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The Editorial continues under the heading SNIPPETS on page 7.

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SPACE - LINK

Compiled by Nik Steggall

SEARCHING FOR GRAVITY WAVES IN SPACE

Currently three interplanetary spacecraft, ESA's ULYSSES and NASA's MARS OBSERVER and GALILEO, are now travelling to separate destinations (the poles of the Sun, Mars and Jupiter). These craft may soon prove the existence of waves in the universe's gravitational field by bobbing on ripples in space like corks bobbing on ripples in a pond.

Such gravitational waves have never been directly detected, although their existence was predicted in Einstein's theory of relativity and there is indirect evidence that they exist. The waves are believed to be produced by supernova explosions, collapsing black holes and other events of this kind. Past searches with ground-based equipment and single spacecraft have failed to discover them.

This joint ESA/NASA experiment will be the first time that three spacecraft will make observations simultaneously therefore greatly increasing the reliability of any detection. Astrophysicists will spend the experiment 'listening' for passing gravitational waves with the three spacecraft and so they will have the most sensitive detection system yet assembled to search for very low frequency gravitational waves.

MOON LANDING REMEMBERED

This July marked a remarkable anniversary, that of Apollo 11. Twenty five years ago a small lunar module named Eagle touched down on the desolate surface of the moon and astronauts Neil Armstrong and Edwin Aldrin became the first inhabitants of Earth to set foot on another world - an event thought by many to be the most enduring accomplishment of the century.

The landing of the Apollo 11 astronauts on the Sea of Tranquillity on July 20, 1969, fulfilled the primary goal of the largest non-military technological endeavour ever undertaken by the United States.

US astronauts landed on the moon five more times after the epochal Apollo 11 landing, with Apollo 17 making the last lunar touchdown in December 1972. Each succeeding lunar visit was longer than the preceding one, and astronauts on the last three used a lunar rover vehicle to travel in the vicinity of the landing site, but no landing equalled the excitement of Apollo 11's.

President John F. Kennedy started the United States on its journey to the moon on May 25, 1961, when he issued this challenge: "I believe this nation should commit itself to achieving the goal, before the decade is out of landing a man on the moon and returning him safely to the Earth".

It was an audacious proposal, considering that the United States thus far had only managed to send astronaut Alan Shepard on a 15 minute flight into space.

It took eight years, 420,000 workers, $25,000 million and 21 manned space flights to get those first footsteps on the moon - six Mercury project launches, 10 Gemini flights and five Apollo missions prior to the landing. It also took the lives of seven astronauts, three dying in a launch-pad fire and four in plane crashes.

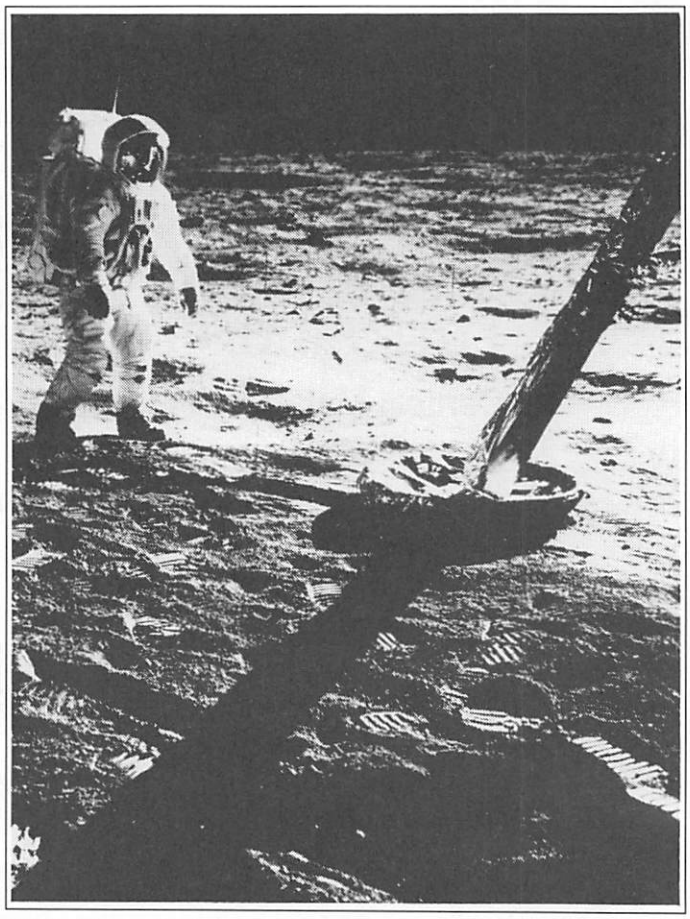
While some like to talk about the technical spin-offs from the Apollo programme, many believe that the most enduring aspect of Apollo 11 was that for the first time ever humans had left Earth and visited an alien body.

"In all the history of the human race, Apollo was the programme that took a human being from the planet Earth and let him set foot on a body other than Earth", said former astronaut Stuart Roosa, who flew on Apollo 14, the third flight to reach the moon. "It's a tremendous achievement. And when we celebrate the 25th anniversary of Apollo 11, everybody ought to reflect on that".

(From a report by Jim Fuller, USIA Science Writer).

ON THE MOON

Astronaut Edwin Aldrin Jr. on the way towards one of the four legs of the lunar module Eagle.



NASA/Hasselblad photograph

This picture gives a better idea than any other taken on the Apollo 11 mission of the relative size of man and machine. In the foreground the lunar dust bears numerous footprints from the boots of the astronauts. The Eagle landed as planned by the Sea of Tranquillity on July 20, 1969, at 10.56 pm EDT. It remained on the moon for 22 hours during which the astronauts spent 2 hours 40 minutes on the surface of the moon.

