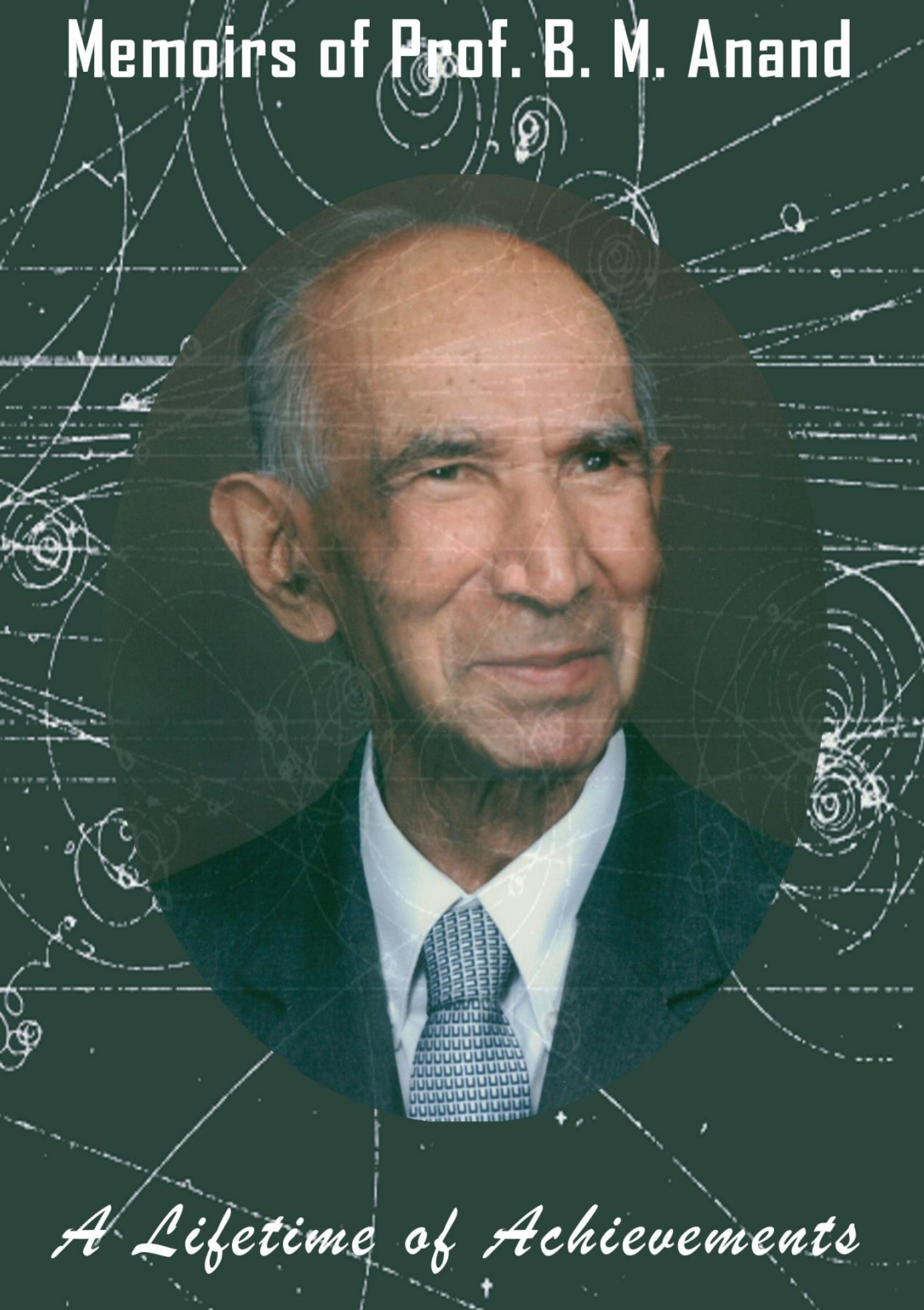
Memoirs of Prof. B. M. Anand



A Lifetime of Achievements

Prof. B. M. Anand

Prof. Bal Mokand Anand was history's choice for establishing Panjab University's Physics Department in its permanent campus at Chandigarh and initiating research activity there. He published original research in the 1930s and 1940s and had the distinction of working for his doctorate, in the 1950s, under the supervision of Professor Cecil Frank Powell who a few years previously (1947) had been awarded physics Nobel Prize for his discovery of a subatomic particle pion (or pi meson), using nuclear emulsion technique. Anand's 20-page research paper, based on his Ph. D. work, and published by the Royal Society, London, in 1953 is still considered relevant.

Bal Mokand was born in a village, Domel, in the Bannu district of what is now the Khyber Pakthunwa province of Pakistan. An only child who lost his mother at birth, he was raised by an aunt until the age of seven. With a view to be with his son and educating him, his father gave up his job as a travelling salesman, and moved to Peshawar where he opened a small grocery store, the back portion of which was improvised to serve as the family's modest living quarter.

Anand was a brilliant student whose studies were financed by scholarships. He passed his Matriculation Examination from Frontier High School, Peshawar, in 1922. A highlight of his school days was his playing the disguised Portia character in Shakespeare's Merchant of Venice. For his role in the play, Anand got a special suit stitched for him. This was the first time, he was wearing a suit. He passed his F.Sc. with Biology from Dayanand Anglo-Vedic College, Lahore, in 1924. He would have liked to become a doctor, but the attraction of a two-year scholarship brought him to basic science. He passed his B.Sc. with Honours in Physics from Government College, Lahore, in 1926; and M.Sc. in 1928, from Panjab University. He was mentored by two eminent faculty members: J. B. Seth of Indian Education Service, and Partap Kishan Kichlu. During 1928-1930, Anand worked at Government College, Lahore, on a Panjab University research scholarship, whereas the next two years, 1932-1934, were spent at the Irrigation Research Institute, Lahore, as a Research Assistant. Both these temporary appointments were marked by good-quality research output, including publications in the well-respected journal, Nature, and Soil Science (U.S.A). In 1934, when Panjab University introduced Honours School in Physics, Anand was appointed a Lecturer. He was promoted to Readership in June 1947.

