TRANSIT

The Newsletter of

Cleveland & Darlington Astronomical Society

12th November, 2004. Julian Day 2453322

The galaxy to name this month, together with the Messier number, NGC number and the constellation it is in. This is the "false colour" version of the image, as available from the Hubble Space Telescope website. There is a more usual black-and-white version on the back page. It is one of those galaxies studied by Lord Rosse with the Leviathan.

Editorial

October meeting. On October 8th, the quiz night for the Thomas Wright Trophy was held at Thorpe Thewles. Two teams battled for the trophy, which was won on a tie-breaker question, by Durham AS. Congratulations to them.

November meeting. On Friday, November 12th, the meeting will be addressed by Dr. Mike Lancaster, of Derby AS, on "Magellan at Venus".

Yorkshire Astromind 2004. Neil Haggath was the question master again this year and Darran Summerfield represented CaDAS. Read Neil's report later for the result.

Front and Back Page Pictures. Last month's galaxy was the Sombrero (type Sb), M104, NGC4594 in the constellation of Virgo. You may win a quiz with this knowledge! This month gives you another well known galaxy to recognise.

Cassini and Huygens. A heartening piece of good news from the probe – first big crisis over. Cassini went into orbit around Saturn as planned after a long and complex journey to the planet. We await another crisis point, as Huygens is released and descends to the surface of Titan after Christmas.

Light Pollution Issues. Did you see that Phillips, in conjunction with the BAA Campaign for Dark Skies, has published a map showing the darkness of the skies in the UK? The map of the UK has colour-coded areas showing the apparent magnitude of the faintest star which can be seen with the naked eye. The scale, in nine bands, goes from mag 3.75 to mag 6.0 for the best areas. A possible Christmas present suggestion?

Mars Rovers and Surveyor. More good news on the space exploration front – the Mars rovers, Spirit and Opportunity, are expected to celebrate their first anniversary on Mars, in January 2005, by continuing to function and send back exciting new pictures and data. This is about twice the expected lifetime for the rovers. The Mars Odyssey orbiter continues to send images of the surface, which are being co-ordinated with rover images.

Comet Machholtz. The comet will appear above the horizon in early December, in Eridanus, just below Orion and Lepus. It will be difficult to spot so low down and at magnitude 6 but there will be plenty of CaDAS eyes looking in that direction at the first opportunity. Please send in your reports.

NASA Shuttle. The date of the next launch of Discovery continues to go back. Earliest launch date is now May 14th, 2005.

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Yorkshire Astromind 2004

by Neil Haggath

This year's Yorkshire Astromind contest was held on 9 October. It was jointly hosted by Hull and East Riding A.S. and Blackburn Leisure A.S., at the meeting place of the latter society in Brough, East Yorkshire. The question master, for the second time, was Yours Truly.

This time, we had a new contestant upholding the honour of CaDAS – Darran Summerfield, who had been a member of our Thomas Wright Trophy team the previous evening (I had to be very careful not to duplicate any questions between the two!), and was making his first appearance in Astromind.

In a closely fought contest between six contestants, Darran finished a respectable fourth; there was only a margin of seven points between the first four. The defending

champion, Marcus Armitage of Huddersfield A.S., came in third, with Darran only a single point behind him.

The winner was Joe Jones of Mexborough and Swinton A.S. Joe is a veteran of several Astrominds, but this was his first win.

I have been invited to chair the contest again next year, and Darran has already said that he wants to compete again.

(*Neil also sent a picture of Darran "in the hot seat", which I will include in next month's edition. Ed.)*

Winter Astronomy Events With Yorkshire Museum

Below are details of the Winter Astronomy programme being run at Yorkshire Museum & Gardens, Museum Gardens, York.

Martin Lunn MBE, FRAS
Evening Lecture: The Fathers of Variable Star Astronomy.
Tuesday 16 November, 7:30pm
John Goodricke and Edward Pigott made astronomical discoveries throughout the 1780s that briefly made York one of the astronomical centers of the world.
Tempest Anderson Hall, admission: £2 (payable on the door)

Observatory Open Evening: Moon Watching
Saturday 20 November, 6-8pm
Visit the York observatory and using the Cooke 4 ½ inch, 1850 telescope enjoy some spectacular views of our nearest neighbour in space.
York Observatory, Museum Gardens: Free admission.

Evening Lecture: The Star of Bethlehem
Tuesday 21 December, 7:30pm
Scholars debate whether the Star of Bethlehem is a legend manufactured by the early church, or a miracle which marked the advent of Christ. But if the star was a real astronomical event, what could it have been?
Tempest Anderson Hall, admission: £2 (payable on the door)

Evening Lecture: The Winter Sky
Tuesday 4 January, 7:30pm
Discover how to navigate your way around the night sky by identifying the brightest stars.
Tempest Anderson Hall, admission: £2 (payable on the door)

Observatory Open Evenings
Mondays 10, 17, 24, 31 January, 6-8pm
York Observatory, Museum Gardens: Free admission.

Evening Lecture: Cassini Mission
Saturday 8 January, 7:30pm
Launched from the Kennedy Space Centre on 15 October 1997, the Cassini spacecraft reached Saturn in July 2004. Cassini will spend 4 years studying the planet. On 25 December 2004 Cassini will eject a probe called Huygens that will land on Saturn's largest moon Titan on 14 January 2005, and hopefully tell us what conditions on the moon are like.
Tempest Anderson Hall, admission: £2 (payable on the door)

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Forthcoming Astronomy Weekend at Burton Manor College, Burton, Nr. Chester 3-5 December 2004

sent by Clive Sutton

The speakers this year will be **Ian Morrison** & **Dr Tim O'Brien**, from **Jodrell Bank,** & the course is entitled **"Astronomy - Our Place in Time & Space"**.

