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 1963

PATRONS:

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Minister for Industries, Government of Madras.

DIRECTOR:

Professor Alladi Ramakrishnan.

HONORARY PROFESSOR ASTROPHYSICS:

Professor S. Chandrasekhar, F.R.S.,

Distinguished Service Professor, Enrico Fermi Institute of Nuclear Studies,

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

The 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 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.

Facilities will be offered to visiting scientists to spend considerable time in the Institute and work in collaboration with the members of the permanent staff. In the first instance it is proposed to have four faculties: Theoretical Physics, Astrophysics, Mathematics and Applied Mathematics. The permanent staff will consist of professors and members in these faculties whose duty will be to pursue research and participate in discussions, lectures and symposia.

Board of Governors

1.	Mr. R. Venkataraman, Minister for Industries, Government of Madras, Madras.	Chairman
2.	Mr. V. Balasundaram, I. A. S., Secretary to Government, Education & Public Health Department, Government of Madras, Madras.	Member
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4.	Professor Alladi Ramakrishnan, Director, The Institute of Mathematical Sciences, Madras.	,,
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. V. Balasundaram, 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 (on leave), The Institute of Mathematical Sciences, Madras.	"

THE INSTITUTE OF MATHEMATICAL SCIENCES

The year 1963 in retrospect

It has been a year so crowded with events of such portent and significance to our Institute that I seem to lose the sense of sequence in reviewing the period in retrospect. The Institute, born out of travail into freedom, does not seem to have had and infancy; it has grown into its present stature under the unceasing stimulus from the scientific community throughout the world and from generous administrative support within our country.

In estimating this period of activity we have to keep in mind the ideals to which our Institute is devoted and the hopes we had stirred up in the rising generation of scientists in our country.

Our aims needed a three-fold effort:

Firstly, to set in motion a visiting scientists programme in which professors of established reputation and gifted scientists of great promise from outside India could spend a few weeks or months at the Institute giving lectures, participating in seminars and collaborating with the workers here in research activities.

Secondly, to set young researchers in India working on fundamental problems without waiting for opportunities outside the country, and

Thirdly, to create the nucleus of a permanent staff to carry on the academic responsibilities of the Institute.

We seem to have made considerable progress in all these directions, particularly relating to the visiting scientists programme. The response was spontaneous and warm, particularly from four great centres of learning—Berkeley, Stanford and Rochester in the U.S.A. and the Japanese universities in the East. It has been a 'grand alliance' transcending national boundaries which may have far great consequences than intellectual collaboration in the domain of mathematical sciences. To this effort have now joined scientists from Saclay in France and CERN in Geneva and Copenhagen in Scandinavia so graciously represented today by the distinguished visitor, Professor Rosenfeld of NORDITA. As the second Niels Bohr professor he has aquired a vested interest in our Institute even as his eminent predecessor Professor Marshak of Rochester. The ties with Rochester have grown stronger still through Professor Sudarshan and our chief guest of today, Professor Hazlett, the Vice-President of the University.

As regards our second objective, we have just made an earnest and hopeful beginning. The task is particularly difficult for obvious reasons. The situation in physics today is similar to that before the birth of quantum theory. The vast and mounting mass of accurate experimental data pouring fourth from the great laboratories of world have brought to light "new channels" in the ways of nature hidden from us at "lower energies". The maze of new particles and resonances have

puzzled the mind of Heisenberg as much as those of eager novices in physical research. New entrants to theoretical physics must feel a particular thrill in being alive and young at this critical period of the expansion of our empirical knowledge of the universe when every day brings forth a puzzling problem and each problem brings forth its tentative solution.

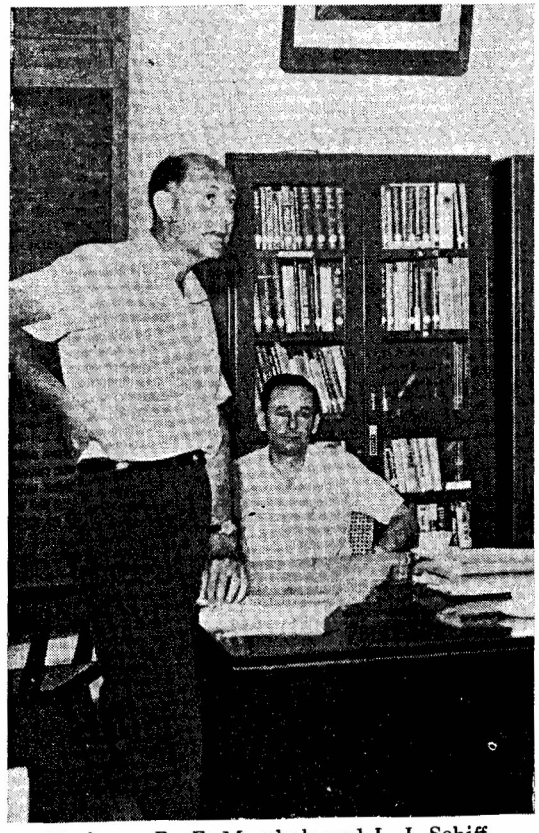
The third task of selecting and training a permanent staff is of course the most onerous of all. I had naturally to be very cautious after the experience and trials of the past decade in my academic life. Fortunately, our sponsors are quite convinced of the dictum that if a scientist is not noticed before thirty, we can as well forget about him. It obviously meant that it was not just enough if one was young, though one must be young enough to have the initiative and zest for creative work. In theoretical physics we have started with a very small nucleus of permanent staff ; and it has done well, I may say with the vanity of a complacent teacher. Dr. Vasudevan, my main support in building this Institute, has derived his strength from the bracing air of California from San Diego to San Francisco. Dr. Radha, now at Stanford, is doing well under the able guidance of Profesor Schiff. Dr. Ranganathan, hitherto interested in high energy physics, has widened his interests by learning new techniques in many body problems at the Brandeis University.

In the Faculty of Mathematics, we excerised even greater caution. We could not have started better than the way we have done with Sriram Abhyankar as the first visitor and Professor Marshall Stone as our first Ramanujan visiting professor. They have set such a high and exacting standard that we have to wait and watch for a gifted mathematician who, by our fundamental postulate, should be noticed before he is thirty.