East Panjab University (renamed Panjab University on 26 January 1950) came into existence on 1 October 1947. For two years, the Physics (as well as the Chemistry) Department was housed in Delhi University. The Department started operating from Government College, Hoshiarpur, on 15 May 1949. In August 1949, Anand was appointed Head of the (teaching) Department, while Dr H. R. Sarna was made the Director of Physics Laboratories. From December 1950 till July 1953, Anand was on study leave to avail of a Government of India scholarship to work for his Ph.D. He was made Professor in March, 1955.

Physics Department moved to Chandigarh on 15 September 1958 and finally to its own building in 1960. In Hoshiarpur itself, Anand had set up a nuclear emulsion laboratory with grants from the Union Ministry of Education and University Grants Commission. Now, thanks to grants from various agencies, including Department of Atomic Energy, and the US Wheat Loan Programme, research facilities were strengthened in nuclear emulsions, spectroscopy and nuclear physics. Two Ph. D. theses were written under Prof. Anand's supervision: Prem Kumar Aditya (1961) and Prakash Mohan Sood (1967). Aditya's is the first Physics Ph.D. from (the post-1947) Panjab University. If the Panjab University Physics Department today enjoys a world-class reputation, its roots go back to the Anand era. Professor Anand retired from the University on 10th November 1967.

(Rajesh Kochhar)

Prof. B.M Anand with colleagues at Bristol University, England, 1952

H. H. Wills Physical Laboratory,
University of Bristol,
Royal Fort,
Bristol, 8,
England.

27th May, 1954.

This is to Certify that Dr. B. M. ANAND worked in this Laboratory from 1951 - 1953, studying the cosmic radiation by the photographic method.

His most important achievement was to make measurements on the mean lifetime of the neutral π-meson. These measurements depended on the fact, which he did much to establish, that a small fraction of the neutral π-mesons decay in an alternative mode, viz. into one quantum and a pair of electrons. It follows that if a π-meson created in a nuclear disintegration decays in this mode, the pair of electrons originate from a point coincident with the point of decay of the meson. By studying the distribution in the origins of electron pairs emerging from disintegrations recorded in photographic plates, Anand was able to show that the points of origin are distinguishable from the centres of the parent disintegration: and by measuring the corresponding values of the displacement he was able to deduce a value for the mean lifetime of the parent neutral π-mesons. The result was about 4.10^{-15} secs., the smallest mean lifetime of an entity hitherto observed.

Anand also made measurements on the flux of heavy nuclei through plates exposed at high altitudes by means of balloons. He gave particular attention to the interaction of the heavy nuclei in their passage through the emulsion. This subject is important because of its bearing on the origin of the primary radiation. In such studies the problem arises as to the extent by which the primary radiation reaching the top of the atmosphere has been modified through collisions with interstellar hydrogen. The effects of such collisions can be studied by observations of the nuclear interactions of heavy nuclei in their passage through photographic plates. These studies made by Anand although not exhaustive gave him a first hand acquaintance with the technical methods employed in identifying heavy nuclei, and with the cosmological problems associated with the origin of the cosmic radiation.

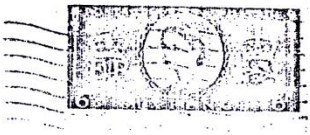
Dr. Anand was a most agreeable colleague. His success in bringing important investigations to a successful conclusion

was largely due to the persistence with which he attacked the problems and he well deserved the success which he gained.

I shall be very glad to answer any questions about his suitability for any post for which he may be a candidate.

C.F. Powell.

Professor of Physics



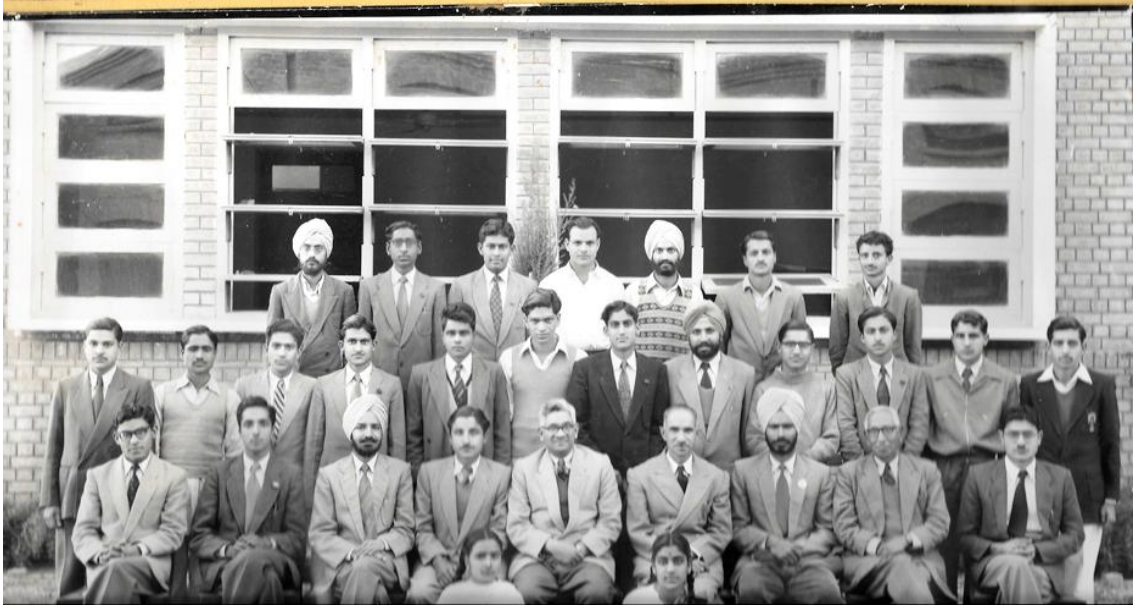
Dr. B. M. Anand,
Physics Department,
University College,
Hoshiarpur,
Panjab,
India.