The atmosphere is very relaxed and the courses have always proved most enjoyable. They are also good value for money – as well as the talks, the price (resident) includes full board, all meals from Friday dinner to Sunday lunch (non-resident excludes breakfast), with bar facilities also being available.
This year, in addition to the are 6 talks at Burton Manor itself, there is also a **visit to Jodrell Bank radio telescope** on the Saturday afternoon, with a "behind the scenes" tour & lectures. The course programme is as follows:-

Friday
· Introductory Lecture "What makes up our Universe" - galaxy clusters, galaxies, stars, solar systems, gas and dust.
Saturday
· The size and age of the universe - How Edwin Hubble was able to estimate the size of the Universe, show that it was expanding and hence estimate its age. Models of the Universe: Big Bang versus Steady State.
· Proof of the Big Bang Models and a discussion of the evolution of the universe. How the elements Hydrogen and Helium were created in the Big Bang. How Stars have built up heavier elements within them

· Afternoon visit to Jodrell Bank - tours and lectures about how we observe the Universe at radio wavelengths. The observations of the Cosmic Microwave Background and the future of the Universe
· Exploding stars - one result of which is that the space between the stars is enriched with heavy elements in the form of Dust.

Sunday

· Solar systems - our own and others. How conditions for life can arise. The search for life elsewhere.
· Question and Answer session.
· Course disperses after Lunch

Weather permitting, evening observing also takes place – a number of course participants normally bring along their telescopes. I would add that I am a member of the Chester & Altrincham Astronomical Societies & have no personal involvement with the College, but wish to publicise the courses more widely than the College generally does.

Cost: £155 residential (full board); £111 non-residential (incl. lunches + dinners); For further details and/or to book, contact: Burton Manor College, Burton, Neston, Cheshire, CH64 5SJ 0151 336 5172 or enquiry@burtonmanor.com

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The CaDAS Interview – Viv Blundell

The Interview tries to be balanced in its choice of candidates. Such as the right proportion of ladies to gentlemen, new members and long-time members, professionals and amateurs, keen observers and armchair enthusiasts, well known members and the more private. There are many keen lady members, some of whom have been in the Society for almost as long as it has existed, and it was time to ask just such a member to be interviewed. It has to be said that for some the prospect of being interviewed is a daunting prospect. When I approached Viv Blundell, she seemed reluctant but agreed. She came over to Darlington and we chatted in relaxing surroundings. I hope the experience was a pleasant one.

Do you mind me using this recorder? It helps to remind me of the things we talk about.
I'll try to ignore it. It seems a bit formal.

Think of this as just a conversation.
I'm not used to talking about myself. I'd like to buy one of those little machines to record some conversations with my mother about her life and the family. If you can get someone to talk about all the things which happened to them and to yourself years ago, it's fascinating, I find.

On the phone, you said you moved to the area about 20 years ago, implying that you were not brought up in the North East.
I was brought up in Manchester; my mother still lives there in the same house. School was in Manchester. It was a girls' school but I have brothers, so there was plenty of

mixed social life outside school. I have a sister and a brother older than me and a brother younger than me.

You went to University after schooling in Manchester?
My first degree was in Physics at Bristol. That was very enjoyable. After the grime of Manchester, it was wonderful to discover such a clean city. I met my husband David, who was doing research in polymer physics, at Bristol. We were married in Manchester, from my home. He took a job with ICI and we moved to Merseyside.

Did you enjoy that?
Oh, yes. I'd done a Diploma in Medical Physics at Bristol and got a job in the Department of Nuclear Medicine in Liverpool. We used radioisotopes in the diagnosis of various medical conditions. David & I lived in Runcorn and I travelled to Liverpool each day. Liverpool was a great place to be – I preferred Liverpool to Manchester but feel a bit guilty about being a disloyal Mancunian.

What about your own family?
Our first son, Richard was born in Runcorn and I gave up work to concentrate on being a mother – the most important job in the world in my opinion. Then we moved to Welwyn Garden City, David moving job with ICI, which was a very pleasant place to live. Our second son, Michael, was born there. We lived there for 10 years. Then we moved to the North East, 21 years ago.

You must have joined CaDAS almost immediately.
Yes, I went to the library to enquire about a society. The meetings were in the Scientific Institute in Middlesbrough in those days but it has moved around quite a lot since then. John McCue and John Nicoll ran it all then. John McCue has done such a lot for amateur astronomy in this area. Jack Youdale was also very much involved. Did Jack persuade you to grind your own mirror? No, it's not really my thing. I wouldn't have the patience. I remember the merger with the Darlington Society.

Had you been an astronomer before, then?
Well, I wouldn't call myself an astronomer. I'd bought a 60mm refractor about 40 years ago and had always enjoyed looking at the sky and been interested in astronomy as a hobby. It goes back to being a Girl Guide and reading correspondence from Guides all over the world about the wonderful night skies in Hawaii & places like that. My parents encouraged us all to take an interest in outdoor activities generally. I don't use the telescope now except for projection of solar eclipses. I just go out & look at the sky with the naked eye or binoculars. I've always intended to go to the observatory at Thorpe Thewles more often but it hasn't worked out. There is so much on, it's difficult to just drop everything on a clear night. In Nunthorpe there was a lot of light pollution and trees, making it difficult to observe. Now we live in Stokesley we have a much more open aspect and I harbour a wish for a computer controlled telescope!

