

MATSCIENCE

**INSTITUTE OF MATHEMATICAL SCIENCES
MADRAS, INDIA.**

FOURTEENTH ANNIVERSARY

ANNUAL REPORT 1976

**The Institute of Mathematical Sciences
Madras**

“The pursuit of science is its best
when it is a part of a way of life”

Annual Report 19 5

Patron :

Mr. C. Subramaniam

Union Minister for Finance, Government of India

Chairman of the Board of Governors :

Mr. V. R. Nedunchezhiyan

Minister for Education, Government of Tamil Nadu

Director :

Professor Alladi Ramakrishnan

Board of Governors

1. Hon'ble Thiru V. R. Nedunchezhiyan
Minister for Education
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2. Thiru C. G. Rangabashyam, I.A.S.
Secretary to Government
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4. Professor K. G. Ramanathan
School of Mathematics
Tata Institute of Fundamental Research
Bombay. Member
5. Professor Alladi Ramakrishnan
Director
The Institute of Mathematical Sciences
Madras. Member
6. Professor K. R. Unni
The Institute of Mathematical Sciences
Madras. Member

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Member

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Director
Department of Atomic Energy
Chhatrapati Shivaji Maharaj Marg
Bombay.

Member

Professor Alladi Ramakrishnan
Director
The Institute of Mathematical Sciences
Madras.

Member

Advisory Committee

Thiru C. G. Rangabashyam, I.A.S. Secretary to Government Education Department Government of Tamil Nadu Madras.	Chairman
Professor Alladi Ramakrishnan Director The Institute of Mathematical Sciences Madras.	Member
Dr. A. N. Mitra Department of Physics & Astrophysics Delhi University Delhi.	Member
Dr. M. S. Narasimhan School of Mathematics Tata Institute of Fundamental Research Bombay.	Member
Dr. V. C. Kulandaiswamy Director of Technical Education Guindy, Madras.	Member

Academic Council

Professor Alladi Ramakrishnan Director Institute of Mathematical Sciences Madras-600020.	Chairman
Professor R. Vasudevan Institute of Mathematical Sciences Madras-600020.	Member
Professor K. R. Unni Institute of Mathematical Sciences Madras-600020.	Member
Dr. N. R. Ranganathan (Associate Professor) Institute of Mathematical Sciences Madras-600020.	Member
Dr. T. S. Santhanam (Associate Professor) Institute of Mathematical Sciences Madras-600020.	Member

General Information

Aims and Objects

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 of fundamental sciences in general with particular emphasis on 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 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 academic activity.

Academic Activities

The primary activity of the Institute is creative research in 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.

To commemorate the inauguration of the Institute an anniversary Symposium is held in January for which scientists from India and abroad are invited to deliver one hour addresses summarising their original work on recent advances in various branches of Mathematical Sciences. The Institute also organises a Seminar in Analysis.

Academic Staff

The Academic Staff consists of Senior Professors, Professors, Associate Professors, Assistant Professors, Visiting Professors, Visiting Scientists, Research Fellows and Research Trainees.

Ph.D Programme

Facilities are available for postgraduate students to work for Ph.D. degree under the guidance of the academic staff of the Institute in various faculties. Senior and Junior research fellowships are awarded by the Institute.

The Standing Committee of the Inter-University Board of India and Ceylon at its meeting held in February 28, 1967 adopted a resolution recognising the Institute as a suitable centre for research work. In view of the above resolution the Institute is now recognised by the various Indian Universities as a centre for research for the doctorate degree in Theoretical Physics and Mathematics.

Publications

1. RESEARCH PAPERS (Preprints and reprints are available on request)
2. MATSCIENCE REPORTS based on the lecture courses delivered at the Institute both by visiting scientists and academic staff (Price Rs. 5/- within India or U. S. \$ 1-00 outside India). PROCEEDINGS OF THE SEMINARS AND CONFERENCES conducted by the Institute are also published as special Matscience Reports.
3. PROCEEDINGS OF THE SEMINAR IN ANALYSIS is based on lecture courses delivered at the Institute by visiting scientists or members of the Institute during the Annual Seminars in Analysis (Price 5/- within India or U. S. \$ 1-00 outside India).

News of the Institute

Thirteenth Anniversary

The Thirteenth Anniversary of the Institute was celebrated on the 4th of February 1975. Hon'ble Thiru V. R. Nedunchezhiyan, Minister for Education Government of Tamil Nadu and Chairman of the Board of Governors of the Institute, gave the Anniversary Address and the Director of the Institute presented the Annual Report. On that occasion the Hon'ble Minister released Matscience Reports numbered 81, 82 and 83.

A one-day-symposium on 'Computational Methods and Numerical Analysis, was held at the Institute on January 25, 1975. His Excellency Shri K. K. Shah inaugurated the symposium and released the book 'Introduction to Computers and Programming' by Dr. K. Srinivasa Rao. (S. Viswanathan (publishers and Printers) Pvt. Ltd.) Mr. D. C. Kothari delivered the Key-note address on 'Science and Industry'. Lectures in the symposium were delivered by Professor Alladi Ramakrishnan, M. R. Subrahmanya, R. Jagannathan, Alladi Krishnaswami and G. N. Keshava Murthy.

Seventh Seminar in Analysis

A Ten-day Matscience Conference entitled 'Seventh Seminar in Analysis' was inaugurated by Professor K. R. Unni at Mysore on the 8th March 1975. More than 25 participants from various institutions all over India participated in the Conference. The proceedings of the conference are in the process of being published as a Matscience Report.

