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Astronaut Alan Bean in conversation with Sri Lanka Prime Minister

Vol. 4 No. 1 1976

THE JOURNAL OF THE CEYLON ASTRONOMICAL ASSOCIATION

Price Rs. 3

The Sri Lanka Astronomical Association

Objects : The Sri Lanka Astronomical Association was founded in June 1959, with the following aims and objects :

(*a*) to promote the science of astronomy and all branches of astronomical study and research.

(*b*) to promote the association of observers, especially naked-eye observers and possessors of small telescopes, for mutual help, their organisation in the work of astronomical observation and the encouragement of a popular interest in astronomy.

Membership : Open to all people interested in astronomy . Application forms for membership may be had from the Secretarial Address, 29, Moor Road, Colombo 6, Telephone 84597. Applications must be signed by two members proposer and seconder, to one of whom the applicant must be personally known. An applicant unknown to any member must be recommended by two resident householders to whom the member is personally known.

Entrance Fee : Two rupees and fifty cents.

Annual Subscription : (Due on August 1) Ten Rupees. A member who is aged twenty years or less on his last birthday preceding August 1 will have the option of paying, Five Rupees. All cheques and Postal and Money be Orders are to made payable to the ' Ceylon Astronomical Association '. Cash should be paid to the Treasurer or Secretary.

Meetings : The meetings of the Association are usually held at the Lincoln Auditotium U.S.I.S., A.A.C. Building, Galle Face, Colombo, at 6.30 p.m., on the last Friday in each month. Calendars of Meetings are circularised at the begining of each year.

Note to prospective contributors to the Journal : In addition to domestic matters of the Association, news and notes of observations contributed mainly by amateur astronomers, the Editor also welcomes articles suitable for the non-specialist on particular topics. Contributions may be on Astronomy or any other related subject. Whilst welcoming congributions from any part of the World the Editor would be particularly pleased to have contributions from Ceylon and countries of the equatorial region. The languages of the Journal for the present would be English and Sinhala. Within these limits the Editor is always glad to hear from prospective contributors to Equatorial.

Manuscripts must preferably be type written and all line drawings must be in Indian ink, shaded drawings of planets or lunar formations can be included if they have sufficient contrast in them. The U.T., instrumental details and sky conditions must be clearly indicated in all cases where they would be relevant.

THE SRI LANKA ASTRONOMICAL ASSOCIATION
COUNCIL 1975/1976

Equatorial A Jouanal of Astronomy & Related Sciences Vol. 4 No. 1 1976

CONTENTS

Cover Picture

The Cover picture shows Apollo Astronaut Captain Alan Bean the fourth human being to set foot on the surface of the Moon, in conversation with the Sri Lanka Prime Minister Mrs. Sirimavo Bandaranaike. Captain Bean presented the Prime Minister a model of the space shuttle with complements from (N. A. S. A.) the Shuttle would be operative by the year 1980. Astronaut Bean said that the prospects are favourable for Sri Lanka Astronomers to travel aboard the Shuttle to conduct their own experiments in Outer Space.

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The Exhibition and Seminar on Astronomy and Space Exploration

held in March 1976 with Apollo Astronaut Captain Alan Bean as Chief Guest of Honour.

At 5.30 p.m. on Monday 1st March 1976, the current President of the Sri Lanka Astronomical Association, Fr. Mervyn Fernando welcomed the Honourable Speaker of the National State Assembly, Mr. Stanley Tillekeratne at the Sri Lanka Foundation Institute, amidst the Council members of the Association and other special invitees. Earlier during the day Astronaut Bean the fourth human to set foot on the moon had called on the Sri Lanka Prime Minister, Mrs. Sirimavo Bandaranaike and presented her a model of the proposed orbiting space shuttle with the compliments of N.A.S.A. Among those present was Captain Alan Bean, Astronaut, the Guest of Honour of the occasion. This marked the beginning of the very first Exhibition on Astronomy and Space Exploration organised by our Association with the assistance of the U.S. Information Service.

The idea of an Exhibition had been mooted the previous year and steps were taken to contact Observatories and Astronomical Institutions abroad for material—photographs, posters, models etc.,—to complement the exhibits that would be produced by the members of our Association. We sought the help of the USIS, which had always been a good friend, to make a request to NASA to send out an Astronaut as well as the mobile "Treasures of Space" Exhibition. The then Director of the USIS, Mr. Briggs, and his staff spared no pains to push NASA to accede to this request. The coincidental visit of our past President, Mr. Herschel Gunawardene, to the U.S. enabled him to plead our case there at the same time. The end result was that NASA sent both Astronaut Alan Bean and "Treasures of Space" exhibit to Sri Lanka sooner than we expected. Consequently the Association had to abandon many of its plans for exhibits to be made by its own membership, and hurriedly organise the exhibition with the NASA package constituting the bulk of the exhibition.

After the formal opening of the Exhibition by the Honourable Speaker, he was shown round by the President and Astronaut Alan Bean, with the other guests following. Having viewed the Exhibition all assembled in the Conference Hall for the talk by Astronaut Bean on "Resource Observations from Space, and the benefits to Developing Countries". The Speaker was introduced by the President and the vote of thanks at the end was made by the Patron of our Association, Mr. Arthur C. Clarke. Two of the most recent films of the USIS on Astronomy were screened for the conclusion of the evening's program.

The Seminar on "Uses of Astronomy and Space Exploration in a Developing Country", which was organised in connection with the Exhibition in collaboration with the Sri Lanka Association for the Advancement of Science commenced on the following day, Tuesday, 2nd March at 8.45 a.m. with a welcome address by the President of the Astronomical Association, followed by Astronaut Bean's Keynote address on "Benefits of Space Exploration for Socio-Economic Development". A comment on this address was made by Mr. Arthur C. Clarke. Subsequently four speakers dwelt on special projects in Sri Lanka viz. "The Padukka Satellite Telecommunication Station" by Mr. F. V. V. Watson, "Detection of Earth Resources in Sri Lanka by Satellite Photography" by Mr. D. B. Pattiarachchi, "The Landsat Project" by Mr. S. D. F. C. Nanayakkara and "Prospects for Astronomical Activity in Sri Lanka" by Mr. Herschel Gunawardene. Variety was added by the screening of a film on Sky Lab II in which Astronaut Bean himself "performed", and another on Planet Probes. Several questions were addressed to the speakers by the participants during the discussion period. The summing up and conclusion was done by Mr. Justin Samarasekera, President of the Sri Lanka Association for the Advancement of Science.

Captain Alan Bean in his address highlighted the importance of the Space Shuttle programme. He said that many experiments that could not be carried out by ordinary satellites, could easily be performed using the shuttle. He said that the assembly and repairing of orbital space stations and the placing of multiple satellites in orbit, with one single launch, would be some of the unique functions of the shuttle. Captain Bean said that many types of Astronomical observations that could not be done from the surface of the Earth could be performed using the space shuttle. He said that before long Sri Lanka Astronomers too would be able to use the shuttle for their Astronomical Observations.

Of the 400 participants in the Seminar about 300 were Science Teachers of Secondary Schools in the Colombo area, who had been invited to attend it by the Department of Education.

Reports of the Exhibition and Seminar in the local Press provoked many inquiries about the activities of the Association.

Sri Lanka Astronomical Association Summaries of Meetings

Meeting of 30th November, 1973.

Chairman: Mr. Arthur C. Clarke.
Secretary: Mr. W. S. Goonawardena.

This meeting was held at the U.S.I.S. Lincoln Auditorium, Galle Face Colombo. After confirmation of the minutes of the previous meeting, the Chairman invited Rev. W. J. T. Small to speak on Comet Kohutek. Rev. Small said that some members of the Galle Astronomical Association, had made several sightings of the Comet. During the discussion, Mr. K.U. Ratnatunge gave a predicted ephemeris for the Comet till February 1974. The Chairman, Mr.Clarke, next gave his impressions of the Total Solar Eclipse, of 30th June, 1973, which he said he had the good fortune of observing from the Eclipse Cruise Ship 'Cunard Adventurer'. Mr. Clarke showed colour slides that he had made of the Eclipse. Mr. Clarke said that there were several thousand persons on board this ship, and it was a good effort to popularize Science, by means of this eclipse. Answering questions Mr. Clarke said that it was sometimes difficult to take good pictures of the eclipse, due to the swaying of the ship. He also said that although the sky was not completely dark during totality, yet many first magnitude stars like Rigel and Betelgeuse could be seen during totality. Two science report films on Solar Eclipse were also screened.

Mr. Herschel Gunawardena next read a brief paper entitled 'The Protection of Aluminised and Silvered Mirror Surfaces', in which he gave hints on how members could by taking more care to protect these surfaces, greatly prolong the life of coatings (see Equatorial Vol. 3, No. 5, 1975). After the screening of the film entitled 'Communications Explosion', by courtesy of the U.S.-I.S. the meeting was terminated by the Chairman.

Meeting of 25th January, 1974.

Chairman: Mr. Herschel Gunawardena.
Secretary: Mr. W. S. Goonawardena.

