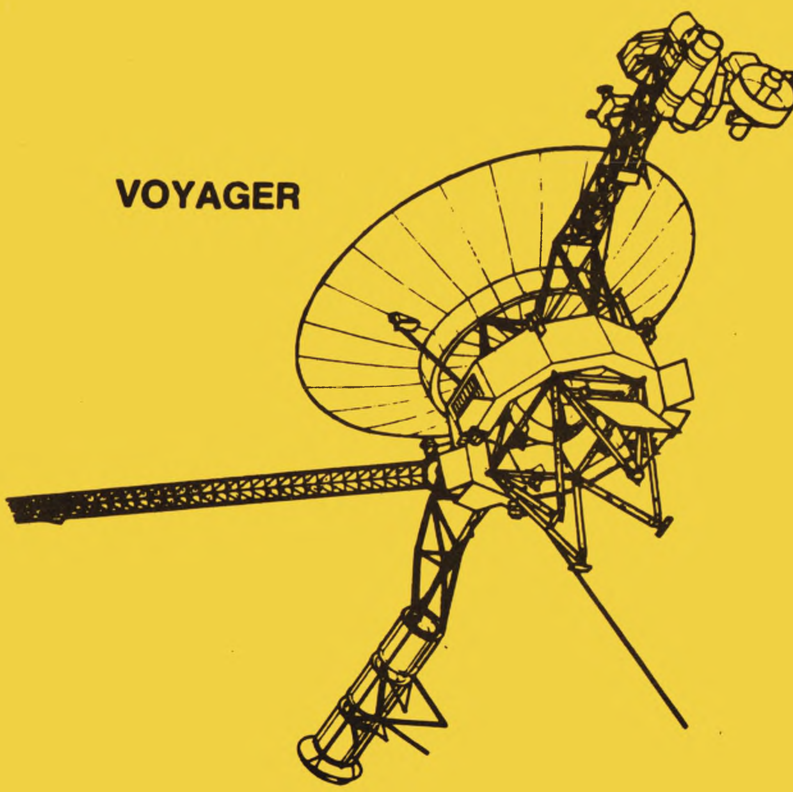
NOVA NOTES

VOYAGER



BI-MONTHLY JOURNAL OF THE HALIFAX CENTRE

MAR-APR 1982 VOL. 13, No 2

1982 HALIFAX CENTRE EXECUTIVE:

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Treasurer	-	Dale Ellis, 5 Rockwood Avenue, DARTMOUTH, N.S., B3A 2X9
Editor	-	Peter Steffin, 8 Auburn Drive, DARTMOUTH, N.S., B2W 3S6
National Rep.	-	Cathy Chiasson, 2-6067 Fraser St., HALIFAX, N.S., B3H 1R8
Librarian	-	Guy Harrison, 16 First Street, DARTMOUTH, N.S., B2X 1W1
Observing Ch'person	-	Kathy Oakley, 3140 Hemlock Avenue, HALIFAX, N.S., B3L 4B6
Mailing Address	-	HALIFAX CENTRE, R.A.S.C. c/o 1747 Summer Street, HALIFAX, N.S., B3H 3A6

NOTICE OF MEETING

Date: Friday, 19 March, 8:00 PM

Place: Nova Scotia Museum: Meeting to be held in lower auditorium/theatre. Access from parking lot and side door.

Speaker: Mr. Randall Brooks, Halifax Centre Secretary (82).

Topic: Randall brooks will be discussing "Why We Survived The Jupiter Effect".

Minutes of January Meeting

The January meeting began with the new President, Walter Zukauskas, thanking the outgoing Executive for their work in 1981. Before the main speaker was called on, the Observing Chairperson, Kathy Oakley, presented some notes on objects to be seen and details of the January observing session. The evening's topic discussed by Peter Edwards was Variable Speed Drives for Telescopes. Although most people who have no experience with electronics might have attended with apprehension, they need not have. Peter gave an excellant component by component description of the function of the electronics required to convert 120 AC or 12 DC voltage sources to a variable frequency signal suitable to drive a telescope. He pointed out the advantages of using IC's (integrated circuits) over transistors in such applications, what was actually required in the way of frequency of the signal and power requirements for the telescope. He demonstrated his version compared to a Celestron model. Although Peter's was assembled for about 1/3 the cost (excluding the test equipment required), it provided superior frequency stability and higher power output. Those who attended will certainly have a better idea of the purpose and funtioning of variable speed units. One or 2 may have been encouraged to build their own!

Randall Brooks

Minutes of February Meeting

The February lecture was given by Walter Zukauskas and the topic this time was How Large are Stars?. Walter began by demonstrating how the relative diameters of eclipsing binary stars are determined from light curves. He explained the physical relation of the stars' size and shape to the appearance of the light curve and how very close binaries distort their own shape as well as the shape of the light curve. These problems along with the fact that we may not accurately know the distance to the star system of course add some difficulty to star size determinations. With spectroscopic observations added, these can be overcome and the actual radii can be found in kilometers. For single stars in space other techniques are required and Walter discussed these in turn. These techniques included the Michelson interferometer used on the 100" at Mt. Wilson in 1920, the intensity interferometer of Hanbury Brown which could measure the size of only 32 stars, specle interferometry and the new French interferometer which may be capable of separations up to 300 m. and capable of measuring several hundred star diameters.

Randall Brooks

PLANETARIUM NOTICE

The Halifax Planetarium has an opening for a volunteer planetarium lecturer to provide popular evening shows to childrens' groups and families.

The planetarium is housed in the Sir James Dunn Building, Dalhousie University. No planetarium experience is necessary, but lecturers should be familiar with naked-eye sky features and enjoy talking about astronomy with people of all ages.

