

B.S. Madhavarao

59 Kanakpura Road, Basavangudi,
Bangalore-560004

My research work falls into two streams : (i) critical work; and (ii) original work.

Critical Work

(1) The German Nobel Laureate, J Stark, had published a paper in 1938 in which he had proposed a theory of ring-structure of the electron. While working with Prof. Max Born, who was in Bangalore for six months during 1938, I had developed on the basis of Born's non-linear field theory, the possibility of a ring structure for the electron. This work was done before Stark's work on the same subject. On looking at his work, I noticed some serious errors consequent on the fact that he had not used the principles of the theory of relativity, since he did not believe in it. My criticism and Stark's reply to the same were published in Phys Z (1939). My final strongly worded reply to his observations was published in the same journal. Thereafter, he took no further part in the controversy.

(2) Raman and Nagendranath had published in the Proc Indian Acad Sci (1938) a paper in which they claimed that many properties of light could be explained on the basis of a neutrino theory. In a later issue of the same journal I published a paper showing the inadequacy of the neutrino theory of light, and Raman was gracious enough to accept the correctness of my criticism.

Original Work

- (1) My work on Born's non-linear field theory done in 1938 was referred^{to} as 'Madhavarao's theory of action functions' in the Poincare Institute Memoirs of 1938. In a letter written to me, Prof. Pauli explained how some of the points I had raised about Born's non-linear field theory could be explained satisfactorily.
- (2) Papers on Newtonian classical mechanics relating to the Lagrangian and Hamiltonian formulations were published during 1932-35. One of these papers on "Separable systems in classical and wave mechanics" published in Math Annalen in 1935 has been referred to in several books on mechanics published in Germany.
- (3) In my work done in 1937, I used elliptic function formulae for the study of plane cubic curves, and in particular a special type of cubic curve studied by Newton. My theorem has been referred to as "Madhavarao's theorem on apolar cubics" in an article published by Acad Lincei, Rome (1937).
- (4) The most important part of my research work was done during 1942-47. This work related to the application of the theory of groups and group representations in modern theoretical physics, specially in the theory of elementary particles. I was possibly the first one in India to undertake work of this type. I set up order relativistic wave equations of the Dirac type

for particles of arbitrary spin, and derived the commutation relations satisfied by the β -matrices of the wave equation. I published six papers on this subject. Bhabha who was in Edinburgh at the time wrote to me enquiring if he could come to Bangalore and work with me on these topics. I readily agreed, and for a period of three to four years myself, Bhabha, and Harishchandra worked together on the topic of relativistic wave equations, but published mostly individual (not joint) papers. Later, Bhabha left Bangalore to undertake work connected with the establishment of ^{the} atomic energy establishment, and Harishchandra (who died recently) left for Princeton, where where he did very significant work on Lie groups. I continued to work on the subject, and a paper of mine published in the Proc R Soc relating to particles of spin $3/2$ raised some points which have not been solved up to now. References to my work are to be found in (i) E.M. Corson's book (Princeton University Press, 1953) in which "Madhavarao algebra", and "Madhavarao's ring" are referred to extensively, (ii) correspondence with N. Jacobson on the subject, (iii) in six papers published by Krajcik and Nieto in the Physical Review (1975-77), where a special mention is made of my work on particles of spin $3/2$ and also in several other papers published by various other authors working on quantum statistics, and the Pauli exclusion principle. On the basis of this work, I was awarded the Ramanujan Prize of the Madras University in 1965.

(5) A joint paper was published along with Bhabha in 1945 on the scattering of charged mesons.

(6) A paper on a conjecture of Ramanujan in number theory published in the Proc Benares Math Soc in 1952 attracted the attention of some workers in number theory.

(7) Being out of touch for the last three decades with the rapid developments in physical theories, specially the unification theories, I have undertaken work on recreational mathematics during the last three to four years, and have almost completed a book on magic squares wherein I have highlighted the work on the subject contained in the last chapter of the book entitled Ganitha Kaumudi in Sanskrit written in 1356 A.D. by Narayana Panditha, and also the work on magic squares done by Ramanujan while he was a school student.

Selected Publications

List of published research papers

(1)

7

Dr. B. S. Madhava Rao

- (1) On the equivalence of three definitions of irrational number -
J. Ind. Math. Soc. 15, 1923, p. 53.
- (2) On the collinearity of three points on a non-singular cubic -
Ibid, 15, 1923, p. 163.
- (3) _____ do _____ (Journal of Science, Vizianagaram College, 1924)
- (4) On the covariant curves of a singular n -ic - Bull. Calcutta Math. Soc., 14, 1923, pp. 55-64.
- (5) Groups of points on the equi-anharmonic cubic - J. Mysore Univ. 1, 1927, pp. 1-10.
- (6) On the equations of motion of a non-holonomic dynamical system - *ibid*, 7, 1933, pp. 1-14.
- (7) On the theory of suspension bridges - Bull. Mysore Engineers' Association, 1934, pp. 1-14.
- (8) Elliptic function formulae and plane cubic curves - Proc. Ind. Acad. Sci. A. 1, 1934,
pp. 363-71.
- (9) Mixed polar theorems on plane cubics - J. Mys. Univ. 8, 1935, pp. 62-68.
- (10) Note on a theorem on homologous stars - Math. Student, 1, 1933, pp. 81-85.
- (11) Über die einp. mechanischen System betreffenden Theoreme von Liouville und
Stäckel - Zs. f. Phys., 93, 1935, pp. 320-28.
- (12) Separable systems in classical and wave mechanics - Math Annalen, 3, 1935, pp. 459-68.
- (13) Ring singularity in Born's field theory - Proc. Ind. Acad. Sci. 4, 1936, pp. 355-376
- (14) A theorem on action functions in Born's field theory - *Ibid*, 4, 1936, pp. 377-
- (15) Complex representation in Born's field theory - *Ibid*, 5, 1936, pp. 575-
- (16) Semi-vectors in Born's field theory - *Ibid*, 4, 1936, pp. 437-
- (17) On the fine structure of Balmer lines - *Ibid*, 5, 1937, pp. 56-
- (18) Generalised action functions in Born's Electrodynamics - *Ibid*, 6, 1937, pp. 129-
- (19) Biquaternions in Born's Electrodynamics - *Ibid*, 7, 1938, pp. 333-
- (20) Ring singularity in Born's unitary theory - *Ibid*, 6, 1937, pp. 129-
- (21) Bemerkungen zur "Ringstruktur des Electrons" - Physikalisches Zeitschrift, 39, 1938, p. 187.
- (22) Antwort auf Stark's Bemerkungen - *Ibid*, 39, 1938, p. 193.
- (23) Names in Mathematics - Intr. College Magazine, Bangalore, 5, 1938, pp. 59-
- (24) Question of invariance in the neutrino theory of light - Proc. Ind. Acad. Sci., 7, 1938,
pp. 293-

- (25) On an inequality concerning lattice sums - *Ibid.*, 8, 1938, pp. 524 -
- (26) Quantum-mechanical interpretation of a result concerning Hermite's polynomials
- *Ibid.*, 10, 1939, pp. 217 -
- (27) Generalised geometry and physical theories - *Math. Student*, 8, 1940, pp. 11-34.
- (28) Notes on Dynamics - *J. Mys. Univ.*, 9, 1940, pp. 93 -
- (29) On an invariant relation of dynamical systems - *ibid.*, 1940, pp. 1-3.
- (30) On the reduction of dynamical equations to the Lagrangian form - *Proc. Benares Math. Soc.*, 2, 1940, pp. 53 -
- (31) The scattering of charged mesons (with Dr H. J. Bhabha) - *Proc. Ind. Acad. Sci.*, 13, 1941, pp. 9-24.
- (32) Evolution of Stars - *Annamalai Univ. Jubilee Commemoration Vol.* 1941, pp. 247-71.
- (33) Commutation rules related to particles of higher spins - *Proc. Ind. Acad. Sci.*, 15, 1942, pp. 139-47.
- (34) Commutation rules related to particles of spins half and one - *J. Mys. Univ.*, 3, 1942, pp. 59 -
- (35) Notes on Dynamics - 2 - *Ibid.*, 5, Part 7, 1944, pp. 35-43.
- (36) Some examples of radial fluid motion - *Ibid.*, 5, Part 4, 1944, pp. 21 -
- (37) Modern Algebra and theory of elementary particles - *Math Student*, 12, 1944, pp. 30-58.
- (38) Some trigonometric inequalities - *J. Mys. Univ.*, 6, 1945, pp. 1-12.
- (39) Solution of cubic equations - *Ibid.*, 1945, pp. 13 -
- (40) Pauli's identities in the Dirac algebra - *Proc. Ind. Acad. Sci.*, 22, 1945, pp. 408-22.
- (41) Algebra related to elementary particles of spin $\frac{3}{2}$ - *Proc. Roy. Soc. London, Series A*, 187, 1946, pp. 385-97.
- (42) - Do - *Current Science*, 14, 1945, pp. 180 -
- (43) Commutation rules for matrices related to particles of higher spin - *J. Mys. Univ.*, 6, 1945, pp. 57-62.
- (44) On an inequality concerning orthogonal polynomials - *Proc. Ind. Acad. Sci.*, 29, 1949, pp. 391-93.
- (45) Notes on operational Calculus - *J. Mys. Univ.*, 10, 1950, pp. 1 -
- (46) Existence of elementary particles of higher spin - *Proc. International Conf. T.J.F.R., Bombay*, 1951, pp. .
- (47) Military applications of von Neumann's theory of games - *Proc. Second Defence Sci. Conference, New Delhi*, 1952
- (48) On a problem on linkages - *J. App. Math.*, 1954 London, 1954
- (49) Problems in External Ballistics - *Defence Sc. Journal*, 1955.

- (50) Vivial problems related to simple wing profiles - Proc. Ind. Acad. Sci. 43, 1956,
pp. 53-66.
- (51) Games of mixed strategy - Defence Sci. Journal, 1957.
- (52) Modern Algebra and Theory of elementary particles - Presidential Address to Ind. Sci. Congress
1958, pp. 1-19.
- (53) Physical applications of the Lorentz group - ~~Presidential~~ Address to Ind. Acad. Sci.,
Proc. Ind. Acad. Sci. 47, 1959, pp. 105-115.
- (54) Projectiles in flight - Defence Science Journal, July, 1958, pp. 70-76.
- (55) Geometry and Gravitation - Presidential Address to Ind. Math. Soc., 1959,
pp. 1-26.

ENCLOSURE 2.