Second fold here

Sender's name and address: Professor C.F. Powell, F.R.S.
H.H. Wills Physical Laboratory,
University of Bristol, Royal Fort,
Bristol, England.

IF ANYTHING IS ENCLOSED THIS LETTER MAY BE SENT BY ORDINARY MAIL

M.Sc. STUDENTS WITH DR. F. C. AULUCK D.Sc.
AT
PHYSICS HONOURS SCHOOL, HOSHIARPUR.
1956-57.



DR. B. M. ANAND
Formerly University Professor and Head of Physics Department
Panjab University
India

M. Sc. I Class (Panjab University), 1928.
Ph. D., Bristol University, 1953.
Date of Birth 12-30-1905

Has been associated with the University ever since the inception of the Physics Honours School in 1934. Has been teaching B. Sc. and M. Sc. Honours School classes and guiding research of M. S. students, research scholars and other members of the staff.

Specialized in Spectroscopy, especially of the Extreme Ultraviolet region between 1926-1947.

Got interested in Nuclear Physics and Cosmic Rays in 1948. List of research publications given in Appendix (i).

To keep abreast of the latest developments in Physics, was selected by the Government of India for research abroad. Worked at the Bristol University with Professor C. F. Powell, F. R. S., Nobel Laureate from January 1951 to June 1953.

While abroad, took part in conferences on Nuclear Physics and Cosmic Rays at Bristol, Brussels (Belgium) and Glasgow.

Reference of the above research work in books and scientific publications are given in Appendix (ii).

Brief outline of the research work by research scholars and some members of the staff is given in Appendix (iii).

List of research problems for M. Sc. students (1953-1961) is given in Appendix (iv).

Details of academic record given in Appendix (v).

Papers published by:

B. M. Anand, M. Sc., Ph. D. (Bristol),
University Professor of Physics and Head,
Department of Physics, Panjab University,
Chandigarh-3, India.

1. A study of the Electric Glow Discharge through Air by an Interferometric arrangement.
J. B. Seth, Chetan Anand and Balmokand Anand.
Indian Journal of Physics, Vol. II, 1929.

2. On the passage of an Electric Discharge through gases.
J. B. Seth and Balmokand Anand.
Nature, 1930.

3. A modified apparatus for Raman Effect.
Balmokand Anand.
Journal of Scientific Instruments (London), Vol. VIII, No. 8, Aug. 1931.

4. A modified apparatus for Raman Effect.
Balmokand Anand.
Journal of Scientific Instruments (London), Vol. IX, No. 10, Oct. 1932.

5. Coronium Spectrum.
P. K. Kichlu and B. M. Anand.
Current Science, Vol. I, No. 5, Nov. 1932.

6. An electrometric titration method of finding the pH values and lime requirements of Soils.
Amar Nath Puri and Balmokand Anand.
Soil Science (U.S.A.), Vol. XXXVII, 40, 1934.

7. A Galvanometer method of study of the soil reaction.
Balmokand Anand and Amar Nath Puri.
Memoir in the Government of Panjab Publications, 1934.

8. Reclamation of Alkali Soils by Electrodianalysis.
Amar Nath Puri and Balmokand Anand.
Soil Science (U.S.A.), Vol. 42, No. 1, July 1936.

9. Raman Effect in Dibasic Acids in Crystalline State.
Balmokand Anand.
Proceedings Indian Academy of Science, Vol. IV, No. 6, Nov. 1936.

10. A simple type of Electrical Salinometer for estimating soluble salts in soils and irrigation waters.
Amar Nath Puri and Balmokand Anand.
Soil Science, Vol. 44, No. 3, Sept. 1937.

11. On Raman Effect in Camphor.
B. M. Anand and S. Narain.
Indian Journal of Physics, Vol. XIII, Part III, June 1939.

12. Bands forming Rydberg series and ionization potential of Carbon Monoxide.
B. M. Anand.
Science and Culture, Vol. VIII, 1942-43.

13. Anomolous Distribution of Intensity in Lyman Series and the Extinction of L4 (949.7A).
B. M. Anand.
Science and Culture, Vol. VIII, 1942-43.

14. Spectrum of Active Nitrogen in Schumann Region.
B. M. Anand, P. N. Kalia and Mela Ram.
Indian Journal of Physics, Vol. XVII, Part II, April 1943.

15. Development of and Bands of Nitric Oxide in active Nitrogen and Lyman-Bands in Helium-Nitrogen Mixture.
B. M. Anand.
Indian Journal of Physics, Vol. XVII, Part V, Oct. 1943.

16. Metal-Covered Silica Fibres.
P. K. Kichlu and B. M. Anand.
Journal of Scientific and Industrial Research, Vol. 3, No. 11, May 1945.

17. Energy Requirements for Cooking Food.
B. M. Anand.
The Defence Science Journal, 1950.

18. Absorption Spectrum of Lead Molecule (Pb_2) in the Vacuum Ultraviolet region (600-900 A).
B. M. Anand.
Research Bulletin, East Panjab University.

19. Observations on the Lifetime of the Neutral π-meson.
B. M. Anand.
Proceedings of the Royal Society, A. Vol. 220, pp. 183-202, 1953.

20. The Collision Mean Free Path of the Heavy Nuclei within G-5 Nuclear Emulsions.
B. M. Anand.
Contributed to the Indian Science Congress, 1956.

21. The Interaction of positive K-mesons with Nuclei in Photographic Emulsions at Energies in the region 240 to 300 Mev.
P. K. Aditya, B. M. Anand, I. S. Mittra, K. K. Nagpaul, P. M. Sood and S. K. Tuli.
Proceedings Cosmic Ray Symposium organized by cosmic ray research Committee of Department of Atomic Energy, Government of India, 1960.

22. Present status of K-meson Research and Allied Phenomena.
B. M. Anand and I. S. Mitra.
Proceedings of the Seventh Annual Cosmic Ray Symposium, Chandigarh, 1961.

