

stream formation is based on the good agreement they found between the theoretically calculated meridional profile of zonal wind speed at constant absolute vorticity and constant angular momentum (which is dependent on the latitudinal variation of the speed of rotation of the earth) and the observed mean geostrophic wind profiles.

Sir Raman had a unique capacity to examine a problem *de novo* in a fundamental way. He examined meteorological problems as a classical physicist and not as a meteorologist with preconceived ideas. His interest in meteorology started perhaps with his interest in atmospheric optical and acoustic phenomena in the early years. He mentioned once or twice that the high wind speeds in jet streams may have some influence on the scintillation of stars. Apart from jet streams and the general circulation of the atmosphere, he was much interested in the Indian south-west monsoon and in medium and long-range forecasting of the strength of the monsoon for the benefit of Indian agriculture. He was convinced that the tropics, specially "the equatorial belt on the surface of the earth, plays a highly important role in terrestrial meteorology" and that tro-

pical meteorologists, specially Indian meteorologists, had a duty to show, by their researches, in what way the tropics and tropical convection controlled and contributed to the general circulation of the atmosphere and the monsoons. He mentioned to me once or twice that he would welcome study of one or two important tropical meteorological problems being undertaken at the Raman Research Institute.

Sir Raman knew the India Meteorological Department for over 50 years since the time of Sir Gilbert Walker. A number of his students became meteorologists and have played, and are playing, an important part in the development of Indian Meteorology. He asked one of them to give a talk on "Modern Developments in Meteorology" at the last Annual Session of the Indian Academy of Sciences held at Bangalore in September 1970, two months before his death.

It would be a tribute to the memory of Sir C. V. Raman if Indian meteorologists play an active part in researches on tropical meteorology, specially on the Indian monsoon, and make contributions of lasting value to meteorology and to India.

SIR C. V. RAMAN AS A METEOROLOGIST

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INTRODUCTION

THE intellectual greatness of Sir C. V. Raman was seen at its best in his passion for knowledge and his remarkable ability to go into the fundamentals of any subject in which he felt interested. His sense of curiosity would never be satisfied until he felt that he had found a convincing explanation for any scientific phenomenon which came within his purview. In this regard, meteorology was no exception to him. During the last two decades of his hectic activities, he evinced a great deal of interest in meteorology. His example inspired scores of Indian meteorologists and made them realise that, quite apart from the services which they rendered to various institutions during their professional work, it was their duty to contribute also to basic research in meteorology.

SYMPOSIA AND LECTURES ON METEOROLOGY

Prof. Raman organised many symposia and lectures on various aspects of meteorology. In

the Annual Session of the Indian Academy of Sciences held at Delhi in December 1951, he convened a symposium on the *Physics of Thunderstorms*. Raman's wide interest even in this field may be seen in the fact that the subjects discussed in the symposium included, among others, electrical aspects of thunderstorms and their bearing on the structure of aircraft. During the International Indian Ocean Expedition in 1962, Prof. Raman organised at Bombay, a symposium on *Oceanographic Research*, in which leading oceanographers and meteorologists participated. This was followed in December 1964 by a symposium on *Meteorology*, at Poona. The main purpose of holding this symposium was that Poona was the second most important centre for meteorological activities in India and Raman felt that this opportunity should not be missed for getting together as many meteorologists as possible and giving an impetus to the development of meteorology. These are only a few examples to show Sir C. V. Raman's interest in the

science of meteorology and his ardent desire to make this "infant science" grow fast on the Indian soil.

JET STREAMS IN UPPER AIR

In the Annual Session of the Indian Academy of Sciences held at Waltair in December 1956, the present writer, at the suggestion of Prof. Raman gave a talk on "Jet Streams in Upper Air". The absorbing interest with which Prof. Raman followed the lecture will ever remain fresh in the memory of the present writer. From that time onward, Prof. Raman became interested in the phenomenon of jet streams. During the symposium on meteorology held at Poona in December 1964, he himself raised the question of the origin of jet streams. He was not satisfied with the explanations given by the meteorologists present at the symposium and he expressed his deep conviction that the problem will have to be tackled afresh from fundamentals.

THE ATMOSPHERE OF THE EARTH

Prof. Raman subsequently gave expression to his own ideas about the origin of the jet streams and about the general circulation of the atmosphere in two scientific papers.^{1,2} The second of the two papers is entitled, "The Atmosphere of the Earth". We shall confine our attention to this paper as it contains his later views on this subject.

Raman starts with a number of basic concepts each of which is already known but which have been brought together by him for the first time. The basic concepts are:

- (i) The maximum speed of movement of the ground is at the equator. The speed decreases as we proceed poleward and becomes zero at the poles.
- (ii) The equatorial belt 30° N to 30° S receives the maximum amount of solar radiation in all seasons of the year. The insolation over the belt 30° to 60° (north and south) is notably less than that over the equatorial belt. It also shows large differences as between summer and winter months. In the belt 60° to 90° (north and south), the insolation is much less than in the equatorial and middle latitude belts. It shows, in addition, large variations with the seasons of the year.
- (iii) Frictional forces affect the behaviour of the atmosphere, in the mean, only upto about 600 meters above the ground.

