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ARTICLE

Physics and physicists at Banaras Hindu University: circa 1916–1960

Ritesh Gupta[1,2]

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Abstract
Banaras also known as Varanasi and Kashi is one of the greatest centres of education and learning since ancient times. The city has been called as 'The city of temples', 'The religious capital of India', 'The cultural capital of India', 'The city of light', and 'The city of learning'. Philosophers, men of science and educationalists have lived and worked here, making Banaras a leading seat of learning. Long before the advent of the modern age, Banaras enthusiastically embraced the learning of mathematics, astronomy and medicine. In this lineage of a tradition of knowledge of the city, Pandit Madan Mohan Malaviya established Banaras Hindu University in 1916. Among many departments of knowledge at BHU, modern physics was greatly encouraged and promoted by its founder. Malaviya himself exerted to bring many scientists to BHU to enthuse the cultivation of science. Here we will see the story of the physicists appointed in the early years of BHU, who contributed to the world of physics in their own humble right. They did their own small part in physics that helped develop the discipline in India. The paper attempts to unearth a very important and formative slice of India's history in modern science, exemplified by Banaras Hindu University as a single campus university with both teaching and research in physics.

Keywords Balebail Dasannacharya · Banaras Hindu University · Bisheshwar Dayal · CV Raman · Nihal Karan Sethi · Rango Krishna Asundi · Satis Ranjan Khastgir · VV Narlikar

1 Introduction

The Banaras Hindu University has its genesis in the Indian national movement. Under British colonialism, education was neither national in character nor geared to produce scholars in any branch of knowledge. The colonial education was primarily designed to create a class of Indians who could assist and work in the colonial administration. Thus, this system of education failed to fulfill the needs and aspirations of the nation as a whole. The discontent among the educated Indians and their recurrent demand for educational reforms led to the enactment of the Indian University Act in 1904, which paved the way for teaching and research in Indian universities (Ashby, 1966). Many nationalist minded Indians patriotically endeavoured to establish scientific institutions considering that science and technical education would lead the country to the path of progress. Among many scientific institutions that started in India in the early decades of the twentieth century, Indian Institute of Science (1909), College of Science and Technology of Calcutta University (1914), and Bose Institute (1917) are worth mentioning here because they were founded by the Indians. This accelerated the process of institutionalisation and professionalisation of modern science in India (Krishna, 1992; Sen, 1992).

Around the same time, Pandit Madan Mohan Malaviya, a leader of the Indian National Movement, launched a movement for establishing a national university at Banaras with a provision for teaching and research in sciences and technology. The promotion of scientific, technical and artistic education combined with religious instructions and classical culture was the objective of its founder. Malaviya underlined the need for scientific education as the most pressing need as attested in his 1909 prospectus (Malaviya, 1909). On the one hand, Malaviya wanted to preserve and revive the indigenous knowledge system of India and wished that students of BHU should be given religious instructions for their moral and character development. While on the other

✉ Ritesh Gupta
ritesh.namo6@gmail.com; ritesheddie@yahoo.com

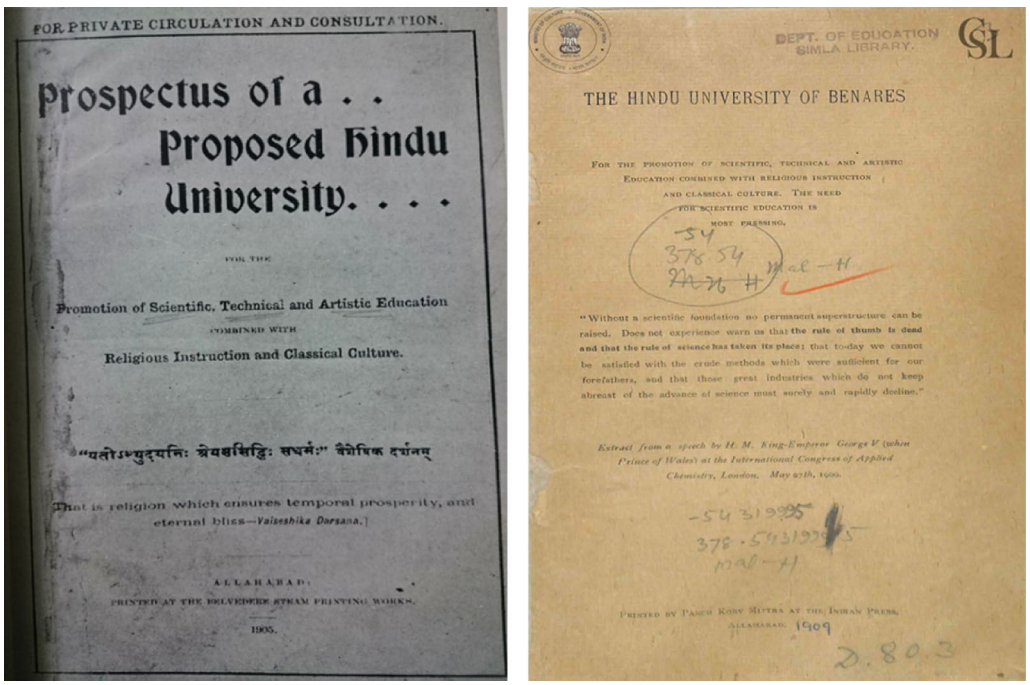
[1] Banaras Hindu University, Varanasi, India

[2] Jawaharlal Nehru University, New Delhi, India

hand, Malaviya clearly understood that the fundamental strength of the Western knowledge system was science. Thus, to mitigate unemployment, regenerate entrepreneurship, and create Indian industrial enterprises, he emphasised on both pure science and its applied aspect, i.e. technology. Though, Malaviya was influenced by nationalism in founding BHU, but his nationalist aspirations were cosmopolitan and transnational, grounded in the Indian culture and values. His nationalism clearly understood that India as a nation could not be developed without modern science.

The first prospectus of BHU published in 1905 comprised 'College of Science and Technology' as an integral part of the proposed university. Interestingly enough, the name suggested for this college was 'College of Sthapatya Veda or Artha Sastra', which as a written science, has been so wholly effaced from the Indian literature. This college was thought to have three distinct departments of science: (i) department of Physics, theoretical and applied, with laboratories for experiments and researches, and workshops for the training of mechanical and electrical engineers, (ii) department of Chemistry with its laboratories for experiments and researches and workshops for teaching the manufacture of acids, dyes, paints, varnishes cements, and other chemical products, and (iii) technical department for teaching the manufacture, by means of machinery, of the principal articles of personal and house-hold use for which India was dependent on foreign countries. Mining and Metallurgy was to form two important sections of this department (The First Prospectus-Pandit Madan Mohan Malaviya, pp. xxxviii–xl) (Fig. 1).

Thus, as early as 1905, the proposed Hindu University at Banaras emphasised the teaching and research in physics both in its theoretical and applied aspects. Many more prospectuses of BHU were issued till its establishment, and all of them included the Department of Physics as an integral part of the Science College of the university. After leading a movement for a decade, Malaviya was finally able to establish BHU in February 1916 on the auspicious occasion of Vasant Panchami, "to promote learning and research in arts and science in all branches" (The Draft Scheme of Proposed Hindu University, p. 68) (Fig. 2). As soon as the university started functioning, teaching and research in different disciplines of science and technology began. However, there was a challenge regarding the appointment of teaching faculty who would also supervise research. Malaviya was determined to appoint well-trained scholars at BHU. As pointed out by Mahadev Rao Balaji Rane, who served the university from the foundation to the early 1940s and held the Chair of Rampur Professor of Chemistry, "to guide the postgraduate students and instill in their minds the spirit of research Malaviya Ji keep his eyes on brilliant scholars" (Rane, 1961).