Appendix (ii)

References of research in some books and scientific publications:

1. Spectra of Diatomic Molecules by G. Hertzberg, F. R. S., Second Edition, on page 459, reference to work on Ionization Potential of CO published in Science and Culture, 8, 278 (1942).

2. The Raman Effect and its Chemical Applications by Hibben,

   (a) on page 29 reference to work on the Optical system for Raman Effect. Published in Journal of Science Instruments 8, 258 (1931) and Journal Science Instruments 9, 324 (1932).

   (b) on page 192, reference to work on the Carbonyl shifts for dibasic acids. Published in Proceedings Indian Academy of Science, 4 A, 603 (1936).

3. Nuovo Cemento, Vol. 12, 1954, reference to B. M. Anand: Proc. Royal Society, 220, 183 (1953).

4. The Philosophical Magazine.
Vol. 46, 381, 1955, page 1146.
In a paper by D. H. Perkins reference to Anand, B. M., 1953 a, Proc. Royal Society, A 220, 183, 1953, b, Ph. D. Thesis, University of Bristol.

5. The Proceedings of the Indian Academy of Sciences. Vol. 39, 1954, page 129, reference to Anand B. M. on the direct conversion of π^0 according to the alternative mode of decay.

6. The Physical Review, Vol. 97, 1, 1955, page 198, in a paper by M. Koshiba and M. F. Kaplan reference to B. M. Anand, Proc. Royal Society, (London) 220, 183, (1953), reviews the results to that date, on the life time of the π^0 mesen, and has a complete bibliography.

Appendix (iii)

RESEARCH WORK GUIDED (Nuclear Emulsion Section)

1. On Pair production by fast electrons by Prem Kumar Sharma, presented at the Indian Science Congress Session-1956.

2. A note on the Trident Process by Prem Kumar, Nuovo Cimento 11, 546, 1959.

3. On the possibility of Neutrons producing secondary interactions in high energy showers, by Prem Kumar, Nuovo Cimento 11, 872, 1959.

4. Possible example of an interaction in emulsion produced by a deutron of 10^{13} ev. by Prem Kumar, Nuovo Cimento 13, 219, 1959.

5. Electromagnetic processes at high energies. Part I Anomalous shower by Prem Kumar, Nuovo Cimento 13, 1013, 1959.

6. A simple method for the energy estimation of electron pairs by Prem Kumar, Ind. J. Phys. 33, 357, 1959.

7. Interactions of K^+ -mesons with emulsion nuclei in the energy region 240-300 Mev.
P. M. Sood, P. K. Aditya, B. D. Sukheeja and V. S. Bhatia,
Proceedings of the Annual Cosmic Symposium, 1961 (pages 119-122).

8. On the causes of spurious scattering in nuclear emulsions.
P. K. Aditya, V. S. Bhatia, and P. M. Sood,
(Proceedings of the Spurious Scattering Conference, Bombay, pages 34-48).

9. Interactions of K^+ -mesons with emulsion nuclei in the energy region 240-300 Mev. - submitted for publication to the Proceedings of Indian Academy of Sciences.

10. On the Causes of Spurious Scattering. To be submitted to Nuovo Cimento shortly.

11. On the Scattering constant at higher cell lengths in G_5 nuclear emulsions (under preparation).

12. On the Russian formula for s.s. in nuclear emulsions (under preparation).

The above work was guided under the Research Project entitled:

"Study of Artificially produced K-mesons using Nuclear Emulsion Plates"

sponsored by the Department of Atomic Energy, Government of India.

Appendix (iv)

RESEARCH WORK GUIDED - M. Sc. Students

1953-54 Session

1. Investigation of nature of Active Nitrogen.

2. Sputtering of thin films on glass and quartz.
3. Determination of the amount of Ozone in the atmosphere.
4. Photomicrography of Nuclear events.
5. Heavy primary Nuclei of Cosmic radiation.
6. Setting up of Micro-photometer.

1954-55 Session

7. Sputtering of thin silver films.
8. Nuclear Disintegrations caused by Cosmic Ray Particles.
9. Preparation of Nuclear Emulsion Plates.
10. Heavy Primaries of Cosmic Radiation.
11. Studies in Raman Spectra.
12. Continuously Sensitive cloud chamber.
13. The Production and study of Hydrogen Continuum.

1955-56 Session

14. Preparation of Nuclear Emulsion Plates.
15. The Range of Alpha Particles.
16. Construction of an Electromagnet.
17. Exploding of fine wires.

1956-57 Session

18. The study of Heavy Mesons by nuclear emulsions.
19. Construction and study of Halogen Filled counter.
20. Hyperfine Structure Study with F. P. Interferometer.
21. Particle density of heavy cosmic rays.
22. Exploding of fine wires.

1957-58 Session

23. Sputtering of thin films.
24. Study of electrodeless discharge.
25. Mean free path of heavy primary nuclei of cosmic radiation in G-5 Nuclear Emulsions.
26. Cloud Chamber Technique.

1958-59 Session

27. Production of high temperatures by exploding fine wires.
28. Construction and study of nuclear resonance absorption magnetic field-meter.
29. Raman Effect Studies in certain liquids.
30. The study of Properties and interactions of K^+ -mesons by nuclear emulsion.

1959-60 Session

31. A source of continuum in the Vacuum ultraviolet.
32. Study of Electrodeless discharge.
33. A study of g vs R curves for different particles in nuclear emulsions.
34. Interactions of K^+ -mesons with matter.

1960-61 Session

35. Studies in Active Nitrogen.

36. Source of continuum in the Vacuum ultraviolet.
37. Studies with 3 metre normal incidence Vacuum Grating Spectrograph.
38. Preparation of Schumann plates.