Seminar on Collective Phenomena in Nuclei and Solids

The seminar on Collective Phenomena in Nuclei and Solids was held from 13th to 16th December 1975 at Mysore. It was inaugurated by Professor Alladi Ramakrishnan, Director, Matscience. The Seminar focussed the attention on the role of collective motion in nuclear and solid state physics and provided the required mathematical back-ground for understanding the same. About 50 participants from all over India participated in the seminar. Besides the members of the academic staff of the Institute, senior research workers lectured on various aspects relevant to the theme of the seminar. The proceedings of the seminar are in the process of being published as a Matscience Report.

Academic Staff

Professor Alladi Ramakrishnan *Director*
Professor R. Vasudevan
Professor K. R. Unni
Dr. N. R. Ranganathan
Dr. T. S. Santhanam+
Dr. V. Radhakrishnan
Dr. K. H. Mariwalla
Dr. K. Srinivasa Rao
Prof. K. Sivasubramaniam (Tamil Nadu Government scholar on deputation)

Senior Research Fellows :

Dr. M. R. Subrahmanya	Dr. Vimala Walter
Dr. G. N. Keshava Murthy*	Dr. A. R. Tekumalla*
	Mr. R. Jagannathan

Junior Research Fellows :

Mr. A. Vijayakumar	Miss S. Poornima
Mr. K. Venkatesh	Miss V. Indumathy
Mrs. Kasturi Ramanath	

Research Trainees :

Mr. H. N. V. Dutt*	Mr. H. Chandrasekar*
Mr. A. K. Gangopadhyaya	Miss Indira**

* Persons who have completed their tenure at the Institute.

**National Science Talent Scholar.

+On leave of absence at Physikalisches der Institut, Wurzburg, Germany.

Administrative Staff

The following persons have completed ten or more years of service in the Institute.

Name	Designation	Date of appointment
Mr. A. J. Duraisingh	Accountant	14-5-1962
Mr. R. Jayaraman	Stenographer	27-12-1962
Mr. N. S. Sampath	Typist	1-4-1963
Mr. S. Krishnan	Stenographer	17-12-1963
Mr. A. R. Balakrishnan	Typist (Library)	1-12-1965
Mr. D. Varadarajan	Skilled Attender	1-5-1962
Mr. M. Gangan	Peon	28-6-1963
Mr. S. Muthusigamani	Peon	5-11-1964

Delegations and Invitations

Professor Alladi Ramakrishnan, Director of the Institute, spent five months in Europe and the United States lecturing on his research work on : 1. Theory of stochastic processes and their applications, 2. L-matrix theory and its ramifications, and 3. A new look on special theory of Relativity.

He was invited as a visiting scientist to the International Centre for Theoretical Physics, Italy, for one month where he delivered four lectures on the above subjects. He also gave a seminar on matrix theory at the International Conference on complex analysis in Trieste.

At the University of Wurzburg, he summarised his work on stochastic processes and at Liege he gave a seminar on Einstein as a natural completion of Newton.

In the United States he delivered lectures at the Yeshiva University, New York; University of New Hampshire, Dover, New Hampshire; Kent State University, Ohio; Oklahoma State University, Stillwater, Oklahoma; University of Texas at Dallas; University of Texas at Arlington; San Jose State University, California.

In Canada he visited the Universities of Montreal and Calgary.

He gave an invited address on inverse probability at the International Conference on Statistics in honour of the late Professor Mahalanobis held at the Indian Statistical Institute, Calcutta, in December, 1974.

At the invitation of the Vice-chancellor of the Osmania University, he delivered a series of four lectures in Hyderabad in November, 1975.

Professor R. Vasudevan gave a series of lectures on invariant imbedding and its applications to solution of differential and integral equations at the invitation from the departments of Mathematics and Hydraulics in the Engineering College, Guindy, Madras. He was invited to talk on persistent states in neural networks at the Institute of Neurophysiology, Madras Medical College and at the Winter School conducted by the Indian Institute of Technology, Madras on Bioengineering. Delivered a series of ten lectures on WKB approximations and generalized Bremmer series solutions of second order equations at Matscience. He participated and delivered talks reviewing the present status of '*Helium three*

in its condensed phase at Matscience Conference on 'Collective Phenomena in Nuclei and Solids' in December, 1975. He was invited to deliver a talk on his recent work on 'non-local potentials and phase shifts' at the symposium on Nuclear Physics conducted at the Department of Nuclear Physics, University of Madras, in March 1975.

Professor N. R. Ranganathan was invited to visit the Department of Physics, Marathwada University in March 1975 to deliver few lectures on Theory of disordered solids. During this trip he also lectured in the Department of Electronics and Electrical Communication, Osmania University, Hyderabad, on Walsh functions. He was invited to address the post-Graduate Department of Science College, Nanded, on Motion of Bloch electron in Magnetic field. He was Invited to the Postgraduate Department of Milind College of Science, Aurangabad, to give a lecture on Holography. In July 1975, he was invited to deliver a seminar on Margnetic Bloch functions at the Centre for Theoretical Physics, Indian Institute of Science, Bangalore. In August, 1975 he was invited to lecture on Quantum Mechanics for the benefit of post-graduate students at Trichy, organised jointly by Deri Educational Foundation and Jamal Mohamad College, Trichy. He also lectured on invitation in the Physics Department of A. V. M. Pushpam College, Tanjore, on Symmetry principles and solids and at S. R. College, Trichy, on Theory of Amorphous solids. In September, he visited the departments of Mathematics and Physics, Madurai University to deliver a lecture on Conduction electron in a Strong magnetic field. Four lectures on Probability theory and photographic science were delivered by him at the Regional Engineering College, Warangal in October. He also delivered a seminar in the Physics Department of P. G. Centre of Osmania University, Warangal on Magnetic Bloch functions.