After confirmation of the minutes of the previous meeting, the Chairman invited members to speak on their recent Astronomical Observations. Mr. K. U. Ratnatunge spoke on the near occultation of Saturn, which was due to take place on 3rd February 1974. Dr. Abraham Kovoor mentioned about a S.L.B.C. programme, which mentioned about a Ceylonese Astrologer who he said had predicted the appearance of a Comet in 1973. He said that Comets are discovered every year and that the particular Astrologer could not lay claims to Comet Kohutek. He said that such programmes are misleading, and urged the Association to rectify future errors from these broadcasts. The Chairman next gave a briefing

about the latest position with regard to the Colombo Planetarium. He said that at present the Planetarium only catered for school children. Although it had commenced highly successful public presentations some time back, yet these had been discontinued lately. The Chairman urged that these public presentations be restarted as early as possible.

Mr. Arthur C. Clarke next briefly addressed the Association on the latest U.S. Space Projects. He mentioned about the Sky lab programme, and said that the Skylab Astronauts would have a unique opportunity of having some of the best views of Comet Kohutek. He also mentioned about Mariner 10 launched on November 3rd, 1973. He said that this would doubtless yield much new information concerning this Planet.

Meeting of 29th March, 1974.

Chairman: Fr. Mervyn Fernando.
Secretary: Mr. W. S. Goonawardena.

This meeting was held at the U.S.I.S., Lincoln Auditorium, Galle Face Colombo. After the confirmation of the minutes of the previous meeting, the Secretary read out a letter which he had received from Dr. Asoka Mendis, University of California, San Diego, in which he described Comet Kohoutek. He said that although the Comet did not prove to be a spectacular sight as was expected, yet astronomers had gathered a lot of physical data about its structure as it approached the Sun. He had said that these observations would be evaluated for a number of months, and many new facts concerning the Comet's large tail and its interaction with the Solar wind would be forthcoming. There was then a lively discussion about Comets in general. A film concerning mission Skylab was also screened.

Meeting of 24th May, 1974.

Chairman: Mr. Herschel Gunawardena.
Secretary: Mr. W. S. Goonewardena.

This meeting was held at the lecture hall of the 'Family Services Institute', Galle Road, Colombo 4. After the reading and confirming of the minutes of the meeting held on 29th March, 1974, the Chairman requested Mr. Eric Rajapakse to address the meeting. Mr. Rajapakse then formerly presented an eight and half inch reflector telescope to the Association. The President thanked Mr. Rajapakse for his generous gift. Members next proceeded to discuss 'Sky News', Mr. K.U. Ratnatunge reminded members of the partial eclipse of the Moon, which was to take place shortly. Mr. Arthur Clarke next addressed the meeting on the N.A.S.A., ATSF satellite, which was to be launched on 30th May. He said that it would have a 30ft. diameter dish, and would be initially placed over a stationary point in the U.S.A. after a careful check out and testing, of all the systems it would be placed over a stationary point in East Africa, from where it could provide educational television programmes to the Indian Sub Continent. He said that with a proper set of equipment, Ceylon too could receive these pictures very easily.

Mr. Herschel Gunawardena next spoke about his recent visit to Europe. He said that he had attended meetings of both the British Astronomical Association and the Royal Astronomical Association in London. At these meetings he had given a short account of Astronomical activities in Sri Lanka. The Presidents of these institutions had requested him to send their greetings and good wishes to the S.L.A.A. Mr. Gunawardena also said that he had visited several observatories in Europe and U.K. chief among which were a visit to Mr. Horace E. Dall's private observatory in Luton, Bedfordshire, which contains a 16 inch Dall/Kirkham type of reflector. Mr. Gunawardena also said that he had the good fortune of visiting the Royal Observatory at Hertmonceux, in the south of England. He said that he was also able to see the 98 inch Isaac Newton telescope, which had been recently completed. After a general discussion, the meeting was called to a close by the Chairman.

Meeting of 5th July, 1974.

Chairman: Mr. Herschel Gunawardena.
Secretary: Mr. W. S. Goonawardena.

After confirmation of the minutes of the previous general meeting, the Chairman re-

quested members to report concerning any observations they might have made during the past month. There was some discussion concerning the recent eclipse of the moon. The Chairman mentioned that Rev. W. J. T Small, a keen observer, had gone to the United Kingdom on holiday. He paid a tribute to Rev. Small's observations, in spite of his advanced age of over 90 years. He next invited Dr. Osmund Jayaratne of the University of Sri Lanka, Colombo Campus, to address the meeting on the subject of 'cloud forms and their behaviour'. Dr. Jayaratne gave a brief introduction about cloud classification and described the various heights at which different kinds of cloud occurred. He mentioned about methods employed by meteorologists in forcasting weather, and said that orbiting satellites would play a vital role in forecasting in the future. Dr. Jayaratne next went on to describe about the different techniques in the production of artificial rain. After an interesting discussion on the relationship between Astronomy and clear skies, Dr. Abraham Kovoor, proposed a vote of thanks to the speaker, for his most lucid and interesting talk. The meeting was then called to a close by the Chairman.

Meeting of 8th August, 1974

Chairman: Mr. Herschel Gunawardena.
Secretary: Mr. W. S. Goonawardena

The minutes of the previous meeting held on the 5th July, 1974 were read and confirmed. The Chairman invited Dr. D. A. Mendis, associate Professor of Physics, of the University of California, San Diego, to address the meeting on the subject of "The Origin and Evolution of the Solar System". Dr. Mendis explained how the Solar System might have been formed from the material of the interplanetary plasma. He said that the discrepency concerning the distribution of angular momentum could be well explained by this theory. He said that phenomena such as Asteroids and the rings of Saturn could be explained by a process of condensation of the plasma cloud. A process of pure agglomeration alone was not sufficient to account for these manifestations. He said that agglomeration represented a much later stage in planetary evolution, and said that plasma condensation should come first. After an interesting discussion on the subject of planetary evolution, the meeting was adjourned by the Chairman.

Meeting of 13th December, 1974

Chairman: Fr. A. S. Mervyn Fernando.
Secretary: Mr. W. S. Goonawardena.

This meeting was held at the Family Services Institute, 188, Galle Road, Colombo 4. The Chairman invited a discussion on the subject of the total Lunar eclipse, which took place on 29th November, 1974. Messers Herschel Gunawardena, K. U. Ratnatunge Rex I. De Silva and the Chairman, described their observations. The Chairman referred to several sudden changes of colour during the eclipse. Mr. Herschel Gunawardena said that it was one of the best lunar eclipses seen in recent times, and fully agreed with the President Fr. Mervyn Fernando. Mr. Rex I. De Silva, said that he was planning to time the occultation of two fifth magnitude stars by the moon during the eclipse, but said that owing to the cloudy nature of the sky, he was only able to observe the reappearance events.

The Chairman next briefly addressed the meeting, on some forthcoming events, to popularize astronomy. He said that he was going to organise an Astronomy youth camp where lectures, instruction and observation would play a major part. It was to be organised by the SLAA and was to be held at St. Peter's College, Colombo. He also said that "An Astronomy Exhibition" was also being planned, but a definite date has still to be fixed for this event. A provisional exhibition committee was also appointed at this meeting, and members were urged to construct or assemble as many exhibits as were possible, to make this event a success. A film entitled "The Domes of Cerro Tololo" depicting Astronomical Observatories in Chile was next screened, after which the meeting was terminated by the Chairman.

Meeting of 21st March, 1975.

Chairman: Fr. A. S. Mervyn Fernando.
Secretary: Mr. W. S. Goonawardena.

A Meeting of the association was held on 21st March, 1975. After confirmation of minutes of a meeting held on 6th February, 1975, the Chairman invited members to report on any observations they have carried out during the month. Mr. Rex I. De Silva then addressed the meeting concerning some observations he had carried out on 'Lunar Occultations'. He said that lunar occultations of stars were the easiest occultations to observe, due to the Moon lying close to the Earth, and also because of its quicker movement across the ecliptic. Planetary occultations were more difficult to observe. An accurate stopwatch was an essential requirement in carrying out these observations. He said that observations should be carried out systematically over a long period of time, in fact over several years, to get best results. He described the method of observing the disappearance and reappearance phenomena and said that normally predictions were given with respect to the dark limb of the moon. He next enumerated the procedure in reporting these observations. After an interesting discussion on the subject of occultations and the screening of two astronomical films, the meeting was adjourned by the Chairman.

Meeting of 29th April, 1975

Chairman: Fr. A. S. Mervyn Fernando.
Secretary: Mr. W. S. Goonawardena.

After the usual confirmation of minutes of the previous meeting, the Chairman invited Mr. Arthur C. Clarke, to address the meeting on the following subjects: The first Indian satellite Aryabhata, launched by (ISRO) and USSR collaboration; The A.T.S. 6 Television Satellite; and the Apollo Soyuz Test Project (ASTP).