Appendix (v)

Particulars of B. M. Anand (Balmokand Anand)

EXAMINATION	Year of Passing	School/College Attended	Subject	Division	Remarks
Matriculation	1922	Frontier High School Peshawar	English, Math., G.K., Science, Physiology, Hygiene	First	First position in the School.
Intermediate (Science)	1924	DAV College Lahore	English Biology Physics Chemistry	First	Second position in the University, was awarded Gov't. Scholarship.
S. Sc.	1926	Government College Lahore	English Physics Chemistry	Second Honours Physics	First position in the College.
M. Sc.	1928	Government College, Lahore	Physics	First	Second position in the University.

5. Won all the prizes in Physics as well as in Chemistry for the years 1925-26-27 and 1928 in the Government College, Lahore.

6. Had the distinction of inscribing the name in the College Academic Roll of Honour twice.

7. Was awarded Panjab University Research K. L. Scholarship in Physics for two years 1928-30.

8. Worked as Research Assistant in the Irrigation Research Institute from 1932-1934.

9. Was appointed Lecturer in Physics, Panjab University, Lahore, in October 1932 when the Physics Honours School was started.

10. Was appointed reader in Physics, Panjab University in June, 1947.

11. Was appointed Head of the University Teaching in Physics, Panjab University in August 1949.

12. Went abroad as a Government of India Scholar in December 1950. Worked at the Bristol University with Professor C. F. Powell, F. R. S., Nobel Laureate, from January 1951 to June 1953.

13. Was appointed University Professor of Physics in March 1955. Retired in 1968.

14. Visiting Professor, California State University, Los Angeles, 1963-1964.

15. Visiting Professor, Ursinus College, Collegeville, Pennsylvania, 1968-1969.

RESUME

PERSONAL:

Name: B. M. Anand ADDRESS: 108 Lee Ave., Mifflin Park
Shillington, Pa. 19607 Telephone 215-777-2198

Birth Date: December 30, 1905. Nationality: Indian
Place of Birth: Demel, Pakistan. Weight; 120 lbs.
Height: 5 feet 8 inches. Marital Status : Married.
Health: Good. Physical Handicaps: None. Visa: Permanent Resident.
Social Security Number: 184-44-5682

ACADEMIC RECORD:

Ph.D. Bristol University, England.	1953	Thesis on, "Life-Time of Neutral Pi-Meson and Fragmentation of Heavy Primary Nuclei.
M.Sc. Panjab University, India.	1928	I Class(Physics)

Professional Experience:

Physics Teacher:	1969-1970	Upper Merion Senior High School, King of Prussia, PA. 19406
Visiting Professor:	1968-1969	Ursinus College, Collegeville, Pennsylvania, 19426
Chairman, Physics Dept.	1964-1968	Panjab University, Chandigarh, India.
Visiting Professor	1963-1964	California State College, Los Angeles.
Chairman, Physics Dept.	1953-63	Panjab University, Chandigarh, India.

Director, Summer Institutes in Physics, sponsored by the Govt. of India, in collaboration with U.S. Science Foundation, at Chandigarh during summers of 1965, 1966, 1967 and 1968.

Publications:

Published 22 research papers on Optics, Spectroscopy and Meson Physics.

References:

1. Dr. Stewart A. Johnston, Research Professor, California State College, Los Angeles, California.
2. Dr. David Carter, Professor of Physics, San Jose State College, San Jose, California.
3. Dr. J.J. Heilmann, Professor of Physics, Ursinus College, Collegeville, Pennsylvania 19426
4. Dr. William S. Pettit, President, Ursinus College, Collegeville, PA.

Department of Physics,
Delhi University,
DELHI.
Dated:- 1.3.1954

I have known Dr. B.M. Anand since 1929, when I came on the staff of the Government College, Lahore. Dr. Anand worked with me for a time as a Research Scholar of the Panjab University. He joined the staff of the Honours School in Physics of the Panjab University as Lecturer in Experimental Physics in 1934 and was later appointed Reader in Physics. I have been intimately associated with Dr. Anand all these years and I have come to have the highest regard for his ability and character.

After a distinguished career at the Panjab University, he started his investigations in Optics, covering a wide field, with a zeal and devotion which have been characteristic of all his subsequent work. These investigations included, amongst many others, Spectroscopy of the Vacuum Ultraviolet, Raman Effect of Solids and Liquids and the Nature of Active Nitrogen. It is to him that the Panjab University Physics Laboratory owed the starting of the work on Vacuum Spectroscopy, a subject wherein he did pioneering work and brought it to a stage not yet attained anywhere else in India. His researches on the Nature of Active Nitrogen as revealed by its extreme ultraviolet spectrum have attracted wide attention and form substantial and important contributions to the literature on the subject.

Dr. Anand has during the past few years been interested in the study of Cosmic Rays by the Photographic Emulsion Technique, and has spent about three years 1951 - 1953 at the Bristol University for this purpose. His work on the measurement of the mean life of the neutral Π - meson and allied problems, has won for him considerable praise from many competent authorities.

Dr. Anand's skill and dexterity as an experimenter are most remarkable. The development of high vacuum technique, leading to the construction of Electron Tubes of various types Electron Diffraction Apparatus, Coolidge X-Ray Tubes, Rectifiers etc. etc., in the Physics Laboratory of the Panjab University, was essentially due to his tireless energy and enthusiasm.

As a teacher Dr. Anand has built up high reputation extending over a period of 25 years, and he is held in the highest esteem by his students and colleagues. Since 1950 Dr. Anand has been the Head of the University Physics Department, and as such is solely responsible for building up the Department from the completely disintegrated state after the partition. It is fortunate that the Panjab University had had the benefit of his services at this critical period and it speaks volumes for the organising ability and human qualities of Dr. Anand that the Department is again working so efficiently.

It is a matter of deepest satisfaction to me to have been associated with him so long and so intimately. Dr. Anand fully deserves to hold the post of Professor of Physics and I do hope this appointment will not be delayed.