Professor K. H. Mariwalla was a "Chief Invitee" at the Einstein's Twentieth Anniversary Symposium on Relativity at Kolhapur held in April 1975 and delivered a series of eight lectures on Mathematics of General Relativity (G. R.) and an approach to conservation laws in G. R. Delivered a lecture in the Indian Institute of Technology, Madras in August, 1975 on Symmetry in mechanics. He was invited to Centre for Theoretical Studies, Bangalore and delivered a lecture on origin of symmetries in non-relativistic quantum mechanics. Invited to the Mysore University and delivered a lecture on Space-time approach to Physics in December, 1975. He gave two lectures at the Vivekananda College, Madras, in Astronomy and Physics Associations. Gave invited lectures at the International Symposium on

Relativity and Unified Field Theories, on perspectives and prospects of unified field theory and contributed a paper on local conservation laws and symmetry breaking in Relativistic Physics.

Professor V. Radhakrishnan has participated in the Seminar on Collective Phenomena in Nuclei and Solids conducted by Matscience at Mysore and lectured on Random Phase Approximation in Solid State Physics. During the year 1975 he gave a series of lectures and seminars on current research topics.

Dr. K. Srinivasa Rao was invited to deliver a course of ten lectures on 'Computers and Programming' to the M.Sc. students of Mathematics and Physics, by the post-graduate departments of Mathematics and Physics of the National College, Tiruchi, during February 1975. He was invited to deliver a talk on 'Nuclear Models' during the 'Physics Week' celebration of the Department of Physics, Vivekananda College, held in February 1975. He was invited to deliver valedictory lectures and addresses of the Physics Association of A. M. Jain College, Raman Science Club, Hindu High School and Mathematics Association of Vivekananda College, during February-March, 1975. He was invited to give two talks on recent research work in the symposium on 'Perspectives in Nuclear Physics' conducted by the Department of Nuclear Physics, University of Madras, March 1975. He participated and delivered a series of three lectures on 'Collective Phenomena in Nuclei', in the seminar on 'Collective Phenomena in Nuclei and Solids' conducted by Matscience at Mysore, in December, 1975. He gave a seminar on 'Properties of the Racah coefficient' at the Centre for Theoretical Studies, Indian Institute of Science, Bangalore, in December, 1975. He gave a lecture on 'Nuclear Models' to the M.Sc. students of the Physics Department of Mysore University in December, 1975. He was sponsored as a delegate to the Seventh International Conference on 'Few-body problems in nuclear and particle physics,' held at the University of Delhi, from December 29, 1975 to January 4, 1976.

Dr. M. R. Subrahmanya has participated in the Seventh Seminar in Analysis held at Mysore in March 1975 and gave a series of five lectures on some topics in the Theory of Best Approximations. On the basis of his independent research work, he has been awarded a Humboldt-Fellowship of the Alexander von Humboldt Foundation, Germany, to continue his work at the University of Frankfurt under Professor Dr. B. Brosowski.

Dr. Vimala Walter has participated in the Seventh Seminar in Analysis held in Mysore in March 1975 and gave a series of lectures in the seminar on Spline Interpolation. Gave a series of lectures in the Institute on recent developments in Hermite-Birkoff interpolation.

Invited Lectures

Dr. N.V.V.J. Swamy
Department of Physics
Oklahoma State University
Stillwater, Oklahoma, U.S.A.

'One-particle relativistic
Hamiltonians and their symmetries'

Professor P. Ney
Department of Mathematics
University of Wisconsin
Madison, U.S.A.

'On nonlinear Volterra Integral
equation'

Professor J. Hammersley
Department of Mathematics
Trinity College
Oxford, U.K.

- i. 'Gibbs and Markov System'
- ii. 'Self Avoiding Random walks'

Professor I. Vincze
Mathematical Institute of
Hungarian Academy of Sciences
1053, Budapest, Hungary

'On the foundations of statistical
mechanics'

Professor P. Erdos
Department of Mathematics
Hungarian Academy of Sciences
Budapest, Hungary

- i. 'Probability and Number Theory'
- ii. 'Probability and Combinatorics'

Dr. Volodarsky
Institute of History of Science
and Technology
Academy of Science of the USSR
Moscow, USSR.

'History of the Development of
Indian Mathematics'

Professor J. Sethuraman
Department of Statistics
Florida State University
Tallahassee, Florida. U.S.A.

'Central limit theorem and further
sophistications'

Dr K. Sivaprasad
Associate Professor of Mathematics
University of New Hampshire,
New Hampshire, U.S.A.

'Direct and cross polarized
Backscatter Radar cross section
of Turbulant Plasma'

Mr. Krishnaswami Alladi
Vivekananda College
Mylapore, Madras

Generalized Euler functions'

Professor M.R. Kundu
Professor of Physics and Astrophysics
University of Maryland
Maryland, U.S.A.

