

ĀRYABHATĀ MEDAL LECTURE—1977

DEVELOPMENT OF ATMOSPHERIC AND RELATED EARTH SCIENCES IN THE LAST SIXTY YEARS

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MR. PRESIDENT AND FELLOWS OF THE ACADEMY, LADIES AND
GENTLEMEN ;

I AM greatly honoured by the kind invitation by the authorities of INSA to deliver the first lecture dedicated to the memory of the fifth-century Mathematician-Astronomer Āryabhaṭā whose 1500th birthday was celebrated by INSA in November, 1976.

Āryabhaṭā was the first Indian Astronomer to put forward the idea that while the stars, sun and planets appear to go round the earth, the fact is that the earth itself rotates round its axis once a day from west to east.

1500 years is a long period of time, and it is significant that the first Indian Artificial Satellite named *Āryabhaṭā* completed one year of orbiting round the earth in 1976. This shows the tremendous progress that has been made by Man in 1500 years, particularly after the time of Nicholas Copernicus (1473–1543), Kepler (1571–1630), Newton (1642–1727), and Maxwell.

I propose to speak today on the development and progress of Atmospheric and related Sun-Earth Sciences in the last 60 years, during which period, I have been privileged to do some scientific work in collaboration with scientist-colleagues in India and abroad. Right from the time when I began to take interest in science, Professor C. V. Raman has been my guiding star. I consider him to be the twentieth century Āryabhaṭā.

The Institutions and Organisations in India in which I have worked are ;

1914–1921 Maharajah's College, Trivandrum and the Magnetic and Meteorological Observatory, Trivandrum.

1922–1925 Indian Association for the Cultivation of Science, Calcutta and University College, Rangoon.

The work done in Calcutta and Rangoon were mainly Laboratory studies of the molecular scattering of light in gases, liquids, and their vapours over a range of temperatures and pressures including the critical point and beyond, and the experimental verification of the Einstein-Smoluchouski formula for the intensity and polarisation of the scattered light. A number of substances with molecules of different complexity were studied. During all these studies, there was an eye on the scattering of sunlight by the atmosphere and the sea. The work was inspired and guided by Prof. Raman. An important discovery made in Calcutta in April 1923 was a so-called

“Trace of Fluorescence” in filtered sunlight in the indigo-blue region scattered by highly purified, distilled liquids like water, ethyl and methyl alcohols.

1925-1948 — I joined the India Meteorological Department at Simla in 1925. In the winter of 1925-26, I made a study of the intensity and polarisation of skylight in *clear* weather when the sun was $\pm 3^\circ$ of the horizon. In a direction perpendicular to the direction of the sun, the polarisation was 0.87%. India was then under the British Rule, and the Department’s jurisdiction extended from Baluchistan, North-West Frontier Province and Sind on the West to Burma on the East. The Director-General of Observatories was Mr. J. H. Field. He was succeeded by Sir Charles Normand in 1928.

The British were at that time preparing for a rapid expansion of aviation, and great efforts were being made to collect surface and upper air data of various kinds (winds, temperatures, humidity, clouds and various types of atmospheric disturbances) along proposed air routes and at air-ports. One of my primary tasks in the India Meteorological Department was to help in organising the collection and analysis of upper air data over as large a part of the world as possible.

I was transferred to the Upper Air Observatory, Agra in January, 1927. The Meteorologist-in-charge of the Agra Observatory was Mr. G. Chatterjee who had built up a very efficient sounding balloon station there with all the laboratory and workshop facilities. In 1928, I moved from Agra to Poona when the Headquarters of the Department was transferred from Simla to Poona.

Thanks to Mr. Chatterjee’s co-operation and help, I was able to analyse with the help of Mr. P. R. Krishna Rao the upper air data collected in India and abroad during the period July 1925 to March 1928. The results were published as a Memoir of The India Meteorological Department entitled, “*Discussion of Results of Sounding Balloon Ascents at Agra during the period July 1925 to March 1928 and Some Allied Questions*”. The study of the Agra data combined with all available data from other parts of the world resulted in the preparation of a tentative diagram of Upper Air Temperatures and Potential temperatures over the Northern Hemisphere in summer and winter up to a height of 25 km.

Among other papers on the upper Atmosphere, and related Meteorology which were prepared in collaboration with colleagues in Agra and Poona, may be mentioned ;

- (1) Results of sounding balloon ascents at Poona and Hyderabad during the period October, 1928 to December, 1931.
- (2) Soundings of temperatures and humidity in the field of a tropical cyclone and discussion of its structure.
- (3) General circulation of the atmosphere over India and neighbourhood.
- (4) The Indian South-West Monsoon and the structure of depressions associated with it.
- (5) Papers on pre-monsoon and late monsoon storms in Indian seas. In all this work, I received great assistance from the Late Mr. K. P. Ramakrishnan. As I spent many years in Poona and Bombay between 1928 and 1945, I could keep in touch with the Weather Forecasting Sections of the Department and discuss the value of upper air data in objective weather forecasting.