FOR PRIVATE CIRCULATION AND CONSULTATION.

Prospectus of a . .
Proposed Hindu
University. . . .

Promotion of Scientific, Technical and Artistic Education
COMBINED WITH
Religious Instruction and Classical Culture.

"यतोऽभ्युदयनिः श्रेयससिद्धिः सधर्मः" वैशेषिक दर्शनम्

That is religion which ensures temporal prosperity, and eternal bliss—*Vaiseshika Darsana.*

ALLAHABAD:
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1905.

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THE HINDU UNIVERSITY OF BENARES

FOR THE PROMOTION OF SCIENTIFIC, TECHNICAL AND ARTISTIC EDUCATION COMBINED WITH RELIGIOUS INSTRUCTION AND CLASSICAL CULTURE. THE NEED FOR SCIENTIFIC EDUCATION IS MOST PRESSING.

"Without a scientific foundation no permanent superstructure can be raised. Does not experience warn us that the rule of thumb is dead and that the rule of science has taken its place; that to-day we cannot be satisfied with the crude methods which were sufficient for our forefathers, and that those great industries which do not keep abreast of the advance of science must surely and rapidly decline."

Extract from a speech by H. M. King-Emperor George V (when Prince of Wales) at the International Congress of Applied Chemistry, London, May 27th, 1909.

PRINTED BY PANCH KORY MITRA AT THE INDIAN PRESS, ALLAHABAD. 1909

Fig. 1 Left: BHU Prospects, 1905, Right: BHU Prospects, 1909

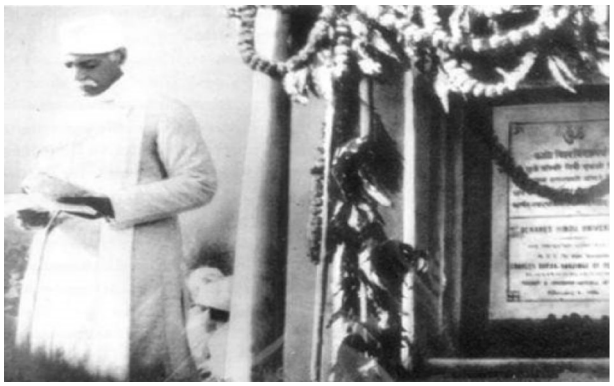


Fig. 2 Pandit Madan Mohan Malaviya on the foundation laying ceremony of BHU, 4th February, 1916 which was followed by a 4 day programme of lectures by Mahatma Gandhi, Annie Besant, P.C. Ray, J.C. Bose, and C.V. Raman among others dignitaries

Fig. 3 Nihal Karan Sethi. Courtesy: Indian Academy of Sciences

2 Physics and the department

From the early days of BHU, great CV Raman was called upon to guide and mentor teaching and research in physics. The Banaras Hindu University Board appointed him the Honorary University Professor of Physics as soon as the university came into existence (Benares Hindu University Minutes 28 October 1917, p. 78). Malaviya was astute enough to have roped in CV Raman in many honorary capacities. Raman also had great regard for BHU and Malaviya. He saw in BHU a great instrument for the upliftment of India that can cement together the people of country into a single nation. Considering BHU truly a national university, he remarked, "I see it a centre of learning with the greatest potentialities for the intellectual, moral and material welfare of our countrymen." This attachment of Raman to a university established in the age-old seat of learning was best reflected in his speech delivered at the convocation of BHU in 1926. Raman said:

> Many a time while travelling in America, I was called upon to speak of India's ancient civilisation and of her new renaissance. They were anxious to hear of our country. When I accept such invitations, I had to unfold a picture of our people, to paint in words India as she was and she is to-day. Do you think I spoke of Madras or of Calcutta? No I spoke of Kashi, of Benares, of the historic city on the ridge overlooking the Ganges which stands as the very heart of India, as the living centre of our ancient culture and learning. I spoke of the new University which has sprung up, so fitly, at this age-old seat of learning and is the living embodiment of the aspirations of new India. That was the message I gave to America (Dr. C.V. Raman's Address, pp. 431–432).

2.1 Nihal Karan Sethi

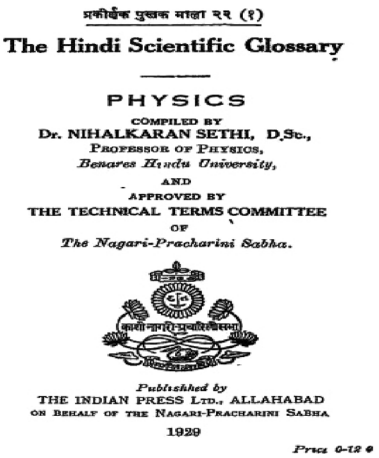
Malaviya, who was always on the lookout for good physicists often used to asked Raman to recommend a well-trained physicist for BHU. One of the early physicists of BHU who was a close associate of Raman was Nihal Karan Sethi (Fig. 3). He was appointed Professor of Physics in 1916 and remained there till 1930, contributing to teaching and research in the early years of the university (Minutes of the meeting of the Faculty of Science, October 1917, p. 82). Sethi belonged to a landed Jain family from Ajmer. He wanted to do advanced research in physics at a foreign university, but Raman dissuaded him from going abroad and urged him to join BHU as a Professor of Physics because of the nationalist orientation of the university. Sethi was a Gandhian who believed in social reforms and simple living, and thus he found the environment at BHU in harmony with nationalist principles where though staffs were paid less than as offered in colonial universities but committed to nationalist values and sense of service towards their motherland (Remembering Our Leaders, 2005, pp. 119–120).

Under Nihal Karan Sethi's direction were built the rudiments of the physical laboratory at BHU. However, it seems that the laboratory was not well equipped in the early days of the department. Because of this, Sethi carried out experimental works either in the laboratory of the Indian Association for the Cultivation of Science or in the laboratory of the Science College of Calcutta University. While a Professor of Physics at BHU, he collaborated with Raman in the early 1920s that led to the publications in leading scientific journals like *Philosophical Magazine* and *Physical Review*. For instance, in 1920, Raman and Sethi performed experiments to test the theory of relativity that was published in *Philosophical Magazine* in 1922 (Raman & Sethi, 1922, pp. 447–455). This project

was supported by a special grant by Calcutta University (Singh, 2019, p. 79). During this period, Sethi performed many more experiments in the laboratory of the Indian Association for the Cultivation of Science in which Raman took an unfailing interest. The quality of Sethi's research can be discerned from the fact that the findings of all his experiments conducted at Indian Association for the Cultivation of Science were reported in *Physical Review*.

