Some WAS members went to Spain to see the annular phase and they were blessed with a very clear sky throughout.



Annular Solar Eclipse 03.10.2005 – Alex Vincent

I went to the Spanish Island of Ibiza to see the eclipse. I arrived the morning before and the sky was overcast, but cleared later to see the sunset. On the day of the eclipse, it was clear in places with large clouds about.

I first saw the partial phase about ten minutes after first contact. Cloud came and went during the whole eclipse,

and there was a nice clear patch only a few minutes before annularity.

A dark cloud covered the Sun during most of the annular phase, but I managed to get the first 20 seconds of it, before it became obscure. By the time the Sun came out of the cloud a few minutes later, annularity had just ended.

The rest of the eclipse was seen now and again in clear patches. Despite the cloud, it was worth the visit. I stayed in San Antonio, which has a medieval church.

Solar Section Report - October 2005

Section director, Brian Halls

Sunspot activity – and indeed, solar activity in general remained quiet this month.

The large naked eye sunspot group that had traversed the solar disk over the last several months failed to reappear, having decayed while on the far side of the Sun.

Sunspot activity was confined to small sunspot groups – indeed on several days, some of these groups were so small, they were beyond the resolving power of my telescope and the days were recorded as blank!

A number of days were truly spotless.

Observations were reported on 25 days by Graham Boots (25) and the Director (9).

MDF = 0.48 (R = 6)

All solar drawings and photographs being produced are automatically saved to computer, and I am in the process of digitising the solar section archive (something to do during the dark, cloudy winter days ahead)! Eventually, a CD copy of the 40 years worth of solar section observations will be available to any member who wants a copy.

Vice-Chairman's Report - 2004-2005

Jan Young

My year as VC has certainly gone very quickly. The main project has of course been the move of the observatory to Windlesham House and I would like to thank Graham and the telescope committee for including me in their activities for me to photograph and create a record of the event. I have also had the good fortune to be part of the WAS 40th Anniversary committee.

The most enjoyable part of being Vice Chairman, however, has been meeting and getting to know more of our members, something I hope to do more in the future.

I end this short report by thanking our retiring Chairman, Glenn for all his hard work over the last two years.

Mars

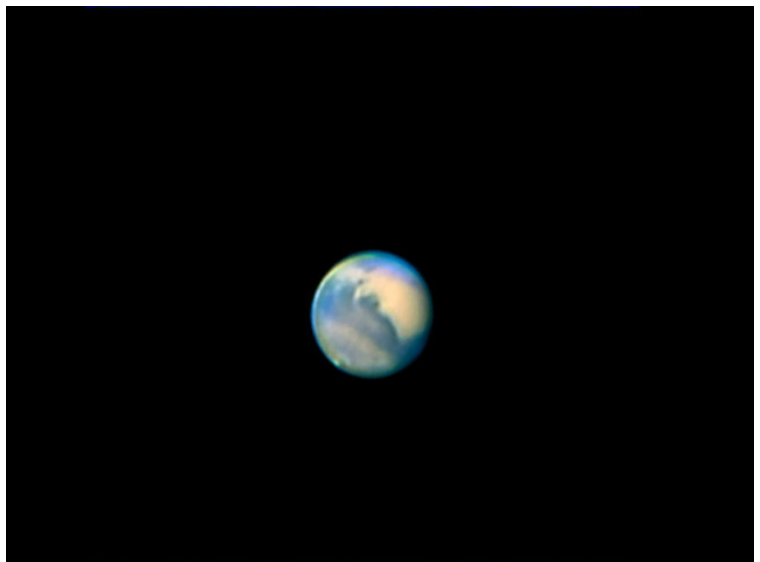
Ed Sampson

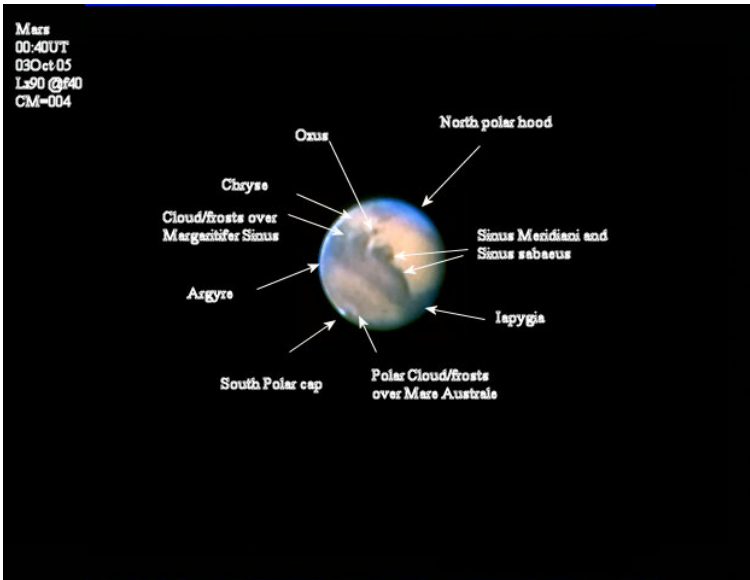
Here are my latest mars shots. Two are f40 and one is f30.