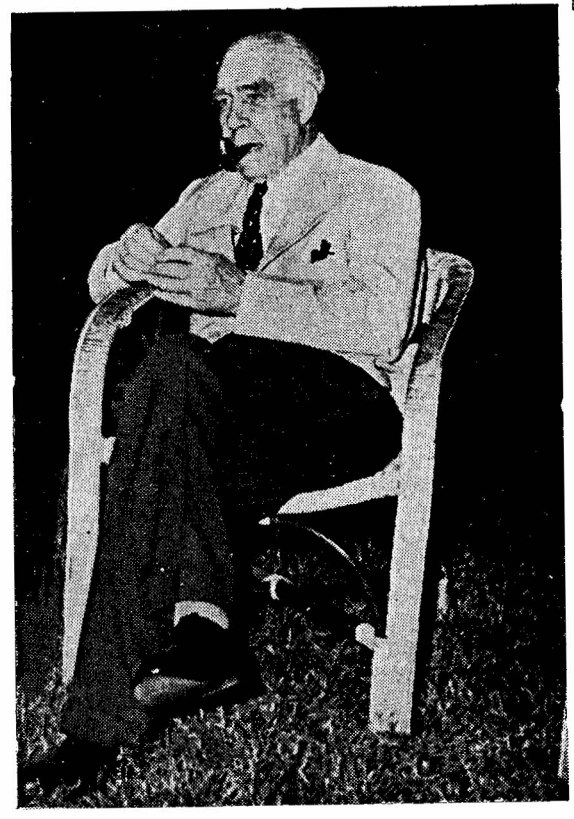
The generosity of our sponsors has matched the response from the great centres of research all over the world. The Madras Government, so graciously represented by our Chairman, Mr. R. Venkataraman and the Secretary for Education have given their unstinted support and encouragement. It is a matter of particular pride that our Chief Minister the Hon. Bhaktavatsalam is taking an active and solicitous interest in our progress. To this is added the willing aid of the Government of India through the Council of Scientific and Industrial Research and the Atomic Energy Department.

Above all, we are enjoying the benignant influence and inspiring guidance of our two esteemed Patrons, the Prime Minister and Mr. C. Subramaniam. Their anxiety that our ideals should be similar to those of the great institution at Princeton will be one of the most important factors in the advancement of higher science in India today.

This unity of purpose has so intoxicated us that we seem to have lost the distinction between dream and reality. The feeling of exaltation should not overwhelm us for we must be aware that this intellectual movement is not the beginning but just the origin of the beginning of a scientific awakening in our country.



Professor R. E. Marshak and L. I. Schiff.



Professor Niels Bohr.

News of the Institute

The Institute entered the second year of its activities this year. The first anniversary was celebrated on Pongal Day, 14th January, 1963. The Hon'ble Sri M. Bhakthavatsalam, Finance Minister, Government of Madras, presided over the function and the Hon'ble Sri C. Subramaniam delivered the Anniversary address.

Two professorships entitled "NIELS BOHR VISITING PROFESSORSHIP" and "RAMANUJAN VISITING PROFESSORSHIP" were announced on the occasion. The first is a tribute to the memory of the creator of modern physics and the founder of quantum theory whose life has been a glorious example of the universality of science and the eternal quest for the laws of nature. His benign interest in the advancement of Indian science and in particular the work of the group of theoretical physicists at Madras was the immediate stimulus for the creation of our Institute.

Professor R. E. Marshak, Chairman, Department of Physics, University of Rochester, U. S. A. accepted the first Niels Bohr visiting professorship for this year.

The second visiting professorship ("RAMANUJAN VISITING PROFESSORSHIP") is to honour the memory of the greatest mathematician India has produced. Professor Marshall H. Stone, Distinguished Service Professor of Mathematics, Chicago University (U. S. A.) accepted the Ramanujan visiting professorship of 1963.

A symposium (which will be a regular feature of all future anniversaries of the Institute) was held on January 14, 15 and 16, 1963 on the "Resonant States in Elementary Particles". Professor R. E. Marshak and all the members of MATSCIENCE took part in the symposium. The proceedings of the symposium have been published as Matscience Report 1. Professor L. I. Schiff, Head of the Physics Department of Stanford University (U. S. A.) released the Report on 27th February 1963.

The visiting scientists programme, approved by the Government of Madras, under which distinguished scientists of established reputation are being invited periodically to give lectures, participate in seminars and symposia and to work in collaboration with the members of the Institute, got into full swing this year. With the assistance of the Government of India, this scheme has now been extended to young post-doctoral workers from outside India who are willing to spend at least one term (three months) in the Institute and participate in its activities.

A list of the visiting scientists under the above schemes for the year 1963 with the period of their visit and the titles of the lectures delivered by them is given at the end of this report.

Another feature was the introduction of the Research Training Scheme, the purpose of which is to train promising young people fresh from the M. Sc. classes in the methods of research and to provide them with facilities for attending lectures and seminars at the Institute. This scheme which is tenable for a year in the first instance may be continued at the discretion of the Director.

The publications of the Institute include in addition to the research papers (which are published in scientific journals), the MATSCIENCE REPORTS and Seminar Lectures. A new feature introduced this year is a monthly report on the recent experimental data. Eighteen Reports were published during the period and a few others are under publication. A list of the MATSCIENCE Reports and Seminar Lectures are given at the end of the present report.

Delegations

Professor Ramakrishnan was invited by Professors R. E. Marshak and E. C. G. Sudarshan of the Rochester University, U. S., to participate in a seminar on Unified Field Theories held at the University of Rochester for three weeks from 8th July 1963. He gave a seminar on "An unconventional view of perturbation expansion" there on 19th July. He also contacted scientists in New York, London and Geneva during his visit.

He was invited by the Ministry of Scientific Research and Cultural Affairs, Government of India, to be the Director of a Summer School in theoretical physics held from 1st to 15th June 1963 at Kodaikanal.

Dr. T. K. Radha, Associate Member, was a delegate from the Institute of Mathematical Sciences, Madras to the International Conference on Nucleon Structure held at the Stanford University U. S., from 24th to 28th June 1963.

Dr. A. P. Balachandran, Associate Member, now at the University of Chicago, U. S. A. was also a delegate to the Stanford Conference.

Dr. T. K. Radha, now at the Stanford University (U. S. A.) Associate member, was a delegate to the Brookhaven International Conference on Weak Interactions held at the Brookhaven National Laboratories from 7th to 11th September 1963. A research paper on "New Baryon-lepton symmetry principle for leptonic weak interactions" by Professor R. E. Marshak, Dr. C. Ryan, Dr. T. K. Radha and Mr. K. Raman was presented at the conference.