However, a unique contribution of Sethi to physics education lies in the fact that he endeavoured for teaching physics in Hindi. He belongs to a class of science educators who firmly believed that scientific knowledge could not progress in a country until imparted in the mother tongue. He was instrumental in preparing proper Hindi vocabulary for scientific terms in physics. The Nagari Pracharni Sabha of Banaras undertook the task of preparing and publishing the Hindi Scientific Glossary comprising the technical words of all science disciplines with their equivalent in Hindi. Nihal Karan Sethi was assigned to compile a glossary for physics that he prepared with great effort in 1929 (Sethi, 1929) (Fig. 4). Among his important textbooks on physics written in Hindi for university students, *Prārambhik Bhotikī* (Elementary Physics, 1929), *Prārambhik Bhotik Vigňan* (Elementary Physical Sciences, 1930), *Cumbakatva aur Vidyut* (Magnetism and Electricity, 1930), and *Bhāratīya Bhotikī* (Hindi Vishwavidyalaya Granthmala, 1948) are worth mentioning here.

Sethi was happily teaching physics at BHU, but circumstances created by the political stir amid the Civil Disobedience Movement in 1930 compelled him to move over to Agra College. The nationalist uprisings always had badly effected BHU that also led to the distubance in the functioning of the univesity. Not only did many students and teachers of the university participated in various political movements, but in the upheaval of the Civil Disobedience Movement, the


प्रकीर्णक पुस्तक माला २२ (१)

The Hindi Scientific Glossary

PHYSICS

COMPILED BY
Dr. NIHALKARAN SETHI, D.Sc.,
PROFESSOR OF PHYSICS,
Benares Hindu University,
AND
APPROVED BY
THE TECHNICAL TERMS COMMITTEE
OF
The Nagari-Pracharini Sabha.

Published by
THE INDIAN PRESS LTD., ALLAHABAD
ON BEHALF OF THE NAGARI-PRACHARINI SABHA
1929

Price 6-12 0

Fig. 4 The Hindi Scientific Glossary: Physics, complied by Dr. Nihal Karan Sethi

Vice-Chancellor Malaviya himself was arrested in August 1930. It is worth mentioning that U.A. Asrani, who was Assistant Professor in the Department of Physics at BHU, joined the Satyagraha directed against the colonial government. He had to resign because of the government pressure but was reappointed to his post when Malaviya retook the charge of VC after his release from the jail. The participation of students and teachers of BHU in Civil Disobedience Movement displeased british rulers to the extent that they stopped non-recurring grants and cut ten percent in the recurring grants of the university. During this difficult time, BHU was forced to make a cut in the salary and allowance of its teachers and other staffs. To protect the objectives and interests of the university, many faculty members of BHU issued a 'Teacher's Declarations' that assured their services at the disposal of Malaviya in financial stringency. Such a patriotic action of the scientists of BHU along with the other faculty members of different departments of the university must have to do with the reputation of BHU as a national institution devoted to the cause of nation-building and Malaviya as a most respected nationalist leader of the time being called Mahamana (great soul). P.K. Dutt and C.M. Sogani of the Physics Department duly signed the "Teacher's Declarations" and agreed to work on reduced remuneration (Dar and Somaskandan, 1966, pp. 613–646).

Sethi with his large family, found it difficult to sustain in the reduced salary. His son, Pramod Kumar Sethi, born in Banaras in 1927 who became a distinguished orthopaedic surgeon of the country, mentions that considering the financial pressure on BHU, Pandit Malaviya called his father and told him that with his emoluments, it would be difficult for him to marry his six daughters. So, he advised him to go to Agra, where remuneration would be better (Bhargava, 2008, p. 1206). Thus, Sethi joined Agra College as a Professor of Physics where he later promoted to the post of the Principal. On account of his accomplishment in physics, Indian Academy of Sciences elected him a fellow in 1935 (Indian Academy of Sciences, Bengaluru, Fellows' portal). His scholarly activities continued at Agra, and he translated many scientific texts from English to Hindi. He translated into Hindi, Harlow Shapley's "Of Stars and Men: Human Response to an Expanding Universe" with the titled, Tare aur Manushy [Brahmand ke Badte hue Vistar ki Manviya Prakrtiya] (Sethi, 1967).

In the period from 1916 to 1930, when the Department of Physics at BHU was mainly the teaching department, apart from Sethi, Prafulla Kumar Dutt, a Cambridge post-graduate, who was already teaching physics at Annie Besant's Central Hindu College of Banaras since 1904, was hired to teach physics at BHU (Minutes of the Meeting of The Board of Appointment, 6 November, 1916, p. 80). While Shridhar Nehru, a cousin of Jawaharlal Nehru who did his PhD under Nobel Laureate Philipp Lenard from Heidelberg

University in 1911, was also appointed to the Faculty of Science to teach physics (Minutes of the Meeting of The Faculty of Science, 7 November, 1916, p. 129). However, he left the university soon. These early physicists of BHU tried to build up a centre for physical research in the university but considering the colonial background, financing the department was not an easy task. Nevertheless, by 1925, a double-storied Physical Laboratory covering about 45,000 sq. ft. was built in the university that comprised a large lecture theatre, three large practical halls, three big rooms for instruments and stores, professor's rooms, rooms designed for advanced work in various branches of physics, a library, and a workshop. The B.Sc. laboratory consisted of a lighted central hall for general experiments, one dark room for work with reflecting galvanometers, and one room for acoustical experiments. Whereas M.Sc. Laboratory consisted of a large hall for experiments on Heat & General Properties, two rooms for Electrical experiments, one room for Radioactivity, two rooms for Optical & Spectroscopic work and one room for acoustical experiments (Benares Hindu University Calendar 1922–1925, pp. 1147–1150). But it appears that the laboratory of the Physics Department was still not so well equipped, and there were also not sufficient funds for carrying out research. Therefore, for the first 15 years, the department mainly offered teaching and early physicists of BHU did not initiate students into research. The only known important experiment done in the Physical Laboratory of BHU during this period was 'Effect of a Retarding Plate on White Light Interferometer Fringes.' Conducted by Nihal Karan Sethi in April–May 1923, this work was published in the *Physical Review* in January 1924 (Sethi, 1924). Thus, it was only from the early 1930s that research began in the Physics Department of BHU (Fig. 5). The department got its first research-oriented Professor in Balebail Dasannacharya, who joined the university in 1930.

Fig. 5 Department of Physics, BHU, circa 1935

Fig. 6 Balebail Dasannacharya, Courtesy: Physics Departmentmt, BHU

2.2 Balebail Dasannacharya

B. Dasannacharya, born 5th June 1895 near Mangalore was one of the few of his times who went to Germany for research in physics (Fig. 6). He acquired his doctoral degree from the University of Munich working under German physicist Wilhelm Wien, a Noble laureate. At Munich, he joined Wien's laboratory and wrote a thesis titled, 'Light Emission from Positive Rays in a Discharge Tube' for which he was awarded D.Phil. (*Magna Cum Laude*) in 1925. Impressed by the quality of Dasannacharya's work, Wein sent his research to *Handbuch der Physik* for publication. He also had the distinction of writing a research paper in German titled 'über die freien Weglängen der Lichterregung und ihre Storungen bei Wasserstoffatomen' for one of oldest journal on physics, *Annalen der Physik* (Dasannacharya, 1929). It may be noted that, German was then a leading scientific language; therefore, he wrote a few more papers in German even after leaving Germany.

