MATSCIENCE

INSTITUTE OF MATHEMATICAL SCIENCES
MADRAS, INDIA.

ANNUAL REPORT 1965

THE INSTITUTE OF MATHEMATICAL SCIENCES,

MADRAS

"THE PURSUIT OF SCIENCE IS AT ITS BEST
WHEN IT IS PART OF A WAY OF LIFE"

ANNUAL REPORT 1965

PATRONS:

Mr. Lal Bahadur Shastri, Prime Minister of India,

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DIRECTOR:

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HONORARY PROFESSOR OF ASTROPHYSICS:

Professor S. Chandrasekhar, F.R.S.

Distinguished Service Professor, Enrico Fermi Institute of Nuclear Studies,

University of Chicago, Chicago, Illinois, U.S.A.

Board of Governors

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5. Dr. R. Vasudevan, Permanent Member, The Institute of Mathematical Sciences, Madras.	
6. Professor G. N. Ramachandran, Department of Physics, University of Madras, Madras.	

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1.	Mr. S. Krishnaswamy, I.A.S., Secretary to Government, Education and Public Health Department, Government of Madras, Madras.	Chairman
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3.	Professor Alladi Ramakrishnan, Director, The Institute of Mathematical Sciences, Madras.	,,
4.	Dr. R. Vasudevan, Permanent Member, The Institute of Mathematical Sciences, Madras.	,,

Academic Council

1.	Professor Alladi Ramakrishnan, Director, The Institute of Mathematical Sciences, Madras.	Chairman
2.	Dr. R. Vasudevan, Permanent Member, The Institute of Mathematical Sciences, Madras.	Member
3.	Dr. N. R. Ranganathan, Associate Member, The Institute of Mathematical Sciences, Madras.	,,
4.	Dr. T. K. Radha, Associate Member, The Institute of Mathematical Sciences, Madras.	,,

General Information

Aims and Objects

The aims and objects of the institute are:

1. To create and provide an atmosphere and environment suitable for creative work and the pursuit of knowledge and advanced learning in the mathematical sciences for their own sake,
2. To promote and conduct research and original investigation in fundamental sciences in general, with particular emphasis in Mathematics, Applied Mathematics, Theoretical Physics and Astrophysics,
3. To foster a rigorous mathematical discipline, to stimulate a zest for creative work and cultivate a spirit of intellectual collaboration among academic workers in pure and applied branches of science,
4. To arrange lectures, meetings, seminars and symposia in pursuance of its academic work and for the diffusion of scientific knowledge,
5. To invite scientists in India and abroad actively engaged in creative work to deliver lectures and participate in its academic activity.

The primary activity of the Institute is creative research in the mathematical sciences. In pursuit of the objectives of the Institute, weekly seminars as well as series of lectures on various topics of interest, both by visiting scientists and the academic staff of the Institute are held.

Academic activities

The Institute organises a Summer School in Theoretical Physics in the month of August in which lectures range from introductory to advanced levels, the aim being to introduce the participants to new developments.

To commemorate the inauguration of the Institute an Anniversary Symposium is held in the first week of January in which scientists from India and abroad are invited to deliver one hour addresses summarizing their original work or recent advances in various branches of mathematical sciences.

Academic staff

The academic group consists of Professors and Permanent Members of the various faculties, visiting scientists, temporary members, research fellows and research trainees.

Facilities are available for post-graduate students to work for the Ph. D. degree under the guidance of the academic staff of the Institute in various faculties. Senior and junior research fellowships of value Rs. 500/. per mensem and Rs. 300/- per mensem are awarded by the Institute. Besides these, fellowships tenable at the Institute are awarded by the Department of Atomic Energy and Council of Scientific and Industrial Research.

Mode of admission

Memberships (temporary and permanent) of the Institute are made available either on invitation or by application to the Director.

Students intending to become research trainees and research fellows of the Institute are expected to apply on prescribed forms which are available on request.

Visiting scientists programme

Facilities are available for visiting scientists to spend a considerable time in the Institute and work in collaboration with the academic staff of the Institute.

Distinguished scientists of estabilshed reputation are invited by the Director on behalf of the Board of Governors as Visiting Professors of the Institute. They are expected to stay for six weeks or more and the Institute will pay their travel expenses by air (round trip tourist) from the place of their residence to Madras. An allowance of Rs. 75/- per day will be made available to them during their stay at the Institute.

The Visiting membership programme of the Institute is designed to enable young, active and promising scientists to pursue research and take part in various academic activities of the Institute. Such memberships are available on invitation or by request for such periods as may be fixed in consultation with the visiting members. A living allowance of Rs. 50/- per day and travel expenses by air (round trip tourist) from the place of the residence to Madras are made available to residents outside India and salaries of Rs. 600 to Rs. 1,500 to research workers in India. Scientists intending to be admitted under this scheme can contact the Director of the Institute giving particulars of their academic career and indicating the probable period of their stay.

Publications

Besides the above, scientists from various institutions may be invited to deliver lectures and seminars for which suitable honorarium will be offered.

1. **Research papers** (Preprints) and reprints are available by request).
2. **Seminar lecture notes** (available by request).
3. **Matscience reports** based on the lecture courses delivered at the Institute both by visiting scientists and academic staff. (Price Rs. 5/- or U. S. $ 1.00 outside India.)
4. Proceedings of the Summer School and the Anniversary Symposium published as a series entitled **"Proceedings of the Summer School and Winter Matscience Symposia"** by the Plenum Press, New York.

Academic Group (1965)

Permanent Staff:

1.	Professor Alladi Ramakrishnan	Director
2.	Dr. R. Vasudevan*	Permanent Member
3.	Dr. N. R. Ranganathan**	Associate Member
4.	Dr. T. K. Radha***	Associate Member

Temporary Members:

1.	Dr. K. Venkatesan	Temporary Member
2.	Dr. K. R. Unni	Temporary Member
3.	Mr. K. Ananthanarayanan	Temporary Member
4.	Dr. I. V. V. Raghavacharyulu	Temporary Member
5.	Dr. S. C. K. Nair	Pool Officer, C. S. I. R.

Research fellows:

1.	Mr. T. S. Santhanam	Senior Research Assistant, C. S. I. R.
2.	Mr. T. S. Shankara	Junior Research Assistant, C. S. I. R.
3.	Mr. K. Srinivasa Rao	Jnnior Research Fellow, C. S. I. R.
4.	Mr. A. Sundaram	Junior Research Fellow, C. S. I. R.
5.	Mr. R. Sridhar	Junior Research Fellow, C. S. I. R.
6.	Mr. G. N. Keshavamurthi	Junior Research Fellow, C. S. I. R.
7.	Mr. S. K. Singh	Junior Research Assistant, C. S. I. R.
8.	Mr. A. R. Prasanna	Junior Research Fellow, Matscience.