'Recent observations of the Radio
sun with seconds of Arc resolution'

Dr. R.M. Phatarfod
Department of Mathematics
Monash University
Clayton, Victoria, Australia

i. 'Theory of Dams I'
ii. 'Theory of Dams-II'
iii. 'Theory of Dams-III'

Professor B. K. Kale
Head of the Department of Statistics
University of Manitoba
WINNIPEG, Canada.

'Handling of outliers and spurious
observations in the statistical
analysis of data'

Mr. K. V. N. Sarma
Nuclear Physics Department
Andhra University, WALT AIR.

'External Bremsstrahlung generated
by inhomogeneous beta radiation

Professor Joseph Cerny
Lawrence Radiation Laboratory
BERKELEY, U.S.A.

'Studies of e^- -transfer by the
(e^-, Be) reaction'

Dr. K. M. Rangaswamy
Department of Mathematics
Madurai University, MADURAI.

'Classification theorems in
Abelian groups'

Dr. A. Sankaranarayanan
Research Scientist of TRW Systems,
Los Angeles, California, U.S.A.

'Finite Element method and its use
in electromagnetic theory'

Dr. R. Sridhar
Mathematics Department
P.S.G. Arts College, COIMBATORE.

'Multi-branch structure of excitation
spectra in liquid Helium-II'

Dr. A. Sundaram
Pool Officer
Mathematics Department
Madurai University, MADURAI.

'Amplitude analysis of an isobar
production process'

Dr. L. Satpathy
Physics Department
Berhampur University
ORISSA.

'Density dependent interactions
and nuclear structure'

Professor George Gratzel
Department of Mathematic and
Astronomy
The University of Manitoba
Winnipeg, CANADA.

'Transferable Lattices'

Dr. S. C. K Nair
Department of Physics
Calicut University
CALICUT.

'Generator coordinate theory of
the breathing mode'

Dr J. Pasupathy
Tata Institute of Fundamental Research
BOMBAY.

'New Particles'

Dr. Y. S. T. Rao
Physics Department
Calicut University, CALICUT.

'Off-shell effects in Liquid helium-3'

Dr. K. N. Venkataraman
Professor of Statistics
University of Madras, MADRAS.

'Explosive processes'

Dr. A. R. Prasanna
Physical Research Laboratory
AHMEDABAD.

'Einstein-Cartan theory'

Dr. V. V. Rama Rao
St. Saviors College
PALAYAMKOTTAI.

'Characterisation of stone lattices'

Professor Mario Schonberg
University of Sao Paulo, Sao Paulo
BRAZIL.

'Basis of Relativity'

Professor Gordon Shaw
Department of Physics
University of California
Irvine, California, U.S.A.

i 'Recent developments in
particle physics'

Professor Thomas N. E. Greville
Mathematics Research Centre
University of Wisconsin
Wisconsin, U.S.A.

ii 'Persistence in neural networks'

'Iteration of Linear smoothing
formulas'

RESEARCH PAPERS

Professor R. Vasudevan

A new approach to Radiative Transfer Theory using Jones's vectors I Fundamentals (with A. L. Fymat), published in journal of Astrophysics and space/sciences (1975).

Stochastic behaviour of two unit stand by redundant system with single repair facility (with S. Kumar), submitted to the I.E.E. Journal.

Mathematics in medicine, Tumor detection, Radiation Dosimetry and simulation in psychotherapy (with R. E. Bellman, B. G. Kasheff, S. Ueno, N. Sujiyama etc.), to be published in Academical Journal (Russian). IZVESTIJA of the Estonian Academy of Science (1975) U.S.S.R.

Generalisation of Bremmer series solutions of wave equations (with R. E. Bellman), published in J.M.A.A. (1975)

Compensation function and method of images (with Vijayakumar and Vittal) Preprint.

Localisation of electron wave-functions in a random medium (under preparation).

Professor N. R. Ranganathan

'On Generalized Clifford Groups-II' (with R. Jagannathan) Rep. Math. Phys. 7 (1975) 229.

'A new form of negative Bloch functions and applications to magnetic band structure calculations' (with R. Jagannathan) submitted to Physica Status Solidi.

Professor V. Radhakrishnan

'On the localisation of electron wave-function in a random system' (with R. Vasudevan) (under preparation).

'Chemisorption of Hydrogen atoms on Transition element linear chains' (under preparation).

'The oscillation of cell-membrane, treated as a liquid-crystal' (under preparation).

Professor K. H. Mariwalla

'An introduction to vectors, tensors and relativity', Matscience Report No. 84 (July 1975).

'The origin of Dynamical Symmetries in Non-relativistic Mechanics' Lettere Al Nuovo Cimento, Vol. 12, No. 8, Feb. 1975, pp. 253-256.

'Dynamical Symmetries in Mechanics', Physics Reports Vol. 20C, No. 5 September 1975, pp. 287-362.

'Local conservation laws and symmetry breaking in Relativistic Physics', to be published in Proc. Symposium on Relativity and Unified Field Theory.

Professor K. Srinivasa Rao

'Relativistic effects on the tensor polarisation in electron-deuteron scattering' (with D.W.L. Sprung), Phys. Letts. 53B (1975) 397.

'On the symmetries of the Racah coefficient' (with T. S. Santhanam and K. Venkatesh), Jour. Math. Phys. 16 (1975) 1528.