This picture is part of an original used for a 10 cent commemorative stamp with the biggest sale in US postal history, showing man's first descent on to the moon. So far, 152 million of the stamps have been sold.

BOOK REVIEWS

HOW THE UNIVERSE WORKS by Heather Couper and Nigel Henbest, Eyewitness Science Guides Series ISBN 0-7513-0080-2 published by Dorling Kindersley £12.99, 160 pages.

I was won over to this book by its combination of 'astronomy is fun' and the bite-sized chunks of information. It is clearly intended for children and is described as 'Suitable for Key Stages 2,3 and 4 of the National Curriculum'. The text is splendidly paced and full of information. No subject is examined in great depth, but there is lots of skilful appetite whetting.

My son Alexander, his friend Thomas (both 12) and my daughter Eleanor (9) read the book and made enthusiastic comments. They found it interesting and wanted to do some of the experiments. There are lots of illustrations of children doing experiments and they really do look as if they are doing them and are not just photogenic mannequins posed in the vicinity.

The 'Eyewitness' series has established a formula of bright colours, plentiful illustrations and experiments. Teachers seem to welcome the series in their classrooms and I guess they can control the experimental chaos. The usual necessary warnings about looking at the Sun and reminders that many experiments should be supervised are firmly made. One experiment shows how streetlight design controls or causes light pollution. Another encourages the reader to record the phases of the Moon over at least one complete cycle. Still another shows how to make a sort of cardboard ready-reckoner of the 'Drake' equation.

The Solar System gets a large, appropriate share of the book (70 pages). However nothing of importance is left out: stellar evolution and types, galaxies, the Big Bang, interstellar matter all get a share. I was quickly satisfied with the accuracy of the information presented. There is a useful glossary and a good number of 'potted' biographies of astronomers and scientists. I was glad to see Henrietta Leavitt among the biographies. The star charts at the end of the book are adequate to their context. The index is brief, but not skimped. I would have liked to have seen a suggested further reading list.

The authors have written a number of other books on astronomy and both are well known as writers and broadcasters on the subject. Heather Couper is Gresham Professor of Astronomy.

Roger O'Brien

JUNO MISSION by Helen Sharman, Association for Science Education (Editor John K. Gilbert) ISBN 0-86357-190-5, price in the region of £20.

This pack of a booklet and slides has been published by the ASE and is the long awaited classroom guide to the Juno mission of 1991, in which the first and so far only UK citizen to orbit the earth was carried aloft. The booklet clearly outlines the aims of the suggested learning activities, the aims and history of the mission itself, and in particular includes a helpful description of each slide including appropriate questions of varying difficulty. The pack is designed to be flexible in use and is suitable for individuals, groups or whole classes. Although no particular route through the material is pre-determined, various themes are possible such as the chronology of the mission, life in a spacecraft, regional geography, land use and the weather.

The material is well-produced but, rather confusingly, in the first part whole sections of prose are referred to as figures perhaps relating to a previous publication of this material in another format. The main section which details the activities around each sub-theme and slide is well presented but some of this material would need further work by teachers on supporting materials which pose questions appropriate to the age and ability of their own pupils. In general, the level of writing is appropriate to older secondary pupils of average or higher ability particularly as familiarity with units and chemical formulae is generally assumed without further explanation.

The fact that the living in space section is based on personal experience brings this rather remote topic to life. The life support topic is similarly thought-provoking especially the diagram which seems to imply that "faeces" after "minor reprocessing" end up back in "food preparation". I would hope for *major* reprocessing at the very least!

In general the booklet is a rich source of information and although it will need some modification for different audiences there are lots of opportunities for related work in English and Drama as well as the more obvious work in geography, science and technology. The strongest feature of the pack is the slide collection and its associated commentary. As we are not likely to see another personal account for some time I recommend readers to buy this pack and put it to use.

Tony Lacey

STUDENTS DISCOVER SOUTH POLE ON "TOP"

Research on the astronomical and educational aspects of Pipehenge, an astronomical teaching aid developed in New Zealand and displayed at the ASE conference at Birmingham in January, has turned up some very surprising results as students, particularly in Australia and New Zealand, have carried out their investigations. Many of these findings have been exploding "the myths of convention" such as the North Pole is at the top of the earth, Australia is "down under", and the far east is Asia.

From a Southern Hemisphere perspective students see the earth with the South Pole "on top", UK and Europe is "down under" and "far east". This also means that in the UK one would travel down to Aberdeen and up to Plymouth.

Most readers will find these ideas absurd because "everyone" knows that "north is at the top".

It has been found that "everyone" refers mainly to adults as most children have no difficulty with the concept that, because there is no top or bottom in space, wherever you are on the earth is "top".

Students working with Pipehenge grasp more easily many of the principles of astronomy using the observable relationships between the nearest star (Sun), nearest planet (Earth), and the nearest moon (our Moon). By doing this during the day, while they are at school, astronomy study becomes much more accessible, and any night-time observations more understandable and rewarding. If, for some reason, observations can't be done today, there is always tomorrow and the rest of the year. The parade of daytime astronomical events throughout the year plotted with Pipehenge makes the structure a valuable teaching aid for maths, science, and language, and now with the development of wire models, a valuable item for technology.

Following the demonstration of Pipehenge at the ASE conference at Birmingham University last January, there were many inquiries from around Britain and overseas. Pipehenges have been purchased by several Field Study Centres in England and one in Scotland and it is anticipated that eventually most camps, field study centres and many schools will install a Pipehenge as part of their equipment to teach the relevant Key Stages of the science syllabus.

The introduction of the slightly smaller, dismantleable version of the structure has met with wide appeal particularly to those schools and centres who found that they couldn't place a larger permanent in-ground version.