Mr. Clarke said that the A.T.S. 6 satellite was already in geocentric orbit over the U.S.A. and would be pushed in stages towards a stationary point over East Africa, (Lake Victoria) from where it would transmit educational T.V. programmes to India. Regarding the Apollo Soyuz Project, he said that American astronauts and Soviet cosmonauts would meet and dock together in outer space, and carry out joint scientific experiments. After the screening of two science report films, on Jupiter and Mars, the meeting was brought to a close by the Chairman.

Meeting of 10th June, 1975

Chairman: Fr. A. S. Mervyn Fernando
Secretary: Mr. W. S. Goonawardena.

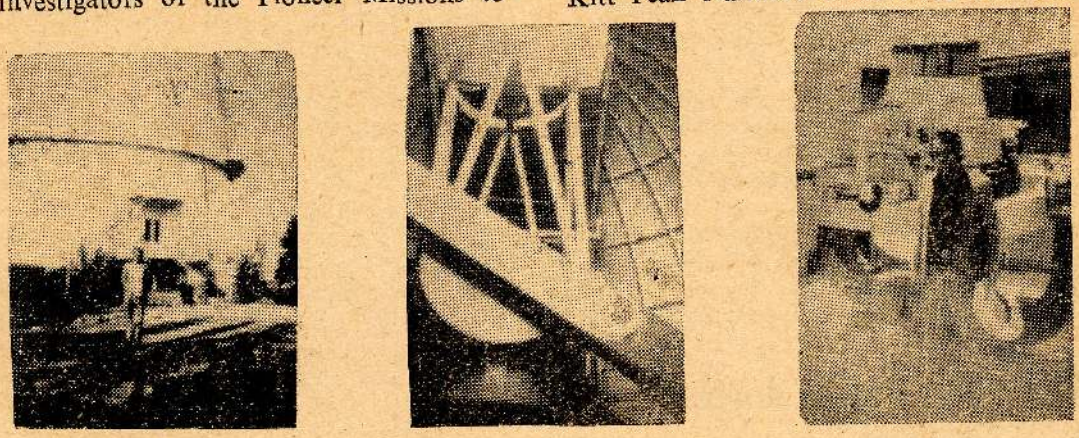
With the commencement of the meeting, the Chairman invited members to report on sky news and observations. Mr. Rex I. De Silva said that with the aid of binoculars, he had recently spotted both Uranus and Neptune. The Chairman next briefly addressed the meeting on the proposed exhibition and said that in response to his communications several astronomical institutions had sent photographs and publications, which he said were of high educational value. He appealed to members to build models and exhibits, and said that in spite of several appeals made by the Secretary, the response was poor in this direction. The Chairman next invited Mr. Vital Subramaniam to talk on the subject of Astronomy in Air Navigation. Mr. Subramaniam said that in spite of the latest Dopplar instruments and computers on board the latest aircraft, a knowledge concerning stars and their positions was very essential for safe air navigation, and added that with a knowledge of the stars, man is never 'lost in the sky! Tracing the history of navigation by the stars, he said that ancient Arabs and Polenesians seem to have used this method very effectively for navigation in the high seas. He next described the technical aspects of air navigation, and described the various navigational instruments in modern aircrafts, and the methods of fixing points of co-ordinates, using such instruments. The Chairman thanked the Speaker for the excellent address and expressed the hope that the speaker would give further talks in this field, so that members may have a better understanding concerning the celestial sphere and the phenomena concerning the movement of stars. The meeting was then terminated by the Chairman.

Meeting of 31st July, 1975

Chairman: Fr. A. S. Mervyn Fernando.
Secretary: Mr. W. S. Goonawardena.

This meeting was held at the U.S. Information Service auditorium in Colombo. After the reading and confirmation of the minutes of the previous general meeting, the Chairman invited Mr. Herschel Gunawardena to address the meeting on the recent conference concerning planet Jupiter. In introducing the speaker the Chairman said that Mr. Gunawardena was invited to attend an International Conference on planet Jupiter, sponsored by N.A.S.A. and NSF. Mr. Herschel Gunawardena said that this conference was held at the University of Arizona in Tuscon. He said that this was a conference summoned by the principal investigators of the Pioneer Missions to planet Jupiter. All the leading Solar System astronomers attended this conference. Famous astronomers such as James Van Allen, Carl Sagen, Thomas Gold and Prof. W. H. McCrea attended this meeting. Mr. Gunawardena showed a number of colour slides of planet Jupiter, taken by the Imaging Photopolarimeter, mounted on board the Pioneer spacecraft. He said that the new view of planet Jupiter was that it was a body composed mainly of Hydrogen in its various states, with a little amount of Helium with a very small solid core. It had an internally driven meteorology with a swirling cloud system, with spaces in between which were the belts.

The Red Spot was a great hurricane or vortex. The many changes visible from the Earth were mainly due to the rapid rotation of the planet, combined with the rising high energy gases from the inside. He said that Jupiter had a magnetic field which was thousands of times stronger than that of the Earth and with powerful radiation belts. After the conference Mr. Gunawardena said that he visited the N.A.S.A. Ames Research centre, Moffet field, California, the control centre for Pioneer. Later on invitation he visited and had discussions with Dr. George B. Field, Director of the Smithsonian Astrophysical Observatory and the Harvard College Observatory. While in the U.S. he said that he also had the good fortune of visiting the Kitt Peak National Observatory and saw the 158 inch reflector and the great solar telescope. He also visited the Lowell Observatory, and the International Planetary Patrol Center and had discussions with its Director Dr. Baum. At the University of Arizona Campus he visited the Optical Sciences Center which had some of the largest optical workshops in the world. This workshop had facilities to handle mirrors up to 300 inches in diameter and is currently finishing six 72 inch mirrors for the Smithsonian Multi Mirror Telescope (MMT) which will have six 72 inch mirrors mounted in a hexagonal array around a common core.



(a) (b) (c)

Some pictures of the Editor's tour of U. S. observatories in 1975. a) Shows the dome of the historic Lovell observatory b) The telescope and mounting of the famous Catlina Planetary telescope on mount Lemmon c) The Editor is seen besides the Baker-Nunn Camera on top of Mt Hopkins Arizona, this facility is maintained by the Smithsonian Astrophysical observatory.

Among the other institutions and observatories he visited included the 60 inch Catalina Planetary telescope on Mount Lemmon and the Smithsonian complex at Mount Hamilton, Arizona. Mr. Gunawardena showed slides that he had made of these observatories. He said that all these visits and the people he had met, would no doubt help to foster development of Astronomy in Sri Lanka, with the help and collaboration from the United States astronomers. After this talk there was an interesting discussion about planet Jupiter. Mr. Gunawardena answered a number of interesting questions from the audience. Next the film "Jupiter Odyssey", which describes the Pioneer missions to Jupiter was screened, after which the meeting was terminated by the Chairman.

Meeting of 6th February, 1976

Chairman: Fr. A. S. Mervyn Fernando.
Secretary: Mr. W. S. Goonawardena.

The minutes of the previous meeting were read and confirmed. The Chairman invited Mr. Arthur C. Clarke, to briefly speak about the Apollo Soyuz Test Project (ASTP). He said that this was a joint endeavour of the United States and the Soviet Union, and said that the experiment would attempt to rendezvous and dock a manned Apollo spacecraft with a manned Soyuz spacecraft. He also mentioned about the first Earth satellite tracking station, which was now nearing completion at Padukka.

The Chairman next invited Dr. M. L. T. Kannangara, of the Department of Physics, University of Sri Lanka (Colombo campus) to address the meeting on the subject of "The Earth's Magnetosphere". Dr. Kannangara traced the magnetic studies that are being conducted around the Earth, and spoke about the magnetic changes that took place as one moved away from the surface of the Earth. He spoke about the Van Allan radiation belts, and explained the interaction between the Earth's magnetic forces and those of the Solar Wind. He spoke of the magnetic fluctuations during day and night and described his studies concerning Geomagnetic Micro pulsations as observed from Sri Lanka. He said that Sri Lanka being in the geomagnetic equator some important research could be carried out from this region. He summarised the various characterists of the Micro pulsations events that have been observed from Sri Lanka. Mr. Herschel Gunawardena, next showed the meeting some slides of observatories and instruments that he had photographed during some visits abroad. The meeting was then called to a close by the Chairman.

The Giant Planet Jupiter

by Dr. Tom Gehrels*

A "Pioneer" Spacecraft recently flew by Jupiter for a first reconnaissance. The planet has a vicious radiation environment and a deep atmosphere consisting mostly of hydrogen and helium, with tracer constituents to show intricate cloud patterns.

The major planet named Jupiter, after the chief of the Roman Gods, has a radius of 61,400 kilometers, which is 11 times that of the Earth. The period of rotation is nearly 10 hours, compared to 24 hours for the earth, and this planet thereby acts like a huge dynamo driving turbulent cloud motions and frightfully strong radiation belts that reach out among the satellites.

This outer planet and its satellites are so inaccessible to earthbased telescopes and radio receivers, the first spacecraft to Jupiter showed the enormous distance by travelling 21 months even though it was the fastest man-made object doing 60,000 kilometers per hour on the average.