'Effect of short range correlations in charged pion photoproduction from ^{16}O ' (with V. Devanathan), Can. J. Phys. 53 (1975) 1292; Also, in 'Few Body Problems in Nuclear and Particle Physics', The Laval University Press (1975) p. 650.

'Many-particle many-hole states in ^{16}O and positive pion photoproduction', Can. J. Phys. 53 (1975) 1299.

'On coherent neutral pion photoproduction from the deuteron', (with K. Venkatesh and S. Srinivasa Raghavan), Contribution to VIIth Int. Conf. on Few Body Problems in Nuclear and Particle Physics, Delhi (1975), to appear.

'Positive pion photoproduction from Helium-3' (with K. Venkatesh and S. Srinivasa Raghavan), submitted to the D.A.E. Nuclear Phys. and Solid State Phys. Symp. (1975)

'A computer-time saving program for the Racah coefficient' (with K. Venkatesh), submitted to the Computer Society of India Annual Convention, CSI-76.

'Introduction to Computers and Programming', S. Viswanathan (Publishers and Printers) Pvt. Ltd. (1974), 327 pages (illustrated), was released on January 25, 1975.

Dr. Vimala Walter

'On fundamental and interpolating spline functions', Matscience Report No. 82.

Dr. M. R. Subrahmanya

'On the existence of functions with prescribed best approximations' (with B. Brosowski), Journal of Approximation Theory, Vol. 15 (1975) pp. 111-123.

Mr. R. Jagannathan

'A negative energy relativistic wave equation', (with H. N. V. Dutt), Journal of Mathematical and Physical Sciences, Indian Institute of Technology, Madras, 9, (1975) 301.

'A new form of negative Bloch functions and applications to magnetic band structure calculations' (with N. R. Ranganathan) (submitted to Physica Status Solidi).

'Identities involving some products of number theoretic functions', Matscience Preprint No. 1 (1975).

LIBRARY

Books and Periodicals :

During the year under report 609 new books including bound periodicals and 81 lecture notes were added to the library bringing the total number of volumes to 13790. These include many of the recent publications in pure and applied mathematics and theoretical physics. We are regularly receiving periodicals and lecture notes from 50 institutions throughout the world in exchange to MATSCIENCE REPORTS and SEMINAR IN ANALYSIS.

Lists Published :

1. List of Preprints received in the library (issued Fortnightly).
2. List of New Additions (issued Bi-monthly).
3. List of available MATSCIENCE REPORTS and SEMINAR IN ANALYSIS (issued yearly).
4. List of Institute Publications (Reprints & Preprints), (issued yearly).
5. List of Periodicals received in the library (issued yearly).

LIST OF AVAILABLE MATSCIENCE REPORTS AND SEMINAR IN ANALYSIS

Report No.	Author(s)	Title
9	L. I. Schiff	Lectures on Gravitation. 47 p. (1963).
55	H. S. Shapiro	Smoothing and approximation of functions. 109 p. (1966).
57	K. Srinivasa Rao & R. Sridhar	Nuclear models and nuclear matter. 202 p. (1967).
59	D. A. Dubin	Relativistic physics in one space and one time dimension. 32 p. (1967).
61	T. S. Santhanam	Group theory and unitary symmetry. 90 p. (1967).
62	R. H. Good	Description of practicles with any spin and with internal symmetry. 51 p. (1968).

Report No.	Author(s)	Title
66	F. Riahi	Lectures on non-relativistic scattering theory. 62 p. (1969).
67	K. Srinivasa Rao (Ed.)	Proceedings of the one day symposium on computers in science and technology. 55 p. (1969).
69	P. K. Geetha	Topics in modern mathematics. 110 p. (1970).
71	A. R. Prasanna	General relativity and cosmology. 57 p. (1970).
72	A. R. Prasanna	Gravitational collapse and gravitational radiation. 69 p. (1971).
74	Krishnaswami Alladi	Contributions to number theory. 62 p. (1972).
75	Alladi Ramakrishnan	Essays on scientific topics. 73 p. (1972).
76	—	Proceedings of the conference on "Cosmology, Gravitation & Applications to Particle Theory", Bangalore, 1971. 289 p. (1973).
77	—	Proceedings of the conference on "Fourier Optics, Lasers & Holography", Bangalore 156 p. (1973).
78	—	Proceedings of the conference on "Nuclear Physics", Mysore, 1973. 284 p. (1973).
79	—	Proceedings of the conference on "Numerical Analysis & Combinatorial Methods", Bangalore, 1973.
80	Krishnaswami Alladi	Lectures on Diophantine Approximations. 55 p. (1974).
81	Alladi Ramakrishnan	Applications of the theory of stochastic processes to physical problems. 144 p. (1974).
82	Vimala Walter	On fundamental and interpolating Spline functions. 64 p. (1975).

Report No.	Author(s)	Title
83	Krishnaswami Alladi	New concepts in Arithmetic functions. 65 p. (1975).
84	K. H. Mariwalla	Introduction to Vectors, Tensors and Relativity. 153 p. (1975).
85	R. Vasudevan (Ed.)	Proceedings of the conference on "Mathematics in Medicine and Biology", Bangalore, 1974. 221 p. (1975).

SEMINAR IN ANALYSIS

1	K. R. Unni	Lectures on Bernstein approximation problem. 107 p. (1969).
4	A. L. Brown	Abstract approximation theory. 118 p. (1970).
6	S. P. Singh	On Fixed point theorems. 157 p. (1975).

These Reports are available at Rs. 5/- (within India) & at \$ 1.00 (outside India).