Training will be provided. Contact Debra Burleson at the N.S. Museum at 429-4610.

A NEW STAR ATLAS

Well, after many weeks my new star atlas has finally arrived. It's the SKY ATLAS 2000.0 by Wil Tirion and made to take us amateur observers into the 21st. century. I immediately set to work drawing in the constellations and their boundaries. While doing this I found a few mistakes because I am the type that uses a magnifying glass to check objects on the charts.

For those of you who have this atlas, the field or the desk edition here then are the objects that are not right or have not been color coded properly; Chart 1 lists M34 as a diffuse nebula but it is corrected on chart 4 while on charts 4 and 5 the object 1465 is a diffuse nebula and not a galaxy. Chart 7 has 5116 not colored in, chart 13 has M91 as 4548 and chart 14 has 4825 not colored in. On chart 18, 1515 is not colored in, chart 24 has 434 not colored in and charts 12 and 19 have 2289 as a galaxy - it is a diffuse nebula.

Those of you who are going to get this atlas can check and fix these objects up and look for others. To verify my findings I went through the Skalnate Pleso Atlas and 'A Field Guide To The Stars and Planets'.

I would highly recommend this atlas, especially the Deluxe Edition, which is what I have. Even though there are mistakes they can be disregarded. With the Deluxe Edition one gets a plastic overlay grid to accurately find objects on the charts which the field and desk editions don't have. All in all it is a fine sky atlas to buy. Don't forget to add 10% to the purchase price to cover the import duty. It can be purchased from Sky Publishing Corporation. For further information check the latest issues of 'Sky & Telescope'.

Michael Boschat

TREASURER'S REPORT FOR 1981-HALIFAX CENTRE

The Treasurer's Report for the Halifax Centre for the year 1981 was sent to the National Office in early January 1982 for inclusion in the April Supplement to the Journal. Here, in addition, I have also included the corresponding figures from the 1980 Treasurer's Report by Sherman Williams. Note that on item by item comparison of the two years will not always be valid since we seem to have put similar items under different headings.

There are a number of things to note:
a) In 1980 we had a surplus of $642.62, in 1981 we had a deficit of $359.25 - a difference of over $1000. While our expenses were indeed higher this year much of this difference is apparent, as noted below.
b) We had a very successful year of Handbook sales in 1981, although the report does not show it. (A net income of $500 would be more reasonable). Early in 1981 we paid over $300 in 1980 bills, and by late 1981 paid for 100 1982 Handbooks. This accounts for $600 of the difference between 1980 and 1981.
c) Life member grants of $76.80 for 1981 were included in last year's report. This accounts for another $150 difference between 1980 & 81.
d) We sent a representative to the General Assembly in Victoria this year, which cost about $300! Last year we hosted the GA and broke even.
e) Nova Notes was quite expensive this year due to purchase of supplies and increased mailing costs. Part of the increased cost is balanced by $150 in advertising revenue. The 1980 costs are very low - possibly postage is included under a different heading.
Outlook for 1982: Handbook sales seem to be going well, and our membership (69 as of Dec. 81) will probably rise to near 80. Postage has

increased for Nova Notes but the size has been reduced, and the Editor is keeping a close eye on the postmaster's scales. We hope to break even in this coming year.

Itemized Treasurer's Report:

REVENUE	1980	1981
Membership Fees	1684.00	1879.50
Life Members Grants	139.20	.00
Donations		.00
Educational Activities	200.00	.00
Interest & Dividends		.00
Sales of Handbooks, Net	184.75	153.61
Advertising		150.00
General Assembly	176.00	252.00
Miscellaneous	234.37	76.36
Total Revenue	2618.32	2565.01
EXPENDITURES		
Fees Remitted to N.O.	1250.40	1508.60
Library	56.90	86.07
Meetings and Newsletters	62.20	520.40
Annual Dinner, Net		2.65
General Assembly	175.14	477.00
Equipment & Supplies	30.00	20.67
Office Administration	209.74	105.42
General Expenses & Audit	53.85	16.60
Educational Activities		.00
Insurance		.00
Awards and Donations	17.47	95.46
Operating Expenses-Observ.		.00
Miscelaneous	120.00	91.39
Total Expenditures	1975.70	2924.26
Surplus on Operations	642.62	
or Deficit		359.25
Balance from 1979	352.79	
to 1980/31 Dec.		995.41
Balance from 1980	995.41	
to 1981/31 Dec.		636.16

11 January, 1982

Respectfully submitted, DALE ELLIS, Treasurer

DOWN (con't)

7) The NDP part of the raven.
9) One of the twins.
14) One of the two guardians of the pole.
17) The head of the ram.
19) Lies on the vane of the arrow in the archer's hand.
20) The "Wonderful".
21) Fourth magnitude star northwest from Alphecca.
25) The southern of the two stars flanking Altair.
26) Will be the pole star in 2000 years.
29) Brightest star in the Southern Triangle.
30) When Pluto was discovered near this bright star marking a twin's waist, they said "What's That".
32) Beta Leporis.
33) The beginning of the scorpion's tail.
34) Brightest member of the Summer Triangle.