List of Published Papers
of
Dr. B.S. Madhava Rao

- (1) On the equivalence of three definitions of irrational numbers -
J. Ind. Math. Soc. 15, 1923, p. 53
- (2) On the collinearity of three points on a non-singular cubic - Ibid, 15
1927, p. 163.
- (3) -do- (Journal of Science, Vizianagaram College, 1924)
- (4) On the covariant curves of a singular cubic - Bull. Calcutta Math. Soc. 14
1923, p. 55-64.
- (5) Group of points on the equi-anharmonic cubic - J. Mys. Uni. 1, 1927, p. 1-10
- (6) On the equations of motion of a non-holonomic dynamical system,
-ibid, 7, 1933, p. 1-4
- (7) On the theory of suspension bridges - Bull. Mys. Engineers' Association,
1934, p. 1-14
- (8) Elliptic function formulae and plane cubic curves - Proc. Ind. Acad. Sc. A.
1, 1934, p. 363-71
- (9) Mixed polar theorems on plane cubics - J. Mys. Uni. 8, 1935, p. 62-68
- (10) Note on a theorem on homologous stars - Math. Student, 1, 1933, p. 81-85
- (11) Über die ein mechanisches System betreffende Theoreme von Liouville
Und Stackel - Zs. f. Phys. 93, 1935, p. 320-28.
- (12) Separable systems in classical and wave mechanics - Math. Annalen,
3, 1935, p. 459-68
- (13) Ring Singularity in Born's field theory - Proc. Ind. Acad. Sci. 4, 1936,
355-76
- (14) A theorem on action functions in Born's field theory - Ibid, 4, 1936
p. 377
- (15) Complex representation in Born's field theory - Ibid, 5, 1936, p. 575
- (16) Semi-vectors in Born's field theory - Ibid, 4, 1936, p. 437
- (17) Ring-singularity in Born's unitary theory - Ibid, 6, 1937, p. 129
- (18) On the fine structure of the Balmer lines - Ibid, 5, 1937, p. 56
- (19) Generalised action functions in Born's Electro-dynamics - Ibid, 6,
1937, p. 129
- (20) Biquaternionics in Born's Electro-dynamics, - Ibid, 7, 1938, p. 333
- (21) Bemerkungen zur "Ringstruktur des Electrons" - Phys. Zs, 39, 1938, p. 187
- (22) Antwort and Starks Bemerkungen - Ibid, 39, 1938, p. 193
- (23) Names in Mathematics - Inter-College, Magazine, Bangalore, 5, 1938, p. 59
- (24) Question of invariance in the neutrino theory of light - Proc. Ind. Acad.
Sci. 7, 1938, p. 293.
- (25) On an inequality concerning lattice sums - Ibid, 8, 1938, p. 524
- (26) Quantum-mechanical interpretation of a result concerning Hermites
Polynomials - Ibid, 10, 1939, p. 217

- (27) Generalised geometry and Physical theories - Math.Student, 2, 1940 p.11-34.
- (28) Notes on dynamics - J.Mys.Uni. 2, 1940, p. 93
- (29) On an invariant relation of dynamical systems - *ibid*, 1940, p. 1-3
- (30) On the reduction of dynamical equations to the Lagrangian form - Proc. Benares Math.Soc. 2, 1940, p.53
- (31) The scattering of charged mesons (in collaboration with Dr. H.J.Bhabha) Proc.Ind.Acad.Sci. 13, 1941, p.9-24
- (32) Evolution of stars - Annamalai Uni.Jl. Commemoration Vol. 1941, p. 247 - 271.
- (33) Commutation rules for matrices related to particles of higher spins Proc.Ind.Acad.Sci. 15, 1942, p.139-47
- (34) Commutation rules related to particles of spins half and one - J.Mys. Uni. 2, pt.10, 1942, p.59
- (35) Notes on dynamics 2 - *ibid*, 5, part 7, 1944, p. 35-43.
- (36) Some examples of radial fluid motion - *ibid*, 5, part 4, 1944, p.21
- (37) Modern Algebra III and theory of elementary particles - Math.Student, 12, 1944, p.30-58.
- (38) E.S.K.Iyengar - in Memoriam - Proc. Ind.Acad.Sci. 19, 1944, p.414
- (39) Some trigonometrical inequalities - J.Mys.Uni. 6, 1945, p. 1-12.
- (40) Solution of cubic equations - *ibid*, 1945, p.
- (41) Pauli's identities in the Dirac Algebra - Proc.Ind.Acad.Sci. 22, 1945, P. 408-22
- (42) Algebra related to elementary particles of spin 3/2 - Proc. Roy.Soc. London, A, 187, 1946, p. 385-97.
- (43) -do- Current Science, 14, 1945, p. 180
- (44) Commutation rules for matrices related to particles of higher spin. J. Mys.Uni. 6, 1945, p. 57-62
- (45) Sir C.V.Raman as Physicist and teacher - Proc.Ind.Acad.Sci. 28, 1948, p. 254.
- (46) On an inequality concerning orthogonal polynomials - Proc. Ind.Acad. Sci. 29, 1949, p. 391-93.

NOTES AND COMMENTS

- (47) The mathematical theory of a new relativity by Sir Shah Sulaiman - A critical review, Current Science, Sept. 1935, p. 145-151
- (48) Reply to Sir Sulaiman - *ibid*, Oct. 1935, p. 401
- (49) Sulaiman's predictions - *ibid*, March 1938, p. 459.
- (50) The Mesotron - *ibid*, March, 1939, p. 143.
- (51) Classical and quantum mechanics, *ibid*, April 1942, p. 163.
- (52) Relativity - *ibid*, April 1938, p. 515.
- (53) Logic and Probability in Physics, - *ibid*, October 1938, p. 201.
- (54) The Raman Jubilee Volume - *ibid*, Jan. 1939, p. 22.

(55) Gregory Tercentenary Memorial - *ibid*, July 1940, p. 240.

(56)

UNDER PUBLICATION

(56) The virial problem in hydrodynamics - *Quart.App.Math.* Brown Uni. 1954.

(57) On a problem in linkages - *J. App.Math.* London, 1954.

(58) On symmetries of spherical harmonics - *Canadian J.Math.* 1954.

ANNEXURE 'C'

Research and allied work done from 1962 onwards:-

67. On the role of Mathematics in Quantum Theory--Presidential Address at the 26th Conference of the Indian Mathematical Society--The Mathematic Student, Vol.39, Nos 1&2, 1962.
68. Principles of Relativity and Quantum Mechanics--Brochure printed by the Annamalai University, based on three lectures of mine at the Deptt. of Mathematics.
69. Inequalities worked in Papers Nos 25,39 & 46 of Annexure B have been deepened, and sent to Prof D.S. Mitrovic of the Belgrade University, on his own request, for inclusion in his forthcoming book on the subject of inequalities (Under Publication).- Sent on 7 Oct 66.
70. Quantum Theory & Gravitation--Article sent for inclusion of the Sir Ashutosh Mukherjee Commemoration Volume (Under publication) - sent on 7 Jun 65.
71. Article on "A conjecture of Ramanujan" has been sent on 25 Jul 66 for inclusion in the B.N.Prasad Commemoration Volume of the Allahabad Mathematical Society.
72. An article on "Dirac's reformulation of Born's field theory has been communicated to the Proc Royal Soc. on 28 Aug 67.

In addition, I have done an evaluation of two books viz:

- (1) "Elements of Modern Algebra" by Tu, for the Ministry of Education, and
- (2) "Cybernetics within us" by Y.Saparina, for the University Grants Commission. Further a contribution has been sent on Mathematics & Astronomy to the Telugu Bhasha Samiti, and has been published.

Regarding reviews, I have done six for the Mathematical Reviews of the Amer. Math. Soc, two for Current Science, and one for the J.S.I.R (Vol 22 No 4, April 1963, p. 177), and one on the "Design and Analysis of Experiments" by Oscar Kempthorne.

ANNEXURE 'C'

Research and allied work done from 1962 onwards:-

67. On the role of Mathematics in Quantum Theory--Presidential Address at the 26th Conference of the Indian Mathematical Society--The Mathematic Student, Vol.39, Nos 1&2, 1962.
68. Principles of Relativity and Quantum Mechanics--Brochure printed by the Annamalai University, based on three lectures of mine at the Deptt. of Mathematics.
69. Inequalities worked in Papers Nos 25,39 & 46 of Annexure B have been deepened, and sent to Prof D.S. Mitrinovic of the Belgrade University, on his own request, for inclusion in his forthcoming book on the subject of inequalities (Under Publication).- Sent on 7 Oct 66.
70. Quantum Theory & Gravitation--Article sent for inclusion of the Sir Ashutosh Mukherjee Commemoration Volume (Under publication) - sent on 7 Jun 65.
71. Article on "A conjecture of Ramanujan" has been sent on 25 Jul 66 for inclusion in the B.N.Prasad Commemoration Volume of the Allahabad Mathematical Society.
72. An article on "Dirac's reformulation of Born's field theory has been communicated to the Proc Royal Soc. on 28 Aug 67.

In addition, I have done an evaluation of two books viz:

- (1) "Elements of Modern Algebra" by Yu, for the Ministry of Education, and
- (2) "Cybernetics within us" by Y.Saparina, for the University Grants Commission. Further a contribution has been sent on Mathematics & Astronomy to the Telugu Bhasha Samiti, and has been published.

Regarding reviews, I have done six for the Mathematical Reviews of the Amer. Math. Soc, two for Current Science, and one for the J.S.I.R (Vol 22 No 4, April 1963, p. 177), and one on the "Design and Analysis of Experiments" by Oscar Kempthorne.

ANNEXURE 'C'

Research and allied work done from 1962 onwards:-

67. On the role of Mathematics in Quantum Theory--Presidential Address at the 26th Conference of the Indian Mathematical Society--The Mathematic Student, Vol.39, Nos 1&2, 1962.
68. Principles of Relativity and Quantum Mechanics--Brochure printed by the Annamalai University, based on three lectures of mine at the Deptt. of Mathematics.
69. Inequalities worked in Papers Nos 25,39 & 46 of Annexure B have been deepened, and sent to Prof D.S. Mitrinovic of the Belgrade University, on his own request, for inclusion in his forthcoming book on the subject of inequalities (Under Publication).- Sent on 7 Oct 66.
70. Quantum Theory & Gravitation--Article sent for inclusion of the Sir Ashutosh Mukherjee Commemoration Volume (Under publication) - sent on 7 Jun 65.
71. Article on "A conjecture of Ramanujan" has been sent on 25 Jul 66 for inclusion in the B.N.Prasad Commemoration Volume of the Allahabad Mathematical Society.
72. An article on "Dirac's reformulation of Born's field theory has been communicated to the Proc Royal Soc. on 28 Aug 67.

In addition, I have done an evaluation of two books viz:

- (1) "Elements of Modern Algebra" by Hu, for the Ministry of Education, and
- (2) "Cybernetics within us" by Y.Saparina, for the University Grants Commission. Further a contribution has been sent on Mathematics & Astronomy to the Telugu Bhasha Samiti, and has been published.

Regarding reviews, I have done six for the Mathematical Reviews of the Amer. Math. Soc, two for Current Science, and one for the J.S.I.R (Vol 22 No 4, April 1963, p. 177), and one on the "Design and Analysis of Experiments" by Oscar Kempthorne.

ANNEXURE 'C'

Research and allied work done from 1962 onwards:-

67. On the role of Mathematics in Quantum Theory--Presidential Address at the 26th Conference of the Indian Mathematical Society--The Mathematic Student, Vol.39, Nos 1&2, 1962.
68. Principles of Relativity and Quantum Mechanics--Brochure printed by the Annamalai University, based on three lectures of mine at the Deptt. of Mathematics.
69. Inequalities worked in Papers Nos 25,39 & 46 of Annexure B have been deepened, and sent to Prof D.S. Mitrinovic of the Belgrade University, on his own request, for inclusion in his forthcoming book on the subject of inequalities (Under Publication).- Sent on 7 Oct 66.
70. Quantum Theory & Gravitation--Article sent for inclusion of the Sir Ashutosh Mukherjee Commemoration Volume (Under publication) - sent on 7 Jun 65.
71. Article on "A conjecture of Ramanujan " has been sent on 25 Jul 66 for inclusion in the B.N.Prasad Commemoration Volume of the Allahabad Mathematical Society.
72. An article on "Dirac's reformulation of Born's field theory has been communicated to the Proc Royal Soc. on 28 Aug 67.

In addition, I have done an evaluation of two books viz:

- (1) "Elements of Modern Algebra" by Hu, for the Ministry of Education, and
- (2) "Cybernetics within us" by Y.Saparina, for the University Grants Commission. Further a contribution has been sent on Mathematics & Astronomy to the Telugu Bhasha Samiti, and has been published.

Regarding reviews, I have done six for the Mathematical Reviews of the Amer. Math. Soc, two for Current Science, and one for the J.S.I.R (Vol 22 No 4, April 1963, p. 177), and one on the "Design and Analysis of Experiments" by Oscal Kempthorne.

Biodata

re.

Dr. B. S. Madhavarao, D.Sc., F.N.A., F.A.Sc.

(1) Name & date of birth -

Madhavarao Bangalore Srinivasatao

Born on 29/5/1900 at Chamarajanagar,

Mysore Dist

(2) Academic Degrees

(a) B.Sc. Mys. University 1919 - First Class First

(b) M.Sc. Calcutta University 1921 - First Class Second

(c) D.Sc. Degree Calcutta University, 1938 - Thesis on

"~~Born's~~ Born's non-linear field theory" with-panel of examiners
consisting of

(i) Hermann Weyl

(ii) Jacques Hadamard

(iii) Oswald Veblen

ENCLOSURE 3.