PROCEEDINGS OF THE CONFERENCE ON CLIFFORD ALGEBRA, ITS GENERALIZATION AND APPLICATIONS.

—Conference organised by MATSCIENCE, 30th January–1st February 1971, held at Ootacamund, South India.

CONTENTS :

T. Nono	:	Generalized Clifford algebra and linearizations of a partial differential equations.
K. Yamazaki	:	Structure of algebra extension of finite Abelian group.
A. O. Morris	:	Projective representations of finite groups.
Alladi Ramakrishnan	:	Generalized Clifford algebra and its applications OR A new approach to internal quantum numbers.
I. Popovici & A. Turtoi	:	Generalized spinor structure.

(103 p. (1972) Rs. 10/- within India and \$ 2.00 outside India)

APPENDICES

Matscience - A Haven of Freedom*

The Institute of Mathematical Sciences or MATSCIENCE as it is well-known or the Jewel of Tamil Nad as I called it before the President of India, is the only one of its kind in our country devoted to the pursuit of mathematical sciences in all their ramifications from abstract mathematical logic to the applications of analytical methods to technology and the life sciences. In structure and constitution it is modelled on the famous Institute for Advanced Study at Princeton with accepted emphasis on creative research on international standards of excellence. Its academic staff is divided into three groups, permanent members who are full or associate professors of established reputation in their respective fields, visiting scientists providing stimulus and competition for creative thought and younger members working for their Ph. D. under the guidance of the permanent members. The Ph.D. programme is intended to bring senior scientists into close contact with the younger generation and in this sense it is an additional feature not usually present in centres for advanced learning outside the universities.

The most striking feature of the Institute is the complete freedom given to a scientist during the tenure of his work here. It is accepted as axiomatic that excellence in creative work can be achieved only when a person is able to think and work in 'enlightened leisure' with 'absolute freedom' to publish the results of his research. The relevance of research to economic development and the utilisation of mathematical methods are achieved by bringing scientists in different disciplines together rather than by prescribing, imposing, predetermining or restricting the nature of work of a creative scientist. To stimulate exchange of ideas, active workers from other centres are frequently invited to give seminars at the Institute on their research work and opportunities are afforded to members of our Institute to participate in scientific meetings at home and abroad.

To estimate its present achievements and understand the future programme we must be aware of the circumstances that led to the creation of the Institute. The stirring story of its creation is part of the annals of Indian science. I take this opportunity to recall the magic moments when the miracle happened. Till the year 1952 there was no research department in physics in the University of Madras. I had the privilege of joining as its first member in June 1952. Frequent travels during the ten years of my tenure at the University convinced me that theoretical physics should be fostered side by side with experimental work and mathematics should form the real basis for theoretical physics. Since opportunities in the university

*Talk delivered by Professor Alladi Ramakrishnan at the All India Radio, Madras, on Friday, the 23rd August, 1974.

were meagre for theoretical physics, I gathered a group of young aspirants in my family home Ekamra Nivas where we discussed current problems at informal seminars. This attracted the attention of Professors Bohr and Dirac, Bellman and Lighthill, Salam and Chandrasekhar and through a series of events each improbable as the other, the Institute was created on the 3rd January, 1962 by the Government of Madras with the support of the then Prime Minister of India, Jawaharlal Nehru and the finance minister of our State C. Subramaniam. The creation of Matscience set in motion an intellectual renaissance, the nature and magnitude of which will be realised in the years to come. We have been fortunate in receiving the continued support of the Government of Madras through the successive Chairmen of the Board of Governors, Subramaniam, Venkataraman and now Nedunchezhiyan. We hope the assistance of the Government of India will match the magnificent support of the State Government.

Our initial efforts for the first four years were confined to the theory of stochastic processes and the physics of elementary particles. Professor Bhabha can well be considered the father of research in stochastic theory in India and Matscience as the rightful heir to this legacy and tradition. I was initiated into stochastic theory in the year 1947 when I worked under Professor Bhabha on the famous fluctuation problem of Cosmic Radiation. The work done in association with my colleagues amounts to an extension, expansion, modification and development of Bhabha's original ideas and this is the highest tribute I can pay to my most revered teacher and guide. This has naturally resulted in the creation of new techniques and methods which are finding increasing applications. In the year 1971, a summary of this work was presented at the International Conference on Point Processes at I. B. M. Yorktown Heights, New York. It is extensively quoted in text books of A. T. Bharucha-Reid (McGraw Hill), M. S. Bartlett (Cambridge), T. E. Harris (Springer Verlag) and in innumerable papers.

My distinguished colleagues Professors Vasudevan, Ranganathan and Radhakrishnan are carrying on this 'stochastic tradition' with remarkable ingenuity to a wide range of application in statistical mechanics, solid state physics and even biology and medicine.

After the amazing triumph of Feynman's formalism of quantum electrodynamics in 1949, no one dared to attempt improvements or suggest alterations in the theory. For the first time the division of the propagator was suggested at Matscience, the new concept of Feynman patterns introduced and the mathematical consequences studied in intricate detail. Reference to this has been made by Professor Weinberg and the most recent work in the Physical Review indicates a surge of interest in these new aspects of Feynman formalism. Detailed announcements were made in a well-attended seminars at Stanford and Berkely as early as 1962, in Rochester in 1963. A summary was presented at the Capital Conference on graph theory in 1973 at Washington, D. C.