Research Trainees:

1.	Mr. N. R. Nandakumar	M. Sc. (Mysore University)
2.	Mr. M. R. Subramanya	M. Sc. (Mysore University)

* *On deputation to Berkeley, California, U. S. A., June 1965–January 1966.*

** *On deputation to Saclay, France, October 1965–January 1966.*

*** *On deputation to the Institute for Advanced Study, Princeton, U. S. A. October 1965 – March 1966.*

Visiting Scientists (1965)

Prof. Milne Thompson (*U. K.*)

Prof. M. Gourdin (*France*)

Prof. Ph. Meyer (*France*)

Prof. C. De Dominicis (*France*)

Prof. Marshall H. Stone (*USA*)

Prof. A. Sjolander (*Sweden*)

Dr. L. A. P. Balazs (*T.I.F.R.*) Bombay

Prof. V. Weisskopf (*Switzerland*)

Dr. K. Dietz (*Switzerland*)

Prof. P. T. Landsberg (*England*)

Prof. R. Blankenbecler (*USA*)

Prof. Harishchandra (*USA*)

Prof. J. J. de Swart (*Sweden*)

Dr. J. V. Narlikar (*U. K.*)

Prof. M. Jacobson (*USA*)

Prof. R. H. Capps (*USA*)

Prof. P. Jastrom (*USA*)

Prof. T. Kotani (*Japan*)

Prof. K. Symon (*USA*)

Prof. K. Neilson (*USA*)

Prof. A. Grossmann (*USA*)

Dr. R. J. Oakes (*USA*)

Prof. J. L. Kelley (*USA*)

Dr. V. L. Teplitz (*USA*)

Dr. S. Kichenassamy (*France*)

Prof. G. Marx (*Hungary*)

Dr. H. Ruegg (*Switzerland*)

Prof. R. Arens (*USA*)

Dr. B. Gruber (*Italy*)

Prof. G. Goldhaber (*USA*)

Prof. (Mrs.) S. Goldhaber (*USA*)

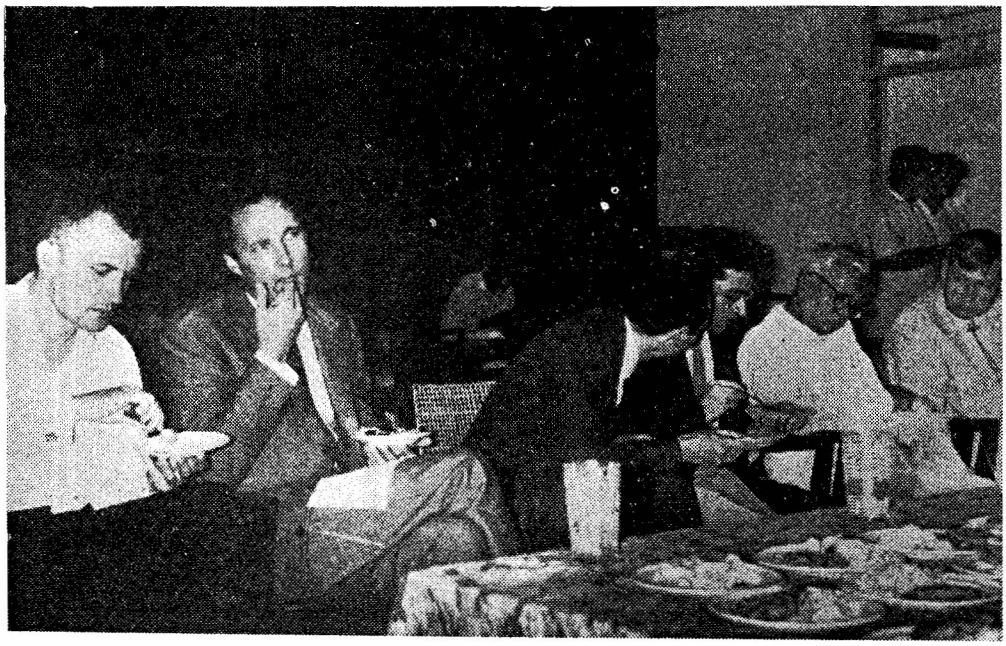
Dr. L. Picman (*Finland*)

Prof. Y. Takahashi (*Ireland*)

Prof. G. Kallen (*Sweden*)

Prof. J. Rzewuski (*Poland*)

Prof. W. K. Hayman (*U. K.*)



Professor Ph. Meyer, Professor C. De Dominicis and Professor Marshall Stone with the Hon'ble Sri M. Bhaktavatsalam, Chief Minister of Madras. Dr. J. Lukierski and Professor M. Gourdin are at the extreme left.

Mr. Albert B. Franklin, U. S. Consul-General at Madras and his wife in the company of Professor K. Symon and Professor P. Jastrom.

The year 1965 in retrospect

Our fifth year

As the Institute enters the fifth year of its career we are becoming conscious of a new tradition which will determine the direction and mode of its growth in the years to come. At its inception, Professor Chandrasekhar expressed the view that its creation was a departure from the conventional scientific scene in India. The events of the last four years have borne out in adequate measure the prescient observation of our distinguished sponsor.

A new tradition

It is a tradition in consonance with the spirit that has characterised the spectacular growth of scientific effort throughout the world for the past decade. This growth was stimulated by fundamental experimental discoveries made possible since the construction of high energy machines which demanded immense financial and technical resources, available only in affluent countries or through the co-operative enterprise of groups of nations. Similar support from governments and international organisations harnessed the swelling surge of creative talent in the mathematical sciences. It was therefore felt necessary that, despite our limited resources and practical problems, we should devise ways and means of contributing to this international effort particularly in fundamental research.

Our sources of faith

Our Institute represents an earnest effort in this direction and our faith in the successful pursuit of research in so competitive a domain as the mathematical sciences, stems from two sources; the willing and sustained support from the Government of Madras on the one hand and the efforts of the devoted band of young workers who have initiated the academic work at the Institute. The time has arrived when I should mention explicitly their role in its growth and development.

Our principal sponsor

The aspirant community of young scientists in India, particularly in Madras, feel a rightful sense of pride that their State Government has been the primary sponsor of an international effort in fundamental sciences and what is more that our Chief Minister, Chairman and their administrative aides in government are taking as lively and personal an interest in this endeavour as the academicians themselves. It is a natural sequel therefore that we have received additional assistance from the Council of Scientific and Industrial Research and the Department of Atomic Energy of the Government of India.

Kindred spirits

Such welcome support imposes on our permanent academic staff a great responsibility, not only to discharge their normal duties effectively but also fulfil the hopes they have raised in the minds of the scientific community. They have borne this responsibility cheerfully and with credit. We could not have made a better choice of kindred spirits. Dr. Vasudevan's interests have ranged over many allied fields: stochastic processes, statistical

mechanics and many body problems. He is now on a research assignment at Berkeley at the kind invitation of Professor Watson, thus renewing the close and fruitful association he had established during his four year stay in the United States before the inception of the institute. Among the workers in high energy physics, Dr. Radha who has had the most intensive research training in our Institute and obtained her doctorate degree here based on fifteen published papers, is now enjoying generous support and encouragement from a succession of eminent physicists in leading centres of the world : Salam at Trieste, Schiff at Stanford, Marshak at Rochester and Fubini at Princeton. The award of a visiting membership to her at the Institute for Advanced Study by Professor Oppenheimer should act as a stimulus to new entrants to our Institute to aspire for similar opportunities. Dr. Ranganathan is now actively interested in a new field in fundamental physics demanding knowledge of some of the abstract domains in mathematics like topology and homology. He is now in Paris working in association with Professor Caianiello and the members of the Saclay group whose ties with our Institute have become so close after their visits to Madras last winter.