Additional Remarks under Item No. 27 of the Application Form.

(3) Teaching & Research Experience:

1. Taught all classes up to M.Sc., and classes in Engineering College in several branches of Pure and Applied Mathematics and Engineering Mathematics; taught advanced subjects like Relativity, Quantum Mechanics, Astrophysics, Hydro and Aero dynamics and Analytical Dynamics.
2. Trained several scholars for M.Sc., Ph.D. and D.Sc., Degrees of this and other Universities.
3. Collaborated in research with Prof. Dr. Max Born Sc., D.F.R.S. in the department of Physics, Indian Institute of Science, also with Sir C.V.Raman, F.R.S.M.I., and with Dr. H.J.Shabhu, F.R.S.

(4) Original work:

1. Published over 50 research papers in several leading Journals like Math. Annalen, Ze. f. Physik, Proc. Royal Society, London, Proc. Indian Academy of Sciences and I.Ind.Math. Soc. on
 - a) Geometry of curves,
 - b) Analytical Dynamics,
 - c) Born's electro magnetic field theory.
 - d) Quantum mechanics
 - e) Theory of elementary particles of nature.

Under (a) has been the author of a theorem referred to in the literature as "Madhava Rao's action theorem on apolar cubics"

Ref: (a) T.Ray Pastor - Acad. Lincei, Rome, 1937.

Under (b) has been the author of entitles known as "Madhava Rao's action functions"

Ref: (b) M.Born - Poincare' Institute Memoirs, 1936.

Under (c) was the first to prove the inadequacy of the neutrino theory of light

Ref: (c) Proc. Ind. Acad. Sc. 7, 1938, p.293.

and Under (d) has discovered new types of algebra related to elementary particles referred to as "Madhavarao algebra" and "Madhavarao ring" to which was awarded the Ramanujan Prize of the Madras University, 1945.

Ref: Book by E.M.Corson - Zensors,

(i) Spinors & relativistic wave equations, 1953-

References in the chapter on wave equations, in the bibliography and the index.

(ii) reference in the article by Jehle - Reviews of Modern Physics, 1953-54.

(iii) Ref. by M. Nzebo, Phys. Rev, 1952.

2. Has been the author of two well known papers of Critical Nature on

(a) Sulaiman's theory of relativity (Referred to by the Astronomer Shapley in the American Journal "Science".

(b) Ring theory of the electron by J.Stark M.I. (Correspondence in Physics 33, 1932)

3. Published reviews and critical notes in Current Science Journal, Sc. & Industrial Research etc.

(5) ~~(2)~~ Lectures and Symposia.

1. Has delivered University lectures under the auspices of the Madras, Travancore and Annamalai Universities and special course of lectures by invitation at the Indian Institute of Science and the Travancore Statistical Department.
2. Has presided over symposia organised by the Indian Mathematical Society, The Indian Academy of Sciences and the Indian Science Congress.
3. Read a paper by invitation at the International Conference on Elementary Particles held at the Tata Institute of Fundamental Research, Bombay, in 1951.
4. Invited to read a paper at the Second Defence Science Conference at Delhi, April 21-26, 1952. Under the section of operational research, read a paper on "Military applications of Neumann's theory of games", presided over by Air Marshal Mukherji and in the discussion on which Mr. Johnson, the Head of the Institute of Armament Studies took part.

(6) ~~(4)~~ Membership of Learned Bodies.

2. Fellow of the Indian Academy of Sciences - Member of the Council and Secretary, Section A, *and Vice-President of the Indian National Science Academy for one year*
- ~~1.~~ Fellow of the ~~National Institute of Sciences of India.~~
3. Fellow of the Royal Astronomical Society, London,
4. Member of the Mathematical Sectional Committee and Recorder of the Indian Science Congress *and President of the Section for one year*
5. Member of Council of the Indian Mathematical Society.
6. Member of the American Mathematical Society, ~~Mathematical Association of America~~, the London Mathematical Society, the Edinburgh Mathematical Society, ~~Mathematical Association of England~~, the Benares Mathematical Society and the ~~Current Science Association.~~ *and been President of the Indian Math. Society for 2 years.*

(7) ~~(5)~~ Academic Duties:

1. Member of the Academic Council of the Universities of Mysore and Travancore;
2. Member and once Dean of the Faculty of Science, Mysore University, Member of Faculty of Science of Travancore University, also member of the Faculty of Arts, Faculty of Engineering and Technology, and the Faculty of Teaching of the Mysore University.
3. Chairman, Board of Studies in Mathematics, Mysore University and member of Board of Studies in Mathematics and Mathematical Physics and Statistics of the Andhra, Annamalai, Travancore, Osmania and Karnatak Universities.
4. Member of the Ad Hoc Selection Committee of the Andhra University and several as expert to Committees of Poona, Madras, Annamalai, Travancore, Mysore Universities and to the Madras Public Service Commission and Union Public Service Commission, *and the Sri Lanka Public Service Commission.*

5. Served as Chairman, Board of Examiners of Mysore, Andhra, Madras, Travancore and Annamalai Universities and member of Boards of Examiners of the above and Osmania, Karnatak, Poona, Bombay, Patna, Calcutta, Gauhati, Rajputana, Nagpur and Ceylon Universities.
6. Served as examiner for Ceylon Civil Service, Indian Civil Service, Institution of Engineers, Military Wing, Survey of India and Madras Provincial Local Service Examinations.
7. Valued theses for M.Sc., Ph.D & D.Sc. of Madras, Bombay, Poona, Annamalai, Andhra and Travancore Universities.
8. Adjudicator for the G.R.Reddy National Prize for Mathematics and Physics.
9. Drew up the scheme of studies and syllabuses for the Honours and M.Sc. courses in Mathematical Physics of the Andhra University and the M.Sc. in Statistics of the Travancore University and the present Honours and M.Sc. syllabuses of the Mysore University.

10. Drew up syllabus for Internal and External Ballistics for inclusion of Ballistics as an optional subject for the M.Sc.
11. *Drew up syllabus for Ballistic Operations Research and Theory & Games at the Inst. of Advanced Technology, Pune.*

(2) ~~(A)~~ Administrative duties.

1. Deana member of the Senate of the Mysore University.
2. Member of the University Council of the Mysore University for over five years.
3. Member and Chairman, Mysore University Commission and Member of a former Travancore University Commission.
4. Principal, Central College and Chairman of Admission, Freestudentships and several other Committees, President of the Hostel and Union.

(7) Extra-curricular

1. Member of the National Sports Club of India,
2. Member of Council of the Mysore Horticultural Society,
3. Former captain of the University side in Hockey and state player in the same, and played in Calcutta, Bombay and Madras.
4. Winner of the B.K.S. Memorial Shield as College Champion in Tennis in 1932.
5. *Champion in Tennis at the Inst. of Advanced Technology, Pune from 1955-59*
6. Served as President, Vice-President, Secretary or member of Associations like the Mysore State Hockey Association, Mysore Lawn Tennis Association, the Basket Ball Federation and Table Tennis Association.

At present Associate, Centre for Theoretical Studies, Inst. of Space Science, Bangalore.

5. Professor of Ballistics, Institute of Armament Technology, 1955-1960
6. Late. Tilak Professor of Applied Mathematics, University of Pune, 1960-65
7. D.G. O.A.S.S. R. Scholar for a period of 4 years from 1966-70 at Inst. of Space Science, Bangalore

ENCLOSURE 2.

List of Published Papers
of
Dr. B.S. Madhava Rao

- (1) On the equivalence of three definitions of irrational numbers -
J. Ind. Math. Soc. 15, 1923, p. 53
- (2) On the collinearity of three points on a non-singular cubic - Ibid, 15
1927, p. 163.
- (3) -do- (Journal of Science, Vizianagaram College, 1924)
- (4) On the covariant curves of a singular n-ic - Bull. Calcutta Math. Soc. 14
1923, p. 55-64.
- (5) Group of points on the equi-anharmonic cubic - J. Mys. Uni. 1, 1927, p. 1-10
- (6) On the equations of motion of a non-holonomic dynamical system,
-ibid, 7, 1933, p. 1-4
- (7) On the theory of suspension bridges - Bull. Mysc Engineers' Association,
1934, p. 1-14
- (8) Elliptic function formulae and plane cubic curves - Proc. Ind. Acad. Sc. A.
1, 1934, p. 363-71
- (9) Mixed polar theorems on plane cubics - J. Mys. Uni. 8, 1935, p. 62-68
- (10) Note on a theorem on homologous stars - Math. Student, 1, 1933, p. 81-85
- (11) Über die ein mechanisches System betreffende Theoreme von Liouville
Und Stackel - Zs. f. Phys. 93, 1935, p. 320-28.
- (12) Separable systems in classical and wave mechanics - Math. Annalen,
3, 1935, p. 459-68
- (13) Ring singularity in Born's field theory - Proc. Ind. Acad. Sci. 4, 1936,
355-76
- (14) A theorem on action functions in Born's field theory - Ibid, 4, 1936
p. 377
- (15) Complex representation in Born's field theory - Ibid, 5, 1936, p. 575
- (16) Semi-vectors in Born's field theory - Ibid, 4, 1936, p. 437
- (17) Ring-singularity in Born's unitary theory - Ibid, 6, 1937, p. 129
- (18) On the fine structure of the Balmer lines - Ibid, 5, 1937, p. 56
- (19) Generalised action functions in Born's Electro-dynamics - Ibid, 6,
1937, p. 129
- (20) Biquaternionic in Born's Electro-dynamics, - Ibid, 7, 1938, p. 333
- (21) Bemerkungen zur "Ringstruktur des Electrons" - Phys. Zs, 39, 1938, p. 187
- (22) Antwort and Starke Bemerkungen - Ibid, 39, 1938, p. 193
- (23) Names in Mathematics - Inter-College, Magazine, Bangalore, 2, 1938, p. 59
- (24) Question of invariance in the neutrino theory of light - Proc. Ind. Acad.
Sci. 7, 1938, p. 293.
- (25) On an inequality concerning lattice sums - Ibid, 8, 1938, p. 524
- (26) Quantum-mechanical interpretation of a result concerning Hermites
Polynomials - Ibid, 10, 1939, p. 217

- (27) Generalised geometry and physical theories - Math.Student, 8, 1940 p.11-34.
- (28) Notes on dynamics - J.Mys.Uni. 2, 1940, p. 93
- (29) On an invariant relation of dynamical systems - *ibid*, 1940, p. 1-3
- (30) On the reduction of dynamical equations to the Lagrangian form - Proc. Benares Math.Soc. 2, 1940, p.53
- (31) The scattering of charged mesons (in collaboration with Dr. H.J.Bhabha) Proc.Ind.Acad.Sci. 13, 1941, p.9-24
- (32) Evolution of stars - Annamalai Uni.Jl. Commemoration Vol. 1941, p. 247 - 271.
- (33) Commutation rules for matrices related to particles of higher spins Proc.Ind.Acad.Sci. 15, 1942, p.139-47
- (34) Commutation rules related to particles of spins half and one - J.Mys. Uni. 3, pt.10, 1942, p.59
- (35) Notes on dynamics 2 - *ibid*, 5, part 7, 1944, p. 35-43.
- (36) Some examples of radial fluid motion - *ibid*, 5, part 4, 1944, p.21
- (37) Modern Algebra III and theory of elementary particles - Math.Student, 12, 1944, p.30-58.
- (38) K.S.K.Iyengar - in Memoriam - Proc. Ind.Acad.Sci. 19, 1944, p.414
- (39) some trigonometrical inequalities - J.Mys.Uni. 6, 1945, p. 1-12.
- (40) Solution of cubic equations - *ibid*, 1945, p.
- (41) Pauli's identities in the Dirac Algebra - Proc.Ind.Acad.Sci. 22, 1945, P. 408-22
- (42) Algebra related to elementary particles of spin $3/2$ - Proc. Roy.Soc. London, A, 187, 1946, p. 385-97.
- (43) -do- Current Science, 14, 1945, p. 180
- (44) Commutation rules for matrices related to particles of higher spin. J. Mys.Uni. 6, 1945, p. 57-62
- (45) Sir C.V.Raman as Physicist and teacher - Proc.Ind.Acad.Sci. 28, 1948, p. 254.
- (46) On an inequality concerning orthogonal polynomials - Proc. Ind.Acad. Sci. 29, 1949, p. 391-93.