Professor Bhabha's predilection towards matrix theory is well known in scientific circles and my own interest in that subject can be traced to my association with him as early as 1947. I need only refer to the series of original papers contained in my book 'L-matrix Theory or the Grammar of Dirac Matrices'. All the papers have been reviewed in Mathematical Reviews.

The new approach to matrix theory was presented at the international conference on Numerical Analysis at Dublin this year in an invited one-hour address.

Today, the Dirac equation for the electron is the only valid equation in physics and attempts were made by Bhabha to extend such equations to other elementary particles. There are other possible extensions than that suggested by Professor Bhabha and this is included in my book on 'L-matrix theory'. This led to higher dimensional Dirac matrices, the generalized Clifford algebra and a new approach to internal quantum numbers and a generalization of the Gell-Mann-Nishijima relation. The paper on internal quantum numbers was presented at the Rutherford Centenary Conference in the year 1971 held at Christ Church, New Zealand.

The most active members of our group in high energy and nuclear physics are Professors Santhanam and Srinivasa Rao who have worked on various branches of physics—weak, electro-magnetic and strong interactions.

The contribution entitled 'Einstein—A natural completion of Newton' has appeared in the Solomn Bochner issue of the Journal of Mathematical Analysis and Applications (1973). It purports to set at rest all futile speculations regarding the existence of faster than light particles by means of a simple and elegant mathematical approach. This work was presented at the University of Texas at Dallas before accredited experts on gravitation theory.

We have an equal interest in the general theory of relativity and the fundamental principles of quantum mechanics and work in these domains is going under the direction of my eminent colleague Professor K. H. Mariwalla.

As will be seen from the above summaries, our research work is closely connected with the contributions of the eminent Indian scientists, Bhabha and Chandrasekhar, the reputed statisticians Bartlett and Kendall, the world famous Nobel Prize winners Feynman and Gell-Mann and the scientific seers of all time, Einstein and Dirac.

While working in theoretical physics, we were quite conscious of our inadequacies and well aware of the all pervasive nature of the mathematical discipline. The preamble to the constitution of our Institute puts unambiguous emphasis on the development of mathematical sciences to the widest possible range. In January 1966, a significant beginning was made in pure mathematics in a spirit so well expressed by Professor Marshall H. Stone the mathematician's attitude to other disciplines

such as physics is something like, "I try to help every one but I have also my own concerns".

Professor Unni is our leading mathematician and with singleness of purpose he devoted himself to the building of the mathematics group with the initial impetus given to him by Professor Hayman, a visiting professor at Matscience in 1966. Unni's main interest is in functional analysis but he is orienting the future programme in our Institute so that it can play a very important role in the applications of mathematical sciences to economic and social needs retaining its identity as an international centre in functional analysis. The success of the International Conference in January 1973 through the active participation of over sixty mathematicians from over twenty countries is the highest tribute which the worldwide mathematical community has paid to our country in general and Matscience in particular.

The students of Matscience are finding easy access to the great centres of learning after obtaining their Ph.D. degree. Our academic staff is in close contact with about 200 research institutes abroad and with more than 300 scientists of outstanding eminence the world over. It is with justifiable pride that we can look back on the achievements of the Institute for the past twelve years.

We look forward to the future with unflinching faith in the mathematical talents of the rising generation. We cannot promise them affluence or soft comforts or pleasant methods of acquisition of worldly goods. What we can offer are, an open window to let in and out the vital breezes of new ideas, a table and a blackboard for serious work, freedom from interference in contemplative thought, a ready access to a well equipped library and above all, stimulating contact with their compeers all over the world.

These are attractions enough to make the mathematician's career worth pursuing despite modest salaries and meagre benefits. We hope the most gifted minds of our country are lured to this enchanting world of numbers and functions, algebraic or analytic, limits and approximations, rational or irrational.

Welcome to MATSCIENCE — the haven of freedom.

Prof. ALLADI RAMAKRISHNAN
Director, MATSCIENCE, Madras-600020
By Courtesy: All India Radio, Madras.

**LIST OF INSTITUTIONS
AT WHICH PROFESSOR ALLADI RAMAKRISHNAN, DIRECTOR,
MATSCIENCE GAVE LECTURES ON HIS RESEARCH WORK**

UNITED STATES OF AMERICA

University of Arizona at Tempe (1970)
Bell Telephone Laboratories, New Jersey (1963)
Boeing Research Laboratories, Seattle, Washington (1968-69)
Boston University, Boston (1967)
University of California, Berkeley (1962, 65, 71)
University of California, Irvine (1966, 71-74)
University of California, Los Angeles (1962, 69)
University of California at Riverside (1971, 72-74)
Case Institute of Technology, Cleveland (1958)
University of Chicago, Chicago (1956)
University of Colorado, Boulder (1967)
Cornell University, Ithaca (1967)
Courant Institute of Mathematical Sciences, New York (1967)
University of Dayton, Dayton, Ohio (1968-70)
Douglas Aircraft Corporation, New York (1966-69)
University of Southern Illinois, Carbondale (1973)
General Motors Research Laboratories, Detroit, Michigan (1969)
University of Hawaii, Honolulu (1966-69)
Hughes Research Laboratories, Malibu, California (1962)
Howard University, Washington, D. C. (1971)
Illinois Institute of Technology, Chicago (1958)
University of Illinois, Urbana (1970)
Florida State University, Tallahassee, Florida (1974)
Institute for Advanced Study, Princeton (1957-58)
Massachusetts Institute of Technology, Cambridge, Mass (1956)
Institute of Theoretical Physics, M.I.T., Cambridge (1968)
Iowa State University, Iowa (1971)
Kent State University, Kent, Ohio (1975)
Lockheed Aircraft Corporation, New York (1969)
St. Louis University, St. Louis (1966-71)
University of Maryland, Maryland (1958)
Massachusetts Institute of Technology, Massachusetts (1956)
Oklahoma State University, Stillwater, Oklahoma (1975)
Ohio State University, Columbus, Ohio (1974)