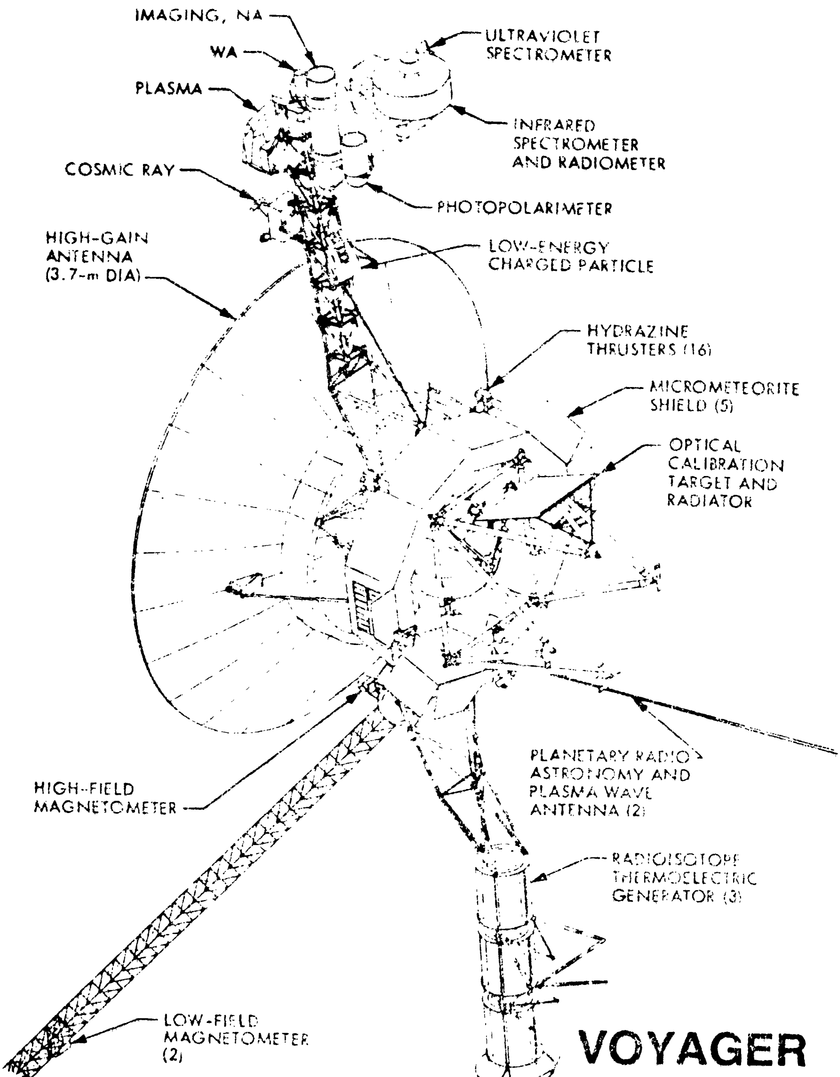
GEMINID METEOR SHOWER REPORT

Well, this years December Geminid meteor shower was much better than last years. On the night of the 12th./13th. a total of 55 were recorded between 0000 hours and 0400 hours UT. The night of the 13th./14th. was good also with 32 recorded between 0000 hours and 0500 hours UT.

Though the moon was near Gemini a few 2nd magnitude meteors were seen but most were between 5th. and 1st. magnitude. The ZHR increased as it got later, due to the fact that the Earth was moving headlong into the stream. So the Geminids made up for our loss of seeing the perseids; I hope you saw them.

If you need further information give me a call at 455-6047 after 5 PM. Good Observing!

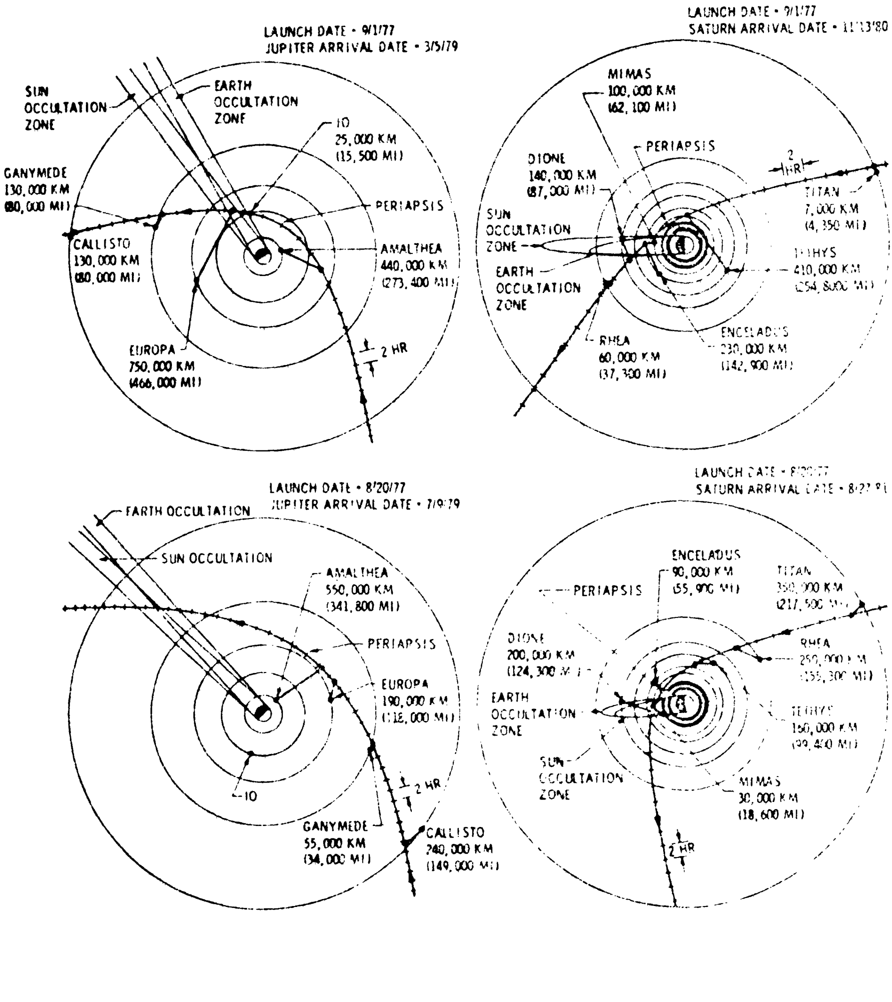
Michael Boschat



(SPACECRAFT SHOWN WITHOUT THERMAL BLANKETS FOR CLARITY)