The Director and Dr. R. Vasudevan continue as mathematical consultants to the Rand Corporation, Santa Monica, California. The Director is a member of:

1. The Editorial Board of the "Journal of Mathematical Analysis and Applications" (US)
2. Advisory Committee of Scientists (Ministry of S. R. & C. A., India)
3. Cosmic Ray Committee (A.E.C., India)
4. Physical Research Committee (C. S. & I. R., India)

International Conference on Cosmic Rays, Jaipur, December 2 to 14, 1963

Professor Ramakrishnan, who is a member of the Organising Committee of the Conference, attended the conference.

Professors L. Rosenfeld and R. Hagedorn and Dr. M. Jacob, visiting scientists to the MATSCIENCE, were deputed by the Institute as delegates to the conference.

The Faculty of Theoretical Physics

The Director of the Institute, Professor Alladi Ramakrishnan, is the Professor of this faculty. At the end of the year, the staff of this faculty consisted of a Permanent Member, three Associate Members, a Temporary Member and nine Research Fellows.

There were nineteen visiting scientists under the visiting scientists programme.

Research activity:

The research work carried out in this faculty was mainly in two fields: Elementary Particle Physics (including general quantum field theory) and Many body problems.

Elementary Particle Physics

Quantum mechanics and quantum field theory:

1. Continuing their earlier work on inequivalent representations, H. Umezawa and S. Kamefuchi studied the case of Bose fields. A paper on the mass of gauge particles and the self-consistent method in quantum field theory was completed by them.

2. Alladi Ramakrishnan, R. Vasudevan and S. K. Srinivasan of the Indian Institute of Technology, Madras, studied the problem of scattering phase shifts in the case of stochastic potentials.

Electromagnetic and strong interactions:

1. Alladi Ramakrishnan is studying the possibility of interpretating the hypercharge within the framework of conventional Dirac theory.

2. Alladi Ramakrishnan and G. Ramachandran carried out an investigation on magnetic bremstrahlung in neutron electron collisions.

3. S. K. Srinivasan and K. Venkatesan investigated same aspects of the problem of the photoproduction of pions. The single pion photoproduction (from both pions and nucleons) was studied in the strip approximation to the Mandelstam representation. An angular momentum and isospin analyses of the problem of photoproduction of pion pairs from nucleons were made. Work on the use of the strip approximation and the multiperipheral model to study the high energy behaviour of photo and electro-production is being pursued.

4. Alladi Ramakrishnan, K. Raman and R. K. Umerjee have used an isobar model to study the problem of pion production in nucleon-nucleon collisions.

Weak Interactions:

1. R. E. Marshak, C. Ryan, of the University of Rochester (U.S.A.) T. K. Radha and K. Raman carried out an investigation on a new baryon lepton symmetry principle for leptonic weak interactions and a universal theory of semi-weak interactions.

2. K. Venkatesan and T. S. Santhanam studied some aspects of the symmetries shared by strong and weak interactions. Further group theoretical properties of these symmetries are being studied.

Cosmic Rays :

Alladi Ramakrishnan, R. Vasudevan and S. K. Srinivasan have studied some new mathematical features of cascades theory. Work on lateral development of cosmic ray cascades is proceeding.

Nuclear Physics :

1. G. Ramachandran and V. Devanathan studied the polarisation produced in the residual nucleus following photoproduction of pions from nuclei.

2. G. Ramachandran and V. Devanathan have given compact expressions for the cross-sections for photoproduction of pions from complex nuclei with configuration closed shells + equivalent nucleons considering all types of angular momentum couplings between the nucleons.

3. G. Ramachandran and R. K. Umerjee studied the deuteron polarisation following neutral pion photoproduction. V. Devanathan and K. Ananthanarayanan studied the photoproduction of charged pions from deuterons.

4. G. Ramachandran is investigating in collaboration with K. Ananthanarayanan the photoproduction of pions from three nucleon systems He^3 and H^3, in the impulse approximation.

5. Work on trace rules for the evaluation of parameters characterising the spin state of a system with arbitrary spin and some applications is being carried out by G. Ramachandran.

Many Body problems

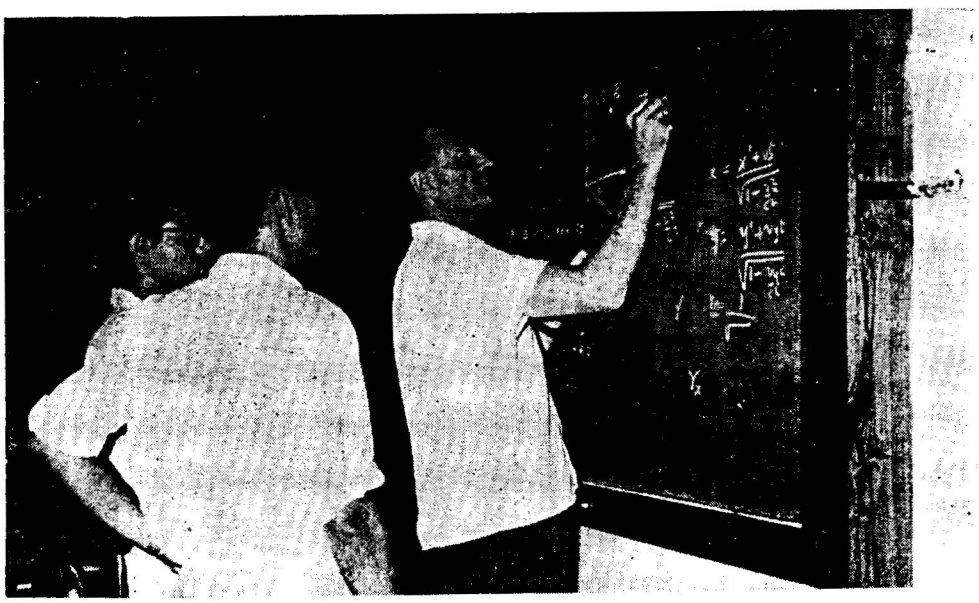
1. N. Fukuda investigated the stability of Hartree-Fock solutions and of collective motions and completed a paper on the subject.

2. A. K. Rajagopal carried out a study of the extended random phase approximation.

3. Hugh Dewitt completed a paper on the pair distribution in a plasma in the random phase approximation.

R. Vasudevan, N. R. Ranganathan and K. Venkatesan, members of the Institute along with the visiting scientist, Hugh Dewitt, are currently investigating the following topics in many body problems :

1. The effect of rotation on the statistical mechanics of classical and quantum mechanical gases.
2. Superconducting material in a magnetic field at non-zero temperatures.
3. Application of Kubo's method and transport coefficients in fluids.
4. Superfluidity of He^4 with attractive interaction included.
5. Relativistic gas.
6. Theories on broken symmetries.
7. Superfluidity of He^3.
8. Quantum statistical mechanics of charged Bose gas.
9. Application of peratisation techniques in many body theory.