After acquiring D.Phil. from the University of Munich, Dasannacharya went to University College of London to join DSIR (Department of Scientific and Industrial Research), where he studied for 3 years from 1925 to 1928. He then moved to Zurzeit Ryerson Physics Laboratory of the University of Chicago for advanced physics research in 1929. At Chicago, he worked with another Nobel Laureate, Arthur Compton. In Compton's laboratory, he studied frontline areas in experimental physics, particularly the polarisation of continuous x-rays (Baliga, 1966). He not only published papers while working at Zurzeit Ryerson Physical Laboratory but was also exposed to new ideas of teaching physics. In particular, the idea of the Physics Museum in a university. In Chicago, one of his papers, 'Polarization of the Continuous X-Rays from Single Electron Impacts', was published in *Physical Review* in December 1930 (Dasannacharya, 1930).

With this advanced training in physics, Dasannacharya returned to India and was appointed to the Physics Department of Islamia College in Lahore. But on the personal call

of Madan Mohan Malaviya (then the Vice-Chancellor of BHU), he joined the university at a salary that was 2/3 of what he was getting at Lahore. The financial crisis that BHU faced in the early 1930s has already been discussed above when the faculty were requested by Malaviya to take a cut in their salaries. Many scientists did this by signing a letter offering to take a cut. Dasannacharya joined BHU during this financially difficult period of the university. However, even at reduced remuneration, Dasannacharya found Banaras conducive for work and started building a research culture even though research funds were meagre. Thus, in the early 1930s, he began researches in positive rays (ion beams) and their spectra, cosmic rays, and nuclear and particle physics in BHU. Dasannacharya's interest in nuclear and particle physics can largely be ascribed to his training in Germany, where experimental physics had also acquired a significant currency along with theoretical physics.

At that time, the specific feature of the College of Science at BHU was that every MSc student was required to undertake an experimental project. In particular, in the Physics Department, the MSc projects on Foucault's Pendulum, Geiger-Muller Counter, and Optical Silvering for Astronomical Mirrors resulted in a number of publications in journals like *Nature*, *The Philosophical Magazine*, and *Current Science* (Ramakrishnan, 2011, p. 954). Dasannacharya's project with his MSc student Amar Chand Seth on the study of Foucault's Pendulum, especially the method of optical silvering of glass, was reported in *Philosophical Magazine* in 1938. Among his papers, 'Ring Deposits on Glass by Positive Ray Bombardment,' 'Steady Performance of Geiger-Müller Counters, Ionization Potential,' 'Doppler Effect in Hydrogen Positive Rays,' and 'Doppler Effect in Positive Rays of Hydrogen' deserves special mention as they were published in one of the most reputed scientific journal of the time, *Nature* (See appendix for Dasannacharya's publications). Significantly enough, studies on emissions from discharge tubes under his supervision led to the award of some early PhD in physics at BHU. One of the early PhD supervised by Dasannacharya was done by Gopal Krishna Das, who was awarded a DSc degree in 1938 (Das, 1938).

As mentioned, the advanced training in physics that Dasannacharya received in the German and American Laboratories exposed him to new ideas of physics education and methods of disseminating knowledge. One such idea was setting the Physics Museum in the Physics Department of the Banaras Hindu University. He believed in the utility of a museum in the teaching of physics that can exhibit and display the model of apparatus and instruments used in the experiments. This idea was developed during his stay in Munich and Chicago, where Physics Museum was in vogue at that time (Dasannacharya, 2018). Dasannacharya worked for 2 years on this project and set up a Physics Museum in 1942 which was inaugurated by none other than CV Raman on Banaras Hindu University's silver jubilee celebration (Associated Press of India, 20 January, 1942). This museum was the first of its kind in India and received much appreciation from Raman. It included a large single crystal of quartz, operating models of miniature telephones and apparatus for demonstrating the theory of sound waves, various electromagnets, optical instruments, other apparatus of physical studies, and wooden model of the astronomical instruments installed in the Man Mandir Astronomical Observatory built by Raja Jai Singh at Banaras in the eighteenth century. The following address of Dasannacharya at the opening ceremony of the Physics Museum provides a vivid glimpse of it.

> The first almirah is named Lenth, Mass and Time. The names are indicative of their contents. We have the next almirah for general physics, containing levers, springs, friction and their applications, hydrostatics and pneumatics. The next almirah is devoted to acoustics, the next to heat, light, electricity in gases, positive rays, electromagnetic waves, x-rays, crystals and the periodic system of elements. In addition to these we have a number of apparatus for all sections of physics which could be partly or completely handled and maintained by the visitor (The Opening Ceremony of the Museum of the Department of Physics by Dr. B. Dasannavharya and Sir C.V. Raman on 20th January, 1942, pp. 5–6).

Raman applauded this endeavour of Dasannacharya. He acknowledged the educative potential of science museums in India by pointing out that mere knowledge of theory is insufficient and the necessity of demonstrating the results in physics museums. Raman commented, "Dr. Dasannacharya has combined the idea of the German Museum of historical development of physics with the idea of the Demonstration Laboratory of the Chicago University. The effect is marvelous. Its educative value is immense" (Associated Press of India, 1942). In his speech at the opening ceremony of this Physics Museum, Raman explicitly said that science museums had not been properly organised in India. He wished that the Physics Museum of BHU should be permanent and be further expanded. Alas! After Dasannacharya retirement in 1956, what Raman thought should be permanent and expanded was dismantled for building purposes.

After independence, Dasannacharya further carried out the costly task of instrumentation in the Physics Department of BHU. Following the German way of doing things, B. Dasannacharya emphasised that his students should be well trained in creating their own equipment for doing good science. He asked his research student K. S. Subudhi in the early fifties to build a Van-de-Graaf machine. Such machines in combination with an ion source were being used for (what we now call) Low Energy Nuclear Physics research in those days. They require large metal domes with rounded edges

(to avoid electrical breakdown) for collecting charge being fed into them using a charged rotating belt to build high voltage. Varanasi (Thatheri Bazar) is a city with a reputation for building brass wares, and the local artisans were approached for building these domes. With all the other paraphernalia from local sources including army disposals a VdeG machine reaching 750–800 kV was built and tested successfully. Subudhi completed his PhD in 1956 and joined the Physics faculty at BITS, Pilani. The title of his thesis was 'Self Excitation and Measurement of Voltage in High Voltage Belt Generator' (Subudhi, 1956). Also, R D P Gupta, a research student of Dasannacharya built a Nuclear Magnetic Resonance instrument and was awarded PhD in 1956 for the thesis, 'Determination of Nuclear Magnetic Moment by Resonance Absorption (Gupta, 1956).