NOTES AND COMMENTS

- (47) The mathematical theory of a new relativity by Sir Shah Sulaiman - A critical review, Current Science, Sept. 1935, p. 145-151
- (48) Reply to Sir Sulaiman - *ibid*, Oct. 1935, p. 401
- (49) Sulaiman's predictions - *ibid*, March 1938, p. 459.
- (50) The Mesotron - *ibid*, March, 1939, p. 143.
- (51) Classical and quantum mechanics, *ibid*, April 1942, p. 163.
- (52) Relativity - *ibid*, April 1938, p. 515.
- (53) Logic and Probability in Physics, - *ibid*, October 1938, p. 201.
- (54) The Raman Jubilee Volume - *ibid*, Jan. 1939, p. 22.

(55) Gregory Tercentenary Memorial - *ibid*, July 1940, p. 340.

~~(56)~~

RECENT PUBLICATIONS

(56) The virial problem in hydrodynamics - *Quart. App. Math.* Brown Uni. 1954.

(57) On a problem in linkages - *J. App. Math.* London, 1954.

(58) On symmetries of spherical harmonics - *Canadian J. Math.* 1954.

(59) Engaged at present in writing a book on magic squares
bringing out Narayana Pandita's work on the
subject in *Ganita Kaumudi*, 1356 A.D.

====

From 1955 to 1965:-

Served as the Head of the Department of Mathematics & Ballistics at the Institute of Armament Studies, Kirkee, Poona under the G.O.I till 1960, and did intensive teaching work, and coaching of Military Officers in Internal and External Ballistics, and Operational Research.

(2) Served from 1960 to 1965 as Lok.Tilak Professor of Applied Mathematics at the Department of Mathematics and Statistics of the University of Poona, & was Head of the Department for two years during the period. Did teaching work on many branches of Applied Mathematics to students choosing several optional subjects.

(3) Has been working as a U.G.C. Scientist at the Indian Institute of Science Bangalore, since January 1965, doing teaching work at the Library of the Institute on Analytical Dynamics, Relativity, and Quantum Mechanics to students of several Departments of the Institute. This U.G.C. Scientistship for teaching work ceases by the end of January 1968, and hence I am making this present application for an opportunity to do research, without being ~~ee~~ committed to any kind of teaching work which I have been doing incessantly since 1922.

List of research & allied work done from 1955 to 1962.

The papers Nos. 56 to 58 listed on p-6 of this Annexure have since been published in the Journals mentioned.

60. Virial problems related to simple wing profiles - Proc. Ind. Acad. Sci. Vol XLIII, 1956, pp. 53-66.
61. Projectiles in flight -- Defence Science Journal, July 1958, Sec. A. pp. 70-76
62. Talk on Magnetohydrodynamics - The Mathematics Student, Vol. 27, Nos. 3&4, July-October 1959.
63. Modern Algebra & theory of elementary particles - Reprint from J. S. I. R., 1958, Vol. 17A, No. 2, pp. 43-45.
64. Physical applications of the Lorentz group -- Proc. Ind. Acad. Sci. Vol. 47, 1958, pp. 105-115.
65. Presidential Address of the Mathematics Section of the 45th Session of the Indian Science Congress, Madras, 1958 on "Modern Algebra and theory of elementary particles" pp. 1-19.
66. Presidential Address of the 25th Conference of the Indian Mathematical Society, 1959, Allahabad, pp. 1-19. - Mathematics Student, Vol. 28, Nos. 3&4, July-October, 1960.

26. Quantum-mechanical interpretation of a result concerning Hermite Polynomials - *ibid*, 10, 1939, p. 127.
27. Generalised geometry and physical theories - *Math. Student*, 8, 1940 p. 11-34.
28. Notes on dynamics - *J.Mys.Uni.*9, 1940, p. 93.
29. On an invariant relation of dynamical systems - *ibid*, 1940, p 1-3.
30. On the reduction of dynamical equations to the Lagrangian form - *Proc. Benares Maths. Sec.* 2, 1940, p.53.
31. The scattering of charged mesons (in collaboration with Dr. H.J. Bhabha) *Prof. Ind. Acad. Sci.*13, 1941, p. 9-24.
32. Evolution of stars - *Annamalai Uni. J1. Commemoration vol.* 1941, p.247-271.
33. Commutation rules for matrices related to particles of higher spins. *Proc. Ind. Acad. Sci.*15, 1942, p.139-47.
34. Commutation rules related to particles of spins half and one - *J.Mys.Uni.*3 Pt 10, 1942, p.59.
35. Notes on dynamics 2 - *ibid*, 5, part 7, 1944, p. 35-43
36. Some examples of radial fluid motion - *ibid* 5, part 4, 1944, p.21.
37. Modern Algebra and theory of elementary particles - *Maths. Student*, 12, 1944, p. 30-58.
38. K.S.K. Iyengar - in Memoriam - *Proc. Ind. Acad. Sci.*19, 1944, p.414,
39. Some trigonometrical inequalities - *J.Mys.Uni.*6, 1945, p. 1-12
40. Solution of cubic equations - *ibid*, 1945, p.
41. Pauli's identities in the Dirac Algebra - *Proc. Ind. Acad. Sci.*22, 1945, p.403-22.
42. Algebra related to elementary particles of spin 3/2 - *Proc. Sec. London*, A.187, 1946, p.385-97.
43. Algebra related to elementary particles of spin 3/2 - *Current Science*, 14 1945, p.180.
44. Commutation rules for matrices related to particles of higher spin. *J.Mys.Uni.*6, 1945, p.57-62.
45. Sir C.V. Raman as Physicist and teacher - *Proc. Ind. Acad. Sci.*28, 1948, p.254.
46. On an inequality concerning orthogonal polynomials - *Proc. Ind. Acad. Sci.* 29, 1949, p.39E-93.

NOTES AND COMMENTS

47. The mathematical theory of a new relativity by Sir Shah Sulaiman - A critical review, *Current science*, Sept. 1935, p.145-151.
48. Reply to Sir Sulaiman - *ibid*, Oct. 1935. p.401.
49. Sulaiman's predictions - *ibid*, March 1938, p.459.
50. The mesotron - *ibid*, March 1939, p. 143.
51. Classical and quantum mechanics, *ibid*. April 1942, p.163.
52. Relativity- *ibid*, April 1938, p. 515.

53. Logic and probability in physics - *ibid*, October 1938, p.201.
54. The Raman Jubilee Volume - *ibid*, Jan. 1939, p.22.
55. Gregory Tercentenary Memorial - *ibid*, July 1940, p.340.

SUBMITTED FOR PUBLICATION

56. The virial problem in hydrodynamics - *Quart. Appl. Math. Brown Uni.* 1954.
57. On a problem in linkages - *J. App. Math. London*, 1954.
58. On symmetries of spherical harmonics - *Canadian J. Math.* 1954.
59. (Parts I & II)
(56-59 Since published)
60. Virial problems related to simple wing profiles - *Proc. Ind. Acad.*, Vol 43, 1956, pp.53-66.
61. Projectiles in flight - *Defence Science Journal*, July 1958, Sec A, pp. 70-76.
62. Talk on Magnetohydrodynamics - *Math. Student*, Vol.27, July-Oct. 1959.
63. Modern Algebra & Theory of elementary particles, *J.S.I.R.*, 1958, Vol. 147, 1958 17 A, No 2 pp.43-45.
64. Physical applications of the Lorentz group, *Proc. Ind. Acad. Sci.*, Vol 147, 1959, pp 105-15.
65. Modern Algebra & Theory of elementary particles - Presidential Address, 45th Session, *Ind Sci. Con.* 1958.
66. Presidential Address - 25th. Conference of the *Ind. Math. Soc. - Math. Student* Vol.28, July-Oct. 1960.
67. Recent trends in Applied Mathematics - *Current Science*, Vol 24, pp. 392-93.

Besides the above, I have done 5 reviews for *Math. Reviews*, U.S.A., 3, for *Current Science*, and 4 more detailed reviews for the *J.S.I.R.* viz: (i) vol 16.A. Dec. 1957, pp 539-40; (ii) Vol 18.A. May, 59, pp.224-5; (iii) Vol 19.A. July, 1960, pp.328-9. (iv) Vol 20 A. No 1., pp 35-36.

~~67. Presidential Address of the Indian Mathematical Society, 26th Conference (8)~~
~~1960, Chandigarh~~

67. Recent trends in Applied Mathematics, -Current Science pp, Vol 24, No 11,
November, 55, pp. 392-393.

Besides the above, I have done 5 reviews for the Mathematical Reviews,
U.S.A. during the period, and
four
3 for Current Science, and ~~three~~ more detailed reviews for the J.S.I.R. viz;

(i) Vol 16A, December, 1957, pp. 539-40.,

(ii) Vol. 18A, May 1959, pp. 234-5.,

(iii) Vol. 19A, July, 1960, pp. 328-29. and

(iv) Vol. 20A, No. 1, pp. 35-36.

BIODATA OF PROF. B.S. MADHAVA RAO

Date of Birth : 29th May 1900

Highest Academic Degree: D.Sc (Thesis on Born's Field Theory)
1938, University of Calcutta.

Positions held : 1930 - 1955 : Professor of Mathematics, Bangalore.))

1955-60, Professor of Ballistics, Institute
of Armament Technology, Pune

1960-65, Lokamanya Tilak Professor of Applied
Mathematics, University of Pune

1966-72 U.G.C and CSIR assignments at I. I. Sc

1974 till his demise^{in June 1987}: Was Associate at the
Centre for Theoretical Studies, Indian
Institute of Science, Bangalore.

Publications: Over 70 publications on Mathematics (Pure and
Applied) and Theoretical Physics in journals
of repute.

Brief account of his research contributions

- (1) He worked on Born's non-linear field theory and this is referred to as " Madhavarao's Theory of Action Functions " in the Poincare Institute Memoirs of 1938/
- (2) Papers on Newtonian classical mechanics relating to the Lagrangian and Hamiltonian formulations were published during 1932-35. One of these papers on " Separable systems in classical and wave mechanics " published in MATH ANNALEN in 1935 has been referred to in several books on mechanics published in Germany.
- (3) In the work done in 1937, Prof Madhava Rao used elliptic function formulae for the study of plane cubic curves and in particular a special type of cubic curve studied by Newton. This theorem has been referred to as " Madhavarao's theorem on apolar cubics " in an article published by Acad Lincei, Rome (1937)
- (4) During 1942-47, Prof Madhava Rao worked in the area related to the application of the theory of groups and group representations in modern theoretical physics, specially in the theory of elementary particles. He set up relativistic wave equations of the Dirac type for particles of arbitrary spin and derived the commutation relations satisfied by the β -matrices of the wave equation. Six papers were published on this subject. He also worked with Dr H.J. Bhabha and Dr Harischandra on the same topic. His work on particles of spin $3/2$ was published in the Proceedings of the Royal Society. References to his work are to be found in E.M. Corson's book (Princeton University Press, 1953) in which " Madhava Rao algebra " and " Madhava Rao's ring " are referred to extensively and also in the six papers published by Krajcik and Nieto in the Physical Review (1975-77) as well as in several other papers published by various other authors working on Quantum statistics and the Pauli Exclusion Principle. For this work ; he was awarded the RAMANUJAN PRIZE by the Madras University.
- (5) Prof Madhava Rao also worked on the scattering of charged Mesons and published a paper with Dr H.J. Bhabha.