Dr. R. Hagedorn of CERN, Geneva.

Dr. Peter Dürr of Max Planck Institute, Munich.

The following are the Reports and research papers published during the year.

MATSCIENCE REPORTS :

	Proceedings of the First Anniversary symposium - The resonant states of elementary particles. (Matscience Report 1)
Ramachandran (G)	Lectures on Angular Momentum (Matscience Report 2)
Thunga Satyapal	Collected topics on Elementary particle theory (Matscience Report 5)
Radha (T.K.) and Venkatesan (K)	Lectures on the Mandelstam representation. (Matscience Report 6)
Raman (K)	Lectures on an introduction to complex angular momentum, Regge poles and high energy scattering (Matscience Report 8)
Schiff (L. I.)	Lectures on Gravitation (Matscience Report 9) *
Sudarshan (E. C. G.)	Lectures on the foundations of quantum mechanics and field theory (Matscience Report 11)
Krishnamurthi (K. V.)	Notes on elementary particle transfer processes in solution chemistry - electron transfer reactions (Matscience Report 12)
Kamefuchi (S)	Lectures on the Stuckelberg formalism of vector meson fields (Matscience Report 14)
Thunga Satyapal & Venkatesan (K)	Lectures on quantum electrodynamics (Matscience Report 15)
Dürr (Peter)	Lectures on the non-linear theory of elementary particles (Matscience Report 16)
Venkatesan (K)	Report on recent experimental data (1963) (Matscience Report 17)
	Collected Seminar Lectures on Elementary Particle Physics (Matscience Report 18)
Fukuda (N)	Lectures on Many Body Problems. (Report under preparation)
Kamefuchi (S)	Lectures on Parastatistics (Report under preparation)
Umezawa (H)	Lectures on Quantum Field Theory (Report under preparation)
Roman (P)	Lectures on an introduction to dispersion relation techniques * (Report under preparation)
Hagedorn (R)	Lectures on relativistic kinematics * (Report under preparation)
Jacob (M)	Lectures on Strong Interactions (Report under preparation)
Rosenfeld (L)	Lecturer on Nuclears Reactions (Report under preparation)
Sudarshan (E. C. G.)	Lectures on the origin of symmetries (Report under preparation)

* For private circulation only.

Research Papers :

Fukuda (N)	The stability of Hartree-Fock solution and of collective motion. Nucl. Phys. 44, 553 (1963)
Venkatesan (K) and Santhanam (T. S)	Some remarks on symmetries shared by strong and weak interactions, Nucl. Phys. 45, 255 (1963)
Marshak (R. E.), Ryan (C), Radha (T. K.) and Raman (K)	New Baryon lepton symmetry principle for leptonic weak interactions. Phys. Rev. Letters, 11, 396 (1963)
,,	Universal theory of semi-weak interactions (to be published)
Ramakrishnan (Alladi), Raman (K) and Umerjee (R. K.)	Isobar model for pion production in nucleon-nucleon collisions (to be published).
Ramakrishnan (Alladi), and Ramachandran (G)	Magnetic bremmstrahlung in neutron-electron collisions (to be published)
Ramakrishnan (Alladi)	A new interpretation for hypercharge within the framework of conventional Dirac theory (preprint)
Ramachandran (G) and Devanathan (V)	Nuclear polarisation following photoproduction of pions from nuclei, I and II. (two papers), Nucl. Phys. (in press)
,,	Photoproduction of charged pions from nuclei, (III) (to be published)
Ramachandran (G) and Umerjee (R. K.)	Deuteron polarisation following neutral pion photoproduction (to be published)
Devanathan (V) and Ananthanarayanan (K)	Photoproduction of charged pions from deuterons (to be published)
Srinivasan (S. K.) and Venkatesan (K)	Angular momentum analysis of photoproduction of pion pairs from a nucleon. (Nucl. Physics, 48,337 (1963))
,,	Photoproduction of a pion from a nucleon in the strip approximation. (Nuovo Cimento, in press)
,,	The strip approximation and the photoproduction of pions on pions. (Nuovo Cimento, in press)
Ramakrishnan (Alladi), Vasudevan (R) and Srinivasan (S. K.)	Some new mathematical features of cascade theory (to be published)
,,	Scattering phase shifts in stochastic potentials (to be published)
Rajagopal, (A.K.)	Some remarks on the extended random phase approximation (to be published)
Dewitt (Hugh)	Pair distribution in a plasma in the random phase approximation (to be published)

Hugh Dewitt of Berkeley, California lecturing on 'Many body problems.'

Summer School at Kodaikanal: Prof. C. Zemach's Lecture.

Summer School on High Energy Physics, Kodaikanal

Professor Ramakrishnan, was the director of the Summer School on High Energy Physics organised by the Ministry of Scientific Research and Cultural Affairs, Government of India, and held in Kodaikanal from 1st to 15th June 1963. All the members of MATSCIENCE were invited as participants. Three members of the academic staff of the Institute, Drs. R. Vasudevan, T. K. Radha and K. Venkatesan, Professor S. K. Srinivasan of the Indian Institute of Technology, Madras and Dr, V. Devanathan, A. C. College of Technology, University of Madras, were invited to give a series of lectures along with the guest professors, Professor Charles Zemach of the University of California, Berkeley, California (U. S. A.) and Professor G. Takeda of the Tohoku University, Sendai, Japan. Dr. N. C. Varshneya of the University of Roorkee and the Professors of Physics of the Presidency College, Madras and the Christian College, Tambaram were also invited. There were also a few seminars by the research students of the Institute.

The following is the list of the lectures delivered at the summer school :

Professor Charles Zemach	Lectures on Strong Interactions
Professor G. Takeda	Lectures on Weak interactions
Professor Alladi Ramakrishnan and Dr. T. K. Radha	An essay on symmetries.
Dr. R. Vasudevan	Regge's theory of potential scattering
Dr. S. K. Srinivasan	Photoproduction of pions from nucleons.
Dr. K. Venkatesan	Photoproduction of pion pairs from nucleons. Photoproduction of a pion from a nucleon in the strip approximation.
Dr. V. Devanathan	Photoproduction of charged pions from nuclei. Photoproduction of pions from deuterons.
Mr. G. Ramachandran	Polarisation phenomena following photoproduction of charged pions from nuclei.
Mr. K. Raman	Scattering amplitudes in perturbation theory
Mr. R. K. Umerjee	Analytic properties of scattering amplitude as a function of energy and momentum transfer.
Mr. T. S. Santhanam	Lectures on symmetries shared by strong and weak interactions.