Balebail Dasannacharya was associated with one of the important events in the history of BHU. He was the guide of M.Shakuntala, the first woman in the university to obtain a PhD degree in Physics. Shakuntala from erstwhile Andhra Pradesh completed her PhD in 1951 on positive rays. The title of her thesis was 'Minimum Doppler Displacement of H2 from Hydrogen Positive Rays' (Shakuntala, 1951). Her PhD work is based on the large exchange processes in positive rays which forms a link in understanding the inversion mechanism in laser action. After completing her PhD, she joined the Physics Department of BHU as a temporary lecturer and later appointed as a physics lecturer in Women's College of the university, where she set up the ISc physics laboratory. On intermittent leaves from there, she contributed significantly at Oklahoma on flowing plasma, in Florida on cancer application and in Atomic Energy Research Establishment at Harwell on plasma physics. She became a recognised scientist in plasma physics. She superannuated from BHU (Sakuntala, 1975). Another woman who worked under Dasannacharya and was awarded a PhD was B.V. Sita Kumari. She successfully worked on positive rays for the PhD that was awarded to her in 1955 (Sita Kumari, 1955). Thus, the Physics department of BHU has the distinction of awarding a few early doctoral degrees to women in India.

T. V. Ramakrishnan FRS, a renowned theoretical physicist of our time and DAE Homi Bhabha Professor of Physics at Banaras Hindu University, argues that due to Dasannacharya's efforts, Banaras Hindu University became one of the first university in the country where nuclear physics was one of its areas of teaching and research. It is to be noted that Ramakrishnan completed his BSc (Hons.) and MSc in Physics from BHU in 1959 and 1961. He then worked as a CSIR research fellow at BHU from 1961 to 1962. Dasannacharya retired from BHU in June 1956 after serving the university for 25 years. On account of his contribution to physics, he was elected a Fellow of the Institute of Physics, a learned society based in London for the promotion of physics education and research.

2.3 Chittar Mal Sogani and Rango Krishna Asundi

CM Sogani received DSc from BHU in 1928 under the supervision of Raman, who was an Honorary Professor of the university. The title of his thesis was 'X-ray Diffraction in Liquids' (Sogani, 1928). He was closely associated with Raman since his days at Calcutta University. Sogani as a student of Raman had a good record of research in X-ray diffraction. This is evident from the fact that he published a good number of papers on this topic with Raman (see appendix for Raman and Sogani joint papers). Most importantly, Sogani assisted Raman in his research, which culminated in the discovery of *Raman Effect* (Parameswaran, 2011, p. 109). He joined the Department of Physics at BHU as Reader in 1928. At BHU, he taught 'X-rays' as a special subject in MSc till he retired in the early fifties as a Reader. TV Ramakrishnan informs that with Raman, Sogani discovered that

> X-rays scattered by dense fluids give rise, not to Bragg spots as in crystals, but diffraction or scattering patterns characterised by concentric circles, that is, intensity peaks not in particular directions but all along a circle formed by a point on the perimeter rotated around the direction of the incident X-ray as centre (Ramakrishnan, 2011, p. 955).

However, about this time, another physicist who tried to initiate and inspire the inculcation and cultivation of physics with locally available resources was Rango Krishna Asundi (14 August 1895–2 February 1982). He joined the Physics Department in 1939 and developed BHU into an important centre for spectroscopic research. He is best known for pioneering molecular spectroscopy in India. Impressed by Malaviya and his national university, he felt that he should contribute his best to the great institution that Malaviyaji established in the holy city of Banaras. Malaviya was such a source of inspiration for Asundi that once remmembering him he wrote, "When darkness surrounded and filled one with utter frustration, a visit to Panditji was one source of inspiration in the University which would clear away the dross of dejection and urge one on to the path of duty. I have had the good fortune of drawing upon such a fountainhead of kindness, understanding and grace everytime I sought his presence" (Asundi, 1961, p. 113). Thus, after joining BHU, Asundi with a deep sense of devotion towards Malaviya and BHU, took the responsibility of instrumentalisation of the Physics Department regarding spectroscopic research.

Born in 1895 in the Dharwar district of Karnataka, Asundi obtained various educational qualifications, including BA and BSc from Deccan College and Fergusson College (Fig. 7). He began his teaching career in 1921, when he joined Wilson College in Bombay as a lecturer. However, his

Fig. 7 RK Asundi Courtesy: INSA Biographical Memoir

enduring passion for research prompted him to visit London in 1927 to work in the laboratory of British physicist Owen Willans Richardson at King's College. On Richardson's suggestion, he worked on the problem of 'The third positive carbon and associated bands.' This research was published in the *Proceeding of the Royal Society* in March 1929 (Asundi, 1929). It is worth mentioning here that when Richardson won the Noble Prize in Physics for his work on thermionic emission in 1928, Asundi was working in his laboratory at King's College.

However, Asundi was introduced to molecular spectroscopy by RC Johnson, under whom he did his PhD in 'bands problem' at the London University. His PhD research contributed in identifying and characterizing electronic states of CO molecules. He discovered the $C^1\sum+--A^1$----II system in the CO molecule. However, another physicist, Gerhard Herzberg, discovered the same band system around the same time. Thus, it came to be known as 'Johnson-Asundi-Herzberg bands.' Asundi continued his research on this problem and found a second band system of $a'^3\Sigma' - a^3$ II, which came to be known after him as 'Asundi bands.' After completing his PhD from Kings College, his thirst for further studies in spectroscopy took him to other important spectroscopy laboratories in Europe. Asundi visited Berlin, Bonn, Leyden, Amsterdam, Eindhoven, and Utrecht and acquired knowledge in molecular spectroscopy. His visits led him to achieve excellent skills in experimental techniques for the excitation of molecular spectra (Narasimham, 1982).

Thus, with such extensive training in spectroscopy, Asundi returned to India and joined the Physics Department of Aligarh Muslim University for a brief period. At Aligarh, Asundi, with Rudolf Samuel (on Albert Einstein's suggestion Samuel was appointed at AMU), established a research laboratory of experimental spectroscopy. His term at Aligarh came to an end along with Samuel's when the latter went to Israel in 1938. However, Asundi who held very high regard for Malaviya, on his personal call, joined BHU as Reader in 1939 and became a renowned physics teacher. In the early years of BHU, he had to contend with meagre facilities for spectroscopic research. But, he soon started designing and fabricating spectrographs and excitation sources to obtain emission spectra of several diatomic molecules and polyatomic molecules such as benzene, toluene, benzaldehyde, benzoquinone, benzonitrile etc. With Nand Lal Singh, who was hired in the Physics Department as a Demonstrator, Asundi built a spectroscopy lab with a Constant Deviation Glass Spectrometer and a Hilger Medium Quartz Spectrograph with the Bunsen burner flames. The locally malleable casting workshop facilities were used to make cast stands and components of electric arc sources, along with components for assembling prism and grating spectrographs. Some high-frequency oscillators and discharge tubes were designed using the local resources and fabricated with the meagre glass blowing and electronic workshop facilities of the Physics Department to investigate gases and vapour spectra. Gradually comparators were also designed and manufactured using a travelling microscope to measure spectral lines and projectors. Viewers were assembled with appropriate lamps to visually inspect the spectra recorded on photographic plates and films (Thakur, 2014). Thus under the brilliant service of Asundi, the spectroscopic laboratory of BHU was so well equipped that discoveries and interpretations of new electronic band system in CO, CO^+, I_2, Br_2, $C1_2$ and the continuous emission bands of fluctuation type in I_2, I, C_1 was made.