You hadn't been in an astronomy society before?
The only formal contact with astronomy was a course at Hatfield Polytechnic, when I lived down south. They must have been one of the first to have modular degree courses and allow people to just "dip in". I did a couple of modules in Stellar Astronomy and Astrophysics. We used the observatory there for some of the projects.

Do you have a favourite memory from astronomy?
My most amazing astronomical experience of recent years was the total solar eclipse of 1999. When I was about 14 and heard there was going to be a total eclipse visible in Cornwall I vowed that I would go and see it (thinking I'd be an old woman by then!). Well, we decided to go to the Scilly Isles, as we'd spent our honeymoon there 32 years previously, and thought it would be nice to return there even if the eclipse was clouded out. As it happened we had perfect views around totality. There was a spontaneous "WOW" from the crowd and I shall never forget the flash of the diamond ring. We were certainly some of the lucky ones that day.

Are you still interested in the outdoors generally?
Living in this part of the world makes it easy to get out walking, with the North Yorks Moors and the Yorkshire Dales so handy. Despite having a hip replacement a few years ago, I still enjoy walking. Botany is another absorbing interest. I have a botany class once a week and we have regular field trips. When we went to Ireland recently The Burren was very interesting for its special botany. Another memorable outing recently has been cycling the Coast to Coast.

You have moved around England a lot. Do you enjoy travelling?
Walking holidays have taken us around the world. One big expedition was to walk 9 miles and 5000 feet down into the Grand Canyon from the south rim, stay overnight at the bottom and walk 14 miles and 6000 feet up again the next day to the north rim. It has the reputation of being a serious walk but we found it wasn't too bad. Take it steady and it all happens. We started at first light and arrived at the bottom about 2.30pm in the heat of the day. It is amazing passing through geological time as you go farther & farther down. The rocks exposed at the bottom are 2 billion years old (an astronomical timescale!) It's surprisingly green – lots of vegetation and trees, not arid, as it looks on photographs. The rangers in the ranch at the bottom, by the raging torrent of the Colorado River, told us about the varied wild life and the geology. We have also been bush walking in Australia and done some famous walks in New Zealand – the Routeburn Track in the Southern Alps and the Tongariro crossing through the northern volcanic area. The latter is reputed to be one of the best one day walks on the planet. The Canadian Rockies are very spectacular, too.

Do you have a favourite place?
No. I enjoy all the places we visit. If I had to choose one place, it would be Australia and my favourite place there is Uluru where the aboriginal spirit is so tangible and the night skies in the outback are incredible.

Do you dance?
David and I are taking ballroom and sequence dancing lessons at the moment. I've always wanted to persuade David to go dancing. We've just moved to Stokesley. There's a dance in Stokesley Town Hall once a month, on a Friday night, and I'm looking forward to it becoming a regular relaxation.

And do you play a musical instrument?
I learned piano as a child but don't play now. We go to concerts quite frequently, at the Arts Centre in Darlington. Another interest is the theatre, particularly the Alan Ayckbourne Theatre in Scarborough, which we manage to visit frequently.

You are obviously maths and computer literate.
Yes, a physics degree gives one a lifetime interest in these things. In the '60s I was writing programs in Algol to computerise the planning of radiotherapy treatment (where to direct the beams and for how long etc). Now it's all extremely sophisticated. We must have had a computer of one sort or another in our house for about 20 years to use as a tool for David's work and for the occasional project I've been involved in and more recently of course for the internet.

What are you reading at the moment?
Pete McCarthy's "McCarthy's Bar". It's very funny and absolutely accurate about Ireland, we found. We went to Ireland recently to do same walking in Connemara, to see The Burren and to visit the Rosse Telescope (after your recommendation) The telescope and the museum in Birr Castle are well worth a visit. There was a big star party on there at the time and we met a lot of people from Macclesfield attending the event. I like to read anything by Paul Davies – the physicist who writes popular books on cosmology. He used to be professor at Newcastle and then went to Adelaide but I believe he's back in London now. His latest interest is to do with the spread of information. He believes an advanced civilisation would use DNA for propagating messages and that SETI should concentrate attention there instead of on radio waves. Any of his books are worth reading and very recommendable.

And what is your answer to my "enthusiasm" question – where does it come from?
I haven't asked myself the question, really. My answer is that it's inherent, in the genes. I think all children have a natural enthusiasm. If it is encouraged, they will never lose it. Unfortunately it can be squashed out of existence and is on many occasions.

At this point, as if on cue, my wife, Nita, came back from a trip, made us a cup of tea and we continued a conversation "off the record".

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Astronomy at Siding Spring

By Rob Sharp
2dF Fellow, Anglo-Australian Observatory

Caption left: In the foreground the 9-storey dome that houses the Anglo-Australian Telescope on Siding Spring Mountain. The dome of the 1.2m UKST in the background.
Caption right : The 3.9m Anglo-Australian Telescope.

A little about me

The Castle Eden Observatory was still under construction when I was sitting my A levels at Stockton Sixth Form, under the expert applied maths tutelage of the society's own John McCue. I then moved down to the Midlands, to the University of Leicester, where I got my undergraduate degree in Physics and Astrophysics. A series of lucky breaks in Leicester gave me the opportunity to take part in the Anglo-Australian Observatory summer student program, at the observatory out in Sydney, during the summer break between the third and final years of my degree. The three months I spent in Sydney, working on data from a tunable narrow band filter that was developed at the AAO, left me convinced that a Ph.D. in Astronomy should be my next move. Perhaps more importantly, the time in Sydney also left me with a rather strong Curriculum Vitae!