The f40 ones include indents and were taken with IR block and orange filters.

The f30 one is the sum of standard unfiltered, IR block and orange. I have included the f30 for consistency with my last shot.

All taken on the 15th October 2005





October 2005 Meeting Report by Peter Atkinson

Superstring Theory

David Storey

This talk was sub-titled Everything you wanted to know?, and set out to cover ten main points:

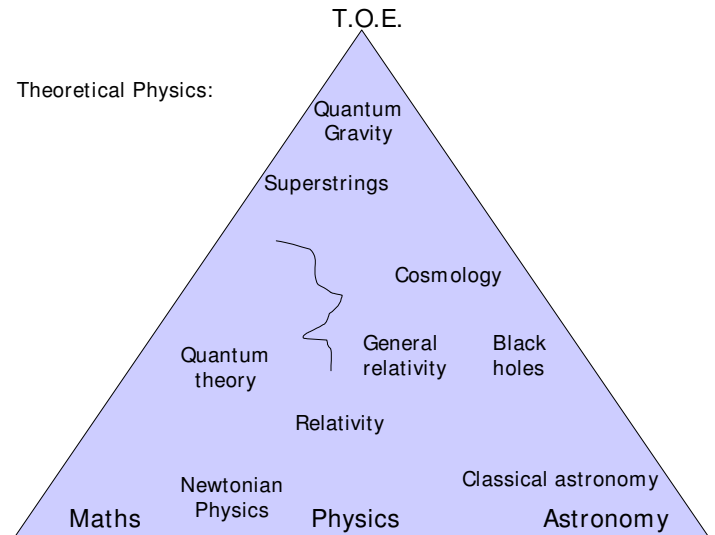
1. What's it about?
2. What's the underlying idea?
3. Where did it come from?
4. What problems is it trying to solve?
5. What's so 'super' about superstrings?
6. Do we really live in 10 dimensions?!
7. Who's famous in string theory?
8. What's the experimental evidence?
9. What are 'cosmic strings'?
10. How seriously should it all be taken?

1. What's it about?

It's an idea in theoretical physics for which great claims have been made such as

i) "Part of twenty-first century physics that fell by chance into the twentieth century" – Witten/Amati ~1987... there are no alternatives ... all good ideas are part of string theory" – Polchinski 1999

It has been developed as part of the search for the elusive TOE (Theory of Everything) which aims to consolidate the various theories relating to parts of theoretical physics into one which would cover quantum gravity at the top of this pyramid:



2. What's the underlying idea?

That the fundamental objects in nature are 'strings' (closed loops in most theories), and that elementary particles correspond to vibrations of these strings. A music analogy was drawn here:

String	String of an instrument
Particles	Notes
Laws of Physics	Harmonies
Chemistry	Melodies
Universe	Symphony

3. Where did String Theory come from?

It's recycled. Originally (in 1968) it was a theory of nuclear particles dealing with a string size around 10-15M. It was fraught with problems: 26 dimensions, tachyons (faster than light particles!) and a mysterious spin 2 particle. Eventually it died away. In 1984, however, it was resurrected by Michael Green and John Schwarz with new features. The string length was down to 10-35M and the spin 2 particle was identified as the graviton.

4. What problems is it trying to solve?

- If it's a T.O.E then everything! But specifically ∞ - solutions tended towards infinity.

Treating electrons, photons etc properly ∞ Quantum Electrodynamics (QED)

- we still get ∞
- Sweep it under the carpet using 'renormalisation': $\infty - \infty = \text{finite} (!)$
- Then we get results accurate to 1 part in a million-million!
- QED is 'renormalisable' but Quantum Gravity is NOT.