BIBLIOGRAPHY

A. Original Research

1. 1923 On the Equivalence of Three Definitions of Irrational Numbers.
J. Ind. Math. Soc. 15, 53
2. 1923 On the Covariant curves of a Singular n-ic.
Bull. Calcutta Math. Soc. 14, 55-64
3. 1924 On the collinearity of Three points on a Non-singular cubic.
J. Science, Vizianagaram Coll.
4. 1927 On the collinearity of Three Points on a Non-Singular Cubic.
J. Ind. Math. Soc. 15, 163.
5. 1927 Group of Points on the Equi - Anharmonic cubic.
J. Mys. Univ. 1, 1-10.
6. 1933 On the Equations of Motion of a Non-Holonomic Dynamical System.
J. Mys. Univ. 7, 1-4.
7. 1933 Note on a Theorem on Homologous Stars.
Math. Student, 1, 81-85.
8. 1934 On the Theory of Suspension Bridges
Bull. Mys. Engineers' Association, 1-14.
9. 1934 Elliptic Function Formulae and Plane Cubic Curves.
Proc. Ind. Acad. Sci. A. 1, 363-371.
10. 1935 Mixed Polar Theorems on Plane Cubics.
J. Mys. Univ. 8, 62-68.
11. 1935 U ber die ein Mechanischen System beffenden Theorem von Liouville and Stackel.
gs. f. Phys. 93, 320-328.
12. 1935 Separable System in classical and wave Mechanics.
Math. Annalen 3, 459-468.
13. 1936 Ring Singularity in Born's Unitary Theory-I.

14. 1936 A Theorem on Action Functions in Born's Field Theory.
Proc. Ind. Acad. Sci. A, 4, 377-381.
15. 1936 Semi-vectors in Born's Field Theory.
Proc. Ind. Acad. Sci. A, 4, 436-451.
16. 1936 Complex Representation in Born's Field Theory.
Proc. Ind. Acad. Sci. A, 5, 575-589.
17. 1937 On the Fine Structure of the Balmer Lines.
Proc. Ind. Acad. Sci. A, 6, 56-62.
18. 1937 Ring Singularity in Born's Unitary Theory-II.
Proc. Ind. Acad. Sci. A, 6, 129-134.
19. 1937 Generalized Action Functions in Born's Electro-Dynamics.
Proc. Ind. Acad. Sci. A, 6, 158-173.
20. 1938 Question of Invariance in the Neutrino Theory of Light.
Proc. Ind. Acad. Sci. 7, 293-295.
21. 1938 Bemerkungen zum "Ringstruktur des Elektrons"
Phys. Z. 39, Heft 5, 187-189.
22. 1938 Antwort und Starks Bemerkungen.
Phys. Z. 39, Heft 5, 193.
23. 1938 Biquaternions in Born's Electro-Dynamics
Proc. Ind. Acad. Sci. 7, 333.
24. 1938 (With K. Venkatachaliengar) On an Inequality concerning Lattice Sums.
Proc. Ind. Acad. Sci. 8, 524-526.
25. 1939 Quantum Mechanical Interpretation of a Result concerning Hermite Polynomials.
Proc. Ind. Acad. Sci. 10, 217-219.
26. 1940 (With B.S. Sastry) On the limits for the Roots of a Polynomial Equation.
J. Mys. Univ. 7, Part II.
27. 1940 Generalized Geometry of Physical Theories.
Math. Student, 8, 11-34.

28. 1940 On an Invariant Relation of Dynamical Systems.
J. Mys. Univ. 9, 1-3.
29. 1940 Notes on Dynamics-I.
J. Mys. Univ. 9, 93-96.
30. 1940 On the Reduction of Dynamical Equations to the
Lagraurgian Form.
Proc. Benares Math. Soc. 2, 53.
31. 1941 (With H.J. Bhabha) The Scattering of charged Mesons.
Proc. Ind. Acad. Sci. 13, 9-24.
32. 1942 Commutation Rules for Matrices Related to Particles
of Higher Spins.
Proc. Ind. Acad. Sci. 15, 139-147.
33. 1942 Commutation Rules Related to Particles of Spins
Half and One.
J. Mys. Univ. 3, 59-63.
34. 1944 (With V.R. Thiruvengkatachar) Some Examples of
Radial Fluid Motion.
J. Mys. Univ. 5, 21.
35. 1944 Notes on Dynamics - 2.
J. Mys. Univ. 7, 35-43.
36. 1944 Modern Algebra and Theory of Elementary Particles.
Math. Student, 12, 30-58.
37. 1945 (With K.S.K. Iyengar and T.S. Nanjundiah) Some
Trigonometric Inequalities
J. Mys. Univ. 6, Part I, 1-12.
38. 1945 Solution of Cubic Equations.
J. Mys. Univ.
39. 1945 Pauli's Identities in the Dirac Algebra.
Proc. Ind. Acad. Sci. 22, 408-422.
40. 1945 (With V.R. Thiruvengkatachar and K. Venkatachaliengar)
Algebra Related to Elementary Particles of Spin 3/2,
Current Science, 14, 180.

41. 1945 Commutation Rules for Matrices Related to Particles of Higher Spin. Part III.
J. Mys. Univ. 6, 57-62.
 42. 1946 (With V.R. Thiruvankatachar and K. Venkatachaliengar)
Algebra Related to Elementary Particles of Spin $3/2$.
Proc. Roy. Soc. London. A, 187, 385-397.
 43. 1947 Generalized Algebra of Elementary Particles.
Proc. Ind. Acad. Sci. 26, 221-233.
 44. 1949 (With V.R. Thiruvankatachar) On an Inequality concerning Orthogonal Polynomials.
Proc. Ind. Acad. Sci. 29, 391-393.
 45. 1956 Virial Theorems Related to Simple Wing Profiles.
Proc. Ind. Acad. Sci. 43, 53-66.
 46. 1958 Physical Applications of the Lorentz Group.
Proc. Ind. Acad. Sci. 47, 105-115.
 47. 1967 On a Conjecture of Ramanujan and Some simple Deductions
Ind. J. Mathematics, 9, 447-450.
-

B. Critical (Expository) Publications

1. 1935 The Mathematical Theory of a New Relativity by Sir Sulaiman Shah
Current Science, September, 145-151.
2. 1935 Reply to Sir Sulaiman Shah
Current Science, October, 401.
3. 1938 Sir Sulaiman's Predictions
Current Science, 459.
4. 1938 Logic and Probability in Physics
Current Science, 201.
5. 1938 Relativity
Current Science, 515.
6. 1938 Names in Mathematics
Inter College Magazine 5, 59.
7. 1939 The Mesotron
Current Science, 143.

8. 1939 The Raman Jubilee Volume
Current Science, 22.
9. 1940 Gregory Tercentenary Memorial
Current Science, 340
10. 1941 Evolution of Stars
Annamalai University JB Commemoration Volume, 247-271.
11. 1942 Classical and Quantum Mechanics
Current Science, 163.
12. 1944 K.S.P. Iyengar - in Memoriam.
Proc. Ind. Acad. Sci. 19, 414-416.
13. 1948 Sir C.V. Raman as Physicist and Teacher.
Proc. Ind. Acad. Sci. 28, 254.
14. 1958 Modern Algebra and Theory of Elementary Particles 1-19.
Presidential Address, Section of Mathematics, 45th
Indian Science Congress, Madras.
15. 1959 Geometry and Gravitation. 1-26.
Presidential Address, 25th Conference of Indian
Mathematical Society, Allahabad.
16. 1960 Role of Mathematics in Quantum Theory. 1-24.
Presidential Address, 26th Conference of Indian
Mathematical Society, Chandigarh.
17. Quantum Mechanics and General Relativity -
An Appraisal for Their Synthesis
(Private Circulation).
18. On a problem of Linkages
(Unpublished)
19. On Symmetries of Spherical Harmonics
(Unpublished)

Annexure B.

1. Name: Dr. H.S. Madhava Rao
2. Father's Name: Late M. Srinivasa Rao, Head Master, for over 40 years in several Middle Schools in the State.
3. Place and Date of Birth: ChamaraJanagar, Mysore District, 29th May 1900.
4. Institutions where educated.
- (1) A.V. School, ChamaraJanagar - Joined 1905 Left 1912
 - (2) ~~Govt. High School~~ ^{Maharaja's College}, Mysore - " 1912 " 1915
 - (3) Central College, Bangalore - " 1915 " 1919
 - (4) University College, Calcutta - " 1919 " 1921
5. Details of Examinations passed and Degrees taken; Medals and Prizes.
- (1) S.S.L.C. Mysore - I class Mathematics & Science 1915
 - (2) Intermediate, Madras University I class Mathematics & Science. 1917
 - (3) B.Sc. Degree, Mysore University I class Mathematics & Science. 1919 (Medalist)
 - (4) B.Sc. Degree, Calcutta University, I class Second - Mathematics. 1921 (Medalist)
 - ✓ (5) B.Sc. Degree, Calcutta University - Thesis on "Born's Electromagnetic Field Theory" 1938
 - ✓ (6) Ramamujan Prize, Madras University - for work on Algebra of Elementary particles 1945.
6. Official Status:
- (1) Research Scholar, Mysore University 1921 - Salary Rs. 100/- p.m.
 - (2) Assistant Professor " 1922 200 - 20 - 300
 - (3) Professor, Class II " 1938 400 - 25 - 700
 - (4) Professor, Class I " 1948 700 - 30 - 850
 - (5) University Professor and Principal, Central College 1953 850-50-1000 plus Ch.A. 100 plus H.R.A. 10%
7. Teaching and Research Experience:
- (1) Taught all classes up to M.Sc. and classes in Engineering College in several branches of Pure and Applied Mathematics and Engineering Mathematics; taught advanced subjects like Relativity, Quantum Mechanics, Astrophysics, Hydro and Aero dynamics and Analytical dynamics.
 - ✓ (2) Trained several scholars for M.Sc., M.Ph.D. and B.Sc. Degrees of this and other Universities.
 - (3) Collaborated in research with Prof. Dr. Max Born Sc., D.F.R.S. in the department of Physics, Indian Institute of Science, also with Sir C.V. Raman, F.R.S., F.I., and with Dr. H.J. Phadnis, F.R.S.

ENCLOSURE 2.

List of Published Papers
of
Dr. B.S. Madhava Rao

- (1) On the equivalence of three definitions of irrational numbers -
J. Ind. Math. Soc. 15, 1923, p. 53
- (2) On the collinearity of three points on a non-singular cubic - Ibid, 15
1927, p. 163.
- (3) -de- (Journal of Science, Vizianagaram College, 1924)
- (4) On the covariant curves of a singular n-ic - Bull. Calcutta Math. Soc. 14
1923, p. 55-64.
- (5) Group of points on the equi-anharmonic cubic - J. Mys. Uni. 1, 1927, p. 1-10
- (6) On the equations of motion of a non-holonomic dynamical system,
-ibid, 7, 1933, p. 1-4
- (7) On the theory of suspension bridges - Bull. Mys. Engineers' Association,
1934, p. 1-14
- (8) Elliptic function formulae and plane cubic curves - Proc. Ind. Acad. Sc. A.
1, 1934, p. 363-71
- (9) Mixed polar theorems on plane cubics - J. Mys. Uni. 8, 1935, p. 62-68
- (10) Note on a theorem on homologous stars - Math. Student, 1, 1933, p. 81-85
- (11) Über die ein mechanisches system betreffende Theoreme von Liouville
Und Stackel - Zs. f. Phys. 93, 1935, p. 320-28.
- (12) Separable systems in classical and wave mechanics - Math. Annalen,
3, 1935, p. 459-68
- (13) Ring singularity in Born's field theory - Proc. Ind. Acad. Sci. 4, 1936,
355-76
- (14) A theorem on action functions in Born's field theory - ibid, 4, 1936
p. 377
- (15) Complex representation in Born's field theory - ibid, 5, 1936, p. 575
- (16) Semi-vectors in Born's field theory - ibid, 4, 1936, p. 437
- (17) Ring-singularity in Born's unitary theory - ibid, 6, 1937, p. 129
- (18) On the fine structure of the Balmer lines - ibid, 5, 1937, p. 56
- (19) Generalised action functions in Born's Electro-dynamics - ibid, 6,
1937, p. 129
- (20) Biquaternions in Born's Electro-dynamics, - ibid, 7, 1938, p. 333
- (21) Bemerkungen zur "Ringstruktur des Electrons" - Phys. Zs, 39, 1938, p. 187
- (22) Antwort auf Starke Bemerkungen - ibid, 39, 1938, p. 193
- (23) Names in Mathematics - Inter-College, Magazine, Bangalore, 5, 1938, p. 59
- (24) Question of invariance in the neutrino theory of light - Proc. Ind. Acad.
Sci. 7, 1938, p. 293.
- (25) On an inequality concerning lattice sums - ibid, 8, 1938, p. 524
- (26) Quantum-mechanical interpretation of a result concerning Hermites
Polynomials - ibid, 10, 1939, p. 217