After a series of applications and interviews, I gained a place on the PhD program at the Institute of Astronomy at Cambridge University. Four years and 42,000 words later, the thesis was written and the PhD was awarded. I worked on a series of surveys for quasars at very high redshifts and lower luminosities than had been possible previously.
www.ing.iac.es/PR/newsletter/news4/science1.html).

During my PhD research, I spent rather a lot of time (about six months in total) at various telescopes on La Palma (www.ing.iac.es), in Chile (www.ociw.edu/lco) and Hawaii (www.cfht.hawaii.edu). Much of this observing was as support astronomer for an infrared camera built by the Cambridge Instrumentation Group. This support work left me perfectly placed to take on my first post-doctoral job as support astronomer for the Cambridge Infra Red Panoramic Survey Spectrograph (CIRPASS). The CIRPASS spectrograph, also designed and built by the Cambridge Instrumentation Group, is one of the first of a new generation of instruments, an integral field spectrograph. It uses an array of fibre optics to allow astronomers to observe the spectrum of a two dimensional patch of the sky. We now think of this as 3D astronomy, the third dimension being the wavelength dimension.

I worked with CIRPASS for two and a half years, working at the 8m Gemini South telescope in Chile (www.gemini.edu) and the 4.2m William Herschel Telescope on La Palma (www.ing.iac.es/Astronomy/telescopes/wht/index.html), but when life in the swampy marshland that is the fens around Cambridge for much of the year became too much for me, it was time to head south for the sun.

I'm currently the UK 2dF Fellow at the Anglo-Australian Observatory (www.aao.gov.au). The AAO is based in Sydney, Australia, and operates the 3.9m Anglo-Australian Telescope and the 1.2m UK Schmidt Telescope on Siding Spring Mountain, near the town of Coonabarabran on the edge of the Warrumbungle National Park, about 6 hours drive from Sydney (and yes, I have to drive out there about once a month; one never quite gets used to the scale of this country).

The history of the AAT is described in some detail on the internet at www.aao.gov.au/AAO/about/aathist.html. The AAT has always been an important research tool for UK astronomers. In the era of giant 8m and 10m telescopes, what the AAT lacks in mirror aperture, it makes up for in cutting edge instrumentation.

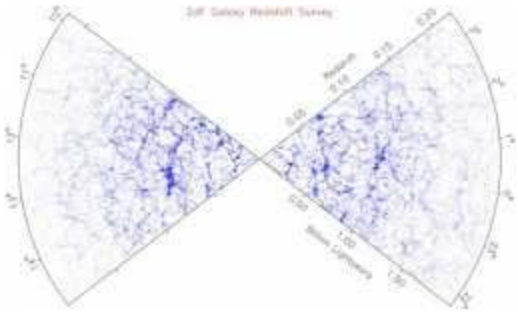
The Anglo-Australian Telescope

Perhaps the best way to describe the work of the observatory is to look at some of the instruments that operate on the telescope. The AAT currently has four facility instruments, with other visitor instruments often brought to the AAT for highly specialized observations.

1. The 2-degree Field spectrograph - 2dF

The 2-degree Field (2dF) is a revolutionary instrument, which allows astronomers to target up to 400 astronomical targets, distributed over a field of view of - you guessed it - two degrees in diameter, and record the spectrum of each object simultaneously. To do this, 2dF uses a robot to position fibre optics in the telescope focal plane, so that the light from each object can be captured. 2dF is a complicated system, and so my job as UK 2dF Fellow is to provide support for UK astronomers when preparing their observations. I then undertake the observations at the telescope and send back the processed data (we have to remove the instrument's signature from the observations) to the astronomers, for them to analyze and do their science. One of the most rewarding aspects of the job is the opportunity to work on many different types of science project, often well outside my own field, learning a new technique and new science for every program.

2dF's most significant achievements to date are the 2dF Galaxy Redshift Survey (www.mso.anu.edu.au/2dFGRS/), and the simultaneously run 2dF Quasar Survey (www.2dfquasar.org/). Both of these surveys used the massive multiplex gain of 2dF (you can observe 400 objects at once!) to undertake huge survey projects, which would have been impossible if we had to do them one object at a time. Over a period of three years, 2dFGRS measured redshifts (and hence distances) for over 200,000 galaxies and 20,000 Quasars. Using these redshifts, the two survey teams measured the structure parameters of the local Universe to unprecedented detail and provided some of the vital constraints that make up the current standard WMAP/2dF *Concordance Cosmology*, describing the fundamental parameters of our Universe.

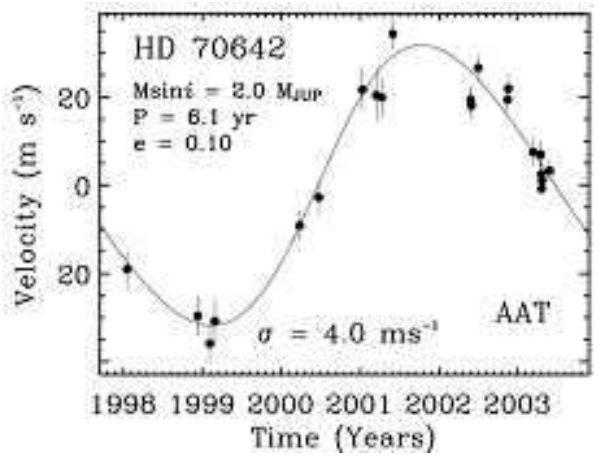


Caption: The bow-tie diagram shows the distribution of galaxies in the two 2dFGRS survey regions. Clustering of galaxies is clearly visible, with galaxies tending to be found along filamentary structure, leaving large voids with very few galaxies in them.