P.K. Kichlu

(P.K. Kichlu)
D.Sc., F.N.I.,

Prof. Bal Mokand Anand – An Inspiring Life and Legacy

Our father was born in 1905 in Domel, a small village in a very primitive part of the country in the North West Frontier region of Panjab. He had a difficult childhood as he lost his mother at birth, had no siblings and was raised by an aunt, and he used to miss his father who was a traveling salesman.

When our father was seven, our grandfather started a small grocery store in Peshawar, and took him there to live with him. Our grandfather was an orthodox man with little formal education, for whom western education had no value. He would have liked his only son to help him at the store, but gave in to our father's desire for learning and the persuasion by relatives to let him go to school.

They lived in a small area behind the grocery store with hardly any facilities. To do his homework, our father would walk across the street and study under a streetlight. But he finished high school with top honors and eventually won a scholarship to study at Government College, Lahore, an elite educational and research institution.

The seminal moment in his career came when he met Professors J.B. Seth and P.K. Kichlu of the Physics Department. They provided much guidance and support, and took him under their tutelage. After completing his B.Sc. and M.Sc., he worked as Research Assistant under them. The Physics Honors School was incepted in 1934 and he was appointed as a Lecturer, and subsequently promoted as Reader.

The partition of India in 1947 decimated the once vaunted Panjab University. Following the partition, Professor Seth retired and Professor Kitchlu moved to Delhi University. Our father was called upon to organize the Physics Department of the newly formed Panjab Universty out of the remains of the old university. Delhi University, in particular Prof. Daulat Singh Kothari, Head of Physics Department, very graciously accommodated Panjab University's Physics and Chemistry Departments in their campus for two years, until more permanent space was secured in Government College in Hoshiarpur. The campus of Panjab University in Chandigarh was completed in 1958, and the various Departments moved to the new campus one by one.

Our mother, Smt. Ram Lubhai Anand, nee Sahni, was born in 1910, in a neighboring village, Basal, in a family of limited means. She was the eldest of four children. The youngest of her three brothers, Sh. Amar Nath Sahni retired as Senior Scientific Officer from the Defense Science Laboratories (now part of DRDO) in Delhi, a career direction he chose inspired by our father's lead.

When our mother moved to Lahore following their wedding in the late nineteen-twenties, it was quite a challenge for his uneducated girl, to adjust to the social environment of a modern city like Lahore. The first thing she did was to engage a teacher who started her off on a intense program of 3R'S. But she adjusted well to the urban life in Lahore.

There was not much time, however, as the family grew and the responsibilities of raising a large family of 2 boys and 5 girls fell on her shoulders. This was especially true when our father took a sabbatical to study for three years at Bristol University for his doctorate, and the youngest two kids were still infants.

For all the stress she endured, it gave her much joy and pleasure that her children did very well in their chosen fields. Their accomplishments and the changes wrought in the family within one generation is a measure of the grit and unusual common sense of this unsophisticated but determined daughter of the earth.

After his retirement from Panjab University in 1968, our father moved to the USA to be closer to the children. For the next few years, he taught at Ursinus College in Collegeville, Pennsylvania. Eventually, he applied his enormous teaching skills to help emotionally handicapped children as a volunteer foster grandparent and to provide computer instruction to young, primary school children. Ever the gifted teacher, he continued to perform these activities to the age of ninety years with the same sense of purpose with which he approached the discourse with his college and graduate students at Panjab University.

In his younger days he had enjoyed mountaineering, and remained active, physically fit and mentally sharp all his life. For our mother, the move to the USA was another test, but once again, she adjusted beautifully in a very different culture.

Our mother passed away in 1974 and our father breathed his last in 1998.

The family of our father, Prof. B. M. Anand, has grown. He is survived by two sons, Ram P. Anand and Yoginder Anand, and five daughters, Santosh Sawhney, Swaran Tuli, Sharda Arya, Sneh Aneja and Sunita Anand, and by eleven grandchildren and seventeen great-grandchildren.

As we remember our father, we want to humbly acknowledge and applaud the following trailblazers and founding fathers of the new Panjab University Physics Department: Professor J. B. Seth, Professor P.K. Kichlu and Professor D.S. Kothari. May God bless their soul and inspire Panjab University students and faculty to mentor and motivate kids from under privileged families. As the lives of our parents, and a big and generous, worldwide community of our father's many students shows: Anything is possible with determination and hard work, and that a helping hand can bear rewards sweeter than any fruit known to man

Source - Anand Family

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Professor and Mrs. B.M. Anand, USA, 1970

B.M. Anand: A Personal Tribute

Had B. M. Anand not been Head of the Department during my student days in Panjab University, I would not have been in the research field that I eventually chose: experimental particle physics. Having himself worked in that field during his stint at the famous particle physics laboratory at Bristol, England, he set up the Nuclear Emulsion group in the Physics Department. This set the stage for collaboration in such experiments between Panjab University and the Tata Institute of Fundamental Research, Mumbai, and my joining this PU group after my M.Sc. (Hons. School) in 1966, and later joining the Tata Institute after my Ph.D.

Prof Anand was a strict disciplinarian, one who insisted on meticulous detail. He would walk into an afternoon laboratory session and one of his favorite questions was: show me how you use the vernier calipers properly. Students dreaded that question, as 95% of the time he would not be satisfied with the answer.

Having said that, I came to know the large and soft hearted side of him and I cherish that memory even after 50 years. After my B.Sc. (Hons. School) I got it into my head to leave the department, and move on to (imagined) greener pastures of engineering. I got admission in the B.Tech. course in Radio Physics and Technology of Calcutta University in September 1965 and off I went. However, after just a week I realized that, for a variety of reasons, I had made a blunder. I wrote to my parents that I wanted to come back and rejoin M.Sc.; but I was afraid the Department might act tough or indifferent. As soon as I returned to my home in Chandigarh, I was told by my father that he had approached Prof Anand with some trepidation, but he was pleasantly surprised that Prof Anand welcomed my coming back, and advised that I start attending classes immediately and the rejoining formalities would be taken care of by the Department. Prof Anand never, ever, mentioned this to me personally! This was his generosity and large heartedness. I appreciated it then and I appreciate it now.