- (27) Generalised geometry and Physical theories - Math.Student, 8, 1940 p.11-34.
- (28) Notes on dynamics - J.Mys.Uni. 9, 1940, p. 93
- (29) On an invariant relation of dynamical systems - *ibid*, 1940, p. 1-3
- (30) On the reduction of dynamical equations to the Lagrangian form - Proc. Benares Math.Soc. 2, 1940, p.53
- (31) The scattering of charged mesons (in collaboration with Dr. H.J.Bhabha) Proc.Ind.Acad.Sci. 13, 1941, p.9-24
- (32) Evolution of stars - Annamalai Uni.Jl. Commemoration Vol. 1941, p. 247 - 271.
- (33) Commutation rules for matrices related to particles of higher spins Proc.Ind.Acad.Sci. 15, 1942, p.139-47
- (34) Commutation rules related to particles of spins half and one - J.Mys. Uni. 2, pt.10, 1942, p.59
- (35) Notes on dynamics 2 - *ibid*, 5, part 7, 1944, p. 35-43.
- (36) Some examples of radial fluid motion - *ibid*, 5, part 4, 1944, p.21
- (37) Modern Algebra and theory of elementary particles - Math.Student, 12, 1944, p.30-58.
- (38) K.S.K.Iyengar - in Memoriam - Proc. Ind.Acad.Sci. 19, 1944, p.414
- (39) Some trigonometrical inequalities - J.Mys.Uni. 6, 1945, p. 1-12.
- (40) Solution of cubic equations - *ibid*, 1945, p.
- (41) Pauli's identities in the Dirac Algebra - Proc.Ind.Acad.Sci. 22, 1945, P. 408-22
- (42) Algebra related to elementary particles of spin $3/2$ - Proc. Roy.Soc. London, A, 187, 1946, p. 385-97.
- (43) -do- Current Science, 14, 1945, p. 180
- (44) Commutation rules for matrices related to particles of higher spin. J. Mys.Uni. 6, 1945, p. 57-62
- (45) Sir C.V.Raman as Physicist and teacher - Proc.Ind.Acad.Sci. 28, 1948, p. 254.
- (46) On an inequality concerning orthogonal polynomials - Proc. Ind.Acad. Sci. 29, 1949, p. 391-93.

NOTES AND COMMENTS

- (47) The mathematical theory of a new relativity by sir Shah Sulaiman - A critical review, Current Science, Sept. 1935, p. 145-151
- (48) Reply to Sir Sulaiman - *ibid*, Oct. 1935, p. 401
- (49) Sulaiman's predictions - *ibid*, March 1938, p. 459.
- (50) The Mesotron - *ibid*, March, 1939, p. 143.
- (51) Classical and quantum mechanics, *ibid*, April 1942, p. 163.
- (52) Relativity - *ibid*, April 1938, p. 315.
- (53) Logic and Probability in Physics, - *ibid*, October 1938, p. 201.
- (54) The Raman Jubilee Volume - *ibid*, Jan. 1939, p. 22.

(55) Gregory Tercentenary Memorial - *ibid*, July 1940, p. 340.

{86}

UNDER PUBLICATION

(56) The virial problem in hydrodynamics - *Quart.App.Math.* Brown Uni. 1954.

(57) On a problem in linkages - *J. App.Math.* London, 1954.

(58) On symmetries of spherical harmonics - *Canadian J.Math.* 1954.

ENCLOSURE 3.

Additional Remarks under Item No. 27 of the
Application Form.

(1) Teaching &
Research
Experience:

1. Taught all classes up to M.Sc., and classes in Engineering College in several branches of Pure and Applied Mathematics and Engineering Mathematics; taught advanced subjects like Relativity, Quantum Mechanics, Astrophysics, Hydro and Aero dynamics and Analytical Dynamics.
2. Trained several scholars for M.Sc., Ph.D. and D.Sc., Degrees of this and other Universities.
3. Collaborated in research with Prof. Dr. Max Born Sc., D.F.H.S. in the department of Physics, Indian Institute of Science, also with Sir C.V.Raman, F.R.S.M.L., and with Dr. H.J.Sharma, F.R.S.

(2) Original work:

1. Published over 50 research papers in several leading Journals like Math. Annalen, Zs. f. Physik, Proc. Royal Society, London, Proc. Indian Academy of Sciences and I.Ind.Math. Soc. on

- a) Geometry of curves,
- b) Analytical Dynamics,
- c) Born's electro magnetic field theory.
- d) Quantum mechanics
- e) Theory of elementary particles of nature.

Under (a) has been the author of a theorem referred to in the literature as "Madhava Rao's action theorem on apolar cubics"

Ref: (a) T-Ray Pastor - Acad. Lincei, Rome, 1937.

Under (b) has been the author of articles known as "Madhava Rao's action functions"

Ref: (b) M.Born - Poincare' Institute Memoirs, 1936.

Under (c) was the first to prove the inadequacy of the neutrino theory of light

Ref: (c) Proc. Ind. Acad. Sc. 7, 1938, p.293.

and Under (d) has discovered new types of algebra related to elementary particles referred to as "Madhavarao algebra" and "Madhavarao Ring" to which was awarded the Ramanujan Prize of the Madras University, 1945.

Ref: Book by E.M.Corson - Tensors,

- (i) Spinors & relativistic wave equations, 1953-

References in the chapter on wave equations, in the bibliography and the index.

- (ii) Reference in the article by Jehle - Reviews of Modern Physics, 1953-54.

2. Has been the author of two well known papers of Critical Nature on

(a) Sulaiman's theory of relativity (referred to by the Astronomer Shapley in the American Journal "Science".

(b) Ring theory of the electron by J.Stark N.L. (Correspondence in Physics Zs. 1938)

3. Published reviews and critical notes in Current Science Journal, Sc. & Industrial Research etc.

(3) Lectures and Symposia.

1. Has delivered University lectures under the auspices of the Madras, Travancore and Annamalai Universities and special course of lectures by invitation at the Indian Institute of Science and the Travancore Statistical Department.
2. Has presided over symposia organised by the Indian Mathematical Society, The Indian Academy of Sciences and the Indian Science Congress.
3. Read a paper by invitation at the International Conference on Elementary Particles held at the Tata Institute of Fundamental Research, Bombay, in 1951.
4. Invited to read a paper at the Second Defence Science Conference at Delhi, April 21-25, 1952. Under the section of operational research, read a paper on "Military applications of Neumann's theory of games", presided over by Air Marshal Mukherji and in the discussion on which Mr. Johnson, the Head of the Institute of Armament Studies took part.

(4) Membership of Learned Bodies.

1. Fellow of the Indian Academy of Sciences - Member of the Council and Secretary, Section A.
2. Fellow of the National Institute of Sciences of India.
3. Fellow of the Royal Astronomical Society, London,
4. Member of the Mathematical Sections Committee and Recorder of the Indian Science Congress.
5. Member of Council of the Indian Mathematical Society.
6. Member of the American Mathematical Society, Mathematical Association of America, the London Mathematical Society, the Edinburgh Mathematical Society, Mathematical Association of England, the Benares Mathematical Society and the Current Science Association.

(5) Academic Duties:

1. Member of the Academic Council of the Universities of Mysore and Travancore;
2. Member and once Dean of the Faculty of Science, Mysore University, Member of Faculty of Science of Travancore University, also member of the Faculty of Arts, Faculty of Engineering and Technology, and the Faculty of Teaching of the Mysore University.
3. Chairman, Board of Studies in Mathematics, Mysore University and member of Board of Studies in Mathematics and Mathematical Physics and Statistics of the Andhra, Annamalai, Travancore, Osmania and Karnatak Universities.
4. Member of the Ad Hoc Selection Committee of the Andhra University and several as expert to Committees of Poona, Madras, Annamalai, Travancore, Mysore Universities and to the Madras Public Service Commission and Union Public Service Commission.

5. Served as Chairman, Board of Examiners of Mysore, Andhra, Madras, Travancore and Annamalai Universities and member of Boards of Examiners of the above and Osmania, Karnatak, Poona, Bombay, Patna, Calcutta, Gauhati, Rajputana, Nagpur and Ceylon Universities.
6. Served as examiner for Ceylon Civil Service, Indian Civil Service, Institution of Engineers, Military Wing, Survey of India and Madras Provincial Local Service Examinations.
7. Valued theses for M.Sc., Phy.D & D.Sc. of Madras, Bombay, Poona, Annamalai, Andhra and Travancore Universities.
8. Adjudicator for the C.S. Reddy National Prize for Mathematics and Physics.
9. Drew up the scheme of studies and syllabuses for the Honours and M.Sc. courses in Mathematical Physics of the Andhra University and the M.Sc. in Statistics of the Travancore University and the present Honours and M.Sc. syllabuses of the Mysore University.
10. Drew up syllabus for Internal and External Ballistics for inclusion of Ballistics as an optional subject for the M.Sc.

(6) Administrative duties.

1. Elected member of the Senate of the Mysore University.
2. Member of the University Council of the Mysore University for over five years.
3. Member and Chairman, Mysore University Commission and Member of a former Travancore University Commission.
4. Principal, Central College and Chairman of Admission, Freestudentships and several other Committees, President of the Hostel and Union.

(7) Extra-curricular

1. Member of the National Sports Club of India,
2. Member of Council of the Mysore Horticultural Society,
3. Former captain of the University side in Hockey and state player in the same, and played in Calcutta, Bombay and Madras.
4. Winner of the B.K.S. Memorial Shield as College Champion in Tennis in 1932.
5. Served as President, Vice-President, Secretary or member of Associations like the Mysore State Hockey Association, Mysore Lawn Tennis Association, the Basket Ball Federation and Table Tennis Association.

ANNEXURE 'C'

Research and allied work done from 1962 onwards:-

67. On the role of Mathematics in Quantum Theory--Presidential Address at the 26th Conference of the Indian Mathematical Society--The Mathematic Student, Vol.39, Nos 1&2, 1962.
68. Principles of Relativity and Quantum Mechanics--Brochure printed by the Annamalai University, based on three lectures of mine at the Deptt. of Mathematics.
69. Inequalities worked in Papers Nos 25,39 & 46 of Annexure B have been deepened, and sent to Prof D.S. Mitrinovic of the Belgrade University, on his own request, for inclusion in his forthcoming book on the subject of inequalities (Under Publication).- Sent on 7 Oct 66.
70. Quantum Theory & Gravitation--Article sent for inclusion of the Sir Ashutosh Mukherjee Commemoration Volume (Under publication) - sent on 7 Jun 65.
71. Article on "A conjecture of Ramanujan" has been sent on 25 Jul 66 for inclusion in the B.N.Prasad Commemoration Volume of the Allahabad Mathematical Society.
72. An article on "Dirac's reformulation of Born's field theory has been communicated to the Proc Royal Soc. on 28 Aug 67.

In addition, I have done an evaluation of two books viz:

- (1) "Elements of Modern Algebra" by Yu, for the Ministry of Education, and
- (2) "Cybernetics within us" by Y.Saparina, for the University Grants Commission. Further a contribution has been sent on Mathematics & Astronomy to the Telugu Bhasha Samiti, and has been published.