VOYAGER

VOYAGER FLYBYS OF JUPITER AND SATURN



lated to tectonic activity and leaving an incredibly smooth surface encrusted in ice. Callisto and Ganymede, although also encrusted in ice like a dirty snowballs, show evidence of much cratering and some complicated geologic history.

Saturn's rings impressed us with their greater than expected complexity and extent including the radial spokes. The moons of Saturn turned out to be of many and varied shapes. Viewed by the Voyager space craft were Enceladus, Hyperion, Tethys and Iapetus. All showed cratered surfaces with signs of may powerful impacts and in a state of deep freeze. Saturn's largest moon, Titan, was obscured by dense cloud cover which seems to be permanent.

The challenge has been met. The scientific return has been immense and much information remains to be interpretet. What wonders still await us?

Peter Steffin

LAWS OF PLANETARY MOTION

Johannes Kepler (1571-1630) formulated three laws of planetary motion, which are:

1. The planets move in elliptical orbits, with the sun at one focus of the ellipse.

2. Their motion is such that the line from the sun to the planet sweeps out equal areas in equal times.

3. The period P is related to the semi-major axis by Kepler's Harmonic Law.

FOCUSING ON CONSTELLATIONS

MONOCEROS: The Unicorn.

This month's constellation feature is Monoceros, the Unicorn. Being so near to the magnificant Orion, and because the main stars of Monoceros (with the accent on the second syllable) are quite faint, this constellation is often overlooked, if not totally unknown by most amateurs. Monoceros is readily located, lying on the equator between the easily recognized Gemini, Canis Major, Canis Minor, and Orion. The Unicorn is not well defined because its brightest star, alpha, is only of magnitude 3.9; nevertheless, Monoceros contains several interesting objects that are accessible with a small telescope.

Beta is actually a true triple star system, and is rare because all three stars are very nearly of equal magnitude, being about 5. A and B have a separation of 7.4 seconds of arc, and C is 2.8 seconds of arc from B, thus forming a narrow triangle. All three stars appear white.

Monoceros also contains several interesting clusters and nebulae. M50, an open cluster, can be found approximately one-third of the way from Sirius to Procyon. This cluster is easily found with binoculars, and is a test for naked-eye observers under the very best of conditions. Toward the southern limit of this cluster one can see a red giant star which is easily contrasted to the numerous white and blue stars of the cluster.

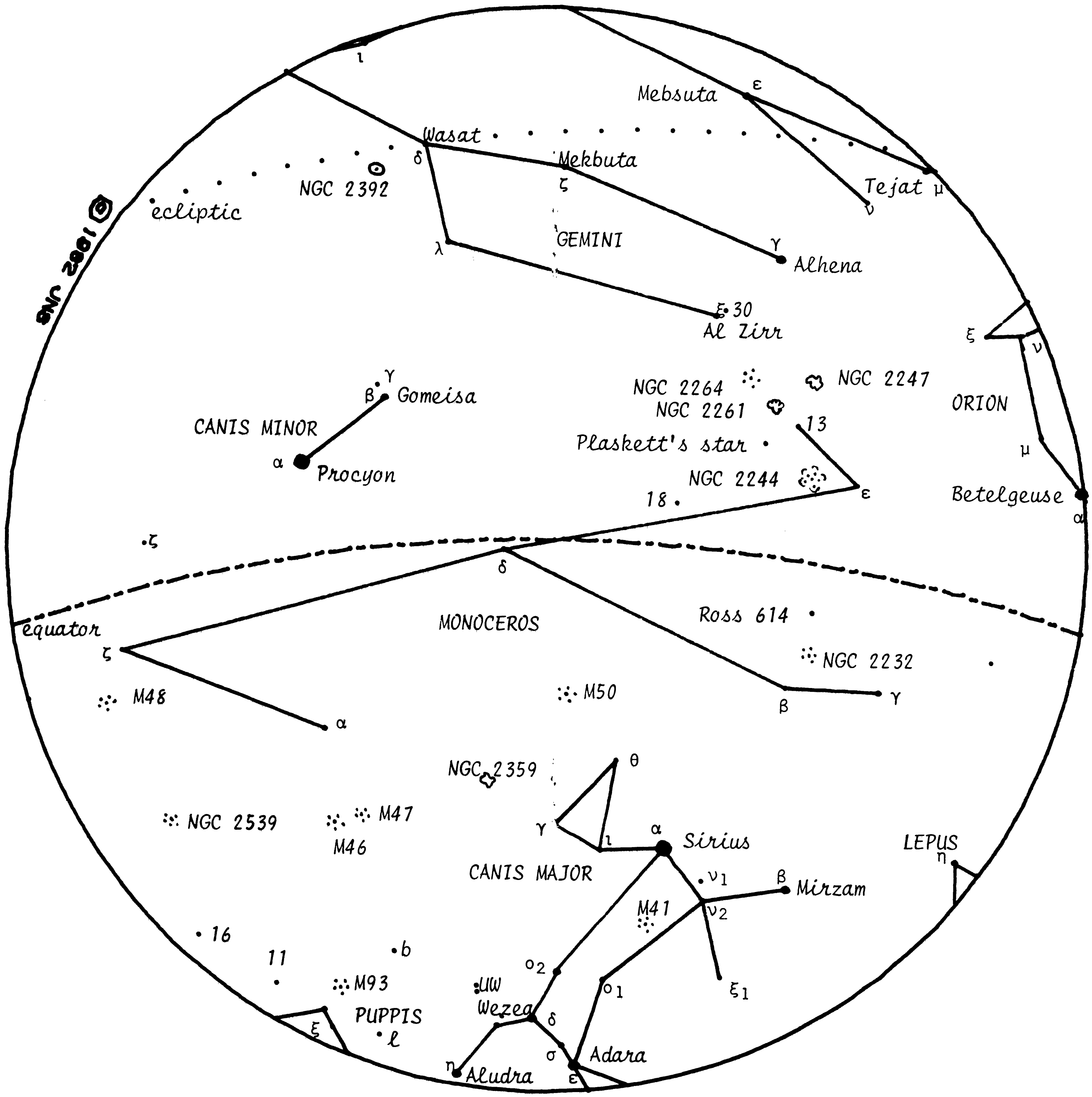
Also in Monoceros is the famous Rosette nebula with the open cluster NGC 2244 at its centre. The nebula is large (about 80 minutes of arc in diameter) and has several bright regions, four of which have their own NGC numbers. With good binoculars, one observer has described the nebula as "a formless aura of soft light encircling the star cluster".