All in all, Prof Anand set up meticulous high standards of teaching and research. The Physics Department continues to flourish today owing to the excellent job he did in setting the tone of excellence. In particular the experimental particle physics group that he set up in the early 1960's has done him proud by having participated in the two major discoveries in the field: those of the top quark at Fermilab (D0 experiment) and of the higgs boson at CERN (CMS experiment). He must be happy and smiling up there seeing the fruits of the seeds he planted.

Atul Gurtu

B.Sc. (Honours School) Physics (1962-65)
M.Sc. (Honours School) Physics (1965-66), Gold Medalist.
Completed Ph.D. work from 1966-69 and joined Tata Institute.
Awarded Ph.D. in 1971.
Retired as Senior Professor, Tata Institute, January 2011.

Department of Physics – Panjab University

The Department of Physics was started, after the partition in Delhi in October 1947 under the supervision of Dr. D. S. Kothari, the then Professor and Head of the Physics Department of the University of Delhi, now the Chairman of the University Grants Commission. The displaced staff and students of the Panjab University (Lahore) were housed in the barracks allotted to the new University by Chief Commissioner of the Union Territory of Chandigarh. On the appointment of Prof. Kothari as Advisor to the Union Ministry of Defence, Prof. P. K. Kichlu took over as Head of the Department. To begin with, there were only six Lecturers on the staff of the Department and 43 students were enrolled during the opening session.

The syndicate of the Panjab University appointed a Reorganisation Committee of the Physics Honours School in 1949 under the chairmanship of Dewan Anand Kumar, the Vice-Chancellor. Its members were Professors D. S. Kothari, P. K. Kichlu and J. B. Seth. It was recommended that the number of the students to be admitted in the Department of Physics should be increased to 160, including 10 Ph. D. Research students, and that the strength of the teaching staff should be raised to 14, including one Professor and three Readers. The Committee further recommended a recurring grant of Rs. 30,000 and a non-recurring grant of Rs. 3,50,000 for the department. Its recommendation was accepted by the University with slight modifications.

The department closed in Delhi on April 30, 1949 and reopened at the Government College, Hoshiarpur, on May 15, 1949. In August 1949, Dr. B. M. Annad was appointed Head of the Department and Dr. H. R. Sarna was made the Director of the Physics Laboratories. After the transfer of control of Government College, Hoshiarpur to the Panjab University in 1950, the staff of the college, belonging to the Government Cadre was also engaged for University teaching. Dr. H. R. Sarna acted

as Head of Department from December 1950 to July 1953, when Dr. B. M. Anand was on study leave in England.

On his return started developing the nuclear emulsion section for investigation of the properties of heavy primary cosmic rays and elementary particles. During 1953-1954, the Union Ministry of Education sanctioned a grant of Rs. 11,000 for fundamental research in the Department. It was remarked for developing the nuclear emulsion section. An additional grant of Rs. 6,000 was made by the Central Goverment for the construction of the special type of electromagnet. Research facilities in the department received a further boost when the University Grants Commission gave a grant of Rs. 50,000 to the Panjab University for the development of postgraduate studies in Physics.

On September 15, 1958 the department of Physics shifted to Chandigarh, where ut was housed temporarily in the building of the Department of Chemical Engineering and Technology. Two years later, the present three-storied building was ready to house the Department.

The University Grants Commission gave a grant of Rs. 6 lakhs under the scheme, 'Development of Higher Education' during the second Five Year Plan period for expansion of the Department. This helped the Department to strengthen its research activities in the fields of Nuclear Emulsion Work, Spectroscopy and Nuclear Physics. During 1959, the Department of Atomic Energy, Government of India sanctioned a scheme, with Professor B. M. Anand as Investigator-in-charge, for the study of artificially produced K+ mesons with the help of nuclear emulsions. During 1961-62, Dr. David Carter, Fulbright Visiting Professor, helped the Department in setting up a number of experiments in the fields of Micro-waves and Solid State Physics. For this purpose, workshop facilities were increased with the purchase of equipment worth Rs. 50,000 through the Wheat Loan Programme of U.S.A. Two research projects, one on the application of Beta-gamma spectroscopy to investigation in low energy Nuclear Physics and Solid State Physics, and the other in the "Collective Motion in Nuclei" were sanctioned in 1962 by the Department of Atomic Energy, Government of India. Considerable research work was done in the Department under these projects. In 1963, a research project, entitled "Investigation of the decay of radio-active nuclei in the medium-weight region" was sponsored by the National Bureau of Standards, Washington (U.S.A.), for a period of four years, with Dr. P. N. Trehan as the Chief Investigator.

Dr. B. M. Anand was permitted by the University to work as a Visiting Professor in the California State College, Los Angeles, California, from September 1963 to April 1964. Dr. I. S. Mittra, Reader in Physics, held the charge of Nuclear Emulsion Section during his absence. Proffesor Anand proceeded on leave preparatory to retirement on September 20, 1967, and Dr. H. S. Hans was appointed Professor of Physics and Head of the Department. At present, the Department has a sanctioned strength of three Professors, seven Readers, eleven Lecturers and four Teaching Assistants. Besides, eighteen Research Scholars are engaged in various research projects in this Department. There were 165 students on rolls in the Department in academic session 1967-68. The Department also gives instruction in Physics as a subsidiary subject to the students of other Science Departments of the University.

In addition to the regular staff, the following two persons have been designated as Honorary Professors of Physics –

1. Dr. Yash Pal, Professor of Physics, Tata Institute of Fundamental Research, Bombay, who was appointed Honorary Professor of Physics by the University in 1965. He has been occasionally lecturing on High Energy Nuclear Physics.

2. Dr. P. S. Gill, M.Sc., Ph.D., F.N.I., Director, C.S.I.O., Chandigarh, who was designated as Honorary Professor of Physics by the Chancellor of the University in 1966.