Regarding reviews, I have done six for the Mathematical Reviews of the Amer. Math. Soc, two for Current Science, and one for the J.S.I.R (Vol 22 No 4, April 1963, p. 177), and one on the "Design and Analysis of Experiments" by Oscar Kempthorne.

Annexure B.

(1)

1. Name: Dr. B.S. Madhava Rao
2. Father's Name: Late M. Srinivasa Rao, Head Master, for over 40 years in several Middle Schools in the State.
3. Place and Date of Birth: Chamarajanagar, Mysore District, 29th May 1900.
4. Institutions where educated.
 - (1) A.V. School, Chamarajanagar - Joined 1905 Left 1912
 - (2) ~~Govt. High School~~ ^{Maharaja's College}, Mysore - " 1912 " 1915
 - (3) Central College, Bangalore - " 1915 " 1919
 - (4) University College, Calcutta - " 1919 " 1921
5. Details of Examinations passed and Degrees taken; Medals and Prizes.
 - (1) S.S.L.C. Mysore - I class Mathematics & Science 1915
 - (2) Intermediate, Madras University I class Mathematics & Science. 1917
 - (3) B.Sc. Degree, Mysore University I class Mathematics & Science. 1919 (Medalist)
 - (4) M.Sc. Degree, Calcutta University, I class Second - Mathematics. 1921 (Medalist)
 - ✓ (5) Ph.D. Degree, Calcutta University - Thesis on "Born's Electromagnetic Field Theory" 1938
 - ✓ (6) Ramanujam Prize, Madras University - for work on Algebra of Elementary particles 1945.
6. Official status:
 - (1) Research Scholar, Mysore University 1921 - Salary Rs. 100/- p.m.
 - (2) Assistant Professor " 1922 200 - 20 - 300
 - (3) Professor, Class II " 1938 400 - 25 - 700
 - (4) Professor, Class I " 1948 700 - 30 - 850
 - (5) University Professor and Principal, Central College 1953 850-50-1000 plus Ch.A. 100 plus H.R.A. 10%
7. Teaching and Research Experience:
 - (1) Taught all classes up to B.Sc. and classes in Engineering College in several branches of Pure and Applied Mathematics and Engineering Mathematics; taught advanced subjects like Relativity, Quantum Mechanics, Astrophysics, Hydro and Aero dynamics and Analytical Dynamics.
 - ✓ (2) Trained several scholars for M.Sc., M.Ph.D. and D.Sc. Degrees of this and other Universities.
 - (3) Collaborated in research with Prof. Dr. Max Born Sc., D.F.R.S. in the department of Physics, Indian Institute of Science, also with Sir C.V. Raman, F.R.S., S.L., and with Dr. H.J. Dhabha, F.R.S.

ENCLOSURE 2.

List of Published Papers
of
Dr. B.S.Madhava Rao

- (1) On the equivalence of three definitions of irrational numbers -
J.Ind. Math. Soc. 15, 1923, p.53
- (2) On the collinearity of three points on a non-singular cubic - Ibid, 15
1927, p. 163.
- (3) -de- (Journal of Science, Vizianagaram College, 1924)
- (4) On the covariant curves of a singular n-ic - Bull. Calcutta Math.Soc. 14
1923, p. 55-64.
- (5) Group of points on the equi-anharmonic cubic - J.Mys. Uni. 1, 1927, p.1-10
- (6) On the equations of motion of a non-holonomic dynamical system,
-ibid, 7, 1933, p.1-4
- (7) On the theory of suspension bridges - Bull. Mysc Engineers' Association,
1934, p.1-14
- (8) Elliptic function formulae and plane cubic curves - Proc. Ind.Acad.Sc. A.
1, 1934, p. 363-71
- (9) Mixed polar theorems on plane cubics - J. Mys.Uni. 8, 1935, p. 62-68
- (10) Note on a theorem on homologous stars - Math. Student, 1, 1933, p.81-85
- (11) Uber die ein mechanisches System belveffenden Theoreme von Liouville
Und Stackel - Zs. f. Phys. 93, 1935, p.320-28.
- (12) Separable systems in classical and wave mechanics - Math. Annalen,
3, 1935, p.459-68
- (13) Ring singularity in Born's field theory - Proc. Ind.Acad.Sci. 4, 1936,
355-76
- (14) A theorem on action functions in Born's field theory - ibid, 4, 1936
p. 377
- (15) Complex representation in Born's field theory - ibid, 5, 1936, p.575
- (16) Semi-vectors in Born's field theory - ibid, 4, 1936, p. 437
- (17) Ring-singularity in Born's unitary theory - ibid, 6, 1937, p. 129
- (18) On the fine structure of the Balmer lines - ibid, 5, 1937, p. 56
- (19) Generalised action functions in Born's Electro-dynamics - ibid, 6 ,
1937, p. 129
- (20) Biquaternionic in Born's Electro-dynamics, - ibid, 7, 1938, p. 333
- (21) Bemerkungen zur "Ringstruktur des Electrons" - Phys. Zs, 39, 1938, p.187
- (22) Antwort auf Starks Bemerkungen - ibid, 39, 1938, p.193
- (23) Names in Mathematics - Inter.College, Magazine, Bangalore, 5, 1938, p.59
- (24) Question of invariance in the neutrino theory of light - Proc.Ind.Acad.
Sci. 7, 1938, p. 293.
- (25) On an inequality concerning lattice sums - ibid, 8, 1938, p. 524
- (26) Quantum-mechanical interpretation of a result concerning Hermites
Polynomials - ibid, 10, 1939, p. 217

- (27) Generalised geometry and Physical theories - Math.Student, 8, 1940
p.11-34.
- (28) Notes on dynamics - J.Mys.Uni. 2, 1940, p. 93
- (29) On an invariant relation of dynamical systems - *ibid*, 1940, p. 1-3
- (30) On the reduction of dynamical equations to the Lagrangian form -
Proc. Benares Math.Soc. 2, 1940, p.53
- (31) The scattering of charged mesons (in collaboration with Dr. H.J.Bhabha)
Proc.Ind.Acad.Sci. 13, 1941, p.9-24
- (32) Evolution of stars - Annamalai Uni.Jl. Commemoration Vol. 1941,
p. 247 - 271.
- (33) Commutation rules for matrices related to particles of higher spins
Proc.Ind.Acad.Sci. 15, 1942, p.139-47
- (34) Commutation rules related to particles of spins half and one - J.Mys.
Uni. 3, pt.10, 1942, p.59
- (35) Notes on dynamics 2 - *ibid*, 5, part 7, 1944, p. 35-43.
- (36) Some examples of radial fluid motion - *ibid*, 5, part 4, 1944, p.21
- (37) Modern Algebra III and theory of elementary particles - Math.Student,
12, 1944, p.30-58.
- (38) E.S.K.Iyengar - in Memoriam - Proc. Ind.Acad.Sci. 19, 1944, p.414
- (39) Some trigonometrical inequalities - J.Mys.Uni. 6, 1945, p. 1-12.
- (40) Solution of cubic equations - *ibid*, 1945, p.
- (41) Pauli's identities in the Dirac Algebra - Proc.Ind.Acad.Sci. 22, 1945,
P. 408-22
- (42) Algebra related to elementary particles of spin $3/2$ - Proc. Roy.Soc.
London, A, 187, 1946, p. 385-97.
- (43) -do- Current Science, 14, 1945, p. 180
- (44) Commutation rules for matrices related to particles of higher spin.
J. Mys.Uni. 6, 1945, p. 57-62
- (45) Sir C.V.Raman as Physicist and teacher - Proc.Ind.Acad.Sci. 28,
1948, p. 254.
- (46) On an inequality concerning orthogonal polynomials - Proc. Ind.Acad.
Sci. 29, 1949, p. 391-93.

YES AND COMMENTS

- (47) The mathematical theory of a new relativity by sir Shah Sulaiman -
A critical review, Current Science, Sept. 1935, p. 145-151
- (48) Reply to sir Sulaiman - *ibid*, Oct. 1935, p. 401
- (49) sulaiman's predictions - *ibid*, March 1938, p. 459.
- (50) The Mesotron - *ibid*, March, 1939, p. 143.
- (51) Classical and quantum mechanics, *ibid*, April 1942, p. 163.
- (52) Relativity - *ibid*, April 1938, p. 515.
- (53) Logic and Probability in Physics, - *ibid*, October 1938, p. 201.
- (54) The Raman Jubilee Volume - *ibid*, Jan. 1939, p. 22.

(55) Gregory Tercentenary Memorial - *ibid*, July 1940, p. 340.

(56)

UNDER PUBLICATION

(56) The virial problem in hydrodynamics - *Quart.App.Math.* Brown Uni. 1954.

(57) On a problem in linkages - *J. App.Math.* London, 1954.

(58) On symmetries of spherical harmonics - *Canadian J.Math.* 1954.

ANNEXURE 'C'

Research and allied work done from 1962 onwards:-

67. On the role of Mathematics in Quantum Theory--Presidential Address at the 26th Conference of the Indian Mathematical Society--The Mathematic Student, Vol.39, Nos 1&2, 1962.
68. Principles of Relativity and Quantum Mechanics--Brochure printed by the Annamalai University, based on three lectures of mine at the Deptt. of Mathematics.
69. Inequalities worked in Papers Nos 25,39 & 46 of Annexure B have been deepened, and sent to Prof D.S. Mitrinovic of the Belgrade University, on his own request, for inclusion in his forthcoming book on the subject of inequalities (Under Publication).-- Sent on 7 Oct 66.
70. Quantum Theory & Gravitation--Article sent for inclusion of the Sir Ashutosh Mukherjee Commemoration Volume (Under publication) - sent on 7 Jun 65.
71. Article on "A conjecture of Ramanujan" has been sent on 25 Jul 66 for inclusion in the B.N.Prasad Commemoration Volume of the Allahabad Mathematical Society.
72. An article on "Dirac's reformulation of Born's field theory has been communicated to the Proc Royal Soc. on 28 Aug 67.

In addition, I have done an evaluation of two books viz:

- (1) "Elements of Modern Algebra" by Eu, for the Ministry of Education, and
- (2) "Cybernetics within us" by Y.Saparina, for the University Grants Commission. Further a contribution has been sent on Mathematics & Astronomy to the Telugu Bhasha Samiti, and has been published.

Regarding reviews, I have done six for the Mathematical Reviews of the Amer. Math. Soc, two for Current Science, and one for the J.S.I.R (Vol 22 No 4, April 1963, p. 177), and one on the "Design and Analysis of Experiments" by Oscar Kempthorne.

ENCLOSURE 3.

Additional Remarks under Item No. 27 of the
Application Form.

(1) Teaching &
Research
Experience:

1. Taught all classes up to M.Sc., and classes in Engineering College in several branches of Pure and Applied Mathematics and Engineering Mathematics; taught advanced subjects like Relativity, Quantum Mechanics, Astrophysics, Hydro and Aero dynamics and Analytical Dynamics.
2. Trained several scholars for M.Sc., Ph.D. and D.Sc., Degrees of this and other Universities.
3. Collaborated in research with Prof. Dr. Max Born Sc., D.F.H.S. in the department of Physics, Indian Institute of Science, also with Sir C.V.Raman, F.R.S.H.L., and with Dr. H.J.Bhabha, F.R.S.

(2) Original work:

1. Published over 50 research papers in several leading Journals like Math. Annalen, Zs. f. Physik, Proc. Royal Society, London, Proc. Indian Academy of Sciences and I.Ind.Math. Soc. on

- a) Geometry of curves,
- b) Analytical Dynamics,
- c) Born's electro magnetic field theory.
- d) Quantum mechanics
- e) Theory of elementary particles of nature.

Under (a) has been the author of a theorem referred to in the literature as "Madhava Rao's ACTION theorem on apolar cubics"

Ref: (a) T-Ray Pastor - Acad. Lincei, Rome, 1937.