An interesting "comet-shaped" nebula is NGC 2261, "Hubble's Variable Nebula", which surrounds the variable star R Monocerotis and was discovered by Sir William Herschel in 1783. The nebula overwhelms the light from the embedded star with its bright glow, making R Monocerotis difficult to observe. Hubble, in 1916, discovered that the nebula was variable, showing noticable changes in size, brightness, and structure from month to month, and even from night to night. This nebula might be an outlying member of the very large, scattered open cluster NGC 2264.

Several other star clusters and nebulae of interest are shown in the accompanying chart. Also shown are two binary star systems of opposite extremes of stellar mass. Plaskett's star (magnitude about 6), found in 1922 by J.S. Plaskett at Victoria's Dominion Astrophysical Observatory is thought to be the most massive pair of stars yet found in our Galaxy. With a period of 14.4 days, these two stars of between 40 and 60 solar masses each, orbit with an estimated separation of about 50 million miles, or just over one-half an astronomical unit (a.u.). The stars are too close together to be resolved with a telescope. The other interesting binary is Ross 614 (magnitude about 11). This faint pair is one of the 25 nearest stars, being 23rd, and having a distance of just over 4 parsecs. The two stars of the system are 0.14 and 0.08 of the mass of the sun, and orbit each other with a period of 16.5 years and an average separation of 3.9 a.u. Only one other visible star (Luyten 726-8 in Cetus, and sixth star from the sun) has a smaller mass than Ross 614B, being only half the mass. Ross 614B has a mass only about 80 times the mass of Jupiter, and being only 13.1 light years distant, has an absolute magnitude of 16.8. This makes it one of the intrinsically faintest stars known.

Norman Scrimger.

35 36



Mebsuta
Wasat
Mekbuta
NGC 2392
ecliptic
GEMINI
Alhena
Tejat
Al Zirr
30
NGC 2264
NGC 2247
NGC 2261
ORION
Gomeisa
CANIS MINOR
Procyon
13
Plaskett's star
NGC 2244
18
Betelgeuse
equator
MONOCEROS
Ross 614
NGC 2232
M48
M50
NGC 2359
NGC 2539
M47
M46
Sirius
LEPUS
CANIS MAJOR
Mirzam
M41
16
11
b
M93
UW
PUPPIS
Wezea
Adara
Aludra

HISTORY OF ASTRONOMY

GUO SHOUJING

This is perhaps the most famous of the great Chinese astronomers. He lived in the middle of the thirteenth century and into the early fourteenth century (1231-1316). At that time Ghengis Khan was the ruler of the young Yuan Dynasty of China. He was a Mongol and rode hard, pillaging and destroying everything. Young Guo, however, did manage to work in reclaiming agriculture from the deprivations of the horsemen and managed to design some irrigation projects. His education seemed to just come from his grandfather but even still he had a very curious mind. He worked on calendars and on timing devices. He saw a design for an ancient clepsydra, or water clock, and designed and built one himself. His greatest contribution, as far as we are concerned, is his designing and building of astronomical instruments. He built a rather massive equatorial mounting for his sighting tubes. This mounting is very similar to that of the Mount Wilson Observatory 100" telescope and with this he determined accurately the obliquity of the ecliptic. It is remarkable how much work can be done, of a basic nature, without optics but with just a good sighting tube and calibrated angles for Declination and Right Ascension. His notes and careful astronomical observations raise Guo to world standards. He has been recognized internationally by having a crator named after him on the far side of the moon.