Asundi and his students carried out some excellent original research at BHU. For example, one of his students, MR Padhye studied ultraviolet absorption/emission of polyatomic molecules, especially benzene derivatives. This was reported in *Nature* in 1945. Another student in his group, NL Singh detected the boric acid fluctuation bands. One of the most important works done in the spectroscopy laboratory of BHU was the study of the spectrum of the Halogen diatoms. In this experiment, P. Venkateswarlu, PhD student of Asundi, investigated the resonance series of I_2 (iodine), Cl_2 (chlorine) and Br_2 (bromine) in great detail (Venkateswarlu, 1947). Thus, Asundi had created a 'school of spectroscopy' in the Physics Department of BHU that developed into an independent Department of Spectroscopy after the independence of India (Fig. 8). In 1953, the then Vice-Chancellor of BHU, Acharya Narendra Dev granted the status of a full-fledged department to spectroscopy. Asundi was made the Head of this newly created Department of Spectroscopy (Singh, 1989). However, after Asundi retirement, this department again became a part of the Physics Department.

Asundi's engagement with physics at BHU was the fusion of nationalist aspirations with a cosmopolitan outlook on science. He assigned himself the responsibility of developing a spectroscopic laboratory to carry original and successful research programme with limited financial resources available at the university, but at the same time wanted to

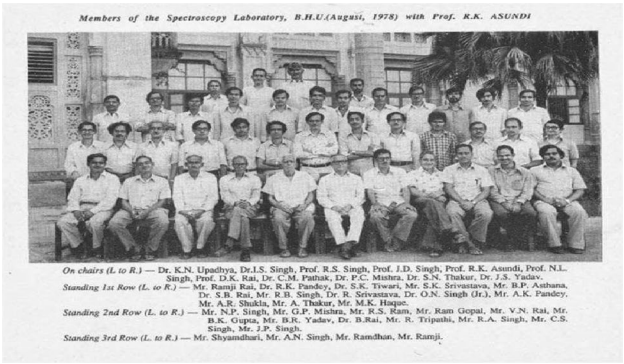


Fig. 8 RK Asundi and Members of the Spectroscopy Laboratory, Courtesy: Physics Department, BHU

Fig. 9 VV Narlikar Courtesy: Progress of Mathematics, VV Narlikar, 60th Birthday, Felicitation Volume, 1969

contribute papers in international scientific journals. A close look at his publications attests to this (Narasimham, 1982, pp. 53–56). Significantly enough, many renowned physicists of the time like G Herzberg, JG Phillips, and Rudolph have referred to Asundi's work in their own papers (Herzberg & Phillips, 1948; Minkowski, 1937). This testifies the quality of his works. He retired from BHU in 1956 and wished to live the rest of his life in Banaras because of his intense love for the sacred city and holy Ganga. However, Homi Jehangir Bhabha wastes no time inviting such a spectroscopist of world reputation to join the Bhabha Atomic Research Centre in Bombay. He played a vital role in building a spectroscopy laboratory at BARC to provide sensitive and reliable analytical service for nuclear materials.

2.4 Vishnu Vasudev Narlikar

Another brilliant young physicist closely associated with BHU was Vishnu Vasudev Narlikar (26 September 1908–1 April 1991) (Fig. 9). He taught at BHU all through his life and created an active school of research on the 'theory of relativity.' In fact, he was one of the pioneer relativists in India. Malaviya met him in England in September 1931, when he went there to attend the Second Round Table Conference as part of his nationalist politics. At that time, Narlikar was at Cambridge working under renowned astrophysicist Arthur Stanley Eddington. It is to be noted that Eddington's solar eclipse experiment of 1919 brought credibility to Einstein's theory. Narlikar was introduced to the concept of 'relativity' by none other than Eddington. Under Eddington's supervision, Narlikar had solved the Einstein field equations for a homogenous and isotropic universe, dropping Einstein's condition of a static model. He found a family of solutions to the expanding universe models that's interested cosmologists and extragalactic astronomers. Narlikar solved Einstein's equations with as well as without the λ-term to generate models of the expanding universe. Eddington was so impressed by his work that he communicated this to the Monthly Notices of the Royal Astronomical Society for publication. A list of Narlikar's publications shows that he wrote ten articles during his stay in Cambridge (Narlikar, 2014; Vaidya, 1991a, 1991b).

Malaviya, who even during his political trips used to search for young scholars for BHU, met Narlikar in Cambridge and saw the reprints and testimonials about the quality of his work that Eddington had given to him. Malaviya was very much impressed by the accomplishment of Narlikar and convinced him to join the university as a Professor of Mathematics. He joined BHU immediately after returning to India in 1932 and served the university for 28 years till 1960. Narlikar, in fact, wanted to go back to Cambridge and even had a plan for working in the Mount Wilson Observatory in America. But, Malaviya persuaded him to continue his research in Banaras while attracting good students to mathematics. It should also be mentioned in passing that Narlikar was trained in applied mathematics and was appointed to the Department of Mathematics of BHU rather than in the Physics Department. It is important to mention here that relativity was taught more as 'applied mathematics' than 'mathematical physics' in the thirties and, to that extent, not included in Physics. Primarily because of this reason, most of the research on relativity done at BHU was carried out in the Mathematics Department. VV Narlikar's son Jayant Narlikar, a renowned cosmologist and relativist of India who was also an alumnus of BHU, recounts how his father was offered a Professorship of Mathematics by Malaviya when they met in Cambridge.

> My father (Vishnu Vasudeva Narlikar) was similarly motivated to take up higher mathematics at Cambridge in preference to the lucrative Indian Civil Service. Hearing of his achievements, Mahamana Madan Mohan Malaviyaji, the founder of Banaras Hindu University, while on a visit to the UK for the Round Table

> Conference personally contacted him in Cambridge and invited him to join the BHU after completion of his studies. And he followed it up with the offer of professorship and the headship of the Mathematics department at the time my father called on him on his return to India. My father accepted the offer in preference to visiting Caltech under an international fellowship, and he stayed in this capacity at the BHU for twenty eight years during which his teaching inspired countless students. Can a Vice Chancellor today exercise the same initiative in attracting a highly talented young man to a senior post in his university? (Narlikar, 2003, pp. 6–7)

At Banaras, Narlikar mainly taught General Relativity and Riemannian geometry, in which he was an expert. He was among the mathematicians who firmly believed that research should be mandatory for efficient teaching. In one place he had stated that "When I started teaching mathematics at Banaras, I was more self-critical and I found that there were so many gaps and voids in my understanding of the topic I taught" (Vaidya, 1991b, pp. 502–503). He found the reasons for these gaps in the continuous development of a discipline and sorted out a solution in teaching and research concurrently. As far as his research activity at BHU is concerned, he has gathered several student collaborators working with him in General Relativity, Gravitation and Cosmology. This evolved into an active research school called 'The Benares School of Relativity' that produced much outstanding research published in *Nature*. It should also be mentioned that Narlikar was trained in mathematical physics and was appointed to the Department of Mathematics of BHU rather than in the Physics Department. PC Vaidya, himself a prominent physicist, who was one of his collaborators at BHU, informs that Narlikar had built a network of young scholars working on the problem of relativity. Under his guidance, there evolved an active research school at BHU engaged in the problem of Einsteinian Relativity. According to Vaidya, the primary researches cultivated at 'The Banaras School of Relativity' were (i) exact solution of Einstein's equations of general relativity, (ii) the solutions of the unified field equations of Einstein and Schrodinger, (iii) equations of motion as derived from field equations, (iv) the fourteen scalar differential invariants of the Riemannian metric, and their physical significance, and (v) the geometrical and physical properties of metrics satisfying Einstein's field equations (Vaidya, 1991a, p. 123).