A preliminary version of the proceedings of the Summer School has been brought out. The final version is under preparation.

Faculty of Pure Mathematics

Professor Einar Hille of the Yale University, U. S. A., Professor Shreeram Abyankar of the John Hopkins University, U.S.A. and Professor M. H. Stone of the University of Chicago, U.S.A. were invited to deliver lectures in pure mathematics at the Institute.

Professor Einar Hille gave a series of three lectures on differential equations. Professor Shreeram Abhyankar who was a visiting professor under the C. S. & I. R. scheme visited the Institute during August-September 1963 and gave a lecture course on the theory of functions of several complex variables which was masterly in originality and treatment. Professor M. H. Stone, Distinguished Service Professor of Mathematics, University of Chicago who was the 'Ramanujan visiting professor' began his lectures on Hilbert Space and functional analysis in December 1963. Professor M. Venkataraman gave a talk on "The real number system". Dr. B. Ramachandran, Pool Officer attached to the Institute, published two papers; one on the Binomial law and the other on the Poisson law.

The following are the Reports and research papers in pure mathematics published during the year :—

MATSCIENCE REPORTS :

1. Einar (Hille)	Lectures on differential equations (Matscience Report 7)
2. Abhyankar (Shreeram)	Lectures on the theory of functions of several complex variables (Matscience Report–under preparation)
3. Stone (M. H.)	Lectures on Hilbert Space and functional analysis (Matscience Report–under preparation)

Research Papers :

Ramachandran, B	(1) A stability theorem for the Binomial law, Sankya: The Indian Journal of Statistics, Series A, 25, 85, 1963.
	(2) Applications of a theorem of Mamay's to a denumerable α – decomposition of the Poisson Law, Publ. Inst. Stat. Univ. Paris (in press)

Dr. Hafner of Rochester in discussion after an Invited Lecture

Professor Marshall Stone of Chicago, First Ramanujan visiting professor at Matscience

Faculty of Applied Mathematics

Professor A. T. Bharucha-Reid of the Wayne State University, U. S. A. who was a visiting professor from July this year for a period of over six months, gave a series of lectures on the following topics in mathematics:

1. Banach spaces,
2. Semi groups of operators, and
3. Random equations.

During his stay he completed a paper on 'Equivalent Markov processes and semi groups of operators'.

Professor Ramakrishnan, Dr. R. Vasudevan, and Dr. S. K. Srinivasan of the Indian Institute of Technology, Madras completed a paper on Multiple product densities.

Professor Ramakrishnan, Dr. R. Vasudevan and Dr. S. K. Srinivasan have carried out work on second order random differential equations with random coefficients.

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

MATSCIENCE REPORTS:

Bharucha-Reid (A. T.):	Notes on Banach spaces, Basic definitions and theorems and related topics (Matscience Report 13)
,,	Lectures on semigroups and random equations. (Report under preparation).

Research Papers:

Bharucha-Reid (A. T.):	Equivalent Markov process and semi groups of operators (to be published)
Ramakrishnan (A), Vasudevan (R) and Srinivasan (S. K.)	Multiple product densities (to be published)
Ramakrishnan (Alladi) Vasudevan (R) and Srinivasan (S. K.)	Second order random differential equations with random coefficients (to be published)

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.

Professor Ramakrishnan, Dr. R. Vasudevan, and Dr. S. K. Srinivasan of the Indian Institute of Technology, Madras, completed a paper on Angular correlations in the brightness of the milky way.

The following is the publication in Astrophysics.

Research paper :

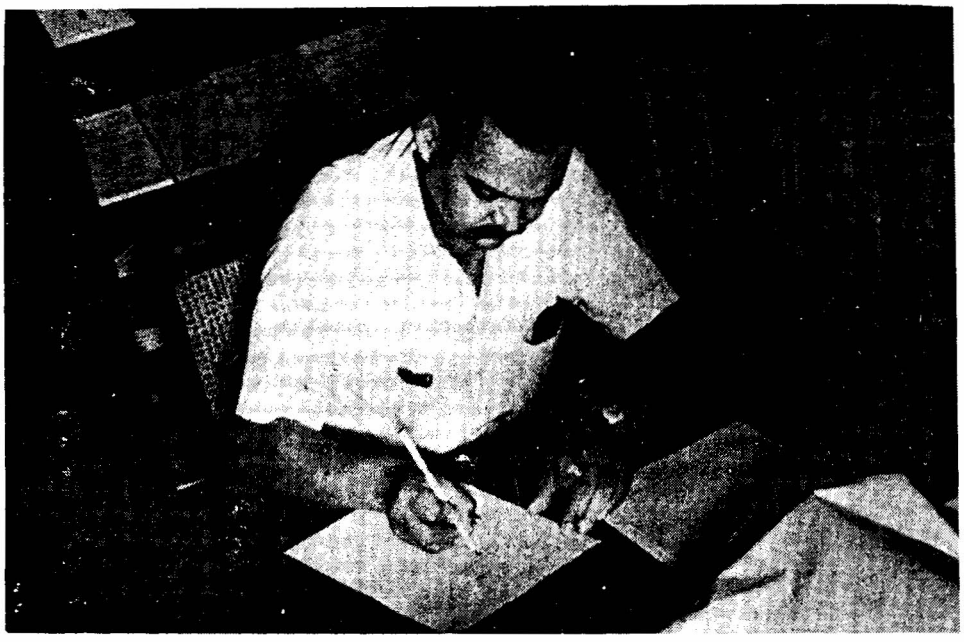
Alladi Ramakrishnan, R. Vasudevan and S. K Srinivasan	Angular correlations in the brightness of the milky way.

Library

During the year under report (January-December 1963), 1500 books and bound periodicals were added to the library at an approximate cost of Rs. 50,000. The number of periodicals subscribed to during the year was 26.

The Institute library has at present a collection of 2,200 books and 30 periodicals. Some back volumes of very important journals, like 'Annals of Physics', 'Nuclear Physics', 'Proceedings of the Physical Society', 'Science Abstracts', 'Physica', 'Reviews of Modern Physics' and 'Progress of theoretical physics' have been recently added. Fifty more new journals, orders for which have been placed already, are expected to be received soon. A catalogue cabinet was added to the library and the index cards were ready for use at the end of the year.