The NASA spacecraft of the PIONEER class are eminently suited for a first reconnaissance mission as they are simpler and cheaper than those of the MARINER

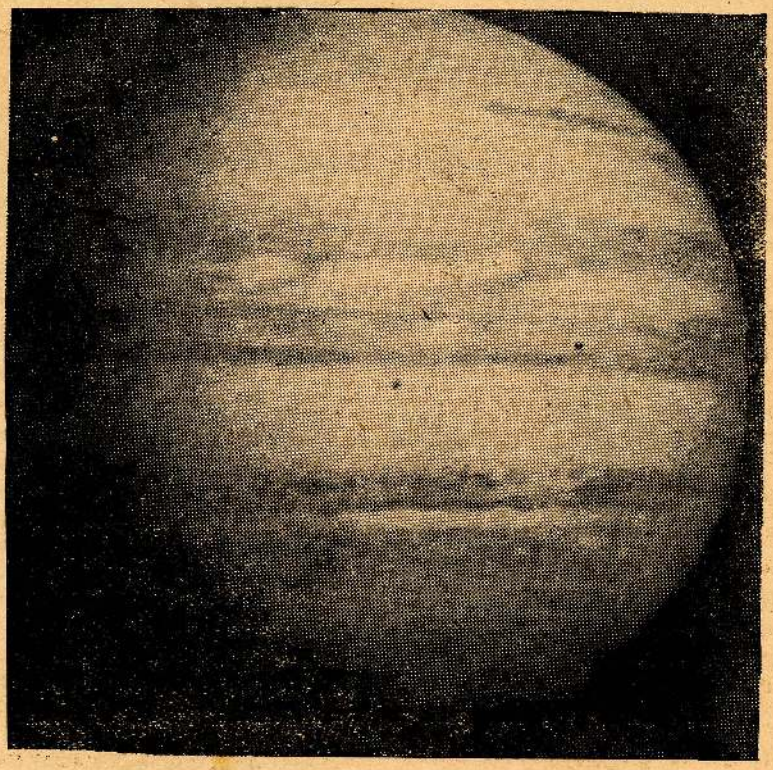
* Dr. Tom Gehrels is Professor of Astronomy at the Lunar and planetary Laboratory of the University of Arizona U.S.A. and was Principal Investigator for the Imaging Photopolarimeter experiment.

class, yet powerful enough to support 14 investigations. The project is managed by an experienced crew at NASA's Ames Research Center, near San Francisco, that still has Pioneers 6, 7, 8 and 9 actively in orbit around the sun between Venus and the earth.

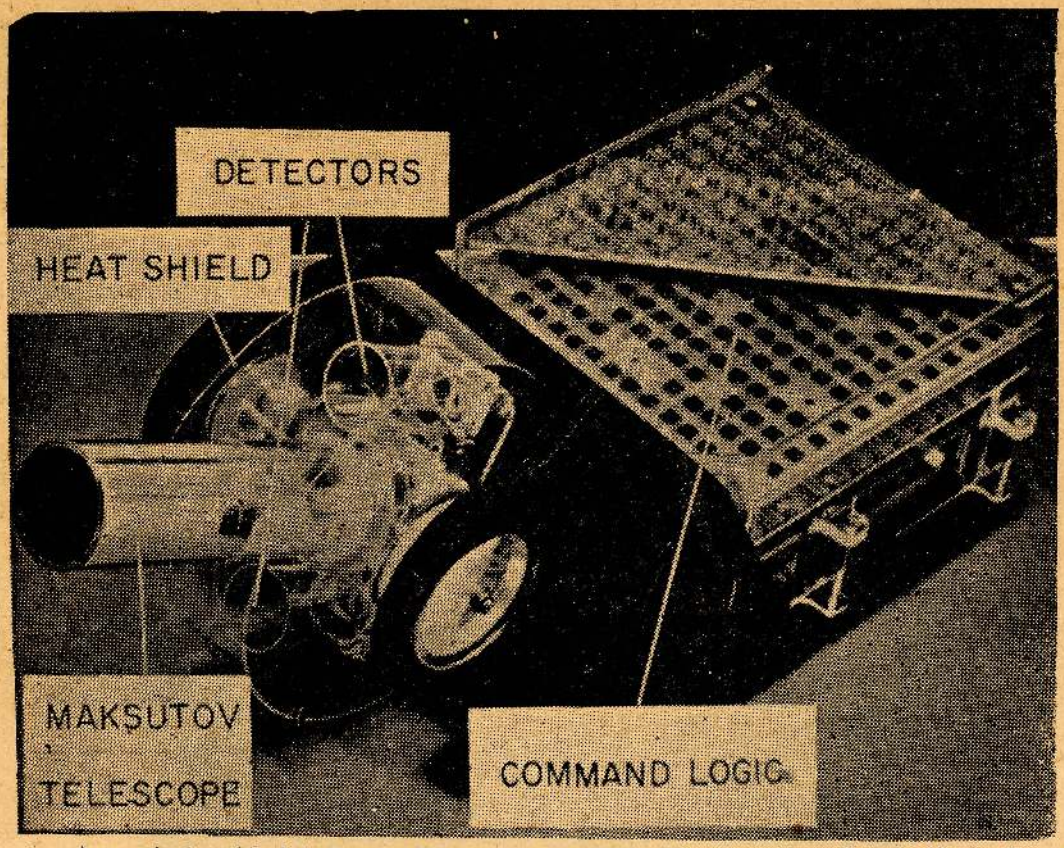
The Interplanetary Medium

Pioneer 10 was launched towards Jupiter in March of 1972 and Pioneer 11 in April of 1973 and immediately after launch they went to work observing the interplanetary medium of electrons, ions, meteoritic particles, and the minor planets. There are 1,800 minor planets for which the orbit are well known, but the volume in which they move, the "Asteroid Belt" between the orbits of Mars and Jupiter, is 10^{25} km^3, the cross section tube of the spacecraft through this belt is 10^3 km^3 and the chance of a collision therefore is small. These well-known asteroids are in the diameter range of about 50—1000 km, but a collision would be dissastrous even with much smaller objects down to about 5 cm: the Asteroid Belt may have as many as 10^{17} of these small members but the collision probability is only 10^{-5}. There are very many meteoritic objects in our solar system, but the space in between them is so enormous that spacecraft have a fair chance of survival.

Impacts of particles near 10^{-3} cm size were observed on special panels mounted on the back side of the Pioneer antenna dish. The impact counts do not show relationship to the Asteroid Belt, which seems to indicate that these tiny grains are of cometary rather than of asteroidal origin.



This view of Jupiter in red light shows never before seen aspects of the planet's cloud tops taken by Pioneer 10 as it flew past the giant planet in December 1973. Details of this picture have now been greatly improved by data analysis and computer processing at the optical Sciences Centre of the University of Arizona.



A true sized model of the Imaging Photopolarimeter (IPP). These were carried on the Pioneer Spacecrafts to planet Jupiter. This instrument designed by Dr. Tom Gehrels was used to gather Photometric and Polarimetric data from the planet. It made use of the spin of the spacecraft to scan narrow strips 0.03 degrees wide and produce breathtaking close ups of the planet. Phototaking were in two channels a Blue and a Red, and an artificial green was introduced by a computer to produce life like colour pictures of Jupiter. Its cost was in the region of $ 10,000,00

Also referred as "particles" are the ions and electrons that come from the sun—one speaks of "the solar wind"—and various detectors are used to observe this environment of "particles and fields" for the first time beyond the orbit of Mars. We now know what was not understood before namely that even near the earth we may be observing particles pinched off, by solar storms or by centrifugal force, from the Jovian radiation environment. Pioneer 10 noticed the effect of Jupiter, already months before the encounter, in the form of clouds of electrons.

The Radiation Belts

November 26 of 1973 was the historic day when mankind's first probe entered the Jovian environment. First encountered was the bow shock wave that Jupiter makes in the solar wind like a ship in the ocean, or, more appropriately because of the high speeds involved, like a bullet plowing through the air. Next was the magnetosheath which is the outer boundary of the Jovian magnetic field affecting the ions and electrons.

Pioneer 10 found that the configuration was not as firmly fixed and as smoothly defined as the models had suggested. Inward bound towards Jupiter, and also when Pioneer 10 was leaving Jupiter, crossings of bow shock and magnetosheath repeatedly occurred. These boundaries occasionally are bulged in by solar wind, or spun off by centrifugal force, so as to liberate the Jovian

clouds of electrons encountered during the interplanetary voyage. The cycle is completed: the particles originally came from the interplanetary wind to be trapped by Jupiter and, after accleration, there is a return back into the interplanetary medium.

The model as we see it in the figure is the result of combination of all the data from these experiments that studied the magnetic fields and the proton and electron fluxes. In addition, extensive earthbased radio observations have been taken into account. The resulting configuration is drastically different from what was expected on the basis of the earth's environment. While for the earth one speaks of the magnetosphere, the word magnetodisc is more appropriate for Jupiter's outer fringes. There is a current sheet in which plasma particles stream inwards and outwards and the fields may be drawn into some spiral structure.