The most noteworthy collaboration of Narlikar was with none other than PC Vaidya (Fig. 10). Vaidya came to Banaras in 1942–1943 amid the Quit India Movement that had taken the university by storm to work on relativity. Vaidya, who became Narlikar's external student, was suggested to work on the problem of the gravitational field of

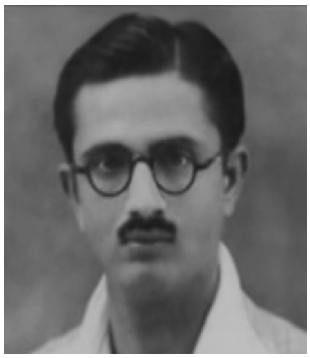


Fig. 10 P.C. Vaidya Courtesy: Indian Scientist Prof. PC Vaidya, YouTube

a radiating star. They approached the problem to calculate the gravitational field of flowing energy by comparing the radiation flowing out of a star with fluid flow. At that time, for such a comparison, it was believed by the physicists that if the fluid were to represent radiation, its density should be three times the pressure. Vaidya and Narlikar started their work on this understanding only but found it difficult to derive any tangible result. Vaidya remembers the success of their experiment in the following words:

> Once, during discussion, I suggested that, instead of assuming the pressure-density relation, we might work on the basis of velocity: if the fluid is to represent the flow of radiation the fluid velocity must be assumed to be the velocity of the radiation, i.e., the velocity of light. Professor readily agreed and said, 'Yes, that is what we should have done. We recast our calculations to suit the new assumption at that very sitting Narlikar derived the first tangible equation. This sitting ended on a happy note to derive the other two equations (Vaidya, April 1991b, p. 502).

The net result of this experiment was not only the derivation of two equations of the problem, but in fact, both solved the three equations simultaneously and came up with the complete solution of the problem. They found a solution to an outstanding unsolved problem that came to be called "Vaidya Metric" (Ramnath, 2018). This breakthrough was the generalization of the Kar Schwarzschild solution. Thus, Narlikar and Vaidya found the solution to the Einstein equation that can be used to study realistic stars. They wrote down the final solution in the form of a paper published in Current Science (Vaidya and Narlikar, 1942).

Narlikar's collaboration with Vaidya continued even after the breakthrough of Vaidya Metrics. He also collaborated with many other students of BHU, which resulted in some critical findings in the field of relativity, gravitation and cosmology. In particular, Ramji Tiwari and Kamala Prasad Singh worked on a curious solution of Einstein's Field

Fig. 11 Satis Ranjan Khastgir Courtesy: INSA Biographical Memoir

Equations. After 1950, Narlikar and KP Singh commenced a series of joint investigations on the physical significance of several metric invariants. The most significant publication of this period may be the one on the role of three index symbols in general relativity. BR Rao, another student of Narlikar at BHU, worked on the derivation of the equations of motion from the field equations themselves. Thus, whether working solo or with his research students, he published regularly in journals like *Nature*, *Physical Journal*, *Proceedings of the Indian National Science Academy* and *Current Science*.

What is remarkable about all these research works related to the theory of relativity, gravitation and cosmology carried out at the Banaras School of Relativity by Narlikar in collaboration with his student was that they were done at a time when Einstein himself was working to unify the field theory of gravitation with electromagnetism. A close look at Einstein's paper that came out during this period clearly shows that Narlikar and his students kept track of his paper and contributed to the field simultaneously. Undoubtedly, Narlikar was one of the important contributors in the field of mathematical physics in India and a teacher of high calibre. He could best be described as a teacher mathematician who uses teaching methods in mathematical research and research methods in mathematics teaching.

2.5 Satis Ranjan Khastgir

A major area of research in the Physics Department of BHU, namely Atmospheric and Ionospheric physics, was started by Satis Ranjan Khastgir (7 September 1898–6 May 1973) (Fig. 11). He was an internationally known researcher who specialized Ionospheric Physics, Atmospheric Physics, and Radio Engineering. Khastgir, born on 7th September 1898, belonged essentially to the same generation as Asundi (b 1895) and Dasannacharya (b 1896). After completing his graduation from Dacca University, he proceeded to Edinburgh for his PhD (1924) and DSc (1926) doctoral theses on the nature of X-rays. He obtained DSc working under Nobel laureate C.G. Barkla. After returning to India, he joined Dacca University in 1931 and changed his field of specialisation to studies in Atmospherics and Radio Waves on the advice of Prof. S. K. Mitra of Calcutta University—a pioneer of Radio Physics in India. He established a laboratory at Dacca University and published many research papers with his students. Unfavourable conditions in Dacca after the partition of India made him shift to the Physics Department of BHU in 1949 as Reader, where he remained till 1958. Renowned physicist Satyendra Nath Bose helped him get this position at BHU (Chaudhuri, 2007). Thus, long before joining the BHU, he already made a name in X-ray diffraction and absorption studies. Khastgir taught physics at Banaras for 10 years and built a strong research school. In recognition of his scholarship and broad experience, he was made University Professor and Head of the Physics Department when Dasannacharya retired.

At BHU, Khastgir contributed to many important different areas like fading of medium wave radio signals; stepped-leader stroke of a lightning discharge; polarization of echoes from the sporadic E (Es) and the F-layers of the ionosphere; cloud to cloud lightning discharge; wave form of atmospherics; ionospheric absorption and moving irregularities and energy spectrum of atmospherics. His engagement with physics at BHU resulted in the publication of a large number of research papers in reputed scientific journals. He published in *Nature*, *Philosophical Magazine*, *Indian Journal of Physics*, *Journal of Science and Industrial Research* and *Proceeding of National Institute of Science* (See appendix for a list of his publications at BHU).

Khastgir in his tenure at BHU supervised a good number of students that led to award many PhD's in Atmospherics and Radio Waves, Electromagnetic Theory and Electricity. Among several students who were awarded doctoral degrees under him, B.A.P Tantry is worthy of mention. One of the most brilliant students of Khastgir's research group at BHU, he was awarded a PhD for the thesis titled 'Studies in Terrestrial Atmospherics' in 1956. He later was appointed Assistant Professor in the same department. First as a student at BHU in the 1950s and later as a faculty in the same department, he contributed a good number of papers to *Journal of Geophysical Research* and *Journal of Atmospheric and Terrestrial Physics*. P.S. Venkatswamy Setty, R.U. Satyanarayana, G.V. Subhaadramma and R.N. Singh were a few other students who obtained their PhD working under the supervision of Khastgir (see reference for PhD awarded under S.R. Khastgir at BHU). A glimpse of teaching and research at the Physics Department of BHU under Khastgir is very well reflected in the following remark of one of his students and later a colleague in the same department, RS Singh.

Dr SR Khastgir joined the Physics Department of Banaras Hindu University in 1949, where he became Professor and Head of the Physics Department in 1956. He became the incharge of the Wireless Section, where he was entrusted by the CSIR to look after two research schemes: Polarisation of Down Coming Radio Waves' and Study of the Nature of Atmospherics'. Thus he was able to develop a group of young research workers in the department and the department became an important centre for doing research work in Atmospheric and Ionospheric Physics. Several persons received their PhD degrees under his guidance, and later held important positions both in the department and elsewhere. His behaviour towards his research students was very affectionate and most of them were like his family friends (Dasgupta, 1973, p. 78).