Academic work

The most valuable contribution in research this year from our Institute was made by Mr. Anantanarayanan who has shown a high degree of independence and initiative in his work which has attracted the attention of experts in the field. Dr. Venkatesan's reports on recent experiments appear with a promptness and regularity which must be an example for his colleagues to follow. In pure mathematics, Dr. Unni is making a single-handed effort in conducting a programme of post-graduate training in a bold attempt to meet the rigorous standards of the great centres of mathematical education in America. This ambitious objective had forward realisation in the prime quality of the Canberra lectures of Dr. Radha who had the coveted privilege of being one of the youngest scientists to be invited for such a visiting assignment.

Matscience–I. I. T. seminars

Besides the efforts of the members of the Institute, there has been an equally welcome development in another direction, that is, the possibilities of collaboration with various universities and research institutions in India. We commenced this programme with the Matscience—I. I. T. seminar in view of the spontaneous and enthusiastic response from Professor Nigam and Dr. S. K. Srinivasan of the Department of Applied Mathematics. This exchange is sure to prove quite fruitful since Dr. Srinivasan has been one of the founding members of our theoretical physics group, particularly in the theory of strong interactions at the same time keeping up a creative interest in the theory of stochastic processes.

Cooperation of T. I. F. R.

A similar situation now exists in our relations with the Tata Institute of Fundamental Research, thanks to the support of Professor H. J. Bhabha and the co-operation of Professor M. G. K. Menon. In reponse to the kind invitation from the Tata Institute, Dr. N. R. Ranganathan spent a fortnight there giving lectures and discussing problems of common interest with

post-doctoral workers. We welcome the presence and participation of some of the leading members of the physics group from that Institute at this anniversary symposium.

The greatest incentive

With unconcealed emotion and faith, we wish to ascribe all these favourable developments to the impetus given to us by the benign and personal interest of the late revered Prime Minister in the creation of our institute. It is our good fortune that the present Prime Minister has agreed, with the same warmth and spontaneity, to be its Patron when I made a request to him in person earlier this year. The Hon'ble Sri C. Subramaniam's concern for the welfare of the Institute and interest in its progress provide the greatest incentive to the members of our Institute, particularly to those who are aware of the circumstances under which it came into existence.

The vital impulses

The steady influx of visiting scientists transmits to us the strong and vital impulses from the main stream of scientific thought in the physical sciences today. The visiting scientists have a made three-fold contribution to the academic work of the Institute; first by their own research, sometimes done in collaboration with the members of our academic group; secondly through systematic series of lectures which are made available to a wider community as Matscience reports and thirdly by their active participation in our scientific meetings.

Proceedings of symposia

The lectures in our anniversary symposia and our August summer schools are now being published as a series entitled " Proceedings of Matscience symposia " by the Plenum Press, New York, following the spontaneous offer by its President, Mr. Earl M. Coleman during his visit to Madras in January year. The handsome effort of the Plenum Press to bring out the series beginning with the very first symposium has been matched by the willing cooperation of our visiting scientists who have made this an international endeavour, the wholesome consequences of which will be felt beyond the domain of science.

Our library

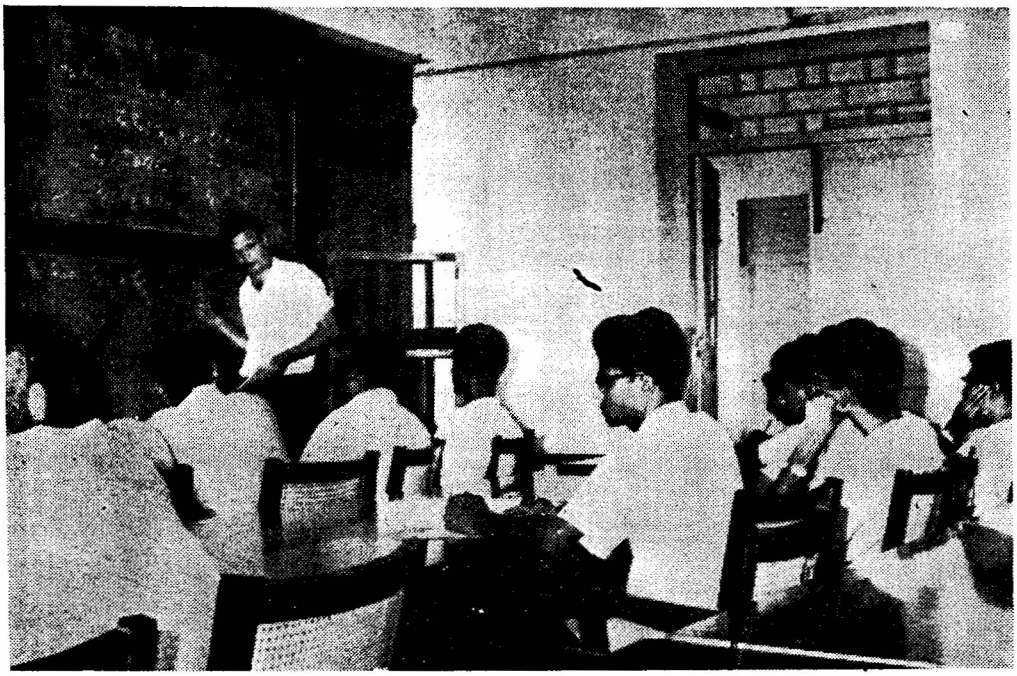
Next to the work of the academic staff, we feel proud of our well-stocked and growing library of books and periodicals. With the journals and preprints all around and the immediate presence of the visiting scientists, it is hard to distinguish the atmosphere inside, from that at CERN or Berkeley, Princeton or the Imperial College except of course when we feel the pleasant warmth of a Madras winter ! The library is growing so fast that it is stretching into the already restricted space allotted to our distinguished guests amounting almost to an invasion of their privacy. The best way to acknowledge the cooperation of the Director of Technical Education who

provided us this comfortable venue is to ask for more accommodation which I am quite sure will be made available soon with the same enthusiasm and willingness.

A time for dedication

Perhaps, this is a propitious occasion to remind ourselves that despite the wide difference in financial conditions and physical comforts between the great institutions in the United States and those in India, our state and central governments are making a magnificent effort towards scientific advancement in our country. The new generation of scientists here who are enjoying privileges unknown or unfelt by their predecessors should, in view of their specialised training, think more of what they can do for their country and not so much of what the country can do for them. For this is not a time for complaint or criticism but for dedication in the service of our ancient land and new republic which is passing through an ordeal of fire and steel, from which it will certainly emerge in renewed strength and substance due to the vitality of its traditions and a faith in its future.

ALLADI RAMAKRISHNAN



Dr. K. Dietz, CERN, (Geneva) lecturing at the Third Anniversary Symposium.

Professor R. Blankenbecler, Dr. L. A. P. Balazs and Dr. Virendra Singh in conversation during the Symposium.

News of the Institute

Anniversary symposium

The Third Anniversary Symposium of the Institute was held during January 3-12, 1965. Professor Victor Weisskopf, Director General, CERN, Geneva, delivered the Introductory address, 'on the present state of elementary particle physics.' The following resident visiting scientists, members of the academic staff of the Institute and invited lecturers from some institutions in India participated in the symposium.

Professor M. H. Stone, U.S.A.; Professor C. De Dominics, France; Dr. K Dietz, Geneva; Dr. L. A. P. Balazs, Tata Institute of Fundamental Research; Dr. J. Lukierski, Poland; Dr. J. J. De Swart, Holland; Professor Alf Sjolander, Sweden; Professor R. Blankenbecler, U.S.A.; Professor P. T. Landsberg, U. K.; Professor A. N. Mitra, Delhi University; Dr. Virendra Singh, Tata Institute of Fundamental Research; and Professor Harish Chandra, Institute for Advanced Study, Princeton, U.S.A., participated in the symposium.