2. University College London Coude Echelle Spectrograph - UCLES

The key to understanding astronomical objects in detail is spectroscopy. A spectrogram of an object shows the dependence of the emission or absorption associated with a star or galaxy (or any other astronomical object) as a function of wavelength. It can be considered as the fingerprint of an object. By analyzing spectrograms in detail, astronomers can learn much about the detailed physics of the object. The higher the resolution of the spectrogram, the more information we can gain. An Echelle spectrograph such as UCLES allows astronomers to look at spectrograms with a resolution of 0.005 nanometers (0.05 Angstroms).

An excellent example of one of the science programs using UCLES is the Anglo-Australian Planet Search project (www.aao.gov.au/local/www/cgt/planet/aat.html). The planet search team are using the AAT and UCLES to look for tiny wobbles in stellar spectrograms, which occur over timescales of a few years, to infer the presence of planets around the stars. The team have been very successful in identifying large planets close to their parent stars, and are well placed to detect solar system analogues over the next few years (www.aao.gov.au/press/planets-03jul03.html).

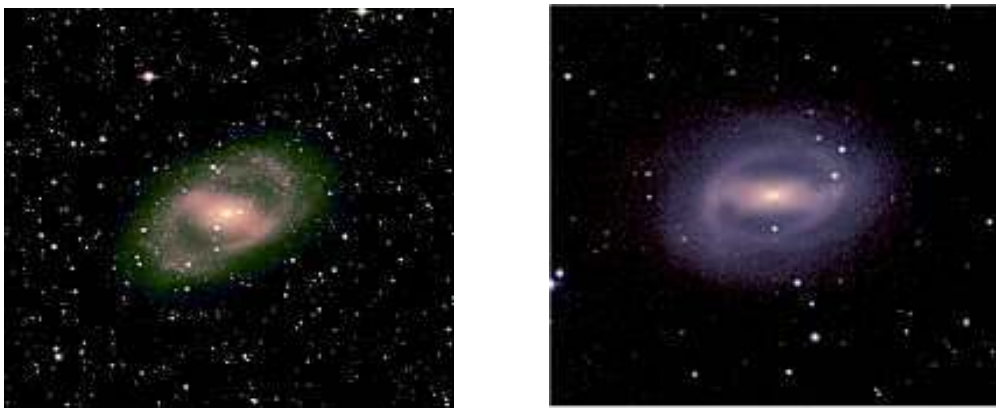


Caption: Over a period of 5 years, the planet search team measured the spectrum of the star D70642 to watch for the change in velocity of the star as it wobbles around its orbit, due to the presence of a planet with a few times the mass of Jupiter.

3. The Infrared Imager and Spectrograph - IRIS2

IRIS2 is, as the name suggests, the AAT's second instrument of this type. IRIS2 uses improved detector technology to provide a wider field of view on the sky and improved sensitivity, compared with the older IRIS instrument. In 2002, IRIS2 won the "Bradfield Award for Outstanding Engineering Achievement" from the Institution of Engineers, Australia (www.aao.gov.au/iris2/iris2_news.html#awards). IRIS2 allows astronomers to record images of the sky at infrared wavelengths (1-2.4 microns) over a field of view of 7.7 x 7.7 arcminutes - a massive field of view by infrared standards. IRIS2 is also a spectrograph, allowing astronomers to record the infrared fingerprints of stars and galaxies, looking in detail at the wavelength dependence of emission and absorption.

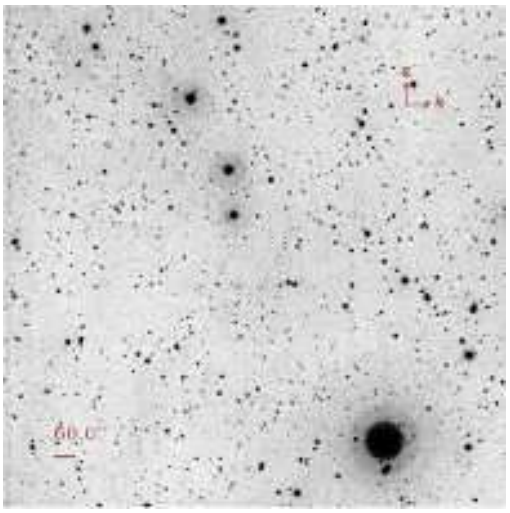
An example science project recently completed with IRIS2 is the RINGS survey. The Rings In the Nuclei of Galaxies Survey, undertaken by AAO staff astronomer Stuart Ryder, aims to identify a sample of galaxies with ring structures in their nuclei. High spatial resolution imaging is required in order to see the ring structures, which are thought to arise from gravitational instabilities in the galaxies, and they must be observed in the infrared to counter the effects of dust, which preferentially absorbs light at wavelengths visible to the eye.