When the spacecraft got within 20 Jovian radii, it found a stable core of high intensity radiation firmly trapped and held by the Jovian Magnetic field and rigorously spinning with the 10-hour rotation period of Jupiter. There the radiation is 10,000 times more energetic than in the earth's Van Allen belts, driven by rotation 2.4 times faster while this spinning planet is 11 times larger than the earth. Pioneer 10 near its closest point to Jupiter, at about 140,000 kilometers from the cloud deck, observed protons with energies as high as 70 million electron volts flowing as densely as 10,000 per cm^2 per second. For electrons in the greater than 30 MeV range, the flux was 10^7 per second, also per square centimeter—the size of a postage stamp.

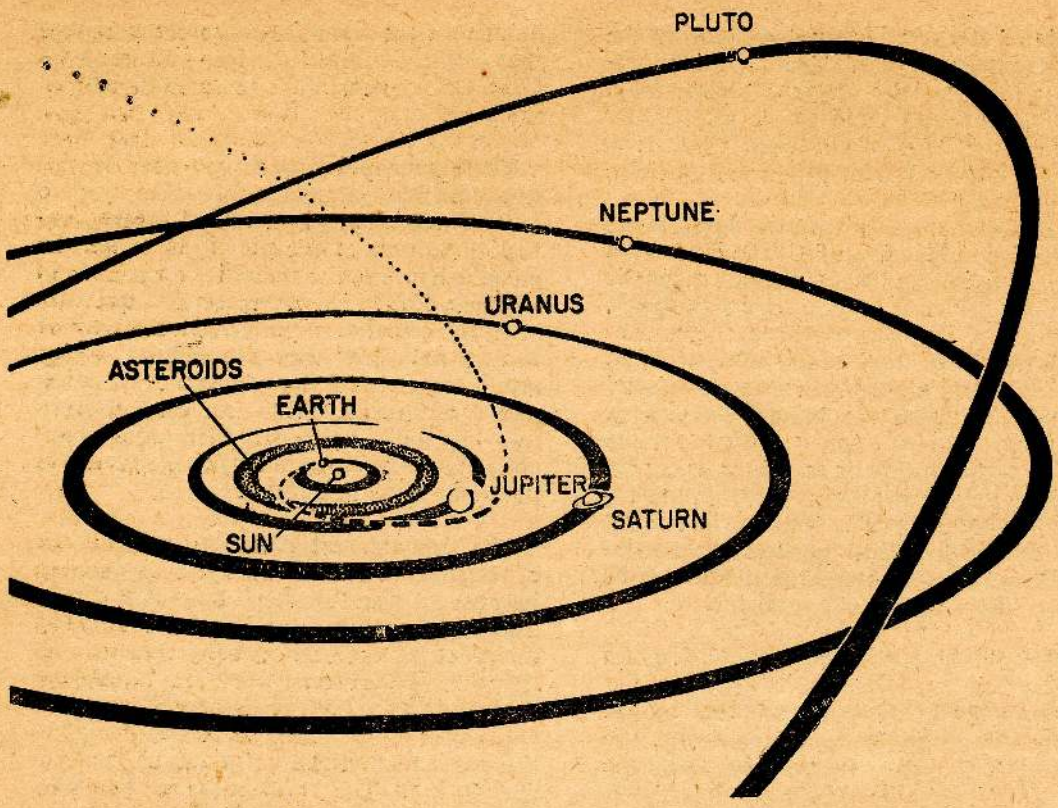
The Body of Jupiter

The axis of the magnetic field is titled by about 9° with respect to the axis of rotation and the field is not centered within Jupiter but offset into the northern hemisphere by about one-tenth of the Jovian radius—a curious asymmetry! The field strength, at the top of the visible clouddeck, ranges between 3 and 6 gauss, depending steeply on the distance to that asymmetric center. The magnetic field is appreciably stronger than that of the earth that has 0.3 — 0.6 gauss at the surface. The direction of the magnetic field is in the opposite sense compared to that of the earth at this time—but then we know that the earth has reversed its field in the past.

These principal conclusions need further study and understanding of the inner dynamo driving the magnetic fields. Is there convective motion of the plastic material, the metallic hydrogen or metallic compounds of an inner core? The more general question is on the circulation patterns in the core of Jupiter and how they are related to the rapid rotation of the planet. A rotation period of 9h 55m 29.75s has been derived from periodicity in earthbased radio observations and this presumably is the period of the main body of Jupiter.

The fundamental parameter of the *size* of the body is not known nor even defined, because no firm "surface" boundary can be observed, not even with radar. The top of the cloud layers is usually taken to set the size of Jupiter, namely at 71,400 km (uncertain by at least 100 km) at the equator, while the fast rotation causes a flattening at the poles so that the polar radius is about 66,800 km. The total mass is precisely determined from the disturbing influence that Jupiter's gravitation has on the motion of asteroids and it is usually expressed in terms of the mass ratio of sun to Jupiter, namely 1047.342 ± 0.002, or a Jupiter mass of 1.9×10^{30} grams. From these numbers it is readily seen that the overall density is low, 1.3 $gram/cm^3$, indicating the predominance of light elements probably mostly hydrogen.

The interior mass configuration is studied with Pioneer's gravitational experiment by John Anderson of the Jet Propulsion Laboratory who observed with great precision the accelerations of the spacecraft as it was flying at various distances from Jupiter. Pioneer 10 got so close that the gravitation no longer acted like that of a point mass. The internal distribution of the mass had to be taken into account and, inversely, could be studied. Mathematically, here was a solution to be made for 63 unknown parameters, of geometry and gravitational structure, while Anderson with some 3,500 observations could make a least squares solution for the 63 unknowns in 3,500 equa-



This illustration shows the Pioneer space craft's path to planet Jupiter passing the zone of Asteroids.

No[illegible]tions? This is a classical case where an experimenter's dream comes true: so many unknowns to solve for, but the number of independent observations is much larger and an exact solution can be obtained only with a powerful computer.

The study of the Jovian interior is in a stage of great flux and activity because of the new type of data obtained by this first fly-by. No final and generally agreed upon model has as yet come forth: we show here only one of the possibilities. The sun and the planets probably condensed from an interstellar cloud of gas and dust: many such clouds are seen between the stars in our Milky Way. Turbulent conditions within the cloud may have caused clumping and gravitational conglomeration. Because much material happend to be available, Jupiter formed rapidly in this manner, without subsequent modification of the composition. The result is a composition, rather similar to that of the sun, of mostly hydrogen.

An electrically conducting high-pressure phase of hydrogen plasma, 'metallic hydrogen' is a primary constituent. There is perhaps one-quarter helium by weight, a ratio not as yet precisely known for Jupiter and it may not be constant throughout the planet.

The temperature in the deep interior is high, on the order of 10^4 degrees Kelvin, but not high enough to set off the nuclear processes such as to cause the heat generation within the sun. Jupiter, having a

thousandth of the solar mass, and therefore much lower interior pressures and temperatures, is not at all a nuclear reacting body that we call a Star. There is, however, some generation of heat by Jupiter which is possibly caused by the planet still being in a stage of gravitational settling.

To help solve the primary problems of origin and evolution there are two experiments on Pioneer 10—an ultraviolet photometer and an infrared radiometer—to determine the crucial hydrogen-to-helium ratio at least for the upper atmosphere. In order to establish the energy radiated by Jupiter it is also crucial to measure the temperature precisely because the radiated energy is proportional to the 4th power of the temperature. Infrared measurements, made already years ago on especially equipped aircraft, established that the mean effective temperature at the top of the cloud layers is near 134° Kelvin, while the predicted temperature from received solar radiation at Jupiter's distance from the sun is 105° K. It followed that Jupiter radiates about 2.7 times the amount of received sunlight: in other words, the excess radiation by Jupiter is about 1.7 the solar flux at the distance of Jupiter. It is not a large amount in terms of stellar energy, but it is an important source of heat and convection in the atmosphere.

The Jovian Atmosphere

The infrared radiometer on Pioneer 10 found that the bright white zone, that is predominant on all pictures taken in December 1973, has relatively a lower temperature compared to the equatorial belt immediately north of it. The top of the white zone is cooler probably because it is rather high and that is confirmed by the polarimetry on Pioneer 10. Presumably, these clouds are formed by saturation of the condensate when a specific low temperature is reached.

In the equatorial regions we appear to be looking deeper into the gaseous atmosphere to a level where a jetstream occurs that has a rotational period of 9 hours and 50 minutes, instead of the general 9h 55m, and that means a velocity of a jetstream on the order of 360 km per hour. There is a long tradition, especially among British amateur astronomers, of visually observing the cloud features of Jupiter and, from repeated crossings of the planetary disc, finding various periods of rotation that show interesting detail for individual dark belts and brighter zones.