Strings to the rescue:

- On a string, the infinity gets ‘spread out’ and becomes harmless
- “String theory is not just renormalisable, but finite”
(But they haven’t quite fully proved this claim yet)

5. What’s so super about Superstrings?

- They incorporate ‘supersymmetry’
- ‘Ordinary’ symmetry has been a guiding light in particle physics for many years – supersymmetry extends this much further

Symmetry in Physics

- Proton mass $\sim 1836 \times$ electron mass
- Neutron mass $\sim 1839 \times$ electron mass

This is called ‘isospin’ symmetry. But it’s not exact – the symmetry must be broken somehow

Symmetry breaking

EITHER

The laws of physics are only approximately symmetric
OR

The laws are perfectly symmetric but the consequences are not. How can this ‘spontaneous symmetry breaking’ (SSB) happen?

At this point a graphic illustration was given involving calculations to connect various points in the shortest possible way and the solutions are not perfectly symmetrical in all directions.

In particle physics, SSB can be achieved with a new kind of quantum field, with particles called ‘Higgs bosons’ (after Peter Higgs).

This mechanism was crucial in the unification of the electromagnetic and weak nuclear forces.

Experimental evidence for Higgs particles –

- Indirect evidence - everything else in electro-weak unification seems to work
- The first Higgs particles might be produced by the ‘Large Hadron Collider’ at CERN in 2007

Supersymmetry

- Ordinary symmetry (e.g. isospin) involves particles of the same spin.
- Supersymmetry relates particles of different spins: bosons (whole number spin) and fermions (half number spin)

Benefits of Supersymmetry

- A better bet for a T.O.E.
- Helps with the infinity problem
- In string theory, reduces 26 dimensions to 10 dimensions
- Removes the tachyons

Experimental evidence for supersymmetry

- None
- What would we be looking for?

New partners for bosons - name ends with “ino”

Photon (spin 1) \ll Photino (spin 1/2)

Graviton (spin 2) \ll Gravitino (spin 3/2)

Z (spin 1) \ll Zino (spin 1/2)

W (spin 1) \ll Wino (spin 1/2)

New partners for fermions - name prefixed with “s”

Electron \ll Selectron

Neutrino \ll Sneutrino

Quark \ll Squark

Lepton \ll Slepton

Maybe they are too heavy, in which case what use are heavy particles which we can’t detect?

Could be DARK MATTER

6. Do we really live in 10 dimensions?

- 6 dimensions can curl up in a lot of different ways
- Calabi-Yau spaces
- Strings can wrap around this 6-dimensional space in a lot of ways

• Pick the right 6-dimensional space to get the get the types of particle we actually see...

• the trouble is, it’s too easy!

7. Who’s famous in String Theory? Chiefly Ed Witten, the developer of M-theory proposing 11 dimensional supergravity

8. What’s the experimental evidence for superstrings?

- None

But The Large Hadron Collider (LHC) may help

- Protons accelerated to 14 TeV (14000 mp)
- Running in 2007

What will the LHC see? (guestimates of the probabilities)

- Higgs particles: 80%
- Supersymmetric particles: 10%
- Evidence for string theory: 1%
- Mini black holes: 0.1%

9. What are Cosmic Strings?

1. “Topological defects formed at phase transitions in the very early universe” (A consequence of spontaneous symmetry breaking.)

2. The expansion of a superstring to cosmic proportions during inflation. Might have observable consequences especially for gravitational waves?

10. How seriously should we take superstring theory? Will it become the Theory Of Everything?

David’s conclusion..... Your guess is as good as mine.

WAS Yahoo Email Discussion Group

Janet Young

WAS now has its own email discussion group on Yahoo. This is to enable members to be able to receive notices, help and have discussions between meetings. To join simply put the address given below into an email and wait to be signed up.

worthingAS@yahogroups.com

Articles

Planetary Magnetism

Michael A Marshall

In the October article Black Holes Re—visited was glibly explained that a rotating accretion disc of plasma endowed the hole with a magnetic field and auroral jets. Whilst a little more explanation needs to be given, a connection can be made with the magnetic fields of planets such as solid Earth and gaseous Jupiter. I have never come across a positive explanation of planetary magnetism, but I have read about transistors, and from that subject arises a further explanation.

With regard to the accretion disc about a black hole, it might be thought that the electrons and oppositely charged atoms (ions) generally rotate equally so that the magnetic field generated by the electrons is cancelled out by the opposing magnetic field generated by the ions. All being equal such would be the case, but all is not equal.

Tons are some multiples of approximately 2000 times heavier than electrons. In collisions, ions are that many times more sluggish than electrons to rebound in collisions, which means that whilst ions continue to follow the general rotation the electrons by their greater mobility are helplessly scattered in all directions as to contribute much less against the opposing magnetic field; the ions according to this argument are responsible for the net magnetic field, and they create the field because they carry electric charges in an elliptical path, which in turn implies an acceleration (centripetal) of the charges and hence the obligatory accompanying magnetic field.