Summer School

The second Matscience Summer School organised at Bangalore from August 17th to September 4th, 1965 was inaugurated by Mr. M. Bakthavatsalam, Chief Minister of Madras. The Chairman of the Board of Governors, Mr. R. Venkataraman, presided over the inaugural function. Approximately fifty lectures were delivered by twelve invited lecturers: six from outside India, one from the Tata Institute of Fundamental Research, Bombay and the rest from Madras.

Lecturers from the educational institutions in Madras and Bangalore availed themselves of this opportunity to attend the Summer School.

Visiting scientists

As in the preceding years under the visiting scientists programme supported by the Government of Madras and the Council of Scientific and Industrial Research, distinguished professors of established reputation as well as younger scientists of great promise have visited the Institute to deliver lectures, participate in seminars, symposium and the summer school and also to collaborate actively with the members of the Institute in their research work.

Matscience-IIT seminar

A new feature of the year was the inauguration of the MATSCIENCE —I. I. T. Seminars under the joint auspices of MATSCIENCE and the Department of Mathematics, Indian Institute of Techonology, Madras.

Publications

The publications of the Institute include research papers based on work carried out by members of our academic staff and the visiting scientists, MATSCIENCE Reports and seminar lectures. The monthly report on recent experimental data are being published regularly.

Delegations

Professor Alladi Ramakrishnan visited the International Centre for Theoretical Physics, Trieste, Italy, under the auspices of the International Atomic Energy Agency at the invitation of its Director. During his two-month stay he carried out investigations on 'Fundamental multiplets'. He visited and lectured at other centres of research in Europe — Naples, Padua, CERN and Saclay (Paris).

Professor Ramakrishnan was invited to participate in the annual Cosmic Ray Symposium under the auspices of the Cosmic Ray Research Committee held at Bombay from 13th December by giving a half-an-hour lecture on "Electromagnetic interactions of pseudo-scalar, spinor and vector particles". As he could not be present, Mr. K. Ananthanarayanan was deputed to represent the Institute at the meeting.

Dr. R. Vasudevan left for U. S. A. in June in response to an invitation by Professor K. M. Watson to spend six months at the Department of Physics, University of California, Berkeley.

Dr. T. K. Radha, was invited by Professor K. J. Le Couteur to delivered a course of lectures on 'Unitary Symmetry' at the Institute of Advanced Study, Australian National University, Canberra. During her three month stay in Australia from April to June, she also gave seminars at the Universities of Melbourne and Sydney at the invitation of Professors Williams and Harry Messel.

Dr. Radha was awarded a visiting membership by Professor J. R. Oppenheimer, Director, Institute for Advanced Study, Princeton (New Jersey) U. S. A. to spend one academic year at the Institute. She was also deputed by our Institute as a delegate to the International Conference on 'Elementary Particles' in Oxford, U. K. held from 19th to 25th September, 1965 which she attended on her way to Princeton. She left for Oxford on 17th September and joined the Princeton Institute on 27th September.

Under an informal programme of exchange of scientists between the Tata Institute of Fundamental Research (T. I. F. R.) Bombay and MATSCIENCE, Dr. N. R. Ranganathan spent a fortnight from 17th April to 1st May, at the department of Theoretical Physics. During his stay he delivered a set of three lectures on 'Some aspects of Renormalization Theory'.

Dr. Ranganathan was invited by Professor E.R. Caianiello, Director, Institute for Theoretical Physics, Naples (Italy), to spend a period of about three months at the Service de Physique Theorique, DPNS, Saclay (S. et O), Paris (France) in order to continue the collaboration on some research work initiated at MATSCIENCE. He left for Paris on 28th October, 1965.

The Director is a member of :

1. The Editorial Board of the 'Journal of Mathematical Analysis and Applications'. (US)
2. Physical Research Committee (C. S. & I. R., India)

Second Matscience Summer School

The Second Matscience Summer School on Theoretical Physics was held in Bangalore for three weeks from 17th August to 4th September, 1965. The Council of Scientific and Industrial Research extended financial support through a generous grant. Professor Alladi Ramakrishnan was the Director of the Summer School and the entire organisation as well as academic matters were left in the hands of the authorities of MATSCIENCE.

The school was inaugurated on the morning of 17th August by the Hon'ble Sri M. Bhaktavatsalam, Chief Minister of Madras. The academic sesson started in earnest from the evening of 17th itself with three or four one hour sessions a day on subsequent days.

Sixteen scientists were invited to lecture at the Summer School. The scientists from foreign institutions who participated were: Dr. A. Grossmann, U. S. A.; Dr. R. J. Oakes, U. S. A.; Dr. V. L. Teplitz, U. S. A.; B. Misra, Switzerland; Dr. S. Kichenassamy, France; and Mr. M. Bhaktavasalu, France. All of them were visiting scientists at MATSCIENCE. The other lecturers were: Professor A. Ramakrishnan, Dr. N. R. Ranganathan, Dr. T. K. Radha, Dr. K. R. Unni, Mr. T. S. Santhanam, Mr. K. Ananthanarayanan, Mr. G. Jagannathan and Dr. S. K. Srinivasan (Indian Institute of Technology, Madras).

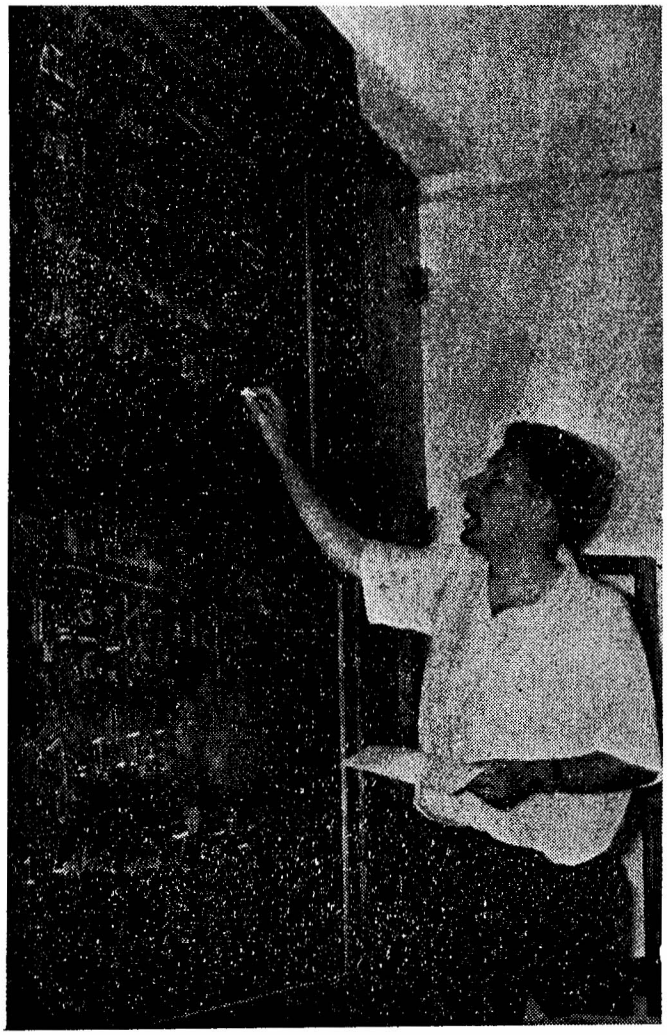
The other participants at the summer school comprised mainly of the research students, lecturers from educational institutions in Madras, research workers of Roorkee, Calcutta and National Chemical Laboratory (Poona). Besides these, quite a few scientists and research workers from educational institutions in Bangalore and from other states also attended the lectures regularly. The conference was held at the Madras Woodlands Hotel, Bangalore where most of the participants stayed.