Under (b) has been the author of articles known as "Madhava Rao's action functions"

Ref: (b) M.Born - Poincare' Institute Memoirs, 1936.

Under (c) was the first to prove the inadequacy of the neutrino theory of light

Ref: (c) Proc. Ind. Acad. Sc. 7, 1938, p.293.

and Under (d) has discovered new types of algebra related to elementary particles referred to as "Madhavarao algebra" and "Madhavarao Ring" to which was awarded the Ramamujam Prize of the Madras University, 1945.

Ref: Book by E.M.Corson - Tensors,

- (i) Spinors & relativistic wave equations, 1953-

References in the chapter on wave equations, in the bibliography and the index.

- (ii) Reference in the article by Jehle - Reviews of Modern Physics, 1953-54.

2. Has been the author of two well known papers of Critical Nature on

(a) Sulaiman's theory of relativity (referred to by the Astronomer Shapley in the American Journal "Science").

(b) Ring theory of the electron by J.Stark N.L. (Correspondence in Physics Zs. 1938)

3. Published reviews and critical notes in Current Science Journal, Sc. & Industrial Research etc.

(3) Lectures and Symposia.

1. Has delivered University lectures under the auspices of the Madras, Travancore and Annamalai Universities and special course of lectures by invitation at the Indian Institute of Science and the Travancore Statistical Department.
2. Has presided over symposia organised by the Indian Mathematical Society, The Indian Academy of Sciences and the Indian Science Congress.
3. Read a paper by invitation at the International Conference on Elementary Particles held at the Tata Institute of Fundamental Research, Bombay, in 1951.
4. Invited to read a paper at the Second Defence Science Conference at Delhi, April 21-26, 1952. Under the section of operational research, read a paper on "Military applications of Neumann's theory of games", presided over by Air Marshal Mukherji and in the discussion on which Mr. Johnson, the Head of the Institute of Armament Studies took part.

(4) Membership of Learned Bodies.

1. Fellow of the Indian Academy of Sciences - Member of the Council and Secretary, Section A.
2. Fellow of the National Institute of Sciences of India.
3. Fellow of the Royal Astronomical Society, London,
4. Member of the Mathematical Sections Committee and Recorder of the Indian Science Congress.
5. Member of Council of the Indian Mathematical Society.
6. Member of the American Mathematical Society, Mathematical Association of America, the London Mathematical Society, the Edinburgh Mathematical Society, Mathematical Association of England, the Benares Mathematical Society and the Current Science Association.

(5) Academic Duties:

1. Member of the Academic Council of the Universities of Mysore and Travancore;
2. Member and once Dean of the Faculty of Science, Mysore University, Member of Faculty of Science of Travancore University, also member of the Faculty of Arts, Faculty of Engineering and Technology, and the Faculty of Teaching of the Mysore University.
3. Chairman, Board of Studies in Mathematics, Mysore University and member of Board of Studies in Mathematics and Mathematical Physics and Statistics of the Andhra, Annamalai, Travancore, Osmania and Karnatak Universities.
4. Member of the Ad Hoc Selection Committee of the Andhra University and several as expert to Committees of Poona, Madras, Annamalai, Travancore, Mysore Universities and to the Madras Public Service Commission and Union Public Service Commission.

5. Served as Chairman, Board of Examiners of Mysore, Andhra, Madras, Travancore and Annamalai Universities and member of Boards of Examiners of the above and Osmania, Karnatak, Poona, Bombay, Patna, Calcutta, Gauhati, Rajputana, Nagpur and Ceylon Universities.
6. Served as examiner for Ceylon Civil Service, Indian Civil Service, Institution of Engineers, Military Wing, Survey of India and Madras Provincial Local Service Examinations.
7. Valued theses for M.Sc., Ph.D & D.Sc. of Madras, Bombay, Poona, Annamalai, Andhra and Travancore Universities.
8. Adjudicator for the C.S. Reddy National Prize for Mathematics and Physics.
9. Drew up the scheme of studies and syllabuses for the Honours and M.Sc. courses in Mathematical Physics of the Andhra University and the M.Sc. in Statistics of the Travancore University and the present Honours and M.Sc. syllabuses of the Mysore University.
10. Drew up syllabus for Internal and External Ballistics for inclusion of Ballistics as an optional subject for the M.Sc.

(6) Administrative duties.

1. Been a member of the Senate of the Mysore University.
2. Member of the University Council of the Mysore University for over five years.
3. Member and Chairman, Mysore University Commission and Member of a former Travancore University Commission.
4. Principal, Central College and Chairman of Admission, Freshmentships and several other Committees, President of the Hostel and Union.

(7) Extra-curricular

1. Member of the National Sports Club of India,
2. Member of Council of the Mysore Horticultural Society,
3. Former captain of the University side in Hockey and state player in the same, and played in Calcutta, Bombay and Madras.
4. Winner of the B.K.S. Memorial Shield as College Champion in Tennis in 1932.
5. Served as President, Vice-President, Secretary or member of Associations like the Mysore State Hockey Association, Mysore Lawn Tennis Association, the Basket Ball Federation and Table Tennis Association.

ENCLOSURE 3.

Additional Remarks under Item No. 27 of the
Application Form.

(1) Teaching &
Research
Experience:

1. Taught all classes up to M.Sc., and classes in Engineering College in several branches of Pure and Applied Mathematics and Engineering Mathematics; taught advanced subjects like Relativity, Quantum Mechanics, Astrophysics, Hydro and Aero dynamics and Analytical Dynamics.
2. Trained several scholars for M.Sc., Ph.D. and D.Sc., Degrees of this and other Universities.
3. Collaborated in research with Prof. Dr. Max Born Sc., D.F.R.S. in the department of Physics, Indian Institute of Science, also with Sir C.V.Raman, F.R.S.N.L., and with Dr. H.J.Bhabha, F.R.S.

(2) Original Work:

1. Published over 50 research papers in several leading Journals like Math. Annalen, Zs. f. Physik, Proc. Royal Society, London, Proc. Indian Academy of Sciences and I.Ind.Math. Soc. on

- a) Geometry of curves,
- b) Analytical Dynamics,
- c) Born's electro magnetic field theory.
- d) Quantum mechanics
- e) Theory of elementary particles of nature.

Under (a) has been the author of a theorem referred to in the literature as "Madhava Rao's ACTION theorem on apolar cubics"

Ref: (a) T.Ray Pastor - Acad. Lincei, Rome, 1937.

Under (b) has been the author of entitles known as "Madhava Rao's action functions"

Ref: (b) M.Born - Poincare' Institute Memoirs, 1936.

Under (c) was the first to prove the inadequacy of the neutrino theory of light

Ref: (c) Proc. Ind. Acad. Sc. 7, 1938, p.293.

and Under (d) has discovered new types of algebra related to elementary particles referred to as "Madhavarao algebra" and "Madhavarao Ring" to which was awarded the Ramanujam Prize of the Madras University, 1945.

Ref: Book by E.M.Corson - Zensors,

- (i) Spinors & relativistic wave equations, 1953-

References in the chapter on wave equations, in the bibliography and the index.

- (ii) Reference in the article by Jöhle - Reviews of Modern Physics, 1953-54.

2. Has been the author of two well known papers of Critical Nature on

(a) Sulaiman's theory of relativity (referred to by the Astronomer Shapley in the American Journal "Science".

(b) Ring theory of the electron by J.Stark N.L. (Correspondence in Physics Zs. (1938)

3. Published reviews and critical notes in current Science Journal, Sc. & Industrial Research etc.

(3) Lectures and Symposia.

1. Has delivered University lectures under the auspices of the Madras, Travancore and Annamalai Universities and special course of lectures by invitation at the Indian Institute of Science and the Travancore Statistical Department.

2. Has presided over symposia organised by the Indian Mathematical Society, The Indian Academy of Sciences and the Indian Science Congress.

3. Read a paper by invitation at the International Conference on Elementary Particles held at the Tata Institute of Fundamental Research, Bombay, in 1951.

4. Invited to read a paper at the Second Defence Science Conference at Delhi, April 21-26, 1952. Under the section of operational research, read a paper on "Military applications of Neumann's theory of games", presided over by Air Marshal Mukherji and in the discussion on which Mr. Johnson, the Head of the Institute of Armament Studies took part.

& Vice-President

(4) Membership of Learned Bodies.

1. Fellow of the Indian Academy of Sciences - Member of the Council and Secretary, Section A.

2. Fellow of the Indian National Science Academy ~~National Institute of Sciences of India~~

3. Fellow of the Royal Astronomical Society, London,

4. Member of the Mathematical Sectional Committee and Recorder of the Indian Science Congress.

5. Member of Council of the Indian Mathematical Society.

6. Member of the American Mathematical Society, Mathematical Association of America, the London Mathematical Society, the Edinburgh Mathematical Society, Mathematical Association of England, the Benares Mathematical Society and the Current Science Association.

(5) Academic Duties:

1. Member of the Academic Council of the Universities of Mysore and Travancore;

2. Member and once Dean of the Faculty of Science, Mysore University, Member of Faculty of science of Travancore University, also member of the Faculty of Arts, Faculty of Engineering and Technology, and the Faculty of Teaching of the Mysore University.

3. Chairman, Board of Studies in Mathematics, Mysore University and member of Board of Studies in Mathematics and Mathematical Physics and Statistics of the Andhra, Annamalai, Travancore, Osmania and Karnatak Universities.

4. Member of the Ad Hoc Selection Committee of the Andhra University and several as expert to Committees of Poona, Madras, Annamalai, Travancore, Mysore Universities and to the Madras Public Service Commission and Union Public Service Commission.

1911-22

1919

1920

1922

1923

1924

1925

5. Served as Chairman, Board of Examiners of Mysore, Andhra, Madras, Travancore and Annamalai Universities and member of Boards of Examiners of the above and Osmania, Karnatak, Poona, Bombay, Patna, Calcutta, Gauhati, Rajputana, Nagpur and Ceylon Universities.

6. Served as examiner for Ceylon Civil Service, Indian Civil Service, Institution of Engineers, Military Wing, Survey of India and Madras Provincial Local Service Examinations.

7. Valued theses for M.Sc., Ph.D. & B.Sc. of Madras, Bombay, Poona, Annamalai, Andhra and Travancore Universities.

8. Adjudicator for the C.R. Reddy National Prize for Mathematics and Physics.

9. Drew up the scheme of studies and syllabuses for the Honours and M.Sc. courses in Mathematical Physics of the Andhra University and the M.Sc. in Statistics of the Travancore University and the present Honours and M.Sc. syllabuses of the Mysore University.

10. Drew up syllabus for Internal and External Ballistics for inclusion of Ballistics as an optional subject for the M.Sc.

(6) Administrative duties.

1. Been a member of the Senate of the Mysore University.
2. Member of the University Council of the Mysore University for over five years.
3. Member and Chairman, Mysore University Commission and Member of a former Travancore University Commission.
4. Principal, Central College and Chairman of Admission, Freestudentships and several other Committees, President of the Hostel and Union.

(7) Extra-curricular

1. ^{Life} Member of the National Sports Club of India,
2. Member of Council of the Mysore Horticultural Society,
3. Former captain of the University side in Hockey and State player in the same, and played in Calcutta, Bombay and Madras.
4. Winner of the H.A.S. Memorial Shield as College Champion in Tennis in 1932.
5. Served as President, Vice-President, Secretary or member of Associations like the Mysore State Hockey Association, Mysore Lawn Tennis Association, the Basket Ball Federation and Table Tennis Association.

Life - (1) Professor of Ballistics at the Institute of
Armament Technology at Pune from 1955-1960

(2) Invited to take up the Sankarany-Tilak Professorship
of Applied Mathematics at the University of Pune
1960 - 65

(3) Worked as a V.G.C. Scientist and C.S.O.R.
Scientist from 1965-1970

(4) He joined as Associate at the Centre for
Studies J. J. Sc. Bangalore

(5) Just now busy with writing a book on magic squares
highlighting the Nally Narayana Padukis on the subject
published in Ganitha Kaurmude of 1356 A.D.