translated by Mary Boyd, St. Mary's University

summarized by Murray Cunningham

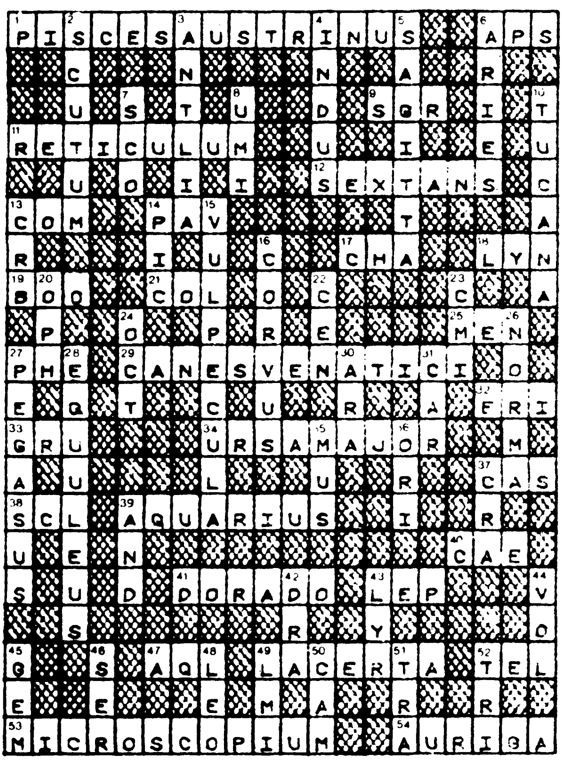
STAR GAZING

This is a reprint from the "American Association of Physics Teachers" Ontario Section Newsletter (Fall'81). The article was written by Doug Cunningham an R.A.S.C. member from Lion's Head, Ontario.

In all fields of human endeavour, achievement arises as the result of a conscious journey of the human spirit. For amateur astronomers this adventure of the spirit can crystallize in many ways - from the methodical sweeps of the dedicated comet hunter, through the journeys of the paripatetic astronomers as they chase grazes, eclipses, and asteroid occultations, to the systematic observing of variable stars and the careful observation and description of splendid deep sky objects. For one of our own AAPT-ONT members, Steve Dodson, this journey of the spirit involved the design and construction of one of the largest reflecting telescopes in Canada. Phoenix II, as it is called, uses a 22 inch f/7.4 primary mirror purchased from Gerard Pardeilhan of the San Francisco Sidewalk Astronomers. Steve's achievement results from his ingenious combination of a scaled up Poncet Platform with a large Dobsonian reflector and a trailer to produce a large mobile telescope with equatorial tracking capability. First sight of this 1500 lb. orange and blue cyclops leaves most amateur astronomers with their mouth agape and an incredible expression on their faces. When the telescope is directed toward the zenith and observers climb up the special giraffe chair to the eye piece they are 16 feet above the ground. And what of the views provided by this huge light bucket which collects 6000 times more light than the dark adapted human eye?.... well, Vega, the brightest star in the constellation Lyra, appears as brilliant as a welder's torch, spiral structure is observed in the famous Whirlpool Galaxy (M51), the huge globular cluster in Hercules (M13) is resolved to the core, and the Trifid Nebula (M20) in the constellation Sagittarius, revealed, besides a bulbous nebulous patch trisected with dark rifts of obscuring matter, colour contrasts and dark lanes in the reddish section. Steve's plans for the future involve refining and motorizing the tracking to develop full photographic capability.

submitted by Roy Bishop

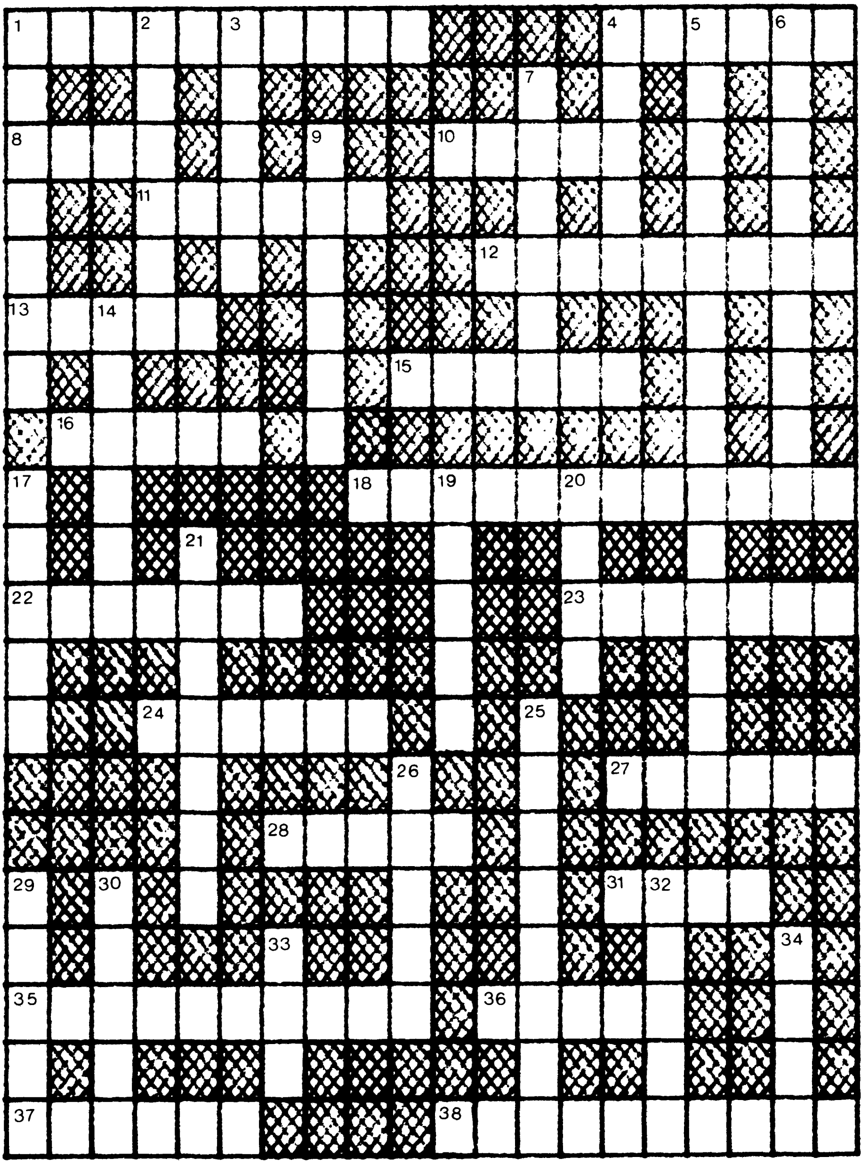
Answers to last issues Puzzle Corner!