- (iv) Momentum from the rotating earth is transported vertically to the upper levels of the atmosphere, quickly and efficiently by parcels of air continuously going up as a result of heating near the surface of the earth by solar radiation. This would be most pronounced and would be a constant feature throughout the year between 10° N and 10° S.

To the above basic concepts, Raman adds the postulate that the uprising air parcels would drift horizontally from the level where their updrift speed would become zero.

On the basis of the above, Raman explains:

- (a) The existence of the mean westerly jet streams in the upper troposphere near 30° N and 30° S.
- (b) The prevailing westerly zonal winds in middle latitudes extending from high levels downward upto the ground.
- (c) Easterly surface winds in the equatorial regions and near the poles at ground level.
- (d) Westerly winds with considerable speed over the polar areas at high levels.

The reader will undoubtedly concede that the broad features of the general circulation including the mean westerly jet stream have been explained by Raman. The sophisticated meteorologist may, however, feel that Raman has rather over-simplified the problem. For instance, he has not taken into account the important contribution to the general circulation by orography.³

It is of interest to mention that Prof. Raman's great emphasis on the vertical transport of momentum by convectional processes is quite consistent with recent findings of dynamical meteorologists^{4,5} from entirely different considerations that convective processes are of great importance and have to be taken into account in the simulation of the general circulation of the atmosphere by numerical models.

CONCLUSION

What, however, impresses the professional meteorologist most in Raman's paper is his remarkable freshness and simplicity of approach. For instance, he starts from the school-boy's concept of the rotating earth and ends with the most important results in modern

meteorology in a paper which does not cover even seven pages. And it will also be remembered that Raman wrote meteorological research papers for the first time when he was 80 years of age. This outstanding fact of Raman's life will undoubtedly be a source of inspiration to meteorologists in this country for generations to come.

1. Raman, C. V., *Proc. Ind. Acad. Sci.*, 1967, 66 A (5), 241.
2. —, *Ibid.*, 1968, 67 A, p. 123.
3. Reiter, R., Elmar, *Jet Stream Meteorology*, Univ. Chicago Press, 1963, p. 384.
4. Manable, S., Smagorinsky, J. and Strickler, R. F., *Mon. Weather Rev.*, 1965, 93, (12), 769.
5. Arakawa, A., Katayama, A. and Mintz, Y., *Proc. WMO/IUGG Symp.*, Tokyo, 1968, Num. Weather Prediction, IV-7, 8.

PROFESSOR SIR C. V. RAMAN AS I KNEW HIM

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THE scientific genius of Professor Sir C. V. Raman began to blossom at the age of 16 or 17 while he was still a student at the Presidency College, Madras, and his passion for science continued unabated till the time of his passing away at the age of 82. For over six decades, he dominated Indian Science and inspired generations of scientists who loved, admired and revered him. He won the highest honours, laurels, distinctions and awards, both national and international, for his researches and discoveries. His life is truly a saga of science. With his versatility and penetrating intellect, he combined child-like simplicity and deep humanity which endeared him to all those who came in contact with him. It is difficult to write about him and the many facets of his personality without getting the feeling that one has not adequately expressed what one wishes to convey.

In 1933—five years after the discovery of the Raman Effect and three years after he was awarded the Nobel Prize—Prof. Raman moved from Calcutta to join the Indian Institute of Science at Bangalore. In the newly-created Department of Physics at the Institute he pursued his scientific activities for a period of 15 years. I was one among the first batch of 8 or 10 students, fresh from the university, who joined to work under him in August 1933 and I was associated with him for the next four years. Anyone who wished to work under Professor as a regular student had to undergo a searching oral examination in which the candidate's knowledge of fundamentals and capacity for original thinking would be severely tested. Although Professor attached importance to academic records, he always made his own assessment of a student.

Once having been selected, the students felt at ease with Professor. He was kind,

generous and large-hearted. He had his own way of developing self-confidence and self-reliance in his students. He would treat them as his equals while discussing scientific matters. It was his habit to go round the laboratory every morning meeting each student, discussing the progress of his work and often suggesting new ideas. He would give free expression to his joy when a new result was brought to his notice. In his public lectures, he would refer to his students by name and talk about their work. All this was a thrilling experience to young students and a powerful incentive for sustained hard work and endeavour. A unique rapport was thus established between Professor and his students.

Professor encouraged his students to develop capacity for clear talk and exposition. He often remarked that one should be able to think on one's feet. His talks and lectures were always scintillating with new ideas and fresh outlook. The concept of the corrugated wave-front which is the basis of the famous Raman-Nath theory of the diffraction of light by ultrasonic waves came to him in a flash of intuition in the course of a talk.

Professor deprecated blind imitation and repetition of the ideas of others. "Let us think and do something original instead of browsing in Prof. Debye's backyard" was his characteristic remark on an occasion when someone was presenting the results of his study on the dielectric constants of liquids.

My work under Professor was concerned with the molecular scattering of light and the Raman Effect. He was still very much interested in problems relating to classical scattering of light, interest in which had somewhat waned with the discovery of the Raman Effect and the vast new vistas of research it opened up. "I began my work on Raman Effect