The educational attributes of Pipehenge have been recognised by Australian astronomers with the installation of the structures at Parkes Observatory (Australia's equivalent of Jodrell Bank), Siding Springs Observatory (Australia's largest array of optical telescopes), and at an astronomy education centre at Coonabarabran, near Siding Springs.

With the increasing number of Pipehenges being installed in schools, field study centres, interactive science museums, and camps in Australia and New Zealand, and now the UK, interest in astronomy is growing. INSET programmes are being requested and run at science teacher conferences, astrocamps organised for teachers and students whose astronomy appetites have been whetted, and more astronomy exhibits are being seen entered into school science fairs and exhibitions.

Astronomy, the oldest science, is staging a modern day comeback!

Eric Jackson
Director
The Pipehenge Foundation
Auckland
New Zealand.

The photograph right shows Pipehenge being demonstrated at the Annual Meeting of the British Sundial Society. *(Photo provided by Bob Kibble.)*

NORSE COSMOLOGY

Present day cosmology is concerned with the creation of the Universe, its age and whether it is open or closed. It is instructive (and fascinating) then to take a detached view of the Universe as seen by the Vikings, and the following articles are taken from "Gods and Heroes from Viking mythology" (see note at end of this article).

The World of Ice and Fire

In the beginning, the mysterious beings told King Gylfi, there was Ginnungagap, the yawning void or the vast abyss. It was a region so tremendous, so limitless that it extended for ever in any direction, with space to contain a billion universes and still find room for more. To contemplate it would make you sick with dizziness, would make you weightless, would bend your mind with terror for it had no length, no breadth, no up, no down. In the beginning there was nothing in Ginnungagap that any human thought could grasp, not a drop of water, a blade of grass or a twig, not even a grain of sand. There was no light, no darkness, no silence and yet no sound - only a yawning void. Although this nothingness was so vast and shapeless, it was still not empty. It had no form but it was definitely not empty. Only the gods knew this secret. After the beginning, this nothing began to be something and there were seen to be in it two contrasting regions. First of all there was the region of fire, called Muspellheim. No ordinary being could live there for the land was ablaze and the air aflame. Later the combusting fire giants were to make Muspellheim their home. Muspellheim means 'home of the destroyers of the world' and, as we shall see before the story finishes, nothing could be more apt than this terrifying name.

The Æsir took care not to approach the boundary of that land for the heat was so intense, the flames so tremendous, that even a million miles away they scorched and shrivelled everything up. To make it even more frightening, Surt, the fiercest of the fire giants, stood sentinel on the flaring borders gripping in this flaming hand a sword of fire. He barred the way to any intruder, including the Æsir, the gods. He was there at the beginning and he would be there at the end, at the Ragnarok, the doom of the gods. The hair of Surt was on fire, shooting brilliant streamers in all directions like tethered comets; his head and face were molten fire and streams of lava continuously rolled down his mis-shapen body. No wonder it was prophesied that at the end of the world he would fling singeing flame and stinking smoke over all the universe and burn everything that lived there to blackened ash!

The three strange informants told Gylfi that the second of the great regions in the vast abyss of Ginnungagap was a cold, bleak wilderness of ice and snow and freezing fog clouds, called Niflheim. Niflheim, like Muspellheim, had existed for countless ages before our earth was created. In the centre of Niflheim there surged and foamed up the mighty fountain of all waters, a raging gusher named Vergelmir, the Roaring Cauldron. All the rivers of all time proceeded from Vergelmir. Their names were fearsome and their forms were magic: Howling, one was called, others Storming, Frightful, Bubble-blasting. One was said to be composed entirely of chunks of ice fighting their way along in the shape of weapons - spears, javelins, swords and battle-axes.

Another tumultuous fountain in Niflheim was called Elivagar or Icy Waves. Elivagar, too, had welled up from its unknown source since time immemorial. Some say that Vergelmir and Elivagar were only different names for the one primeval fountain. However that may be, Elivagar's crunching, creaking, groaning mountains of ice expanded and exploded and spread layer upon layer as glaciers all over the whole of the northern quarter of Ginnungagap. And across the ever growing sierras of ice, whirled winds of hail, blizzards and frozen torrents of rain.

Most important, as we shall see, there bubbled up through Elivagar a poisonous scum which set like the slag which runs out of a furnace. This hardened into black ice. When the mass stopped and flowed no further it hung suspended, forming colossal icicles and icebergs log-jammed up and up, one on top of another. So between them, Vergelmir and the poisoned Elivagar completely filled the northern part of Ginnungagap. At last the yawning void which lay to the north quarter was blocked with heavy and crushing ice and frost; while in contrast, the southern sky of Ginnungagap glared with sparks and molten gases gushing out of Muspellheim.

It was quite obvious that after aeons of time the regions of fire and ice in the yawning void must meet. When this eventually happened there arose that most amazing of all phenomena, which no one since the world began has been able to explain - life. Where the two elements came together in space, the yawning void was as mild as the windless air, but as the ice of Niflheim touched the fire of Muspellheim there was a tremendous explosion and a mighty booming bang. The fermenting drops of venom bubbling up through Elivagar were fused to life by the fire, and across the length and breadth of Ginnungagap there formed the body of a giant. He was shaped like a man and at first he hardly moved. A broth of bubbling and boiling mud and ice gave birth to his ferocious head, his arms, his torso and his sludge-streaked legs. His later descendants, the frost giants, named him Aurgelmir which means Mud Boiler, for they knew the secret of his creation; but others called him Ymir.

For long ages Ymir lay sleeping in his porridge of poisonous, seething mud and ice. At last his body was solid and he began to sweat. Under his armpit grew a male and female; then one of his feet mated with the other and produced a six-headed son. From these creatures sprang the race of frost giants.