U. S. Naval Research Laboratory, Washington, D. C. (1958-74)
New York State University, Buffalo (1967-70, 72)
University of New Hampshire, Dover (1975)
University of North Carolina, Chapel Hill (1971)
North Texas University, Denton (1969-70)
Oak Ridge National Laboratory, Tennessee (1970, 74)
National Bureau of Standards, Washington (1962, 74)
Pennsylvania State University, Pennsylvania (1972, 73)
Purdue University, Lafayette (1968-70)
Rand Corporation, California (1962-71)
University of Rhode Island, Kingston (1971, 72)
Rutgers University, New Jersey (1971-72)
University of Rochester, Rochester (1963)
University of Southern California, Los Angeles (1967-72)
Stanford University, Stanford (1962-72)
State College, Long Beach, California (1966-70)
San Jose State University, San Jose, Calif (1974, 75)
Syracuse University, Syracuse (1966, 69, 72)
University of Texas, Arlington, Texas (1975)
University of Texas at Austin (1970)
University of Texas at Dallas (1970-71, 73-75)
Thomas J. Watson Research Center, IBM, New York (1971)
Utah State University, Logan, Utah (1971-72)
University of Washington, Seattle (1967-69)
University of Wisconsin at Madison (1966-70)
University of Wisconsin at Milwaukee (1966, 67, 71)
Wright-Patterson Air Force Centre, Dayton, Ohio (1968-70)
University of Wyoming, Laramie (1972)
Yeshiva University, New York (1967-72, 75)

ENGLAND

University of Edinburgh, Edinburgh (1949)
Imperial College of Science and Technology, London (1960, 63, 67, 69)
University of Manchester, Manchester (1949, 56)
Oxford University, Oxford (1950, 60)
Physical Society of Great Britain, Birmingham (1949)
University of York, York (1974, 75)

AUSTRALIA

Australian National University, Canberra (1954, 71, 73)
Latrobe University, Melbourne (1954, 71)

University of Melbourne (1954, 71, 73)
University of Sydney, Sydney (1954, 71, 73)
Monash University, Melbourne (1973)
University of Adelaide, Adelaide (1973)
University of Western Australia (1973)

CANADA

University of Alberta, Edmonton (1969)
Carleton University, Ottawa (1969)
University of Ottawa, Ottawa (1958)
Sir George Williams University, Montreal (1971)
McGill University, Montreal (1971-72)
University of Montreal, Montreal (1968, 71, 72, 75)
National Research Council, Ottawa (1958)
Simon Fraser University, Vancouver (1958)
University of Toronto, Toronto (1968)
University of Manitoba, Winnipeg (1973, 74)

WEST GERMANY

University of Bonn, Bonn (1971)
University of Gottingen, Gottingen (1956)
University of Heidelberg, Heidelberg (1956)
University of Marburg, Marburg (1956, 60)
University of Stuttgart, Stuttgart (1956)
University of Wurzburg, Wurzburg (1975)

U. S. S. R.

Institute of Nuclear Research, DUBNA (1964)
Academy of Sciences, Moscow (1968)
Physical-Technical Institute, Academy of Sciences, Leningrad (1968)

JAPAN

University of Kyoto, Kyoto (1956)
Osaka University, Osaka (1956)
Tokyo University of Education, Tokyo (1966, 70)
Yukawa Hall, Kyoto (1956)

BELGIUM

Department of Mathematics, University of Liege, Liege (1971, 75)
Department of Physics, University of Liege, Liege (1971)

IRELAND

University of Dublin, Dublin (1949-74)

Dublin Institute for Advanced Studies, Dublin (1950)

SWEDEN

Cramer's Institute, Stockholm (1950)

University of Uppsala, Uppsala (1950)

NORWAY

University of Oslo, Oslo (1950)

SWITZERLAND

University of Berne, Berne (1960, 69)

CERN, Geneva (1960, 62, 66)

E.T.H. Zurich (Federal Institute of Technology), Zurich (1950)

University of Geneva, Geneva (1967)

Swiss Physical Society, Winterthur (1960)

University of Zurich, Zurich (1950, 56)

NEW ZEALAND

University of Canterbury, Christchurch (1971)

FRANCE

University of Paris, Orsay (1966)

Institute of Henri Poincare, Paris (1960, 66)

C. E. N., Saclay (1964, 1965, 1967, 1968, 1969)

ITALY

International Centre for Theoretical Physics, Trieste (1963, 1965, 67, 68, 70, 74, 75)

University of Naples, Naples (1967)

University of Padua, Padua (1966-69)

University of Rome, Rome (1966, 69)

SINGAPORE

University of Singapore, Singapore (1967)

IRAN

Aria-Mehr University, Teheran (1968)

DENMARK

Bohr Institute, Copenhagen (1950, 1960)

HONGKONG

University of Hong Kong (1975)