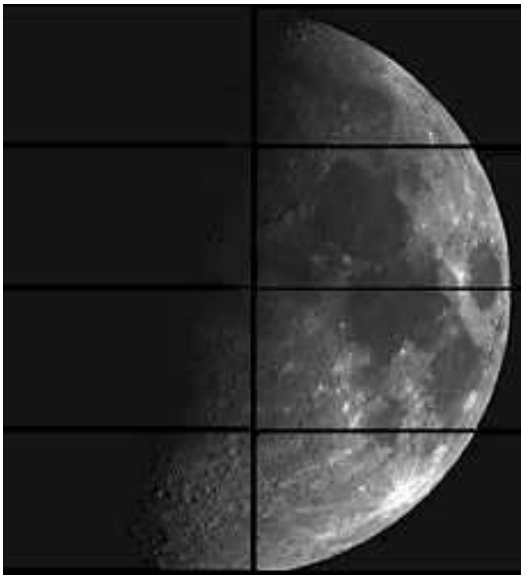
Caption: Two example RINGS galaxies clearly show the nuclear rings structures. The images, provided courtesy of Stuart Ryder at the AAO, show NGC6300 and IC5240 as a colour composite created using J, H and K band images (using filters at wavelengths of 1.4, 1.8 and 2.4 microns).

4. Wide Field Imager - WFI

WFI is the AAT's optical camera. It is a mosaic of 8 2k x 4k CCD detectors making a 67 megapixel digital camera! (The world's current largest camera is MEGAcam on the Canada-France-Hawaii Telescope. It's an array of 40 CCDs, giving a huge total of 340 megapixels! Each image recorded takes up 600 megabytes on a computer's hard disc. www.cfht.hawaii.edu/Instruments/Imaging/Megacam/). WFI was designed and built by Mt. Stromlo Observatory in Australia, and is also used on their 40-inch telescope at Siding Spring. On the AAT, WFI has a field of view of 0.5 degree square - a truly wide field for a professional quality CCD mosaic.



Caption: WFI is used for a wide range of astronomical survey projects. The deep B band (a broad band filter centered around 410 nanometers in the blue region of the visible spectrum) image shown here is a composite of about an hour's worth of observations for a program still under investigation. It's just a little too secret for me to tell you what it is yet.



Caption: A U band image (ultraviolet at 350 nanometers) of the Moon, acquired on the AAT on 2 Feb 2001 by Chris Tinney, Fraser Clarke and Gordon Schafer. The image was 0.1 second long and acquired about 40 minutes after sunset. (Copyright AAO.)

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The Evidence for an Accelerating Universe

By Rod Cuff

The second in the series of essays produced by members for distance learning courses. This one is slightly expanded and updated from an assignment (limited at the time to 1000 words) submitted in February 2004 for the remote-learning Introduction to Cosmology *course from the University of Central Lancashire.*

Introduction

Until recently, the conventional view saw the universe as dominated by matter (visible or dark), whose mutual gravitational attraction ensured that the rate of expansion of the universe would decrease. It was not known whether the expansion would slow to a halt or even perhaps reverse, though inflation theory predicted an eventual rate of expansion asymptotically close to zero.

However, in 1998 two research groups studying remote supernovae produced results indicating that the rate of expansion is accelerating. Later results have reinforced this conclusion. To explain why this view now prevails, we need to understand why these particular supernovae are of such interest, and to study the results that the researchers found.

Type 1a supernovae

Supernovae are the most luminous stars in the universe at their eruptive peak, detectable at great distances. In general, they have no consistent peak magnitude, but in the 1980s it was found that most members of a particular subclass, Type 1a, behave in a highly consistent fashion. The subclass is defined as those supernovae whose spectra show a silicon absorption line at 6150 angstroms, but no lines due to hydrogen [Perlmutter, 2003]. They are thought to occur in binary systems where a white dwarf star's gravitational attraction causes material from its giant companion to spiral onto the smaller star. When it reaches 1.44 solar masses (the Chandrasekhar limit), the star becomes unstable and catastrophically explodes.

The light curves from the eruptions of scores of such supernovae are summarised in the top part of Figure 1, from [Perlmutter, 2003], which is taken from work reported in [Hamuy et al., 1993; 1995]. Further analysis showed that supernovae whose peak brightness differed from most examples in the class also brightened and dimmed over a significantly different time-scale. If the magnitude- and time-values are adjusted in a consistent manner (dependent only on the observed time-scales), the anomalous examples then fit with the rest in an impressively consistent overall behaviour pattern (Figure 1, second part).

The net result is a standard astronomical candle with a variance of about 10% [Jensen, Tonry and Blakeslee, 2003], useful far out into the universe, and hence far back in time. By detecting such supernovae early enough, measuring their light curves and determining the redshifts of their parent galaxies, the value of the Hubble constant (the rate of expansion of the universe) at various epochs can be calculated from the slope of the ensuing graph.

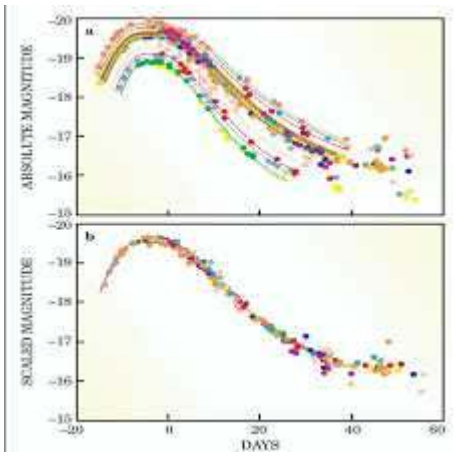

Figure 1: Light curves of low-redshift Type 1a supernovae measured by Hamuy et al. (from [Perlmutter, 2003]).