During the week-ends excursions to places of cultural and historical importance in and around Bangalore city were arranged.

The proceedings of the summer school are being edited and will be published by Plenum Press, New York, U. S. A. as Volume V of the 'Proceedings of the MATSCIENCE Symposia.'

The following is the list of lectures delivered at the Second Matscience Summer School:

Name	*Title of the lecture*
Dr. A. Grossmann	Nested Hilbert spaces.
Dr. R. J. Oakes	Topics in weak interactions.
Dr. V. C. Teplitz	Application of algebraic topology to Feynman integrals.
Dr. B. Misra	Some recent results of Axiomatic field theory.
Dr. S. Kichenassamy	Topics on the theory of gravitation.
Professor M. G. K. Menon	Neutrino Physics.
Dr. S. K. Srinivasan	Random Potentials.
Professor A. Ramakrishnan	Unitary symmetry of Elementary Particle Interactions I, II.
Dr. N. R. Ranganathan	Introduction to Algebraic topology.
Dr. T. K. Radha	Unitary symmetry of Elementary Particle Interactions III and IV.
Dr. K. R. Unni	Certain extremas problems.
Mr. K. Ananthanarayanan	Structure of light nuclei.
Mr. T. S. Santhanam	Unitary symmetry of Elementary Particle Interactions V and VI.
Mr. G. Jagannathan	Fadeev equations and the three particle problem.



Professor J. J. de Swart during one of his lectures on Unitary Symmetry.

The Faculty of Theoretical Physics

The Director of the Institute is a professor of this faculty. At the end of the year, the staff of this faculty consisted of a Permanent Member, Two Associate Members, three Temporary Members, a C.S.I.R. Pool Officer, Seven Research Fellows and One Research Trainee.

There were about thirty visiting scientists under the visiting scientists programme.

Research Activity:

The research work carried out in this faculty was mainly in the field of elementary particle physics and many body problems. The work of the group engaged on the symmetries of elementary particles related to a study of the Gell-Mann-Nishijima relation on the multiplet structure of elementary particles and on some calculations on high energy neutrino reactions in relation to $\bar{U}$ (12) symmetry. In the field of strong interactions application of homological methods in the enumeration of the singularities of the scattering amplitudes has been considered. Investigations on the singularities on the unphysical sheets using the unitarity condition have also been carried out.

The use of the matrix elements for the scattering and photoproduction of pions from nucleons in conjunction with the impulse approximation has enabled the group working on nuclear physics to study the light nuclei, viz. the deuteron, (D-state admixture and hard-core radius), H^3 and He^3 (structure of the ground states and the admixture of $T = 3/2$ state in He^3 ground state).

In quantum mechanics some work on scattering phase shifts in random potentials has been carried out. The problems of construction of a class of soluble potentials for the Schrodinger equation, the nonrelativistic approximation of the Dirac equation and the Klein-Gordon equation and the regularisation of some singular potentials have been investigated. The study of the renormalization of field theories using Caianiello's approach is being pursued.

Matscience Reports:

The lecture courses delivered by the following scientists have been prepared as Matscience reports.

List of Matscience Reports:

Report No.	*Author*	*Title*
35	K. Symanzik	Lectures on a modified model of Euclidean Quantum Field Theory.
36	K. Venkatesan	Report on Recent Experimental Data (1964).
37	A. Fujii	Lectures on Fermi dynamics.
38	M. Gourdin	Mathematical introduction to unitary symmetries.
39	J. V. Narlikar	Theories of Gravitation.
40	K. Venkatesan	Report on recent experimental data (1965).
42	L. Rosenfeld	Lectures on nuclear reactions.

Pre-print List:

Author	*Title*
Alladi Ramakrishnan	Fundamental multiplets (Trieste preprint).
R. Vasudevan, K. Venkatesan and G. Jagannathan	Construction of soluble potentials and regularization of singular potentials.
T. S. Santhanam	High-energy neutrino reactions and SU(12) symmetry.
K. Ananthanarayanan	Admixture of $T=3/2$ state in the ground state state of He^3.
,,	Ground states of He^3 and H^3.
K. Ananthanarayanan and K. Srinivasa Rao	Effects of D-state admixture and hard-core radius on the photo-production of neutral pions from deuterons.
Alladi Ramakrishnan, S. K. Srinivasan and R. Vasudevan	Scattering phase shifts in random potentials.

Re-print List :

Author	*Title*
K. Raman	Regge poles in weak interactions I. /Nuo. Cim. 33 (1964) 545-565/.
G. Ramachandran and K. Ananthanarayanan	Photoproduction of pions from H^3 and He^3. /Nuc. Phys. 59 (1964) 633-640/.
Alladi Ramakrishnan, K. Raman and R. K. Umerjee	Isobar production in Nucleon-Nucleon collisions. /Nuc. Phy. 60 (1964) 401-426/.
R. K. Umerjee	Deuteron polarization following elastic scattering of positive pions. /Nuc. Phy. 60 (1964) 313-318/.
R. K. Umerjee	Scattering of pions from nuclei. /Nuc. Phy. 60 (1964) 497-502/.
Henry P. Stapp	Space, time and elementary particles. /Jour. of Scientific and Indus. Res. 23 (1965) 281-284/.
F. Calogero	Necessary condition for the existence of bound states. /Nuo. Cim. 36 (1965) 199-201/.
G. Ramachandran and K. Ananthanarayanan	Scattering of pions from H^3 and He^3. /Nuc. Phy. 64 (1965) 652-656/.
K. Raman	Formalism for parity-nonconserving reactions I. /Nuo. Cim. 36 (1965) 554-568/.
K. Raman	Formalism for parity-nonconserving reactions II-polarization. /Nuo. Cim. 36 (1965) 569-585/.
Alladi Ramakrishnan, K. Raman and R. K. Umerjee	Isobar production in nucleon-nucleon collisions II-polarization effect. /Nuc. Phy. (1965) 309-331/.
N. R. Ranganathan and R. Vasudevan	Remarks on Dirac spurs and Pfaffians. /Nuo. Cim. 37 (1965) 172-178/.
K. Raman	On scalar K - π resonances. /Nuo. Cim. 36 (1965) 115-119/.
Alladi Ramakrishnan, K. Venkatesan and T. S. Shankara	Sensitivity of the vector coupling to neutrino mass and T-invariance. /Nuo. Cim. 37 (1955) 1046-1048/.

Faculty of Pure and Applied Mathematics

Professor N. Jacobson of the Yale University gave a lecture on the theory of representation in Jordan Algebra.

Professor J. L. Kelley of the University of California gave a lecture on "A Pattern in Functional Analysis."

Professor Richard Arens of the University of California-Los Angeles, gave a course of lectures on the differential-geometric elements of analytical dynamics.

Dr. K. R. Unni who joined the Institute early this year as a C.S.I.R. pool officer was appointed as a member in the Faculty of Pure Mathematics. He started a course, at basic level, on Modern Algebra, Topology and functional analysis. There are two research students in this faculty.