Weekly lists of preprints which are received from other institutions from various parts of the world are issued. The publications of the Institute are being sent regularly to seventy-five individuals and institutions on the mailing list of the institute.



Professor A. T. Barucha-Reid of Wayne State University, Detroit, U.S.A.

Professor E. L. Feinberg of the Lebedev Institute, Moscow discussing after his Lecture.

Lecture Courses by Visiting Scientists

Lecturer	*Period of visit*	*Title of lecture course.*
Professor N. Fukuda, Visiting professor, (Tokyo University of Education, Tokyo, Japan)	December 1962–February 1963	Lectures on Many body problems.
Professor R. E. Marshak, Niels Bohr visiting professor. (Chairman, Department of Physics, University of Rochester, Rochester, N. Y., U.S.A.)	January and February 1963	Lectures on Weak interactions.
Professor L. I. Schiff, Visiting professor. (Head of the Department of Physics, Stanford University, Stanford, California, U.S.A.)	February–March 1963.	Lectures on Gravitation.
Professor H. Umezawa, Visiting professor. (Tokyo University, Tokyo, Japan)	July–August 1963.	Lectures on quantum field theory.
Professor Paul Roman, Visiting Professor. (Boston University, Boston, U.S.A.)	August–September 1963.	Introduction to dispersion relations.
Professor A. T. Bharucha-Reid, Visiting professor. (Wayne State University, Detroit, Michigan, U.S.A.)	July 1963 onwards	Lectures on Banach spaces, semigroups of operators and random equations.
* Professor Shreeram Abyankar, Visiting professor. (Professor of Mathematics, John Hopkins University, Baltimore, U.S.A.)	August–September 1963.	Theory of functions of several complex variable.
Professor Peter Dürr, Visiting professor, (Max-Planck Institute of Physics, Munich, West Germany)	September–October 1963.	Non-linear spinor theory of elementary particles.
* Dr. M. Jacob, Visiting Member, (Department of Physics, Saclay, France)	November 1963 onwards.	Lectures on strong interactions.
Professor R. Hagedorn, Visiting Professor, (Max Planck Institute of Physics, Munich and CERN, Geneva)	November 1963 onwards	Lectures on Relativistic kinematics.
* Dr. S. Kamefuchi, Visiting Member (Assistant Professor, Department of Physics, Tokyo University of Education, Tokyo, Japan)	July–September 1963.	Lectures on "The Stuckelberg formalism for vector mesons" and on "Parastatistics"

* Visiting members under the Council of Scientific and Industrial Research Visiting Membership Scheme.

* Dr. Hugh Dewitt, Visiting Member. (Lawrence Radiation Laboratory, Livermore, California, U.S.A.)	October 1963 onwards.	Quantum statistical mechanics of many particle systems with long range forces.
Professor L. Rosenfeld (Niels Bohr visiting professor for 1964), NORDITA, Copenhagen, Denmark.	December 1963 onwards.	Lectures on Nuclear Reactions
Professor E. C. G. Sudarshan, Visiting Professor (Department of Physics University of Rochester, Rochester, N.Y., U.S.A.)	December 1963 onwards.	Lectures on the origin on symmetries.
Professor M. H. Stone, (Ramanujan visiting Professor for 1963) Distinguished Service Professor of Mathematics, University of Chicago, Chicago, (U. S. A.)	December 1963 onwards.	Lectures on Hilbert Space and functional analysis.

* Visiting members under the Council of Scientific and Industrial Research Visiting Membership Scheme.

A discussion after a Seminar Lecture

Dr. M. M. Shapiro of U.S. and Prof. E. L. Feinberg of Moscow

Invited Lectures

Lecturer	*Date*	*Title of the lecture.*
Professor Einar Hille, Yale University, U.S.A.	22nd to 25th February 1963.	Lectures on differential equations. (three lectures)
Professor M. Venkataraman, Department of Mathematics, University of Madras, Madurai Centre	23rd February, 1963.	The real number system (one lecture)
Professor Charles Zemach, University of California, Berkeley, California, U.S.A.	23rd and 24th May 1963.	On the 3-π resonances (two lectures)
Professor G. Takeda, Tohoku University, Sendai, Japan.	17th June 1963	Resonances in strong interactions (one lecture)
Professor S. K. Srinivasan, Indian Institute of Technology, Madras.	27th July 1963	Multi-point stochastic processes.
Dr. K. Singwi, Argonne National Laboratory. Illinois, U.S.A.	19th September 1963.	The liquid state and cold neutron scattering.
Dr. V. Devanathan, A. C. College of Technology, University of Madras, Madras.	26th June 1963.	Jacob and Wick's helicity analysis.
* Dr. N. C. Varshneya, Visiting Member, (Reader in Physics, University of Roorkee, Roorkee, U. P.)	June–July 1963.	Particle detection (two lectures)
* Dr. B. Misra, Visiting Member. (Institute of Theoretical Physics, University of Geneva, Geneva, Switzerland)	August–September 1963.	The mathematical formalism of quantum fields theory. (two lectures)
* Mr. A. K. Rajagopal, visiting member. (Division of Engineering and Applied Physics, Harvard University, U.S.A.)	August–September 1963.	Some magnetic properties of the of the electron gas (one lecture)
Dr. E. M. Hafner, Department of Physics and Astronomy, University of Rochester, Rochester, N. Y., U. S. A.)	16th December 1963	Galactic and metagalactic Gamma radiation.
Professor G. Yekutieli, Weizmann Institute, Israel.	17th December 1963	High energy cosmic ray cascades in the atmosphore.
Dr. M. M. Shapiro, U. S. Naval Research Centre, Washington D. C., U. S. A.	17th December 1963	The origin of cosmic rays.
Professor E. L. Feinberg, Moscow.	18th December 1963	Cosmic Rays and strong interactions.
Dr. V. K. Balasubramanian, NASA, Washington, U. S. A,	19th December 1963	The present situation regarding the composition of primary cosmic radiation.

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Lectures by the staff of the Institute.

Lecturer	*Date*	*Title of the lecture*
Professor Alladi Ramakrishnan, Director.	11th March 1963	Role of reference frames in scattering theory
	10th Sept. 1963	A new interpretation for hypercharge within the framework of conventional Dirac theory.
	13th Dec. 1963	Inverse probability and Causation.
Dr. R. Vasudevan, Permanent Member.	25th Jan. 1963	Review of the work done during stay in U.S.A.
	11th March 1963	A novel approach to phase shifts.
	March–April 1963	Lectures on Tensors.
	June 1963	Green's functions in many body theory.
Dr. T. K. Radha, Associate Member.	March–April 1963	Lectures on Symmetries.
Dr. K. Venkatesan, Temporary Member.	March–April 1963	Lectures on some topics in weak interactions.
	June 1963	S-matrix theory of strong interactions.
Dr. Thunga Satyapal, Associate Member.	30th July 1963	Theory of positrons.
Dr. B. Ramachandran, C.S.I.R. Pool Officer.	30th March 1963	Wiener measure.