Not all the ice of Niflheim was impregnated with the poison from Elivagar, and where it remained pure but was still melted by the fires of Muspellheim, a vast cow appeared in the thawing ice. Her belly spread across the heights as a colossal cumulus cloud and her legs were columns at the corners of space. From the udder of this great cow flowed four rivers of milk and on this milk the giant Ymir was suckled. The frost giants called her Authumla meaning the Great Nurse. Authumla herself needed sustenance and she began to lick the continents of ice about her, finding them pleasantly salty to the taste. Just as a master sculptor sees in a block of marble an image which only he can release, so when Authumla licked the ice something new began to appear.

By evening of the first day her questing tongue had licked out the hair of a man. All next day she nuzzled and slobbered until a man's head appeared. By the third day she had licked a complete man into shape. The gods called him Buri for they claim him as their first ancestor: he was beautiful and bright to look at, a great and mighty god. As time went on, Buri had a son called Bor, a name which means 'born', for all those thousands of years ago there were still not very many words available. Bor's wife was Bestla the daughter of a giant known as Balethorn. Bor and Bestla had three sons called Odin, Vili and Ve.

All these beings, the ancestors of the giants and the gods, and the universal cow Authumla, had formed in the primeval formlessness of Ginnungagap. Because of the venom proceeding from Elivagar some were evil. Others, like Buri, were good. But it is well known that good and evil cannot live peaceably together and before long there was to be a tremendous battle between the cosmic powers.

The Creation of the World

The frost giants were a dark and violent race, mis-shapen, monstrous and noisy. Old Ymir's son, born by the union of one foot with the other, was a glacier-like being with six heads called Thruthgelmir or Mighty Roarer, and *his* son was known as Bergelmir or Rock Roarer. When they and their ancient father and grandfather Ymir-Aurgelmir or Mud Boiler met in council the noise was ugly and Odin, Vili and Ve, the sons of Bor, were irritated beyond endurance.

Odin and his two brothers quarrelled with the old giant Ymir and after a great battle they killed him. When he fell, hacked to pieces, so much blood flooded from his body that all his giant family were drowned except the youngest, Bergelmir, and his wife. Bergelmir swam through the billows of blood dragging his wife by the hair until he was able to scramble on to a giant mill and there they lay sprawled across the millstone gasping for breath. In this way, the race of the frost giants and hill ogres was able to continue.

Odin, Vili and Ve dragged Ymir's carcass, still pouring volumes of blood, into the middle of Ginnungagap. There were so many wounds in Ymir's body that the blood flowing out formed the sea. All oceans, lakes, rivers, waterfalls, pools and streams came from Ymir's blood.

The sons of Bor went to work on Ymir's body. They pounded, kneaded, chopped and slashed his tremendous corpse, pushing and pulling his flesh this way and that as though it were clay until they were satisfied. When they had finished the first part of their gruesome task they had produced the groundwork of the earth, rolling hills, plains, dry river beds, empty lakes, and the empty sea-bed. Into all these hollows they poured Ymir's blood so that the earth lay entirely surrounded by the sea with rivers running into it. His bones they hacked and splintered to make the mountain crags. They made individual rocks and seashore pebbles from his toes, double-teeth and remaining chips of broken bone. They use Ymir's hair for trees and bushes. From the soil made out of his flesh, the race of dwarfs appeared spontaneously rather like maggots. Bor's sons had now created the earth and the beaches and the sea but as yet there was no sky. So Odin, Vili, and Ve between them heaved up the mighty skull of Ymir to form a dome over the earth. Now they had to find a way to keep it in place.

Fortunately (because without a sky the earth would have been a dark and miserable, not to say uninteresting, place to live in) a solution was at hand: they were able to make use of the dwarfs. Odin, Vili and Ve peremptorily ordered four of them to stand forever at the four corners of the world and to hold up the sky. They called them North, South, East and West. A little later on Odin created the winds by posting a giant (one of Bergelmir's sons) in the form of an eagle at the ends of the earth to flap his wings forever. And into the stream of air Bor's sons cast Ymir's brains to make the clouds.

The dome of the sky was now firmly fixed, but it remained dark and menacing.

Freed from supporting the sky, the sons of Bor caught the glowing cinders and sparks which are thrown up and blown up out of Muspellheim and poised them in the middle of the yawning gulf to give light to both heaven and earth. They appointed positions to all the stars: some were fixed in heaven, some were to pass backwards and forwards in regular patterns. In this way the seasons of the years were marked out, but as yet there was no sun and no moon, and day was not separated from night.

Odin, Vili and Ve now gave a great grant of land encircling the outward shores of the ocean for the race of giants to settle in, calling it Jotunheim or Giantland. Finally the young gods took Ymir's brows to build a circular stronghold of cliff-like walls around the earth. They called this fortress Midgard, the Middle Enclosure.

High, Just-as-High and the Third settled back on their thrones to see what effect their account had had on Wayweary, as King Gylfi still called himself. Gylfi was very astonished at the information he had received so far but, like most people, he was curious to know where the first man and woman, his own ancestors, had come from.

High said: 'You'll have to be patient. There is still information of a universal nature that we have to disclose. Don't you want to learn how day was divided from night, and how the sun and the moon were made? Or indeed what binds the universe together? You must remember that, though men and women may be important to themselves, from the point of view of eternity they are very small indeed. Make yourself comfortable and listen.'

This article is taken from "Gods and Heroes from Viking Mythology" by Brian Branston, with illustrations by Giovanni Caseli, published by Eurobook Ltd, in 1978, ISBN 0-85654-029-3. We are grateful to Eurobook for permission to reproduce these extracts.