On some of the pictures of Jupiter one sees a bright cloud nucleus in the equatorial zone which we believe to be a giant cloud mass—although it appears to be small, the size still is in the order of 1000 km—driven up from below by a local heat source. Equatorial heat sources are observed by earth-based radiometers at a wavelength of 5 microns where ammonia and methane vapors are transparent and the observations penetrate deep into the atmosphere. Such hot spots may be due to statistical fluctuations in the convection cells lower down, similar to the convective cells of solar heating observed in the photosphere of the sun. The hot-spot heat generation would drive the gases up into the atmosphere to regions of lower temperature where the ammonia condensate crystallizes out from the previously invisible vapor to small but now visible cloud particles. The equatorial condensation apparently occurs at the very top of the jetstream where the velocities are no longer quite so high. The cloud formation therefore is dragged behind into a plume that is seen on some of these photographs towards the left of the brighter nucleus.

Other features seen on these Pioneer 10 pictures such as the white ovals and the red spots also may be long-lived eddies as the result of statistical fluctuations in the heat emergence from the interior, driving the vapors up to levels where they condense into particles. Some of the white ovals in the south have dark rings on the periphery where possibly the circulation is downward again such that the condensate gets relatively warmer and transfers back into the vapor stage.

All of the atmospheric activity that we see in constant turmoil occurs at the top of the cloud layers. In addition to hydrogen and helium, Jupiter has some ammonia to form clouds in the upper atmosphere. A cross section shows a model of an upper ammonia cloud layer that may exist in certain parts, such as in the prominent wide white band

across the planet. The upper layer may be missing, or be partially transparent, in the darker belts so that we can look into the deeper parts of the gaseous atmosphere, down to lower and denser cloud layers perhaps partly consisting of water crystals. Careful earthbased spectroscopy at limb and central sections has supported such a model, with ammonia and also methane being primarily, almost exclusively, observable. The brownish colors seen in the photographs may be due to $(NH_4)_2$ Sx for other hydrogen combinations, but there is also a lively debate of possible organic compounds in the Jovian atmosphere to explain the various colours.

The Galilean Satellites

On some of the Jupiter pictures a small black dot is seen which is the shadow of one of the satellites. Twelve satellites are presently known and it seems likely that more will be discovered. The two outer grouped shown in the table probably are capture asteroidal objects while the inner group was formed together with the planet Jupiter.

Of the four inner large ones, Io and Europa were independently discovered by Simon Mayer, in 1609, and by Galileo Galilei, in 1610, who also saw Ganymede and Callisto so that all four are named in his honor "the Galilean statellites." One wonders why Mayer did not also see Ganymede and Callisto. Apparently the optical quality of these first telescopes was very poor because Galileo could not make out the shape of Saturn's rings, but only the fact that there was some peculiar elongation.

While the Galilean satellites are barely seen from earth—as telescopic discs, they actually are as large as the moon or the planet Mercury and they are individually so interesting that we would be conducting separate missions to them if they occurred somewhere else in the solar system! Because of the greater distance of these satellites from the sun than Mercury and the moon have, solar heating did not entirely evaporate away the more icy and snowy components of the original nebula. These components could condense into the satellites with the result that the specific weights of Ganymede and Callisto are quite low, about 2.0 and 1.6 gm/cm^3.

These inner satellites interact with Jupiter's radiation belts and they absorb and shield specially the particles in the lower energy ranges (below about 10 MeV). While the Jovian proton and electron plasma rotates with the 10-hour period, Io's rotation is much slower, with a 42-hour period, so that the shielded cavity actually preceeds Io. In the shielding's wake, turbulence heats and excites the plasma so that it radiates ultraviolet light that was observed by the ultraviolet photometer on Pioneer 10. The turbulent shocks appear to travel along the magnetic lines of force such that they eventually reach Jupiter's ionosphere where they may stimulate emissions that are observed on earth in decametric radio signals.

Future Studies

All these complex but fascinating interactions of satellites, radiation belts, magnetic fields, interior structures, heat generation, and atmospheric circulation are just beginning to be understood and they need to be studied further, theoretically as well as observationally. There is so much to be done! The next burst of activity will come at the time of the flyby of Pioneer 11 on December 3rd 1974. This time we will see more of the polar regions and it will be a closer inspection because Pioneer 11 comes closer to the planet, the polar radius is 4,600 km smaller than the equatorial one, and especially because the polar atmosphere is more transparent to visible light. At the higher latitudes, the atmosphere is very different in dynamical regimes while the radiation belt structures also offer a different aspect. No other spacecraft that NASA is presently planning will pass at high Jovian latitudes—and the Russians appear to have no interest in Jupiter exploration at the moment. After passage of Jupiter, Pioneer 11 is to encounter Saturn in September 1979, after a long journey across the solar system.

There will be just about the right amount of time for intense study of the precious Pioneer data of Jupiter before the next major observational event occurs which is the flyby of the first Mariner spacecraft in 1979. Because of the powerful television cameras that the Mariner spacecraft carry, the pictures are going to be the most spectacular yet obtained on any planetary mis-

sion. Jupiter surely is the planet with the greatest detail and variety in cloud formations: the present pictures demonstrate the turbulent detail and the planet keeps changing its cloud configuration from year to year.

From an extra-terrestrial point of view, Jupiter is the most important of the sun's planets because of the large mass, about 2.5 times that of the other planets combined. Gravitationally, Jupiter affects the other members of the solar system moving even the sun itself in an orbit with respect to the solar-system's center which is mostly determined by the combined mass of sun and Jupiter. If mankind is to search for other planetary systems, the obvious technique is to look for periodic motion in the position and in the velocity to and from us of selected stars. Such searches are being made and positive results will be followed by closely listening for radio signals from such systems. Would it not be a stirring day when we earthlings prove ourselves to be not alone in the universe?

The Origin of the Solar System

by Dr. D. Asoka Mendis.
Department of Applied Physics University of California, San Diego.

From a recording of the lecture given to the Sri Lanka Astronomical Association on August 8th 1974.

Man's interest in his own origin and the origin of his environment is as old as recorded history. It has over the course of time given rise to religious and philosophical speculations and in the more recent time to scientific investigation.

Mankinds three basic questions are on:

(1) The origin of life.
(2) The origin of our local abode of life.
(3) The origin of the Universe.

Of these three the last is the most difficult one to answer since the observational data on the large scale universe available at the present time is far too meager to discriminate between the large number of mathematically elegant and physically plausible theories.

In the past two decades with the advent of space programmes there has been a concentrated effort to collect a large amount of information pertinent to the first two questions resulting in considerable progress. Dr. Cyril Ponnamperuma, would have dealt with the first question the origin of life and I wish to discuss the second.

The origin of our local abode refers to the origin of the Earth and in more general our solar system.

Let me first describe the system which we wish to investigate. It consists of a central main sequence dwarf star, nine planets that revolve around it, an asteroid belt, and 32 satellites which revolve about the planets. In addition to these major bodies there are the Meteors and the Comets.

Meteors are very small bodies which move in the environment of the solar system. They are mostly confined to the ecliptic plane and continuously bombard the earth from above and get burnt up in the upper atmosphere. The longer meteors which survive to fall on the earth are called meteorites.

Comets are estimated to number about 100,000 million and form the Oort's cloud surrounding the sun. They move in highly elliptical orbits which take them to vast distances from the Sun, where they remain for most of the time. They are not confined to the ecliptic plane and approach the sun from all directions.

Finally there is the interplanetary medium of gas and dust and an embedded magnetic field. The dust manifests itself as the Zodiacal light in the ecliptic plane whereas the gas or interplanetary plasma is a part of the continuously expanding solar corona blowing past the earth as the solar wind.

Let me now detail the basic features of the solar system that our theory on its origin must explain.

I. Dynamical properties

(*a*) orbital regularities,

All the planets move in near circular prograde orbits which lie almost on the equatorial plane of the Sun (Prograde means that the sense of revolution is same as the spin of the Sun)

(*b*) The distribution of angular momentum The Sun which contain over 99.8% of the mass has barely 2% of the total angular momentum which is almost entirely packed into the planets and their satellites. This has been the major stumbling block of pure gravitational theories for the origin of the solar system.

(*c*) The Isochronism of Spin.

The bodies in the solar system range over 12 orders of magnitude (ie Jupiter) 10^{30} grams and a typical Asteroid 10^{18} grams) but they all spin with a period roughly between 5 to 10 hours, except in cases like the Earth when tidal or resonance effects are present.

(*d*) The asteroid belt and the Saturnian ring system which are examples of bodies which have not agglomerated into a larger body.

(*e*) The randomly oriented and highly elliptical orbits of comets in the Oort cloud.

II. Chemical properties

A chemical separation groups the planets into two distinct classes. The four inner planets Mercury, Venus, Earth and Mars are relatively small and have a density of 5 gm/cc. The four outer planets Jupiter Saturn, Uranus, and Neptune are large and have a density of 1 gm/cc. Little is known about planet Pluto, but with a density greater than 4 gm/cc it is more like one of the inner planets.

III. Physical properties

Even though there are theoretical models for the structure of Jupiter and Saturn the only definite knowledge of internal structure is of the Earth and recently of the Moon.

The Earth has a small central solid core surrounded by a liquid metal layer over which we have a solid mantle and the very thin outer crust.

When one examines the numerous theories on the formation of the solar system it is apparent that despite all changes the hard core of each theory remains one of two rival ideas both originated in the 18th century. The first suggests that the solar system came into being as an aftermath of a cosmic catastrophe caused by the interaction of another celestial body with our Sun.