In the faculty of Applied mathematics investigations on fluctuating density fields and their application to (1) Browmian motion, (2) Diffusion of plasma and acceleration in magnetic fields and (3) Neutron transport theory with particular reference to crossing problems have been carried out.

The following are the reports and research papers published during the year:

Matscience Reports :

Report No.	*Author*	*Title*
41	Unni (K. R.)	Introduction to Hilbert space
43	Unni (K. R.)	Concepts in Modern Mathematics I (Algebra)

Research Papers :

Alladi Ramakrishnan, S. K. Srinivasan and R. Vasudevan	New Mathematical features in cascade theory (J. Math. Analy. and appl., July 1965)
Q. I. Rahman and K. R. Unni	Extremal problems and polynomials of least deviation.

Faculty of Astrophysics

Professor S. Chandrasekhar, Distinguished Service Professor, Enrico Fermi institute for Nuclear studies, University of Chicago, U. S. A., is an honorary professor of Astrophysics at the Institute.

Dr. J. V. Narlikar, Cambridge University, England, gave a series of three lectures on "Theories of gravitation", the notes of which were prepared by Dr. R. Vasudevan and comprise MATSCIENCE REPORT 39.

Dr. S. Kichenassamy, Institute of Henri Poincare, Paris, France, gave a series of lectures at the Second Matscience Summer School, Bangalore and a set of three lectures at the Institute on the foundations of special and general theory of relativity. Mr. M. Bhaktavatsalu, also from the Institute of Henri Poincare, gave a seminar on conformal groups at the Summer School.

Dr. J. V. Narlikar with the members of the institute.

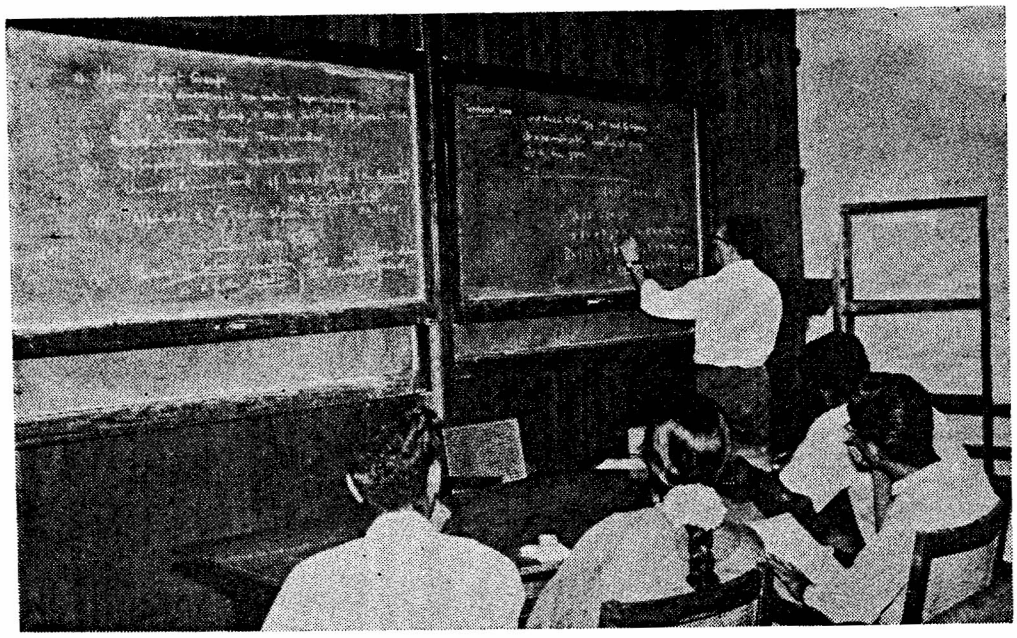
Dr. J. V. Narlikar delivering a lecture on his new theory of gravitation.

Lecture courses by Visiting Scientists

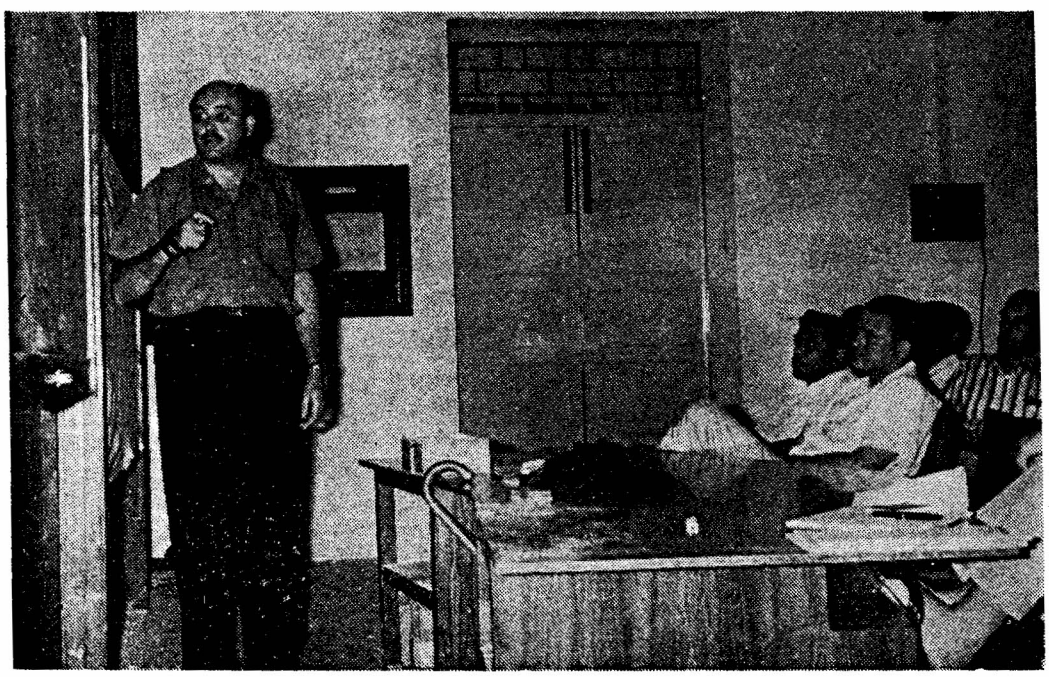
Visiting Scientist	*Period of Visit*	*Title*
Professor J. J. DeSwart, Nijmegen, Holland.	January—February, 1965	Unitary symmetry.
Professor P. T. Landsberg, University of Cardiff, Wales, U. K.	,, ,,	Selected topics in solid state physics.
Dr. K. Dietz, CERN, Geneva, Switzerland.	,, ,,	Lectures on "Bootstrap mechanism and scattering theory."
Dr. A. Grossmann, Courant Institute, New York, U. S. A.	July — September, 1965	Introduction to Nested Hilbert space.
Dr. R. J. Oakes, Stanford University, U. S. A.	,, ,,	Structure of He^3 and H^3.
		Seminars on SU (4) symmetry and strangeness-4 baryon.
Dr. V. L. Teplitz, CERN, Geneva, Switzerland.	,, ,,	Bootstrap theory.
		Seminar on Shadow effects high energy region.
Dr. S. Kichenassamy, Henri Pioncare Institute, Paris, France.	,, ,,	Topics in the theory of gravitation.
Professor Richard Arens, University of California, U. S. A.	November—December, 1965	Differential - Geometric elements in analytical dynamics
Professor H. Ruegg, CERN, Geneva, Switzerland.	December 1965	Relativistic generalisation of SU (6).
Dr. B. Gruber, Naples, Italy.	December 1965	Topological groups and global method.