β PICTORIS REVISITED: ANOTHER PLANETARY SYSTEM?

by Tony Lawton, President of the British Interplanetary Society.

Introduction and Abstract

ß Pictoris (HR2020, HD39060) has been subjected to intense investigation since the discovery by IRAS (Infra Red Astronomical Satellite) of a large Infra Red excess at 12, 25, 60 and 100μm. This has been confirmed by photography showing a large dust disk surrounding the star.

More recent work using a high resolution CCD camera operating at 10μm indicates that this disk is asymmetrical: the distortion may be due to a planetary body at present unresolved. Further work is proposed using a high resolution camera operating at 20 μm.

ß Pictoris - the Star

This is an A5V Main Sequence Star of visual magnitude 3.85 ie. approximately 30 times brighter than our Sun and some 16.5 parsecs (53.4 light years) away.

It is situated in the Southern Hemisphere constellation of Pictor - the Easel, at a Right Ascension of 5h.47m 47.1s and a Declination of -51 deg. 3m59s (Epoch 2000 coordinates).

In 1984 analysis of IR data from IRAS showed that the star had excess IR radiation at wavelengths spanning 12-100μm. It was believed that this was due to a dust cloud surrounding the star. (Aumann *et al*).

Later in 1984 Smith and Terrile imaged the dust surrounding the star, blanking out the primary by coronagraphic techniques. The dust so revealed was in the shape of a flat disk estimated as some 400 AU in radius ie ten times the known size of our Solar System, - See Fig 1. First crude estimates of the dust mass indicated it was approximately that of Earth and was made of grains significantly larger than 'normal' interstellar dust grains. In 1985 Hobbs *et al* discovered a gaseous counterpart to the dust ring. This was visible in nitrogen and calcium spectra.

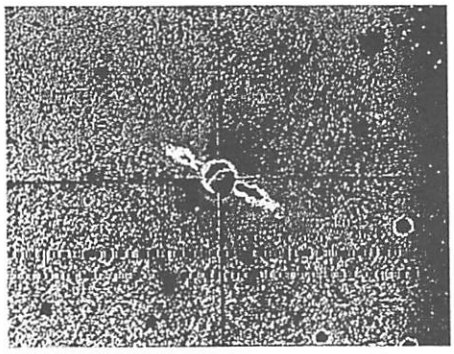


Fig.1 The first image of ß Pictoris showing the dust shell. It is a multiple image blend, with the central star obscured by a coronagraphic 'finger'.

In 1991 the Hubble Space Telescope produced a higher resolution image, details of which were published in Space Telescope Science Institute "Observer" Vol 1, No 3, 1991.

This revealed further disk structure ie:-

An inner gas disk with a radius of approximately 1.5 AU radius surrounded by a dust disk of about 3 AU radius. This in turn is followed by another gas disk of approximately 15 AU radius which in turn is surrounded by another dust disk of about 30 AU radius. Fig 2 is an artist's interpretation of these later findings.

In March 1994 Lagage and Pantin published their findings whilst imaging ß Pictoris at 10-12 μm. At these wavelengths the black body radiation from the central star is approximately equal to the radiation from the surrounding dust and gas.

The imaging camera (TIMMI) uses a chopping system to remove the huge telescope and sky background - some 10^6 times greater than the target signal. Scanning of the detector array across ß Pictoris was achieved by nodding the telescope. α Carina (Canopus) was used as a reference star in order to provide both a photometric standard and a point spread function (PSF) reference.

Processing of the final imagery included removal of the central star contribution. Without deconvolution the FWHM was 0.9 secs. Deconvolution will, of course, improve on this, but Fig. 3 shows the image without sophisticated deconvolution.

Fig.2 Artist's impression of ß Pictoris as seen by Hubble Telescope. The image clearly shows the dust and gas rings making up the whole surrounding disk.

[Acknowledgements: Artist D.Berry, Information from Space Telescope Science Institute.]

There is a marked asymmetry in the disk with the lower section almost twice the width of the upper. Lagage and Pantin consider the best explanation of this asymmetry is the presence of a planetary companion. An approximate scaling of Fig. 3 would place the supposed companion planet some 50-60 AU from the central star. The resultant illumination would be akin to that of Saturn.

Of greater significance is the self-heating characteristics of gas giants the size of Jupiter or Saturn, and it is *this* effect which Lagage and Pantin suspect is the cause of the asymmetry of Fig.3, although the planet itself is not resolved. Nor should it be.

The peak black body radiation temperature at wavelengths of 10μm is 300K (approx. 30°C and representative of Earth's climate).

The external temperature of a typical Jupiter gas giant is of the order of 150K - a temperature corresponding to a black body peak wavelength of 20μm. Following this line of reasoning Lagage and Pantin consider upgrading the thermal imaging camera by the use of a detector array consisting of 128x192 (24,576) elements based on a silicon-gallium binary alloy. Each element is 75μm square (present array elements are 100μm square).

But there are 'downsides' which include:-

i) Reduced resolution based on the relationship between telescope mirror diameter and wavelength of operation.

ii) Reduced atmospheric transmission at the longer wavelength. Our atmosphere has virtually no loss between 8-12μm, a factor fully exploited by military and commercial thermal imaging apparatus.

iii) The detectors operate best at a lower temperature than their 10μm counterparts.

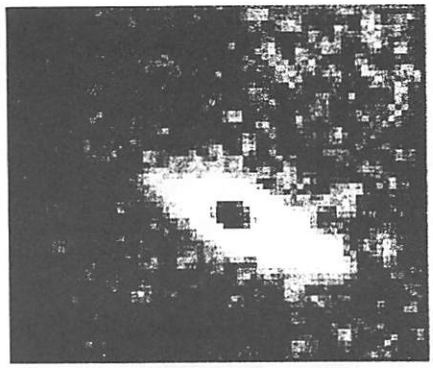


Fig.3 ß Pictoris thermally imaged at 12μm. The asymmetry at the South Eastern end may possibly be due to a planetary companion (as yet unresolved).