This theory seemed to explain how most of the angular momentum is concentrated in the planets but from it arose much difficulty in explaining how the erupted material condensed into a planetary system.

The second suggests that the solar system was the product of a slow development by forces working within itself over long periods of time.

My basic objections against all these theories are.

(1) They all depend on a gravitational instability even to create the small bodies of the system. It is possible by this means to create a body of the size of the Sun and very doubtfully one as big as Jupiter, But if we attempt to create smaller bodies by the pure gravitational collapse of a gas cloud the situation becomes difficult.

(2) They are all pre-Hydromagnetic, and try to explain the formation in terms of a single force Gravitation. Although this is the major force governing the solar system at the present time, Electromagnetic forces played an important and decisive role in the

early formation period. The peculiar distribution of angular momentum can only be explained in terms of magneto hydrodynamic effects which transferred angular momentum from the fast spinning central sun to the planets forming around it.

(3) They quite often neglect the similarity between the planetary system around the sun and the many satellite systems around the outer planets. A theory which is applicable to the planetary system should be equally applicable to any satellite system.

We at the University of California, San Diego, have been working on a new theory under Prof. Hannes Alfven.

The basic features of this theory are

(*a*) A Hetagonic Theory.

The formation of secondary Companion bodies around a central parent body (Hetagonic Greek word for companion).

(2) A Plantesimal Theory

Formation of planets by the gradual agglomeration of small grains into a larger body.

(3) A Hydromagnetic theory.

Formation not only by effects of gravity but also by the interaction of electromagnetic forces with the plasma cloud of gas and dust.

I shall consider the planetary system but the ideas are equally applicable to any satellite system.

The three basic factors that characterise any such system are (1) The Mass (2) The Spin and (3) The Magnetic field of the central body. We assume that the sun had a sufficiently strong dipole magenetic field during the formation period.

Planet formation begins with a interstellar cloud of gas and dust falling towards the gravitational centre and condensing out an embryo Sun. When the atoms have gained sufficient knetic energy by infall, mutual collisions cause ionization. The electrons produced cause further ionization resulting in a very strong cascade process. The ionized particles have their fall impeded by electromagnetic forces which are much stronger than the gravitational attraction and get hung up in the magnetic field.

(*a*)	Helium	25 eV
(*b*)	Hydrogen, Oxygen, Hytrogen	13—14 eV
(*c*)	Carbon, Sulphur	10—11 eV
(*d*)	Iron, Magnesium, Silicon	7— 8 eV

Elements with smaller ionization energies get separated further away from the sun and analysis has shown that the distribution of elements by such a process is in reasonable agreement with that observed today

Electromagnetic forces tend to accelerate the plasma elements that are formed to an angular velocity equal to that of the central Sun. This causes a transfer of angular momentum from the fast spinning central body to the highly conducting plasma around it. This means that the transfer of angular momentum took place before the planets themselves were formed. In such a state the plasma elements attain an equilibrium velocity of $\sqrt{\frac{2}{3}}$ V where V is the well defined circular orbital velocity at that distance. The velocity is less than the orbital velocity but this is compensated by the additional magnetic force acting on it.

As condensation takes place the charge to mass ratio of the grains becomes smaller and at a certain stage are no longer affected by the magnetic field. The detached grain not having sufficient velocity to move it in its original orbit drops towards the sun and moves in an elliptical orbit of eccentricity $\frac{1}{3}$. Even though these orbits are randomly oriented it can be shown to cut the equatorial plane at the same distance of $\frac{2}{3}$ r. So the probability of collisions of these grains are greatest at this distance.

If two bodies collide and stick together the composite body moves with orbital parameters a mean of those of the initial orbits. If fragmentation occurs it is a property of the gravitational field to carry these fragments back through the same place increasing the probability of further collisions Thus mutual collisions over the course of time creates larger bodies, the eccentricity and inclination to the ecliptic averaging out to zero. Such a collection of bodies moving

in approximately similar orbits are known as a jet stream, and their formation at various distances from the parent body is the second stage.

A mathematical theorem predicts that elastic collisions between bodies will disperse them, but this is not the case here. The grains are believed to be rather gluffy like what we see in comets and collisions are sufficiently inelastic with a loss of energy which makes the jet stream focus rather than disperse. This agglomeration of bodies within the jet stream to form a planet is the final stage.

I have so far discussed briefly the formation process and thusis able to explain most of the dynamical properties and the chemical separation, but other very dramatic lines of evidence support this theory.

Let us first consider the early formation stage when the plasma condensed and fell to $\frac{2}{3}$ its distance. Luckily there are two instances where the process did not go beyond this jet stream stage. They are the asteroid belt and the saturnian ring system which occurred for two different reasons.

In the case of the asteroids there is insufficient mass and it would take over 10^{10} years to agglomerate, and this is much more than the age of the solar system (10^{10} years)

In the case of the rings of Saturn the matter is accumulated within the Roche limit of the primary body. Inside this limit the tidal forces of the primary planet on a satellite exceeds the self gravitation of the less massive satellite. A body within the Roche limit will disintegrate and for the same reason a jet stream will never agglomerate.

The brightness profile of the ring system is given in the figure. Various attempts to explain the well-defined Cassini division between rings A and B, using very complicated mathematics on resonances have failed to fit its position to such a resonance.

An interesting fact is that if you project the Cassini division to $1\frac{1}{2}$ times its distance we get the orbit of satellite Mimas. So we could explain the Cassini division as a cosmogonic shadow of Mimas which swept out a region in the original plasma cloud before it fell to $\frac{2}{3}$ its distance to form the present ring system. This evidence was further confirmed when the satellite Janus, whose orbit corresponds to $1\frac{1}{2}$ times the distance of a sharp drop in the intensity of ring B, was discovered in 1967.

There is another somewhat smaller drop in the intensity profile and it will be of great significance if Pioneer II now on its way to saturn should discover a satellite as predicted by this theory.

There is much evidence for the next stage, the agglomeration of particles within a jet stream.

(1) **Structure of Meteorites.**

If we examine a cross-section of a meteor we find that it is a composite of a large number of smaller grains. Further examination of these small grains shows that they have been bombarded by cosmic rays from all sides. This seems to indicate that the grains were suspended in space for a long time before an agglomeration took place.

(2) **Isochronism of Spin.**

We can show that an agglomeration process within a jet stream will produce a prograde spin which is independent of the size of the body. It depends on density and other factors and if we use reasonable values for them we get a period of the order of 10 hours.

(3) **The Physical structure of the Earth.**

At the start, the growing embryo is small and only particles that hit it stick on. This is a slow process. When it has grown to about 100 kilometers or so particles get gravitationally attracted to it and collecting from a large source of grains the growth is rapid. The rate of energy input per unit mass in this stage is sufficient to melt the body. Once the source of grains is depleted growth is again slow and the rate of input of energy again too small to melt the body. Although the heating process is complicated by the presence of radio-active material which obviously produce some of the melting the general structure of a liquid layer between a solid, core and mantle is explained by the formation process.

(4) The short period comets.

Evidence from comets is very important. In view of their structure they are not subject to much metamorphic change and thus present important information about the primaeval conditions and the formation process.

There is a marked relationship between the orbits of Comets and meteor showers. The general idea is that meteor streams are the result of the disintegration of comets which in fact we observe as the dust tail. A comet loses about a thousandth of its mass at each perihelion passage around the sun. For this reason we do not expect to observe many short period comets. The earlier idea was that they are replenished by gravitational capture of long period comets, but it could be shown that this probability is too small to explain the present population of 200 short period comets. A way of overcoming this is to suggest that meteor showers are not just a sink but also a source of new comets. Planetary perturbations form density waves which helps to focus the meteor stream and speed up the process of agglomeration. There are instances where meteor showers have been observed for centuries but the comet associated with it only recently. Although this evidence is not definite it is very suggestive of the formation process.

Some Experiences in Making 6" to 16" Telescope Mirrors

By Dr. V. S. Jayacodi, M.B.B.S.

Way back in 1968 when I first started Astronomy I made my first 6" telescope mirror using two ¼" thick discs of plate glass. The two opposite surfaces of the discs were roughened with colorandum powder and pasted with an epoxy resin made by the Shell Company. This compound called Shell epikote Compound, is a thick colourless paste and is mixed with 7 parts of a liquid called D.T.A. (an Ammonium preparation). These two are well mixed and applied to the roughened surfaces and pressed together in such a way that no air bubbles were present in the pasted area. A heavy weight was next placed over the pasted discs and left for 24 hours for setting. The two ¼" discs which now formed one ½" disc was now ground in the usual way.

The method used by me for mirror grinding is set forth in considerbable detail in a book on Astronomy and Telescope Making written by Herschel Gunawardena. The book which is written in Sinhalese is very clear on this subject and anyone wishing to make a telescope mirror could follow it with ease and in my case it was my only guide as no other book was readily available on this subject at that time. Grinding was followed by polishing and figuring. This compound mirror gave me satisfactory service for a few months, after which, due to the stresses and strains developing on the pasted area, images of the celestial objects became slightly distorted. The mirror was then dismantled and fine ground and repolished. Figuring was then carried out after which it returned to its original form.