Seminars by the Staff of the Institute

Name	*Date*	*Title of the Lecture*
R. Vasudevan, Permanent Member, MATSCIENCE.	Starting from March, 1965	Survey of gravitational theories.
	13—3—1965 } 25—3—1965 }	Decaying states and correlations in quantum mechanics.
N. R. Ranganathan, Associate Member, MATSCIENCE.	12—3—1965	Broken symmetry.
	2—6—1965	Lectures on topics in quantum field theory.
	3—4—1965	Some remarks on the self-energy problem.
T. K. Radha, Associate Member, MATSCIENCE.	17—3—1965	Some observation on SU(6) and SU(12).
	29—7—1965	Recent development in symmetries-weak interactions.
K. Venkatesan, Temporary Member, MATSCIENCE.	March 1965	Problem of moments in dispersion theory.
	17—4—1965	Spinor representation of Lorentz group.
	March 1965	Lectures on analyticity and perturbation groups.
	15—6—1965	Mass formulae, symmetry and dispersion relation.
	25—6—1965	Bootstrap and symmetries.
	Nov. 1965	Extension and Contraction of groups.
K. R. Unni, Temporary Member, MATSCIENCE.	Series of lectures starting from July 1965	Lectures on Hilbert space.
	Nov. 1965	Concepts in modern mathematics.
K. Ananthanarayanan, Temporary Member, MATSCIENCE.	Starting from 23—3—1965	Scattering theory (5 lectures).
	Nov., 1965	Topics in strong interactions
I. V. V. Raghavacharyulu, Temporary Member, MATSCIENCE.	Sep. – Nov., 1965	Strange particles based on ' Kallen's book.



Professor N. Jacobson giving a seminar at the institute.



Professor P. Jastrom delivering a lecture at the institute.

Invited Lecturers

Scientists	*Date*	*Title of the Lecture*
Professor Yu. M. Shirokov, Nuclear Physics Institute, Moscow State University, Moscow, U. S. S. R.	11th, 13th February, '65	1. Covering group of the inhomogeneous Lorentz group and SU_3 group. 2. New connection between fields and particles with spin.
Dr. J. V. Narlikar, Kings College, Cambridge, U. K.	23rd 24th and 25th February, '65	Theories of gravitation.
Professor N. Jacobson, University of Chicago, Chicago, Illinois, U. S. A.	1st March, '65	Theory of Representation in Jordan Algebra.
Professor Richard H. Capps, North Western University, U. S. A.	16th July, '65	Bootstrap Theory.
Professor Philip Jastrom, Ohio State University, U. S. A.	29th July, '65 30th July, '65	1. Double inner bremms-strahlung. 2. Four fundamental forces in nature.
Professor Keith Symon, University of Wisconsin, U. S. A.	30th July, '65 31st July, '65	1. Instability in High Energy accelerators. 2. Non-linear orbit theory.
Professor Carl Nielsen, Ohio State University, U. S. A.	31st July, '65 2nd August, '65	Recent progress in controlled thermonuclear research.
Professor J. L. Kelly, University of California, Berkeley, U. S. A.	12th October, '65	A pattern in functional analysis.
Dr. Ram Gnanadesikan, Bell Telephones, New York, U. S. A.	30th April, '65	Analysis of spectrum of voice.
Professor S. Minakshisundaram Andhra University, Waltair	24th June, '65	Special theory of operators.
Mr. V. Radhakrishnan, T. I. F. R. Bombay.	20th and 22nd March '65	Super conductivity.
Dr. A. P. Balachandran, Syracuse University, U. S. A.	24th July, '65	Partial wave dispers on relations.
Professor George Marx, Stanford University, California, U. S. A.	15th October, '65	Discussion on the Proceedings of the conference on Elementary Particles, Tokyo.

Proceedings of Matscience Symposia

Edited By

ALLADI RAMAKRISHNAN

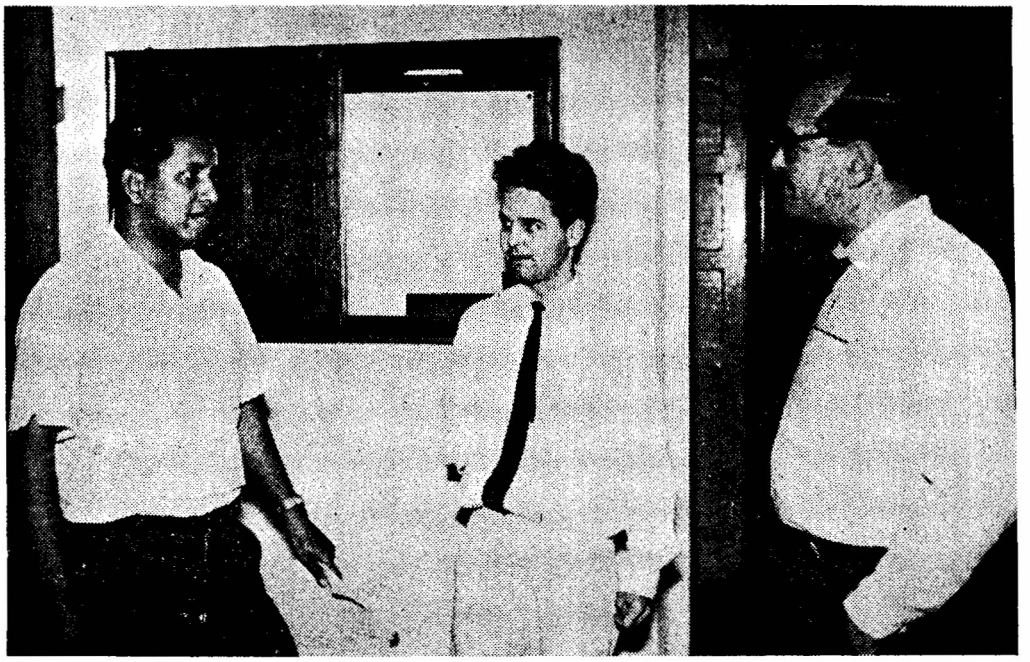
There are two scientific meetings conducted by the Institute one in winter, the Anniversary symposium in January, and the other, the Summer School in August. The proceedings of these winter and summer meetings are being published in a series entitled