Where do transistors come into the explanation? They have electric charge carriers, electrons and holes. Holes are atoms that have a vacant electron or two. Vacancies can move around like hotel vacancies, and they do so as if they were real positive charges. In transistor theory holes have a mobility, but not as great as that of free electrons, whilst the ions (atoms with electron vacancies) form part of the general transistor structure and so are fixated. In short, differing mobility enables a net unopposed current

to flow (when an electric potential is applied), and that difference surely is the explanation for the generation of a net magnetism about a black hole having an accretion disc of plasma.

The magnetic field is not a wave motion with a velocity of light and an attraction to gravity, but a relatively static stress that surely is unaffected by the gravity of the black hole. So a contribution to the hole's magnetism is made within the hole, at least before the ions are crushed out of existence. What is the difference in the mobility of electrons and quarks, considering that it takes three quarks to carry an equal but opposite electrical charge to the charge of one electron?

Concerning the Earth, the molten iron core has rotations that must differ with latitude in the same way as the cloud belts of Jupiter have rotations that differ with latitude and so with orbital diameter. Further complications must arise from varying mantle depths, plate movements, general inconsistencies and thermal currents. Here, the free electrons (as metals have) are more scattered by thermal agitation than are the atoms of ponderous molten iron, and so again a net magnetic field is generated by the iron. As the rotation of the core is not in exact step with the rotation of the Earth, a number of discrete fields may well be generated, and these add up to net fields that have varied over the ages, varied in direction and intensity, even to zero intensity when the destructive solar wind strikes the ground untrapped.

Jupiter does not have a molten iron core of any significance, but it does have a large fluid metallic inner body to create the truly intense magnetic field that is discovered to be there. Hydrogen becomes both metallic and fluid with loosely held electrons under the enormous pressures and temperatures that exist at certain levels within the planet. It would seem that internal motions are more regular in Jupiter than in Earth to generate a more regular field, there being no crust, but as we know there are thermal currents as those causing the great red spot and lesser white spots.

An interesting point about Jupiter's magnetic field, apart from its magnitude and the intense auroras, is its interaction with the trail left by the inner moon Europa with its sulphurous volcanoes. Gravity there is light and sulphur ions and electrons escape to form a conductive ring about the planet and within the magnetic field. It only takes a transverse movement between conductor and field to generate an intense electric current, and this in turn must generate an opposing magnetic field, such one as would try to maintain the status quo. Predominantly it may be that the ring expands continually in diameter to create the necessary movement, or that the magnetic field varies in intensity due to slightly irregular motions. On the scale of Jupiter it must take little change to create huge effects.

Messier Objects - Continued

Janet Young

The Messier Objects are so called because they were a list of fuzzy objects in the night sky compiled by Charles Messier (1730-1817) a French comet hunter. While hunting for comets he kept finding these faint and fuzzy objects, so decided to compile a catalogue of them to avoid them being mistaken for comets. He listed them as M or Messier followed by a number. Charles Messier did discover several comets, but it is for the Messier catalogue he is best remembered.

M25

Constellation: Sagittarius
RA 18hrs 28m
Dec -19.17
Distance: 2,000 light years
Type: Galactic Cluster
NGC -----

Discovered by P.L. de Cheseaux in 1746 this is a small galactic cluster which is a super sight in small telescopes.

M26

Constellation: Scutum
RA 18hrs 42m
Dec -9.27
Distance: 5,000 light years
Type: Galactic Cluster
NGC 6694

Large, rich and compressed cluster close to the Scutum Star Cloud.

M27

Constellation: Vulpecula
RA 19h 57m
Dec 22.35
Distance: 1,250 light years
Type: Planetary Nebula
NGC 6953

Magnitude of eighth magnitude and a popular object for small telescopes, is better known as the Dumbbell Nebula. Discovered by Charles Messier in 1764

M28

Constellation: Sagittarius
RA 18h 21m
Dec -24.54
Distance: 15,000 light years
Type: Globular Cluster
NGC 6626

Discovered by Messier in 1764, it was William Herschel who revealed that this was actually a form of star cluster. Magnitude of 7 it is rich in variable stars.