Top part: Raw values of absolute magnitude against time.

Lower part: The same values after algorithmic manipulation of individual light curves against time.

Results from 1998 and later

Type 1a supernovae are rare (about one every 400 years for a typical galaxy) and flourish for only a few weeks. However, by systematically photographing areas of the sky containing tens of thousands of galaxies just after the Earth's Moon is new (to give the best viewing conditions) and then repeating the exercise just before the next new moon, it proved possible to regularly detect several supernovae at a time. Two international research consortia were set up to pursue this aim: the Supernova Cosmology Project and the High-Z Supernova Search. They both presented initial results in 1998 and subsequently published them [Perlmutter et al, 1999; Riess et al, 1998]. They are summarised in Figure 2 (from [Leibundgut and Sollerman, 2001]).

Different models of the universe (depending on assumptions about the relative roles of matter and radiation, and the rate of expansion at various epochs) predict different forms of the Hubble diagram at redshifts ≈ 0.5 or more. (At redshift z, the universe was about 1/(1+z) of its current age and linear size.) Measurements of relatively nearby supernovae enable the straight-line part to be well calibrated, and measure–ments of more distant examples offer the potential for identifying models that reflect the actual universe. The 1998 results showed that distant Type 1a supernovae were about 20% fainter than would be expected for a universe where the rate of expansion had steadily decreased under gravity since the immediate post-inflation epoch.

Instead, the results suggested that the expansion is currently accelerating. In 2003 Perlmutter's team reported high-precision measurements of a further 11 Type 1a supernovae at redshifts of 0.36–0.86, which strongly support this view [Knop et al, 2003]. Results from subsequent continuing study of more Type 1a supernovae have been calibrated, analysed and summarised in a Hubble diagram in [Jensen, Tonry and Blakeslee, 2003]. It clearly shows the deviation from a 'standard model' universe at distances corresponding to redshifts of ≈ 0.5–1.0. The results support a model in which the expansion of the universe has been accelerating for at least 5×10^9 years.

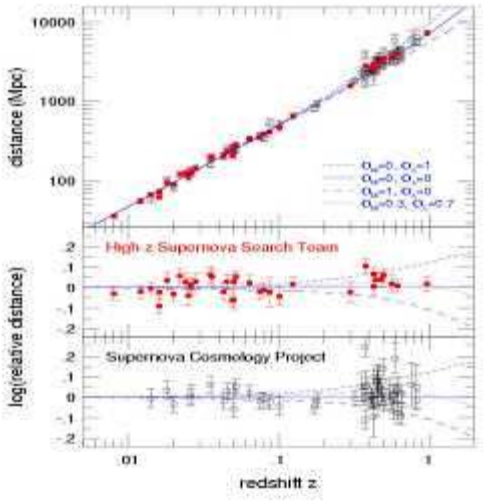

Figure 2: Distance plotted against redshift for Type 1a supernovae studied by the two major research groups (from [Leibundgut and Sollerman, 2001).
The lines represent the expectations for such a standard candle in various models of the universe: solid line, empty universe; dashed line, purely matter-dominated; dotted line, dominated by 'dark energy'.

Later work has focused on fainter supernovae from further back in time, to determine when this acceleration phase began. (If the expansion had always been accelerating, theory indicates that the observable universe of galaxies and clusters could not have formed). A summary article by Riess and Turner (2004) refers to a 2002 paper of theirs:

> *type 1a supernovae with redshifts greater than 0.6 were brighter than what would have been expected if the universe had always been accelerating or if intergalactic dust were dimming their light. … The results show that the transition point between slowdown and speedup occurred about five billion years ago.*

It is beyond the scope of this essay to discuss the *reasons* for the acceleration, but most cosmologists tentatively conclude that 'dark energy' currently dominates the universe, providing a repulsive force that acts in opposition to the attractive gravitational force from matter (whether visible or 'dark') and radiation. However, currently there is a richness of alternative ideas – such as quintessence [Caldwell and Steinhardt, 2000], a ghost condensate [Battersby, 2004] or a modified law of gravity [Dvali, 2004].

Conclusion

The 1998 results were largely unexpected, and inevitably there was some resistance to attributing them to an accelerated expansion of the universe until other possible explanations have been discounted [Leibundgut and Sollerman, 2001]. One suggestion was that unequally distributed intergalactic dust had led to a non-cosmological reddening of the light. Another was that the behaviour of supernovae might have 'evolved' – we know that the chemical composition of stars in the early universe differed from that in later periods because of the absence of heavier elements, which were formed only when these early stars themselves exploded as supernovae.

Experiments to explore these and other possibilities continue, but the new orthodoxy is that the expansion of the universe is indeed accelerating. Cosmologists are refining their measurements and planning orbiting telescopes to detect and measure more supernovae. It looks likely that the issue will be greatly clarified within the next decade or so.

Postscript

After an earlier version of this essay was submitted to UCLan, independent evidence emerged for the accelerated expansion of the universe [NASA, 2004]. An international team of astronomers used NASA's Chandra X-ray orbiting telescope to look at 26 galaxy clusters at a wide variety of distances.

It is known that clusters everywhere seem to have a uniform ratio of 85% dark matter to 15% observable matter. The ratio observed from Earth, however, depends on the distance to the cluster. Armed with the knowledge of what the ratio should be, the researchers calculated the distance to each of the 26 clusters. Knowing the redshift of each, they could then plot how the cosmic expansion (i.e. redshift) has changed over time. The data appears to confirm that the expansion of the universe slowed down after the Big Bang, but began to accelerate about 6 billion years ago.