In 1970 I was able to procure two glass discs with a diameter of 14.5" each being 3/4" thick. These were also pasted in the same way as the 6" discs and ground to F/8 focal ratio. The tool which was also another similar ¾" thick cemented disc was embedded in concrete on the top of a tar barrel which was levelled and filled with rocks and sand. A central hole 2" in diameter was cut in the 1½" thick compound disc, using an improvised biscuit cutter driven by an old 6 volt windscreen wiper motor. The following grades and quantities of Carborandum powder were used for the job.

No. 46 — 1½ lbs. No. 180—¼ lbs.
No. 60 — 2 lbs
No. 80 — 2½ lbs
No. 120 — ¼ lbs.

The focal length was 118" on final course grinding, following Course with above grinding Nos, 302, 303 and 303 ½ were used for fine grinding about ⅛ oz of each being used up on completion. The focal length was now about 112". Polishing was carried out on standard pitch lap, using cerium oxide polishing powder.

This 14 ½" compound Cassegrain Mirror gave the wonderful views of the Heavens for a few months after which distortion of images again set in. Like in the 6"mirror distortion was found to be due to stresses and strains set up due to pasted surfaces. Since the mirror was first ground and polished I have had to regrind, and repolish it on no less than 5 occasions, not forgetting re figuring which was a back breaking but an interesting job. After nearly 5 years the mirror has now become stabilised and continues to give good service.

Recently I was able to obtain a 16" glass disc which is a little over 1½" thick. I have set forth in making a 16" Telescope, this time, without cementing. The problem confronting me was that I had only one 16" disc. So I dug out my old 14 ½" tool from its concrete bed and after turning it over so that the flat surface was now uppermost, I embedded the conclave surface in concrete. To make for the additional 1½" required to make it into a 16" tool I procured 8 pieces of ¼" thick glass and cut them into the shape of an arc with a diameter of 16", each piece being ¾" broad. These thin pieces were pasted with Araldite to form 4 ½" thick arcs of glass, which were now embedded in concrete around the 14½ glass disc as in diagram.

This now forms my 16" tool on which I am currently grinding the new 16" mirror. I hope to describe my new experiences in a future issue of Equatorial. Meanwhile my hints I hope would encrourage more persons to make their own mirror. Sometimes, even if all the necessary materials needed for mirror making are not available, one could do quite with a bit of improvisation.

Letters to the Editor

Dear Sir,

Your very interesting article (Jan. Dec 1975 issue) by Mr. J. E. Amaratunge on Sanskrit Star Names raises the old question of the antiquity of Indian Astronomy. Mr. Allen is not justified in discussing the question because little in Sanskrit literature refers to it. This is a fundamental error in the study of antiquity. Much knowledge was held in secret by Initiates and passed on orally supported by allegorical and cryptic stories. It would as much be justified in saying that Egyptians did not know Mathematics and engineering as no documentation exists, or to say the Sinhala people did not know architecture or hydro-engineering as there are no literary references to the science. Archeologists too make mistakes in giving literal and simple interpretations to structures and artifacts without reference to symbolism especially astrological symbolism of the ancients.

Astronomers should really probe into Astrology for sociological reasons as it is a social phenomena in India and Sri Lanka They could then see that much astrology is based more on Asterims, Nakshatras than simply Zodaical Houses.

The present Hindu Astrology uses 27 Asterims beginning with Aswini. Beta Arietes 3 stars—resembling a horse's head.

Hindu Nakshatra does not mean the same thing as the Chinese *Sieu* which means a simple star. Nakshatra refers to a group of stars. The Chinese *Sieu* is not traceable to more than two or three centuries before Christ whereas Nakshatra are heavenly objects mentioned in Vedic hymns.

The question of which came first, Hindu civilization or Greek civilization is not a settled one as yet. The curious may read Jouis Jacolliot's *The Bible in India* published in 1870 Carleton Publishers New York. The questions raised by him have not been given adequate answers as yet.

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MOLESWORTH ON MARS

Dear Sir,

It is now possible to add an interesting sequel to Mr. Herschel Gunawardena's article (Equatorial Vol 3 No. 1, July/December 1971) "P. B. Molesworth (1867—1906) and Astronomy in Trincomalee".

Captain Molesworth, who was born in Colombo and is buried in Trincomalee, was one of the most distinguished amateur astronomers of his day, and did most of his work with the 12-inch reflector now on the Colombo University Campus. His principal interest was the planet Jupiter, but he also made extensive studies of the Moon and Mars. His house is now part of the Fort Frederick tourist centre, but only the foundations of his original observatory remain.

In his article, our past President laments the fact that there is not even a street in Trinco to commemorate Captain Molesworth's name. But I am happy to say that the International Astronomical Union has not forgotten him, for he is now on Mars!

Recently the Jet Propulsion Laboratory presented me with the beautiful 16-inch globe of Mars based on the Mariner 9 observations. While examining it I was delighted to discover that a crater about ten miles in diameter in the southern hemisphere (211 W, 28 S) has been named "Molesworth".

The crater is on the opposite side of the planet from the Viking I landing point in Planitia Chryse ("The Plain of Gold"), but there must now be some excellent photos of it available from the high-flying cameras in the Viking Orbiters.

This must, surely, be the first link between Mars and Sri Lanka!

Arthur C. Clarke.
25, Barnes Place,
Colombo 7.

Obituary

Mr. Robert A. Naef, who was a leading Swiss amateur astronomer, died suddenly on March 13th, 1975. Mr. Naef was a office bearer of the Swiss Astronomical Society, and edited its journal Orion,which is one of the world's best astronomy journals. Year in, year after he published the astronomical hand book called "Der Sternenhimmel". Mr. Naef along with the editor of Equatorial, was a member of the Founder Council of the I.U.A.A. Mr. Naef maintained his contacts with Sri Lanka by the mutual exchange of the Astronomical Journals of the two countries, the Orian and the Equatorial. His death is a great loss to amateur astronomers throughout the world.

Professor E. E. Vezey, Hony. life member and a founder member of the Sri Lanka Astronomical Association (1959) passed away at his home town, College Station, Texas, U.S.A. on 6th June. 1975. Professor Vezey, was a great encouragement to amateur astronomers in Sri Lanka. He gave many excellent lectures at our monthly meetings in Colombo. He was a member of our Council with almost one hundred percent attendence. Dr. Vezey was primarily a physicist, his speciality was in the field of instruments. He encouraged many of our members to build their own telescopes. (See the article entitled "why not build your own telescope" in Equatorial Vol. 1 No. 1 (1959/60). He left Sri Lanka in 1960. Even in his retirement the U.S. government could not spare to be without his expertise, for after arriving back in the States, he was recruited as a senior nuclear scientist at the Cyclotron Institute. In Sri Lanka, he served as an advisor in installing the engineering faculty equipment at the Colombo Campus. He was a good friend to all who knew him. His loss would be greatly felt by all those who knew him in Sri Lanka.

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121, POINT
NALLUR, JAFFNA
No.....

MEMBERSHIP APPLICATION FORM FOR SRI LANKA AND FOREIGN COUNTRIES

The Sri Lanka Astronomical Association

Membership is open to any person interested in Astronomy whose application is acceptable to the Association. The application must be supported by the signatures of two members as proposer and seconder. In case an applicant is unknown to any member of the Association, thus unable to procure a proposer and seconder, the applicant must get the signatures of two resident householders to whom the applicant is personally well known. The form below should be duly filled and sent to the Hony. ~~Treasurer,~~ Sri Lanka Astronomical Association, ~~193 , Galle Road, Dehiwala~~, Sri Lanka together with the entry fee of Rs. 2.50 and the subscription for the current year. The annual subscription is Rs. 10 (except where a candidate is aged 20 years or less he shall have the option of paying Rs. 5) Cheques or Money Orders should be made out in favour of the Treasurer, Sri Lanka Astronomical Association. For foreign applicants an entrance fee of 1 dollar and an annual Subscription of 2 dollars or its equivalent is payable. For a person under 20 years the membership fee is one dollar or equivalent.

Secretar

Form A

Surname : ..... Other names .....

Date of birth : .....

Permanent Address : .....

.....

Occupation : ....

We the undersigned propose and second/recommend applicant as a proper person to be elected a Member of the Sri Lanka Astronomical Association.

Witness our hand this .....day of ..... 19.....

Signatures of Members/Householders. Names and Addresses of Householders.

1. ....

.....

2. ....

.....

I, the undersigned, do hereby agree that in the event of my election as a member of the Sri Lanka Astronomical Association, I will be governed by the Constitution and the By-laws of the Association as they now are or as they may be, hereafter, altered, provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing from the Association, I shall be free from this obligation.

Date : ....

Signature of Applicant.

FOR OFFICE USE

Date of Acceptance as a member .....

Signature of Secretary : .....

Remarks : .....

COLOMBO CATHOLIC PRESS