Was Link

www.satmann.demon.co.uk/docs/drake.htm

www.satmann.demon.co.uk/docs/universe.htm

www.satmann.demon.co.uk/docs/milkyway.htm

www.satmann.demon.co.uk/docs/eclipse.htm

WAS Ad

Telescope for Sale

Colin Wooldridge



- It is a 200mm Orion optics (UK) Newtonian reflector F4.4.
- Heavy duty field tripod with a built-in polar alignment scope.
- Telrad red dot finder. A new unfitted dew shield for the Telrad.
- 5x30 finder
- It is driven in both axes and comes with a speed controller
- It has a large 12V 15A battery to power the scope, and also comes with a smaller battery pack for travelling use.
- Four eyepieces:- 10mm, 25mm, 40mm and a fantastic 17mm Celestron Plossl eyepiece. I can pick out Orion's nebula filaments with this piece.
- 2x Barlow.

- A SLR manual camera complete with a camera adaptor to fit in the eyepiece tube, complete with a remote shutter release.
- A set of four filters, green, blue, orange, neutral density.
- Other extras included?

This is a fantastic scope with very high quality optics and has had very little use. I am only selling due to it getting no use after setting up my own business.

I may consider a P/X for a pair of large binoculars eg:- 20x100 etc

Please contact Colin on 01243 551208 or email him at: colin@cwooldridge.wanadoo.co.uk

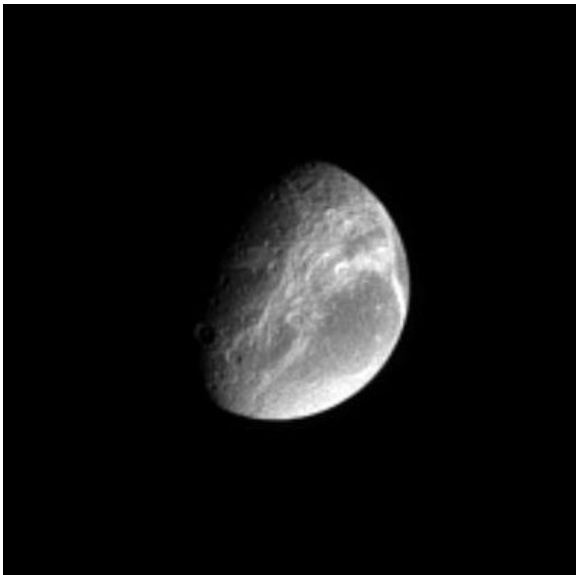
Sussex Astronomy Centre

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 Telephone 01903-247317
 Email worthingastronomy@tiscali.co.uk
 Web Site. www.sussex-astronomy-centre.co.uk
 Ask for Paul Farmer (Club Member)

WAS News News

Dione's canyonlands

Cassini Photo Release



Credit: NASA/JPL/Space Science Institute

The Cassini spacecraft views the far-off wispy canyons of Saturn's moon Dione and sees an interesting dichotomy

between the bright wisps and the bright south polar region at the bottom.

The view looks toward the trailing hemisphere on Dione. North is up. Dione's diameter is 1,126 kilometres (700 miles).

The image was taken with the Cassini spacecraft's narrow-angle camera on Sept. 20, 2005, through a filter combination sensitive to polarized green light. The image was acquired at a distance of approximately 2.1 million kilometres (1.3 million miles) from Dione and at a Sun-Dione-spacecraft, or phase, angle of 64 degrees. Resolution in the original image was 12 kilometers (8 miles) per pixel. The image has been magnified by a factor of two to aid visibility.

The Cassini-Huygens mission is a cooperative project of NASA, the European Space Agency and the Italian Space Agency. The Jet Propulsion Laboratory, a division of the California Institute of Technology in Pasadena, manages the mission for NASA's Science Mission Directorate, Washington, D.C. The Cassini orbiter and its two onboard cameras were designed, developed and assembled at JPL. The imaging operations centre is based at the Space Science Institute in Boulder, Colo.

What's on the Box

Tuesday 15th November 2005



22.00 – 22.30 **Supernova**

Comedy series about a disillusioned astronomer who is swept from his boring life in London to the Royal Australian Observatory in the middle of the Outback.

Saturday 12th November 2005



12.50 – 13.10 **The Sky at Night**

Mars and the Ring of Fire. Patrick Moore takes a detailed look at Mars during a time when it is closer to the Earth than it has been for years.



19.15 – 20.15 **Alien Worlds**

The year is 2020 and the first habitable planets outside our solar system have been discovered. Teeming with life they are eerily familiar, but truly alien. Fantasy? Think again; experts believe that worlds like these - which could support life - could be discovered in the next decade. In a unique