Besides Meteorology, the India Meteorological Department had under it the Magnetic and Seismological Observatory at Colaba-Alibag in Bombay, and the Solar Physics Observatory at Kodaikanal. Between 1934 and 1939, I was in Bombay except for one year (1935) when I went to Kodaikanal as Officiating Director. During my stay in Bombay, various problems in Geomagnetism, Seismology and Twilight scattering of light from the Zenith sky were studied. Two severe earthquakes, the Bihar Earthquake which occurred in June, 1934 and the Quetta Earthquake in May 1935 were studied in detail by Mr. S. M. Mukherjee and myself. The focal depths of earthquakes, particularly in the West Himalayan-Pamir region and in the Assam region were determined.

In my capacity as President of the Mathematics and Physics Section at the Lahore Science Congress in 1939, I presented an address on "The Earth's Magnetism and the Upper Atmosphere".

In 1939, I was transferred back to Poona in view of the impending World War II, for which collection and organisation of meteorological data in a form suitable for use by Indian and British Air Force pilots and meteorologists had to be prepared. The recruitment and training of additional meteorological staff was also required. War duties kept me busy at Poona and Delhi till 1944, when Sir Charles Normand retired and Dr. S. K. Banerji took over as Director-General of Observatories. Between 1945 and 1948, I worked as Officer on Special Duty for planning the reorganisation of the Department for improved weather service in the country.

On my retirement from the India Meteorological Department on 28th February 1948, I joined the Physical Research Laboratory, Ahmedabad as Director and Professor of Atmospheric and Sun-Earth Sciences. On the initiative of Dr. Vikram A. Sarabhai, the nucleus of a Laboratory had already been created with the support of the Karmakshetra Education Foundation and the Ahmedabad Education Society.

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1948-1965 — Shortly after I joined PRL, the Laboratory sent me on a study tour to Europe to see the developments that were taking place in the subjects in which Dr. Sarabhai and myself would like the Laboratory to develop. The period of my tour was 22-6-1948 to 4-9-1948.

The countries visited included UK, Norway, Sweden, Belgium, France and Switzerland. I met scientists in many institutions where the scientific work done in India was known, or to whom I had been introduced by letters from Prof. Raman, Dr. Sarabhai or the Indian High Commissioner in London. I received a warm welcome everywhere. I collected information about the items of equipment which the scientists were using for their work and which were not then available in India. At Oslo, I attended the IUGG Assembly and presented a paper by Dr. R. V. Karandikar and myself on the work on 'Atmospheric Ozone' which had been done in India. The International Association of Meteorology (IAM) elected me as a Vice-President of the Association. That was the beginning of my personal involvement in the activities of IUGG. At the next IUGG Assembly held at Brussels in 1951, I was elected President of IAM for the period 1951-1954. The next Assembly was in Rome in September

1954 and the subject of my Presidential Address in IAM was on "Atmospheric Ozone and the General Circulation of the Atmosphere".

The IUGG was pleased to elect me as the General President for the next three year period 1954-57. The 1957 Assembly was held at Toronto in Canada.

At this point, I wish to mention a major development that was taking place in a number of Unions under ICSU. In 1950, at a meeting of the Joint Commission on the Ionosphere, of which the three Scientific Unions, URSI, IUGG and IAU, were members, Dr. L. V. Berkner and Prof. S. Chapman made a proposal that, following the second International Polar Year (1932-33), an International Geophysical Year should be organised by ICSU in 1957-58. After discussion by the Unions, the decision was reached that the IGY programme should consist of an intensive study of the sun and a global study of all Earth Sciences. A special committee for the IGY enterprise (CSAGI) was appointed by ICSU with Prof. Chapman as President, Dr. L. V. Berkner as Vice-President and Dr. M. Nicolet as Secretary. It was also decided that the IGY should include the eighteen months from July 1, 1957 to December 31, 1958. India was among the countries which immediately accepted the proposal, and an Indian National Committee was formed by CSIR at NPL, New Delhi with representatives of Solar and Terrestrial Sciences, as co-operating members and myself as Chairman.

Other International Bodies of which I have been a member are :

- (a) International Quiet Sun Year (IQSY, 1964-65).
- (2) International Ozone Commission (1961-67).
- (3) Indian National Committees for IGY-IGC and IQSY.
- (4) Indian National Committee for the Hydrological Decade and the International Hydrological Programme (1965-67).
- (5) Scientific Advisory Committee for the Indian Monsoon Experiment (MONEX).

A summary of the work done by the scientists of Physical Research Laboratory since 1948 is contained in the booklet "25 Years of PRL" which was published in 1973.

The scientific work that has been, and is being done in PRL comes under the following heads :

- I. Cosmic Rays.
- II. Interplanetary Space.
- III. Astronomy (including Radio-Astronomy and X-ray Astronomy).
- IV. Aeronomy and Geomagnetism—

(1) Atmospheric Ozone; (2) Winds and Temperatures in the Equatorial Stratosphere and Mesosphere; (3) Twilight Glow; (4) Night Airglow; (5) Ionospheric Studies with Ground-based equipment; (6) Ionosphere Studies with Rocket-borne equipment; (7) Satellite Telemetry and Sounding of the Topside of the Ionosphere; (8) Nuclear Theory; (9) Cosmo-geophysics; (10) Archeology and Hydrology; (11) Remote Sensing of Earth Resources; (12) Infrared Astronomy; and (13) Laboratory Astrophysics.

I realise that my talk has been mainly auto-biographical and I have not referred by name to the many scientists and institutions who have contributed to in our national scientific work.

My apologies.

My grateful thanks to all my Fellow workers.

Namasthe.