PUZZLE CORNER

ASTRO CROSS WORDS

Laureen Burgoyne and Norman Scrimger



BRIGHT STAR NAMES

All answers in this puzzle are bright star names. While most of the forty names required are well known, some are more obscure and may involve a bit of searching. Answers in the next issue. Answers to the puzzle "The Constellations" are found in this issue.

ACROSS

1) The "Head of the Serpent Charmer".
4) The chained maiden's girdle.
8) The upper right hand corner of the chair.
10) Forms a fairly bright equilateral triangle with iota and delta Vel.
11) One of the stars along the river.
12) The "Neck of the Snake".
13) One foot of the Firebird.
15) Also called Deneb Kaitos of Cetus.
16) Sixteen across is a cross.
18) Between this star and Denebola is centred the great cluster of galaxies controlled by M87.
22) Occulted by Mars on April 7, 1976.
23) Diminutive form of the Latin "Rex" or "King".
24) Gamma Eridani.
27) Helps Shaula mark the scorpion's sting.
28) Theta Leonis.
31) Some say "enough" to part of the horse.
35) This name means "Head of the Kneeler".
36) The "Head of the Goat".
37) This star is guarded by Alschain and Tarazed.
38) The shoulders of the "Rein-holder".

DOWN

1) The Queen's knee.
2) A star half-way between M41 and pi Pup.
3) Forms a wide naked eye pair of 4½ degree separation with alpha Centauri.
4) One of the pointers.
5) One of our closest neighbours.
6) Named in honour of England's Charles II.

VOYAGER REPORT

Someone referred to the Voyager space program the other day and remarked how very disappointed he was that after two space craft (Voyager 1 & 2) having explored a significant area of the solar system, we should be left with so many unanswered questions. It was his impression that for all the technology invested and money spent we should by now have all the answers. Does it really matter that there are so many new and unanswered questions?

Man has gone into space to meet a challenge and seek an understanding. In many respects the Voyager program gave us that challenge and the fact that many new questions have arisen only makes it that much more interesting.

The Voyager space probes opened up whole new worlds to us. Astronomers had seen them before from afar, but now we have had close-up views that gave us so much detail that it is a whole new experience. From that very first historic encounter on 5 March, 1979 our ideas about Jupiter and eventually Saturn would change.

Both, Jupiter and Saturn became stars of the show. Each had many surprises and mysteries. Much has been added to our knowledge and all of it has been exciting. There were rings around Jupiter, its great "red spot" proved to be much more impressive than previously imagined and on the dark side lightning was seen within the swirling cloud patterns. Jupiter's four largest moons, Callisto, Europa, Ganymede and Io in particular proved to be as exciting as Jupiter itself. Io has active volcanoes that are constantly reshaping its surface. Europa's surface is laced with a remarcable pattern of linear features likely re-

PARSEC PERCEPTION

by

Roy L. Bishop

In his book *Man and the Stars* (Oxford 1978) Hanbury Brown, inventor of the stellar intensity interferometer, comments:

> Popular books on astronomy usually make a great song and dance about [the size of the universe], but I find it hard to believe that any of the recent increases in size have had much effect on our world view. Once a distance, or a time, becomes unimaginably large, it makes little difference how many noughts we add. For most people, the distance to the Sun is already unimaginable, and that has been known for centuries.

The distance to the Sun, the "astronomical unit" (AU), is a familiar quantity to astronomers, and causes about as much excitement as magnitude scales or precession corrections. Is Professor Brown right? Do most of us not appreciate the distance to the Sun? Is the AU really unimaginably large?

Legends tell us that native peoples measured distances by time and mode of travel: two moons by canoe, for example. Today we often use the same technique, and speak in terms of, for example, hours by automobile. This method gives distance an immediate, tangible meaning, and can be applied in an attempt to bring the AU into the realm of the imaginable.

The highest speed of travel with which many of us have direct experience is that of commercial jet aircraft. At 900 km/h, trips that require several long days by car can be covered in a few hours. Casting aside difficulties such as air, fuel, food, gravitation, radiation, and air fare, how much time would be required for a real SUN-FLIGHT via Air Canada? A moment with a pocket calculator gives the answer: flying 24 hours per day, 7 days per week, one AU would require 19 years, nearly a human generation.

Although this example brings the AU within the bounds of the imaginable, an extension to the Solar System as a whole is less meaningful. e.g. An Earth-Neptune flight would require more than 5 centuries, a time far outside ordinary experience. Had Columbus left by jet for Neptune, he would not yet be there.

If distances within our little Solar System strain comprehension, what then of interstellar space (not to mention intergalactic space)? The novelist Arthur C. Clarke has stated bluntly:

> Even today, many otherwise educated men--like those savages who can count to three but lump together all numbers beyond four--cannot grasp the profound distinction between *solar* and *stellar* space.

An extension of our jet plane trip to Alpha Centauri, the nearest star system to ours and a mere parsec or so away, is meaningless. Such a trip would require 5 million years, a time far longer than *Homo sapiens* has existed. Even the Pioneer and Voyager spacecraft, now plunging away from us at a dozen or more kilometres every second, will require a thousand centuries to traverse the same distance.