PROCEEDINGS OF THE MATSCIENCE SYMPOSIA

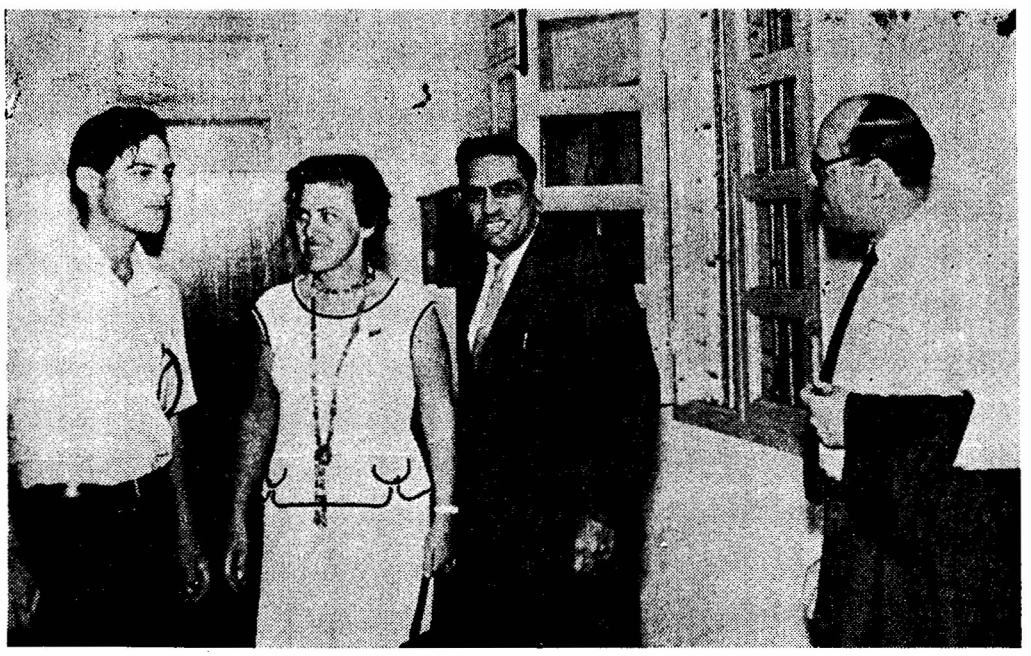
by the Plenum Press, New York, a division of the Consultants Bureau Enterprises Inc.

List of Matscience Reports (1964-65)

Report No.	*Author*	*Title*
35	K. Symanzik	Lecture on a modified models of Euclidean Quantum Field Theory.
36	K. Venkatesan	Report on Recent Experimental Data (1964).
37	A. Fujii	Lectures on Fermi dynamics.
38	M. Gourdin	Mathematical introduction to unitary symmetries.
39	J. V. Narlikar	Theories of Gravitation.
40	K. Venkatesan	Report on recent experimental data (1965).
41	K. R. Unni	Introduction to Hilbert space.
42	L. Rosenfeld	Theory of nuclear reactions.
43	K. R. Unni	Concepts in Modern Mathematics-I (Algebra)
Under preparation		
	H. Ruegg	Relativistic generalization of SU_6



Professor G. Goldhaber and Dr. B. Gruber of Naples
in a discussion after the seminar.



The Goldhabers on the first day at the institute.

Collaboration with Universities

With its permanent staff, its steady influx of visiting scientists and a well-equipped library, the Institute is able to offer facilities for post-graduate students to work in pursuance of the Ph.D. degree of their respective Universities.

It is very gratifying that the Kerala University is the first to take advantage of these facilities and agree to the registration of the M. Sc. graduates for the Ph.D. degree. Mr. T. S. Santhanam, a research scholar at the Institute is the first candidate for such registration.

As regards the University of Madras, hitherto only those who have been registered before the inception of the Institute have been allowed to submit their theses and obtain doctorate degrees.

It is hoped that the University of Madras and other Indian universities will, at the suggestion of the Inter-University Board, agree to a similar procedure, which will be of great assistance to their graduates and thereby to the advancement of scientific education in India.

The list of persons who have worked under Professor Ramakrishnan before and after the inception of the Institute and obtained their Ph.D. degrees are given below:

Before the inception of the Institute:

Dr. P. M. Mathews	1956
Dr. S. K. Srinivasan	1957
Dr. R. Vasudevan	1960
Dr. N. R. Ranganathan	1961

After the inception of the Institute:

Dr. K. Venkatesan	1963
Dr. V. Devanathan	1963
Dr. T. K. Radha	1963
Dr. Thunga Satyapal	1963
Dr. A. P. Balachandran	1963
Dr. G. Bhamathi	1963
Dr. S. Indumathi	1963
Dr. G. Ramachandran	1964
Dr. K. Raman	1965
Dr. R. K. Umerjee	1965
Mr. K. Ananthanarayanan (submitted his thesis)	1965

Matscience—I. I. T. Seminar

A series of lectures (Seminars) organised under the joint auspices of MATSCIENCE and the Mathematics Department of the Indian Institute of Technology was started during the first quarter. It has been arranged that the lectures by the members of MATSCIENCE will be delivered at the I. I. T. and those of the members of the I. I. T. at MATSCIENCE. The following are the list of lectures delivered during the year under the above programme :

Professor S. D. Nigam	Hydrodynamics (3 lectures)
Professor A. Ramakrishnan	Triplets, Mathematical and otherwise
Dr. T. K. Radha	Unitary symmetry
Dr. R. Vasudevan	Gravitation
Professor A. Ramakrishnan	Quarks and Gell-Mann Nishijima Scheme
Dr. N. R. Ranganathan	Differential forms and discontinuity formulae
Mr. Parthasarathy	Theory of graphs
Professor S. D. Nigam	Stokes flow past spheres.

Similarly, as a preliminary step towards closer contact with the Madras University a series of seminars are being arranged in which research workers from the University and the Institute will take part. In pursuance of this programme, Professor P. M. Mathews delivered the first lecture on 7th December 1965 on "Wave equations of particles of spin 3/2".

Prof. (Mrs.) Sulamith Goldhaber

(1923 — 1965)

' The international world of science has lost a leading worker,
America a distinguished citizen and our institute
one of its grand allies''

Library

During the period under report (January – December 1965) 1,400 books (including bound periodicals) were added to the library, bringing the total number of volumes to 5,000. These include many of the recent publications in Mathematics and Physics. The following back numbers of periodicals were added to the library :

Advances in Physics : Vol. 1 (1952) onwards
Astrophysical Journal : V. 120 (1954); V. 124 (1956);
V. 127 (1957); V. 130 (1959);
V. 132 (1961); V. 134 (1960);
V. 136 (1962); V. 138 (1963) onwards.
Communications of pure and applied Mathematics : Vol. 1 (1948) onwards.
Annals of Physics : Vol. 1 (1957) onwards.
Nagoya Mathematical Journal : Vol. 1 (1950) onwards.
Nuclear Physics : Vol. 1 (1956) onwards.
Nuovo Cimento : Series X. Vol. 7 (1958) – V. 18 (1960)
Pacific Journal of Mathematics : Vol. 9 (1959) onwards.
Physica : Vol. 1 (1934) – Vol. 26 (1960); Vol. 28 (1962) onwards.
Physics of Fluids : Vol. 1 (1958) onwards.
Physics Today : Vol. 1 (1948) onwards.
Progress of Theoretical Physics with Suppl : V. 1 (1947) onwards.
Reviews of Modern Physics : Vol. 1 (1929) onwards.
Soviet Mathematics (DOKLADY) : Vol. 1 (1959) onwards.
Theory of probability and its applications : Vol. 1 (1959) onwards.

As in previous years the preprint section has been found to be most useful for the research workers.

Journals :

Six new Journals were subscribed to during the period bringing the total number of periodicals received on subscription basis to 66 (sixty six). With the starting of the pure and applied mathematics section, orders have been placed for nearly 60 new journals in Mathematics and Applied Physics for 1966. Periodicals received on exchange basis from institutions all over the world are being received regularly.

Lists Published :

1. List of Preprints received in the library (issued fortnightly)
2. List of latest additions (issued monthly)
3. List of Periodicals (issued yearly)
4. List of MATSCIENCE Reports (issued yearly)
5. List of reprints (issued yearly)