Student Seminars.

Lecturer	*Date*	*Title of the lecture.*
Mr. G. Ramachandran, Atomic Energy Commission, Senior Research Fellow.	March–April 1963	Lectures on Angular Momentum.
	29th June 1963	Polarisation in nuclear photo-production.
	8th November 1963	Photo-pion production from nuclei and related polarisation phenomena.
Mr. K. Raman, Atomic Energy Commission, Senior Research Fellow.	March–April 1963	Lectures on Regge Poles.
	25th June 1963	Perturbation theory and Regge Poles.
	17th August 1963	K-π resonances
Mrs. S. Kamefuchi, Pre-doctoral visiting research fellow of the Institute.	6th September 1963	Nucleon-nucleon interactions and the nucleon-core.
Mr. T. S. Santhanam, C. S. & I. R. Junior Research Fellow.	13th March 1963	Tests of conserved vector current hypothesis.
	20th June 1963	Symmetries in weak interactions.
	1st August 1963	The unitary symmetry.
Mr. K. Ananthanarayanan, C. S. & I. R. Junior Research Fellow.	23rd March 1963	Collision time in scattering theory.
Mr. R. K. Umerjee, C. S. & I. R. Junior Research Fellow.	21st June 1963	Multiple production and high energy scattering.
Mr. G. Jagannathan, C. S. & I. R. Junior Research Fellow.	15th July 1963	Forced oscillations of a plane disk in a viscous fluid.

List of Matscience Reports.

Report Number.	*Author*	*Title.*
1.		Proceedings of the First Anniversary Symposium. The resonant states of elementary particles.
2.	RAMACHANDRAN (G)	Lectures on Angular Momentum
3.	BALACHANDRAN (A.P.)	Lecture course on Introduction to complex variable theory
4.	SWAMINATHAN (S) and VENKATARAMAN (R)	Lectures on Group theory
5.	TUNGA SATYAPAL	Collected topics on Elementary Particle theory
6.	RADHA (T.K.) and VENKATESAN (K)	Lectures on the Mandelstam representation.
7.	HILLE (EINAR)	Lectures on differential equations
8.	RAMAN (K)	Lectures on an introduction to complex angular momentum, Regge Poles and High energy scattering.
9.	SCHIFF (L.I.)	Lectures on Gravitation *
10.	MARSHAK (R.E.)	Lectures on Weak Interactions
11.	SUDARSHAN (E.C.G.)	Lectures on Foundations of quantum mechanics and field theory.
12.	KRISHNAMURTHI (K. V.)	Notes on Elementary particle transfer processes in solution chemistry-Electron transfer reactions.
13.	BHARUCHA-REID (A.T.)	Notes on Banach spaces, Basic definitions and theorems and related topics.
14.	KAMEFUCHI (S)	Lectures on the Stueckelberg formalism of vector meson fields.
15.	THUNGA SATYAPAL and VENKATESAN (K)	Lectures on Quantum electrodynamics
16.	DÜRR (Peter)	Lectures on the non-linear spinor theory of elementary particles
17.	VENKATESAN (K)	Report on recent experimental data (1963)
18.		Collected seminar lectures on Elementary Particles

* For private circulation only

Professor E. C. G. Sudarshan of Rochester
who gave a course on "Symmetries"

Dr. Jacob of Saclay who lectured on
"Strong Interactions"

Under preparation

1.	ABHYANKAR (Shreeram)	Lectures on the theory of functions of several complex variables
2.	FUKUDA (Nobuyuki)	Lectures on many body problems
3.	KAMEFUCHI (S.)	Lectures on Parastatistics
4.	UMEZAWA (H.)	Lectures on Quantum Field Theory
5.	ROMAN (P.)	Lectures on an introduction to dispersion relation techniques *
6.	HAGEDORN (R.)	Lectures on relativistic kinematics *
7.	JACOB (M.)	Lectures on strong interactions
8.	ROSENFEID (L.)	Lectures on Nuclear reactions
9.	SUDARSHAN (E. C. G.)	Lectures on the origin of symmmetries
10.	STONE (M. H.)	Lectures on Hilbert space and functional analysis
11.	BHARUCHA-REID (A. T.)	Lectures on semigroups and random equations

* For private circulation only

List of Seminar Lectures

1.	Professor S. Frautschi	...	An introduction to Regge poles
2.	Dr. B. Maglic	...	On the new resonances
3.	Professor E. Segre	...	Some remarks on recent experimental data and techniques
4.	Professor R. Guy	...	Some combinatorial problems
5.	Dr. B. Ramachandran	...	Elements of measure theory
6.	Dr. K. Venkatesan	...	Branch points and Riemann surface
7.	Professor C. Zemach	...	Determination of spins, parities and isotopic spins of the three pion resonances
8.	Professor G. Takeda	...	Higher resonances in the pion nucleon system
9.	Dr. N. C. Varshneya	...	Nuclear emulsions
10.	Dr. Maurice Jacob	...	An informal talk on the Sienna Conference, October, 1963
11.	Professor E. F. Hafner	...	Galactic and metagalactic gamma radiation
12.	Professor G. Yekutieli	...	High energy cosmic ray cascade in the atmosphere
13.	Dr. M. M. Shapiro	...	The origin of cosmic rays
14.	Professor E. L. Feinberg	...	Cosmic rays and strong interactions
15.	Dr. V. K. Balasubramanian	...	The present situation regarding the composition of primary cosmic radiation