All these factors can be reduced to tolerable levels by data processing, by choice of sites with exceptional seeing and by use of lower temperature cryogenic coolants (liquid helium as opposed to liquid nitrogen). The required engineering and technological spheres have been developed to a high degree and exceptional seeing sites are already surveyed and in some cases are the areas for very large apertures and interferometers.

This latter technique offsets the low resolution problem completely. Using properly controlled full deconvolution from a synthetic aperture of tens of metres effective diameter probably will resolve giant planets of other stars, for at 20μm the emission from the central star is actually lower than from the companion planet. Lagage and Pantin paint a very optimistic picture and sum up:-

"We can anticipate a large use of this window for all the programmes dealing with dust around stars, whatever their evolutionary stage: young, main-sequence, or late type".

Future Work

This optimism is backed by a long list of ß-Pictoris-like stars produced by Lagrange - Henri *et al* 1990 which quotes 56 additional candidates - many of which are under intense investigation. Imaging of one star 68 Oph (HR 6723, HD 163296) has already revealed a dust disk similar to ß-Pictoris. 68 Oph is a binary with an A2 primary and a G3 Ve companion.

The dust disk is approximately 700 AU in diameter and surrounds both stars (separation approx. 28 AU), and is elliptically distorted. Work continues.

Lagage and Pantin also examined

51 Oph (HR6519, HD158643) a B9.5 Ve main-sequence object 25 parsecs (81.5 l yrs) away. Unfortunately to date the deconvolution programme resolved the reference star α Scorpio (Antares) thus proving that it too had a large dust shell! Fortunately they always have a second PSF reference.

51 Oph is at present imaged as a point-like object for the dust/gas disk is too cool to be satisfactorily detected at 10μm. The future 20μm programme may be more fruitful. Alternatively the disk may be in a plane with an unfavourable line of sight.

Summary

The use of 'mid IR' imaging arrays, large synthetic aperture telescopes, and suitable data processing deconvolution should provide us with very powerful tools for examining suitable stars for the presence of comparison planets of Jupiter-like dimensions. Most of the proposed systems will be operational by, or before the next century.

Eventually we could have catalogues of nearby stars with *known* planetary systems thus avoiding much guesswork.

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VARIATIONS ON AN AUTUMNAL THEME

by Roger O'Brien

Not all stars are unchanging jewels scattered on the black velvet of the sky. Some of the most famous variables in the sky are on view in Autumn. δ Cephei is the first to look for since Cepheus, though an unexciting group, is easy to find. Cassiopeia (the famous "W" or "M") is high up. Cepheus lies on the zenith side of Cassiopeia. They were husband and wife in legend and appropriately close in the sky. Delta (δ) Cephei is one of a small triangle of stars off the main group. However, it is always magnitude 4.3 or brighter so there shouldn't be much confusion. This is a true variable star, which actually changes in brightness. It is a yellow giant and intrinsically brilliant but, over a period of 5.4 days, it rises rapidly to a maximum brightness of magnitude 3.6 then falls back more slowly to 4.3. With a bit of practice, you can follow the changes simply by comparing them with the stars nearby. Once again this highlights the strange astronomical method whereby lower magnitudes are brighter (to the extent that the most brilliant stars have negative magnitudes!).

δ Cephei has used up the hydrogen in its core. It is 'burning' helium, which means that the core is much hotter and more compact than the Sun's. Immediately outside the core, layers of ionisation develop and trap much of the outflowing radiation. The outer parts of the star then cool and shrink towards the core. In turn, this changes the ionisation balance within the star and the trapped energy escapes to inflate and heat the rest of the star. The more massive Cepheids take longer to pulse and, of course, they are brighter.

In 1912, the year the Titanic sank, Henrietta Leavitt studied stars of this type in the Magellanic Clouds and it was she who noticed that their apparent magnitudes were related to their periods. Since the Magellanic Clouds are so far from us, all the stars there are effectively at the same distance and the apparent magnitudes relate directly to the real brightnesses (the Absolute Magnitudes). Thus, Cepheid variables are one of the most useful tools in the cosmologists' bag. If a star in a not-too-distant galaxy can be identified as a yellow giant and shown (by monitoring it over several months at least) to be a Cepheid, it is quite easy to calculate how far away it is by the measurement of its apparent brightness. Fortunately, Cepheids are rather bright and there is now a good chance of detecting them right out to galaxies in the huge Virgo Cluster. Dr Tom Shanks of Durham University is one of a team of astronomers currently engaged in just this search. They have even been successful in picking out individual bright stars from images taken with the 'Martini' image sharpener on the William Herschel Telescope on La Palma and they have access to the Hubble Space Telescope. They already know they can see variables, but have not been monitoring them long enough to be sure which type they might be.

If you leave Cepheus on the δ Cephei side and cross Cassiopeia you'll come to Perseus - not a very bright constellation in the form of an inverted and crooked 'Y'. ß Pegasi is another variable. The Arabs knew of this before 1000 AD and they called the star 'Algol' - the demon. It winks slowly over a period of just under three days. Again, it is possible to see the effect with the unaided eye and a bit of persistence. Algol is, however, a quite different sort of star from δ Cephei. There are actually two main stars in the system: a B type, which is very hot and white, and a G type, which is somewhat like our Sun. They are very close and matter streams between and around them. They can only be identified by careful analysis of their combined spectrum. In fact, a periodic set of changes in the spectrum suggests there is a third star, taking about 21 months to orbit the other two. The demonic changes in brightness occur principally, when the G star passes between us and the B star and cuts off some of its light. There is a similar, but much smaller effect when the B star eclipses the G.