2.6 Bisheshwar Dayal

In the concerned period (1916–1960) of this study, one more physicist who was a student of C.V. Raman and appointed to Physics Department of BHU deserves mention. His name was Bisheshwar Dayal (1908–1981). A junior contemporary of Dasannacharya, Asundi, and Khastgir at BHU, Dayal was born on 9 July 1908 at Muzaffarnagar, a town in Western Uttar Pradesh. After having schooling at his native place, he moved to Banaras and joined BHU, where he did MSc in Physics in 1930. In the same year, he was appointed Lecturer in Physics at Meerut College. But in 1932, he returned to BHU as a Demonstrator in the Physics Department (Calendar 1937–1938, p. 349). As a demonstrator, he was exposed to various research conducted in the physical laboratory of the department, which aroused in him an interest for research.

As already mentioned, Raman was elected Honorary University Professor of Physics as soon as BHU was established. He frequently used to visit BHU and occasionally supervised students of the university also. In 1940, Bisheshwar Dayal enrolled himself as a doctoral student in the Physics Department of BHU but went to Indian Institute of Science in Bangalore to work under the direction of Raman. Under Raman's supervision, he studied specific heats of metallic silicon and alkali halides based on the Raman theory of crystal vibrations. Following the same theory, he worked on thermal expansion of various solids, viz. diamond, tungsten, lithium, sodium, silicon and alkali halides. Dayal also worked on diffuse X-ray scattering. He worked at Indian Institute of Science for 4 years, 2 years (1940–1942) as a Researcher and 2 years (1942–1944) as a Research Assistant. In recognition of his work on X-ray reflection of the second kind in metallic crystals, he was awarded Associateship Diploma by IISc (Khare, 1981). In 1944 BHU honoured Dayal by conferring on him a DSc degree of the University. His thesis titled, 'The Thermal Properties of Some Cubic Crystals' was written under the supervision of Raman' (Dalal, 1944). He received the degree from Sarvapalli Radha Krishnan, who was then the vice chancellor of BHU.

Dayal rejoined BHU and continued his investigations on lattice dynamics. This resulted in the publication of several original papers (For a list of Bisheshwar Dayal publications, see Khare, 1981, pp. 103–108). In 1945, he evaluated specific heats of metals by Born-Forsterling method and vibration spectrum of Rutile. After working for 10 years at BHU, he took an educational leave and went to Britain to join the famous school of J.D. Bernal FRS, one of the highly acclaimed crystallographers of his time. In a brief period of 8 months at Birkbeck College, London, he also worked with distinguished physicists Reinhold Furth, FRS and H.C. Carlisle. Dayal's visit to Britain was very fruitful as in recognition of his contributions to crystallography, he was elected Fellow of the Institute of Physics in London, on 19 July 1955. Most importantly, it also shaped the course of his research in India. Immediately after returning to India, BHU promoted him to a Reader's post in 1955. Dayal became Professor in 1962 and served as Head of the Physics Department from 1965 to 1970.

Around 1956, Dayal formed his own group of lattice dynamics at BHU and remained one of the pioneers and active crystallographers practically to the end of his life. Dayal's group at Banaras extended the studies done by him in Bangalore and London. At BHU, Dayal made use of finer meshes for calculations as demanded by the rigorous lattice theory. Their work included phonon dispersion relations, specific heats, equation of state and thermal expansion of various metals and salts (particularly alkali halides) using the rigid ion model, shell model, modified shell model and Krab's model. He worked on various other aspects of solid-state physics also. Interestingly, he studied the structure of Morelli, an antibiotic by X-ray diffraction method. He calculated the areas of a cross-section of the molecules on liquid surface. The substances studied were some organic compounds and alkali halides (Khare, 1981). Dayal engagement with physics at BHU can also be reflected from the fact that not less than thirty students were awarded PhD in Physics from the university under his supervision (see Raghav, 1986). His students loved him so much that soon after his retirement, many of his ex-students created a fund for awarding 'Prof. B. Dayal Gold Medal' to the topper of MSc (Physics) in the university.

It is worthwhile mentioning that Dayal, in the vision of Malaviya, who thought of teaching science and technology at BHU in Hindi, took a keen interest in the use of Hindi in teaching science and contributed several articles on physics witten in Hindi to 'Hindi Vishwa Kosh'. He also

wrote a book entitled *Radar Parichay* in Hindi. He also wrote another book, *Heat and Thermodynamics*, for the undergraduate student with his student M. Verma and S. Pandey (Dayal et al., 1966). Dayal's 40 years of association with BHU ended when he retired in 1971 and joined the Physics Department of the Institute of Advanced Studies at Meerut University as Emeritus Professor. In recognition of his contribution to physics, two leading scientific bodies of India, Indian National Science Academy (INSA) and National Academy of Science (Allahabad) elected him a Fellow.

3 Conclusion

Banaras Hindu University was established as a national institution with a special focus on modern scientific education and its applied aspects that had contributed to the development of western nations but denied to colonised people. Its founder Pandit Madan Mohan Malaviya was very concerned about appointing talented young Indians well-trained in the metropolitan centres of science in Europe and America. Considering the colonial background, when funding for scientific research in a universities were meagre, and career trajectories for aspiring scientists was also uncertain, the appointment of physicists like Sethi, Dasannacharya, Sogani, Asundi, Narlikar, Khastgir, and Dayal at BHU was quite noteworthy. These physicists working BHU at a low salary, indeed was the manifestation of their nationalism. As the nationalist consciousness and aspirations were already inculcated in the mind of scientific community in India, it must have been a matter of internal satisfaction and pride for the scientists to work in a national institution like BHU. In a way, these physicists were as much partners in the Indian National Movement as Malaviya. U.A. Asrani of the Physics Department directly participated in the Civil Disobedience and Quit India Movement and was detained by the colonial government. Others though did not directly participate in the political struggle, but their dedication for the scientific research reflected their intention of raising the status of BHU and India in physics in the national interest.

Also, to a large extent, the training of physicists appointed at BHU at the metropolitan centres of science determined their teaching and research at the university. For example, Dasannacharya's exposure to new ideas in physics teaching in Germany and America inspired him to establish India's first Physics Museum at BHU. While Narlikar's training in the 'theory of relativity' at Cambridge led to the emergence of "The Banaras School of Relativity". Asundi spectroscopic research in big spectroscopic laboratories of Europe pioneered its study in India and culminated in the establishment of an independent Department of Spectroscopy at BHU. Last but not least, Khastgir, who worked on X-ray diffraction and absorption studies at Edinburgh under Nobel laureate CG Barkla played a pivotal role in introducing Atmospheric and Ionospheric physics at BHU. By the mid-fifties Physics Department at BHU was teaching x-rays, spectroscopy, positive-rays, nuclear physics, cosmic rays, wireless, and atmospherics and radio waves as special subjects to MSc students. At the same time, research in these topics was also promoted at BHU. Thus, BHU, in his own humble right, significantly contributed to the development of physics education and research in India.

Appendix

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