List of Matscience Reprints

1.	RAMAKRISHNAN (Alladi), RADHA, (T. K.) and THUNGA (R.)	Possible resonances in Ξ - π reaction (Nuc. Phys. 32, 517-523)
2.	RAMAN (K.)	Three-particle associated production in pion-nucleon collisions. (Nucl. Phy. 37, 438-448)
3.	RAMAKRISHNAN (Alladi), THUNGA(R.), RADHA (T. K.), BHAMATHI (G.) and INDUMATHI (S.)	Dispersion analysis of Ξ - production in KN collision. (Nucl. Phy. 37, 585-593)
4.	DEVANATHAN (V.) and RAMACHANDRAN (G.)	Photo-production of charged pions from Nuclei, (Nucl. Phy. 38, 654–660)
5.	,,	Photo-production of charged pions from Nuclei. II. (Nuc. Phy. 42, 254-263)
6.	VENKATESAN (K.) and SANTHANAM (T. S.)	Some remarks of symmetries shared by strong and weak interactions. (Nuc. Phy. 45, 255-259)
7.	FUKUDA (Nobuyuki)	The stability of Hartree-Fock solutions and of collective motion). (Nuc. Phys. 44, 1963, 553-571)
8.	BHAMATHI (G.), INDUMATHI (S.), RADHA (T. K.) AND THUNGA (R.)	Pion-production in hyperon-nucleon collisions. (Nuovo Cim. 24, 87-91)
9.	RAMAKRISHNAN (Alladi) and BALACHANDRAN (A. P.)	Partial wave dispersion relations for Lambda-Nucleon scattering. (Nuovo Cim. 24, 980-999)
10.	RAMAKRISHNAN, (Alladi), RADHA (T. K.) THUNGA, (R.), and BALACHANDRAN (A.P.)	On the Y* resonances (Nuovo Cim. 24, 1006-1012)
11.	RAMAKRISHNAN, (Alladi) RADHA (T. K.) THUNGA (R.) and BALACHANDRAN (A. P.)	Photo-production of pions on Λ-hyperons. (Nuovo cim. 25, 939-941)
12.	,,	On the spin and parity of the Y* resonances. (Nuovo Cim. 25, 723-729)
13.	RAMAKRISHNAN (Alladi), RADHA (T. K.) and THUNGA(R.)	The physical basis of quantum field theory. (Journal of Math. Analysis and applications, Vol. 4, 3, 494-525.)
14.	RAMAKRISHNAN (Alladi), RADHA (T. K.) and THUNGA (R.)	On the concept of virtual states. (Journal of Math. Analysis and applications. Vol. 5, 225-236.)
15.	RAMACHANDRAN (B.)	A stability theorem for the Binomial law. (Sankhya : The Indian Journal of Statistical series A. V. 25, 1,85-90)
16.	SRINIVASAN (S. K) and VENKATESAN (K.)	Angular momentum analysis of the photo production of pion pairs from a nucleon, (Nucl. Phys. 48, 337 (1963)

List of Preprints

1.	BHARUCHA-REID (A.T.)	Equivalent Markov processes and semi-groups of operators (to be published)
2.	RAMAKRISHNAN (Alladi)	A new interpretation of hypercharge within the framework of conventional Dirac theory
3.	MARSHAK (R.E.) et. al.	New Baryon-Lepton symmetry principle for leptonic weak interactions Phys, Rev. Lottus, 11, 396 (1963)
4.	,,	Universal theory of semi-weak interactions. Phys. Rev. Letters (to be published)
5.	RAMACHANDRAN (G.) and DEVANATHAN (V.)	Nuclear polarization following photoproduction of pions from muclei. I. (Nucl. Physics. in press)
6.	,,	Nuclear polarization following photoproduction of pions from nuclei. II. (Nucl. Physics, in press)
7.	DEVANATHAN (V.) and ANANTHANARAYANAN (K.)	Photoproduction of charged pions from deuterons. (to be published)
8.	KAMEFUCHI (S.) and UMEZAWA (H.)	Bose fields and inequivalent representation (to be published)
9.	KAMEFUCHI (S.) and UMEZAWA (H.)	The mass of guage particles and the self-consistent method of quantum field theory (to be published)
10.	RAMAKRISHNAN (Alladi) et. al.	Multiple product densities (to be published)
11.	,,	Angular correlations and brightness of milky way (to be pnblished)
12.	SRINIVASAN (S. K.) and VENKATESAN (K.)	Photoproduction of pions from nucleons in the strip approximation (Nuovo Cim. in press)
13.	,,	The strip approximation and the photoproduction of pions on pions (Nuovo Cim. in press)
14.	RAMACHANDRAN (G.) and UMERJEE (R. K.)	Deuteron polarisation following neutral pion photoproduction (to be published)
15.	RAMAKRISHNAN (Alladi) VASUDEVAN (R.) and SRINIVASAN (S. K.)	Some new mathematical features of cascade theory (to be published)
16.	RAMACHANDRAN (G.) and DEVANATHAN (V.)	Photo-production of charged pions from nuclei (III.) (to be published)
17.	RAMAKRISHNAN (Alladi), VASUDEVAN (R.) and SRINIVASAN (S. K.)	Scattering phase shifts in stochastic potentials (to be published)

Late Mr. K. Srinivasan

The late Mr. K. Srinivasan, formerly the Secretary for Education, Government of Madras, was one of the Board of Governors of the Institute at its inception and one of the signatories to its constitution.

The following resolution was passed to condole the demise of Mr. K. Srinivasan:—

All the members and well-wishers of the Institute of Mathematical Sciences were shocked at the sudden and untimely death of our beloved K. Srinivasan, one of the founder sponsors of our organisation. If the Hon'ble Sri C. Subramaniam was the father of this institution, Sri K. Srinivasan was its god-mother. Under his care it outgrew its infancy in less than a year and is now well set on its high endeavour of creative science.

We have now lost our staunchest ally but like Lord Krishna whose name he bears he has left us, his friends, in strength and security. The renaissance in the mathematical sciences in our country can be traced directly to the splendid effort of this genial man and the imagination of the Hon'ble Sri C. Subramaniam as the gracious representative of our State Government.

We share the grief in equal measure with all the members of his family. Memories of our association with him will be a part of the scientific tradition of this Institute.

Acknowledgment

The sponsors of the Institute acknowledge with gratitude and admiration the spontaneous and generous response from the eminent physicists and mathematicians throughout the world to the invitations to participate in the activities of the Institute. The spirit that animates the worldwide community of scientists is best illustrated by the message (by cablegram) from Professor Niels Bohr on the occasion of the inauguration of the Institute.

> "At inauguration of the Institute of Mathematical Sciences in Madras the whole group of the Copenhagen Institute for Theoretical Physics wants to send its heartiest felicitations. The community of physicists has been impressed by the vigour and zeal with which Prof. Ramakrishnan has been able to educate and inspire his young pupils and collaborators and the work in the new Institute will be followed with keen expectations. Indeed as an important asset to scientific research in India the creation of the Madras Institute is eagerly welcomed in that worldwide cooperation in science which offers so great opportunities for promoting the understanding between all peoples".