Not far away is the even more unremarkable constellation of Lacerta. In that is a strange 'star', BL Lacertae, a variable of a most unusual type with a strange spectrum and unpredictable changes in brightness. Actually, it is a very distant elliptical galaxy with an active nucleus. This was such an important discovery that a whole class of objects (they are similar to quasars in many ways) are now know as BL Lacs. The name 'blazar' was given to them, but it seems to be falling out of use.

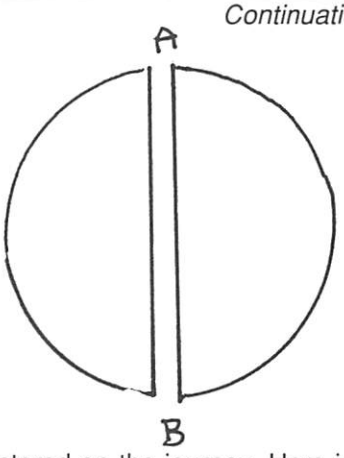
There is rather a good selection of unexciting constellations in early Autumn. Capricorn, Aquarius, Pisces and Aries fail to mark the zodiac very clearly, but they lead the way to the first of the brilliant winter constellations: Taurus. The last of my list of variables, T Tauri, is not really an amateur's object, but it is interesting because it seems to be a very new star, which has not yet settled down to the sedate adulthood of solar-type stars. T Tauri stars show signs of having disks or envelopes of orbiting gas and dust. Many of them have bipolar flows - jets of gas streaming away from the star's poles. There are lots of these stars found in dusty clouds dotted around the galaxy. Astronomers believe the Sun was once a T Tauri star.

Autumn is the time for hunting dark, remote objects in the Kuiper Belt. The dismal autumnal zodiac is well clear both of the Milky Way and the horizon and gives astronomers their best annual chance to spot dim, slow-moving bodies at roughly the same distance from the Sun as Pluto. They might even find Planet X.

SNIPPETS

Continuation of Editorial

Suppose a tunnel were constructed through the Earth, passing through its centre (see diagram). It can be proved that an object dropped into the tunnel would reach the other end of the tunnel about 45 minutes later (taking the radius of the Earth to be 6400 kilometres). This result assumes we can neglect the various hazards encountered on the journey. Here is an interesting exercise for "mathematicians": assume the Earth's atmosphere not only extends above the surface, but down into the tunnel as well. The problem is: what is the air pressure at the centre of the Earth?



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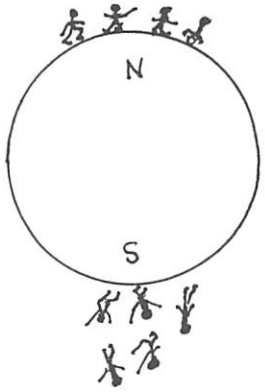
I have been asked by young children why people in the antipodes do not fall off. How would you answer this?



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Light travels in straight lines. This fact does not seem to be widely known, but it is absolutely essential to explain such phenomena as the phases of the Moon, eclipses, etc.

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"What does 'the speed of light' mean?" I was asked by a parent. After further discussion it became apparent that he really did not understand that light actually travelled, with a particular speed! This certainly needs further investigation.

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May I recommend an excellent book published a good 50 years ago, which, in a humorous way, deals with the phenomena of the Universe in an understandable way. The velocity of light is decreased to an extremely low value, and Planck's constant is similarly increased. The book is called "Mr Tomkins in Wonderland", and is by George Gamow. A sequel is called "Mr Tomkins explores the Atom", but is not so good as the earlier work. I do not know whether they are still available.

E.Z.

The AAE response to the draft proposals for the Science National Curriculum

In these proposals there are major changes, some of which affect the astronomy content. The old Statements of Attainment have gone and the new Programme of Study looks very different in layout. There are neatly listed "bullet points", grouped under themes. The astronomy theme, called "The Earth and beyond", states that children should be taught:

Key Stage 1:

* a that the position of the Sun appears to change over a whole day;
* b that there are seasonal changes in the number of hours of daylight.

Key Stage 2:

* a that the Earth orbits the Sun;
* b that the length of the year is the time it takes to orbit the Sun;
* c that the planets orbit the Sun and that the Moon orbits the Earth;
* d how shadows change as the Sun moves across the sky;
* e that the Earth spins around its own axis;
* f how day and night are related to the spin of the Earth.

Key Stage 3: no entry

Key Stage 4:

* a the relative positions of the Earth, Moon, Sun, planets and other bodies in the Universe;
* b that gravitational forces determine the movements of planets, moons, comets and satellites;
* c that planets and the Moon are seen by reflected light;
* d that the Sun and the stars are powered by nuclear fusion and are therefore light sources;
* e about the 'life cycle' of stars;
* f about ideas that are used to explain the character and origin of stars, the Solar System and the Universe.

The major change is the gap at Key Stage 3, which breaks the continuity of this theme. This is at an age when pupils are still fascinated by space and space travel, so that this is a topic which can draw their interests towards science. Some further development of the ideas at this time would advance their understanding of how the Solar System works.

There are also some basic concepts missing from earlier Key Stages, notably some simple observations of the height of the Sun and the shape of the Moon. Experiences like these are needed later on in order to build an understanding of the phases of the Moon and how the seasons arise.

Feedback on these proposals had to be submitted to Sir Ron Dearing by 29 July. Our response has concentrated largely on the Key Stage 3 gap and the absence of any Moon phase recognition. We are urging a modest addition to Key Stage 3 to bridge the gap and to encourage some night observation, even if only of the Moon.