However, a meaningful way to contrast solar and stellar space is available in a scale model. Letting the period at the end of the previous sentence represent Earth, a ping-pong ball across the room becomes our Sun (One AU, the 19-year plane flight, is about 4 metres on this scale). The next nearest star would then be a second ping-pong ball 1100 km away, as far as Ontario is from Nova Scotia. In this model, our Moon is a speck barely one centimetre from the dot representing Earth. During the Apollo moon flights I recall a television announcer solemnly declaring: "Man has now entered deep space".

The Search For A Theory To Obtain A Complete Understanding Of The Universe; Why It Is As It Is And Why It Exists At All.

Scientists are presently engaged in a search for a theory that will unite the two branches of physics that have been at odds with one another for half a century: quantum mechanics, which describes the behavior of matter at the atomic level and general relativity, which explains the operation of the universe as a whole. To date, the best scientific minds have been unable to solve this dilemma but there may be a theory within black holes. Theoretical Physicist, Stephen Hawking believes that black holes can help because all the interactions of matter and all the forces that control them lay within the black hole. It took a long time to get to this stage with some very important contributions along the way. A new theory may give us the answer and still pose new questions.

The originator of the quantum theory was physicist Max Planck. He made the revolutionary discovery that matter does not radiate energy continuously, as had previously been thought by physicists, but rather in small discreet amounts which he called "quanta". Development of this theory helped him to come upon one of the greatest scientific discoveries of modern times, that of the universal constant of nature, which came to be known as Planck's Constant.

Until 1901 light in all forms had been thought to consist of waves. Certain deviations from the wave theory of light on the part of radiations emitted by black objects led Planck to the conclusion that these radiations were emitted in discreet units of energy, called quanta. This conclusion was the first enunciation of the quantum theory.

According to Planck the energy of a quantum of light is equal to the frequency of the light multiplied by Planck's constant. The original Planck theory has since had abundant experimental verification and the growth of his quantum theory has brought about a fundamental change in the physicist's concept of light and matter, both of which are now thought to combine the properties of waves and particles. Thus Planck's constant has become as important to the investigation of particles of matter as to quanta of light, now called photons.

Planck's discoveries founded an entirely new department of physics, known as quantum mechanics. Advances in physics were not to end there because in 1905 the theory was extended by Albert Einstein, who at the age of twenty-six published a paper on the "Special Theory of Relativity" which appeared in the scientific journal, 'Annalen der Physik' and offered an explanation of the photoelectric effect (the emission of electrons from metal surfaces exposed to light). Theoretically this study represented the cornerstone of the quantum theory and practically, it made possible many great inventions, including television and all automation systems.

In 1915 Albert Einstein published his paper "General Theory of Relativity", in which he developed a revolutionary concept of gravitation. This work which vastly extended the scope of the special theory of relativity, held that the forces of gravity and of inertia are equivalent and led to several astronomical predictions. Since 1915 the theory of relativity has undergone much development and expansion by Einstein and other scientists.

Much of this work has been devoted to an effort to extend the theory of relativity to include electromagnetic phenomena. These efforts have been marked thus far by much less success than that obtained by the theories of special and general relativity. No complete development of this application of the theory has yet been generally accepted by scientists. Albert Einstein's long quest for such a synthesis ended a few months before his death with the completion of a set of simplified formulas which were published posthumously in 1956. These formulas failed, however, to provide predictions that may be compared with the results of observations. His work on a unified field theory represented the affirmation of his philosophic belief in a well-ordered universe, in which individual events may be predicted according to immutable laws of cause and effect.

Stephen Hawking, at England's Cambridge University, may hold the key that will give us this major breakthrough. He has established himself as one of the foremost scientific theorists of the century with three major discoveries to his credit, each of which has changed the the course of physics. In 1974 he showed that tiny black holes could emit radiation. A black hole lives most of its life as an ordinary star, withstanding a tug-of-war between the powerful outward force of its heat and radiation and the strong inward thrust of gravity. When the star's nuclear fuel is spent, it dies , collapsing under its own weight to a point where gravity is so strong that not even light can escape. It is there in the black hole, which defies all the laws of physics, that Hawking hopes to unify the most important theories of twentieth century physics: Planck's quantum theory and Einstein's theory of general relativity.

Hawking became convinced that he was on the right track because black holes, a creation of general relativity, could emit particles under the right conditions when applied to the quantum theory. In essence, he declares that space is active and cluttered. Pairs of elementary particles like electrons and their antimatter opposites, positrons, spontaneously come into being and exist for a fraction of a second before uniting and cancelling each other out. He believes that the energy for this creation and annihilation could come from a gravitational field nearby. If some event of this kind were to occur near the edge of a black hole, the event horizon, one of the particles might end up down in the black hole and never seen again. The other particle theoretically could escape. To an observer, it would appear that the particle had been ejected by the black hole. The energy required for these escaping particles could eventually exhaust the black hole.

Although at first very sceptical, many physicists have given Hawking's theory much support. Even if his "unified theory" proves to be correct, it will not be the end of the field of theoretical physics. As Hawking himself says "You've got to be prepared to step outside the currently accepted ideas, out of the mainstream but you've also got to know which way to step."

Peter Steffin

There is an ecellent and very readable article on Stephen Hawking in 'SCIENCE 81' for Nov. 81. This article gives a background to the physicist and more detail on his theories. There is also much information available on Einstein and Planck in physic text books, biographies and encyclopedias.

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