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As the World Turns, It Drags Space and Time

from a NASA press release sent by Ray Worthy

An international team of NASA and university researchers has found the first direct evidence that the Earth is dragging space and time around itself as it rotates. The effect was first predicted in 1918, using Einstein's theory of general relativity. The recent research is the first accurate measurement of this bizarre phenomenon, called The Lense-Thirring Effect or frame dragging. "If a ball spins in a thick fluid such as molasses, it pulls the molasses around itself. Anything stuck in the molasses will also move around the ball. Frame dragging is similar - as the Earth rotates, it pulls space-time in its vicinity around itself. This will shift the orbits of satellites near Earth", Pavlis said.

Data from NASA's GRACE mission gave a vast improvement in the accuracy of new gravity models, which made this new result possible. "We found the plane of the orbits of LAGEOS I and II were shifted about six feet (two meters) per year in the direction of the Earth's rotation," Pavlis said. "Our measurement agrees with general relativity predictions to within our margin of error of plus or minus 5%. Even if the gravitational model errors are off by two or three times the officially quoted values, our measurement is still accurate to 10% or better."

LAGEOS II, launched in 1992, and its predecessor, LAGEOS I, launched in 1976, are passive satellites dedicated exclusively to laser ranging. The process entails sending laser pulses to the satellite from ranging stations on Earth and then recording the round-trip travel time. Knowing the speed of light, this enables a precise determination of the distances between laser ranging stations on Earth and the satellite. The team analyzed an 11-year period of laser ranging data from 1993 to 2003, using a method devised by Ciufolini a decade ago.

Future measurements by Gravity Probe B, a NASA spacecraft launched in 2004, should reduce this error margin to less than one percent. The method will check tiny changes in the direction of spin of four gyroscopes contained in the satellite orbiting 400 miles directly over the poles. The experiment will test two theories relating to Einstein's Theory of General Relativity, including the Lense-Thirring Effect. These effects, though small for Earth, have far-reaching implications for the nature of matter and the structure of the universe.

Gravity probe B promises to reveal much more about the physics involved. The Lense-Thirring effect has recently been observed around distant celestial objects with intense gravitational fields, such as black holes and neutron stars.

For graphics and other material about this research visit:
www.nasa.gov/vision/earth/lookingatearth/earth_drag.html

Transit Tailpiece

From Barry Hetherington

Guaranteed to make you smile..... especially since it's a true story.

On July 20, 1969, as commander of the Apollo 11 lunar module, Neil Armstrong was the first person to set foot on the Moon. His first words after stepping on the Moon, "That's one small step for a man, one giant leap for mankind" were televised to earth and heard by millions. But just before he re-entered the lander, he made the enigmatic remark "Good luck, Mr. Gorsky." Many people at NASA though it was a casual remark concerning some rival Soviet cosmonaut. However, upon checking, there was no Gorsky in either the Russian or American space programs. Over the years many people questioned Armstrong as to what the "Good luck, Mr. Gorsky" statement meant, but Armstrong always just smiled.

On July 5, 1995, in Tampa Bay, Florida, while answering questions following a speech, a reporter brought up the 26-year-old question to Armstrong. This time he finally responded. Mr. Gorsky had died, so Neil Armstrong felt he could answer the question. In 1938 when he was a kid in a small midwest town, he was playing baseball with a friend in the backyard. His friend hit the ball into his neighbor's yard, next to the bedroom window. His neighbors were Mr. and Mrs. Gorsky. As he leaned down to pick up the ball, young Armstrong heard Mrs. Gorsky shouting at Mr. Gorsky....."Sex! .... you want sex ?? .... You'll get sex when the kid next door walks on the Moon!"

Quote/Unquote

Experience is that knowledge which you receive immediately after you need it.
Anon

In Italy for thirty years under the Borgias they had warfare, terror, murder and bloodshed. They produced Michelangelo, Leonardo da Vinci and the Renaissance. In Switzerland they had brotherly love, five hundred years of democracy and peace and what did they produce? The cuckoo clock.
Orson Welles

An optimist is someone who thinks the future is uncertain.
Anon

* *

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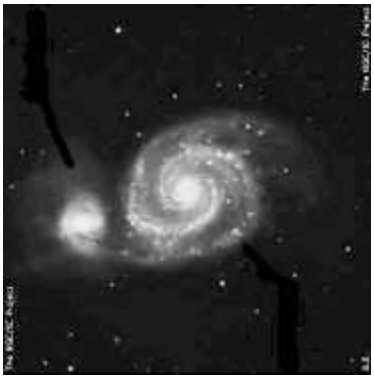
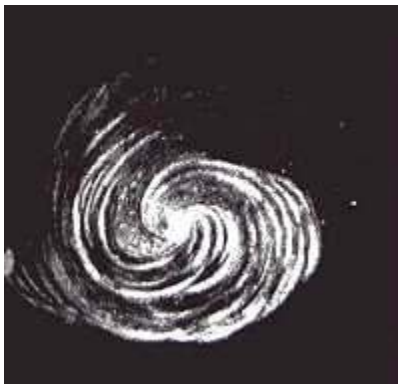
The Back Page Pictures

Interviewed this time – Viv Blundell



Modern b&w picture of this month's galaxy



Sketch by Lord Rosse in the 19th C