Finally, in the Key Stage 4 Single Award Science Programme of Study there are now two items relating to astronomy, under the title "The Earth's place in the Universe". We welcome these, believing that all pupils should have the opportunity to consider the wider Universe and our rather modest position within it.

Anne Cohen, President, AAE

EARTH, MOON AND SUN

The two articles below are taken from the newsletter of the Association of Astronomy Educators (1993), editor K.W. Carlson, published quarterly in the USA. We are grateful to the US AAE for permission to reproduce these articles.

HAPPY BIRTHDAY by Gail E. Tynes, Bushy Creek Elementary School, USA.

Teaching the simple concept that the Earth circles our sun is one that we always take for granted. To complicate matters, educators are always stating that the sun "rises" in the East and "sets" in the West, giving the impression that the sun revolves around us. I have incorporated an activity into my classroom that not only stresses that the Earth revolves around the sun, but offers constant review of this topic.

Each month I check to see what child has a birthday to celebrate. I send home a letter to the parents with specific instructions to keep the note top secret from the child. The note asks the parent(s) to fill out something very memorable that happened to the child during each year of the child's life. The parents then send the note back to school in a sealed envelope.

At some point during the day on the child's birthday, the lights in the classroom are turned off. The children know what is about to happen, having participated in several such events.

The birthday child is asked to go to the front of the class with a globe. Another student volunteers to stand on a chair holding a flashlight. Then the birthday child takes one trip around the chair. As the child walks I read the special event that happened to the child during the first year of his (her) life. For every trip around the chair (sun) a special event is read aloud. With each trip around the chair I stress that it took a year for the earth to go around the sun. Students also repeat that the trip took a year and also that the earth travelled around the sun. This is a fun way of reviewing the revolution of the Earth around the sun eleven times in one day and twenty-four times a year. This activity has been used with kindergarten students but works equally well with fifth grade. Students start hinting around when birthdays approach that someone will be walking around the sun soon and parents usually contribute cute things that will get a chuckle from the students.

EARTH/MOON DISTANCE MODEL

Although several other planets in the Solar system have more moons than earth does, our moon is quite large in relation to the size of our planet. From space, the Earth and moon look almost like the double planet system. In this exercise, students will cut out circles representing the proportions of the Earth/Moon and glue them to a strip of paper to show their scale distance apart.

Materials needed:

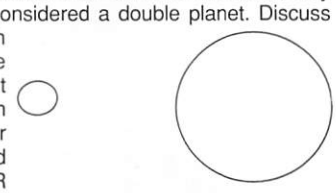
* copy of master (at page bottom)
* one 65" strip of paper (calculator paper works well)
* scissors, crayons, glue

Discuss the diameters of the Earth (about 8000 miles) and the moon (about 2000 miles). The moon is about 1/4 the diameter of the Earth. Have students cut out the moon circle and measure the Earth circle with it. The moon should fit across the Earth's equator about 4 times.

Ask students to cut out the Earth's circle. They should place the "Earth" near one end of the paper and trace it. The Earth circle will be used to measure the distance from the Earth to the moon (approx. 30 earth diameters). Lay the earth circle down so that it is just touching the traced circle and mark the diameter again. Continue until 30 equal diameters have been marked out.

Have the students colour the Earth and moon circles and paste them in the correct places on the paper strip. They should also label the Earth with its name and diameter. Label the moon and its diameter. Label the distance between the two (240 000 miles).

While this diagram may seem to show LOTS of space between the Earth and the moon, they are really considered a double planet. Discuss how much distance there must be between other planets and THEIR moons.



not to scale

Sky Diary Autumn 1994

By Eva Hans

AUTUMN 1994

Equinox: Sept 23d 06h 19m
Solstice: Dec 22d 02h 23m

PHASES OF THE MOON:

New Moon	First Quarter	Full Moon	Last Quarter
			Sept 28d 00h 23m
Oct 5d 03h 55m	Oct 11d 19h 17m	Oct 19d 12h 18m	Oct 27d 16h 44m
Nov 3d 13h 35m	Nov 10d 06h 14m	Nov 18d 06h 57m	Nov 26d 07h 04m
Dec 2d 23h 54m	Dec 9d 21h 06m	Dec 18d 02h 17m	

PLANETS:

Mercury is in the evening sky until Oct 15th, it then reappears as a morning object from Oct 28th to Nov 27th. The best chance to see Mercury is during the first week of Nov.

Venus is in the evening sky until late Oct when it becomes too close to the Sun to be visible. It reappears in the morning sky in mid-Nov. Venus is in conjunction with Mercury on Nov 12th.

Mars is a morning object. It moves from Gemini through Cancer and into Leo, passing 2°N of the bright star Regulus on Dec 8th.

Jupiter is in the evening sky until the beginning of Nov when it becomes too close to the Sun to be visible. It reappears in the morning sky from early Dec, passing into Scorpius by mid-Dec.

Saturn is in the evening sky in Aquarius.

Eclipse

On Nov 3rd a total eclipse of the Sun will be visible from Central and S.America, part of Antarctica, S.Africa and Madagascar. Unfortunately we have to wait till 1999 to see such an event from UK.

Meteors

Orionids

Dates Visible :	Oct 16 - 26
Best Night :	Oct 21/22
Best direction:	before midnight E After midnight SE
Hourly Rate :	30

Leonids

Dates Visible :	Nov 14 - 20
Best Night :	Nov 17/18
Best direction :	before midnight not visible After midnight E
Hourly Rate :	10

Geminids

Dates Visible :	Dec 6 - 16
Best Night :	Dec 13/14
Best direction :	before midnight E after midnight S
Hourly Rate :	90

You may obtain a free copy of the information sheet "Stars and Planets" by sending a s.a.e. to:

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