The Department of Physics organizes seminars, symposia, summer institutes and training courses for science teachers almost regularly. In March 1961, the Cosmic Ray Committee of the Department of Atomic Energy, Government of India, held the seventh session of the Cosmic Ray Symposium in this Department. In February 1962, the Department organized a symposium on the "applications of Field Theoretic Method to problems in Solid State Physics". It was sponsored by the University Grants Commission. The 8th All India Nuclear Physics and Solid State Physics Symposium was organized in this Department by the Department of Atomic Energy, Government of India, in February 1964.

In 1966, Professor V. B. Bhanot of this Department was given charge of two new research schemes, namely, "the study of low-lying states in intermediate nuclei", and the "application of Mass Spectrometry in the field of Nuclear Geology". The former was sanctioned by the University Grants Commission and the latter by the Union Department of Atomic Energy. At present, the following research groups are working in the Department of Physics –

1. Low Energy Nuclear Physics.
2. High Energy Nuclear Physics.
3. Study of Dielectrics in Radio and Microwave Region.
4. Optical Spectroscopy.
5. Geo-Chronology.
6. Theoretical Physics.
7. Ionospheric Studies.

A large number of research papers in various fields of Physics have been regularly published by the staff of the Department. Several senior members of the staff, both in Low and High Nuclear Physics and Mass Spectrometry, have participated in the international conferences, held in India and in other countries, during the past decade.

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A REEVALUATION OF EVIDENCE FOR LIGHT NEUTRAL BOSONS IN NUCLEAR EMULSIONS*

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Electron–positron pair production data obtained by bombardment of emulsion detectors with either cosmic rays or projectiles with masses between 1 and 207 amu and kinetic energies between 18 GeV and 32 TeV have been reanalyzed using a consistent and conservative model of the background from electromagnetic pair conversion. The combined data yield a spectrum of putative neutral bosons decaying to e^+e^- pairs, with masses between 3 and 20 MeV/c^2 and femtosecond lifetimes. The statistical significance against background for these "X-bosons" varies between 2σ and 8σ. The cross-section for direct production of X-bosons increases slowly with projectile energy, remaining over 1,000 times smaller than the pion production cross-section.

Keywords: Emulsion detectors; heavy-ion reactions; neutral bosons; axion-like particles.

1. Introduction

For over 50 years, measurements of e^+e^- pair production by energetic ions incident on emulsion detectors have yielded events with opening angles at the $e^+ - e^-$ vertex larger than those expected[1] for external pair conversion (EPC) by photons.[2–12] On the basis of relatively small data sets, El-Nadi and Badawy[6] and de Boer and van Dantzig[13] proposed in 1988 that such events might represent the decays of neutral bosons with masses considerably larger than generally expected for Weinberg–Wilczek axions. Since then, additional studies of relativistic heavy-ion interactions with emulsion[9–12,14] have been interpreted in terms of massive neutral boson production. While such observations have triggered interest[15–17] and are mentioned in the Review of Particle Physics section on axion searches,[18] no comprehensive attempt has been made to assess whether these observations represent

*Fokke W. N. de Boer (1942–2010) passed away as this work was nearing completion. This paper is dedicated to his memory.

new phenomena worthy of further investigation or background effects resulting from well-characterized processes.

In this paper, we revisit results from six accelerator studies using emulsion detectors, all of which report observations of e^+e^- pairs that are interpreted as evidence for the existence of neutral bosons with masses between 1.5 and 30 MeV/c^2 and lifetimes between 10^{-16} and 10^{-14} s.[4–12,14] Four of these studies[9–12,14] were published after the 1988 proposal that such events might represent the decays of massive neutral bosons,[6,13] and hence can be considered tests of this proposal. The assumptions made regarding background processes are not, however, consistent across these six studies, and the reported neutral boson masses are not identical; indeed Jain and Singh[11,12] report a continuous spectrum of novel neutral bosons with masses up to 85 MeV/c^2. We have therefore reanalyzed these e^+e^- pair production data using a single set of assumptions regarding background processes that are consistent with the experimental data reported by each of these studies. We also reanalyzed the classic cosmic-ray data of Anand[2] and Hintermann[3] as comparisons. The resulting background-subtracted data sets, taken together, raise the possibility of a spectrum of neutral bosons with energies between 3 and 20 MeV/c^2 and lifetimes on the order of femtoseconds. This mass-lifetime window, and in particular the existence of a 9.8 MeV/c^2 neutral boson decaying to e^+e^- pairs, is consistent with measurements of anomalous internal pair production (IPC) in decays of excited states of light nuclei that suggest the existence of both unnatural parity (pseudoscalar and axial-vector)[19–26] and natural parity (scalar and vector) neutral bosons.[27]

The existence of neutral particles decaying to e^+e^- pairs in this mass-lifetime window was not investigated in early beam-dump measurements.[28–31] Due to the long beam dumps, these experiments using high-energy electron and proton beams from laboratories including SLAC, Orsay and FNAL could only rule out lighter, longer-lived axion candidates ($\tau \geq 10^{-9}$ s). Results from a later experiment by Bross *et al.*,[32] using a short beam dump with sensitivity to short-lived bosons with $\tau \leq 10^{-14}$ s, partly overlap the present lifetime window but do not exclude it.

If multiple neutral particles with similar rest masses exist, it is possible that their individual effects on the electron and muon anomalous magnetic moments would cancel out, potentially explaining the lack of evidence for massive axion-like particles in the available magnetic-moment data. We conclude that the observations reviewed and reevaluated here support the existence of fewer massive neutral particles than have been previously claimed.[6,8–12,14] However, we interpret these data as providing sufficient suggestive evidence for novel massive neutral bosons with femtosecond lifetimes to encourage further experimental investigation. If confirmed, the existence of such massive neutral bosons would provide *prima facie* support for theoretical models that propose axion-like particles with masses in the MeV to tens of MeV range,[33,34] as are increasingly motivated by cosmological data.[35–37]

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