

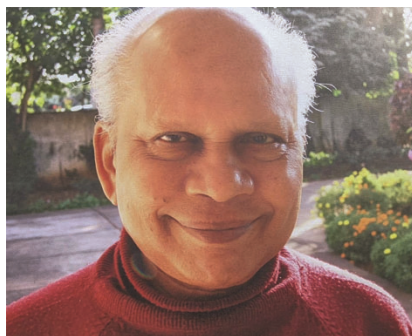
Trilochan Pradhan (1929–2021)

Eminent theoretical physicist and Founder Director of the Institute of Physics (IOP), Bhubaneswar, Trilochan Pradhan expired on 4 December 2021 after a brief illness. He leaves behind his wife, son and daughter.

Pradhan was born on 3 January 1929 in Ghanashalia village, Nayagad district, Odisha. After his matriculation in Nayagad High School, he joined Revenshaw College in Cuttack in 1945 and completed his B.Sc. degree with Physics Honors. He was the best student and received the Mayurbhanj Gold Medal. Pradhan then moved to Banaras Hindu University (BHU), Varanasi in 1949, from where he completed his M.Sc. in 1951, securing the first rank. After his M.Sc., he joined Revenshaw College as a faculty. In 1953, he went to University of Chicago, USA, for his Ph.D. He was taught graduate courses there by celebrities like Enrico Fermi. Pradhan had a beautiful handwriting and was neat in problem-solving. It is a delight to go through the problem sets that he worked out during his graduate courses. Special mention may be made of the problems in quantum mechanics which were given by Fermi. While teaching the quantum mechanics course, these unusual problems came in handy for me. Special mention may be made of the problem of perturbation theory around a two-dimensional rotor which Fermi had given to Pradhan's batch, warning them not to copy from books as it was wrongly done there. I might recall that this problem has been done wrongly in the books on quantum mechanics by Linus Pauling and E. Bright Wilson, and several others. Subsequently, Pradhan and I brought out the subtle aspects of this problem in a paper, in the *American Journal of Physics* in 1973.

Pradhan completed his Ph.D. in 1956 under the supervision of M. Goldberger. His Ph.D. thesis was entitled 'Electron capture by protons passing through hydrogen'. His first paper in 1957 based on his Ph.D. thesis was on atomic collisions. In this paper he essentially introduced the impulse approximation in atomic collisions. This paper has received wide attention and has also been mentioned in the books on atomic collisions. After his Ph.D. Pradhan stayed on at Chicago University and during 1956–57 did postdoctoral work under famous astrophysicist S. Chandrasekhar. It was during this period that his second paper was published. It was about Landau damping in plasma oscillations in

a uniform magnetic field. This has also received wide attention and has been mentioned in books. Subsequently Pradhan moved to Niels Bohr Institute in Copenhagen, Denmark, for his second postdoctoral stint in 1957–58. During this period, he worked in the area of quantum field theory which resulted in his paper in 1958, while in 1960 he had a paper about dielectric constant of a dense electron gas. Special mention must be made of his 1958 paper in *Nuclear Physics B* about what is popularly known as the Schwinger term, though Schwinger's paper came in 1959. His first four papers, all single author, were not only of high quality but also in four entirely different fields, which is unusual. Pradhan continued to write papers on plasma physics and electron gas till 1970, while he had his last paper on atomic collisions as late as in 1994.



Pradhan returned to India in 1958 and joined his previous job at Revenshaw College. During his four years of stay there, he inspired a generation of students who subsequently became good physicists. By now, Pradhan's work had become well known and in 1962 he joined Saha Institute of Nuclear Physics (SINP), Kolkata as Associate Professor in the Theoretical Nuclear Physics Division. For Pradhan, teaching was an integral part of research, and he helped improve and strengthen the post-M.Sc. course there for students who wanted to join for Ph.D. after doing their M.Sc. I might add here that undoubtedly that was the best graduate course in the country at that time. After M. K. Banerjee left for USA in 1965, Pradhan became Professor and Head of the Theory Division and remained in that position till 1974. During this period he would assign some research papers of current interest to the Ph.D. students and ask them to give a se-

minar on them to the entire Theory Group. Besides he invited several eminent physicists to visit the Theory Division and give a series of lectures on some important topics of current interest. Special mention may be made of a set of lectures by G. Rajasekaran on nonabelian gauge theory, which was still in its infancy. Lecture notes were taken by a Ph.D. student and subsequently widely circulated to the physics community in the country. Similarly, N. Mukunda gave a set of lectures on non-compact groups, for which notes were again taken by a Ph.D. student and again widely circulated to the physics community in the country. I am not sure if the younger generation can appreciate how invaluable these lectures were for the semi-isolated physics community in the country.

During this period, Pradhan was also active academically and in several totally different areas. He had several single-author papers till 1967. By 1965, it had been proved that a massless particle with spin one or greater than one cannot have an electric charge. In 1965, in a paper in *Nuovo Cimento*, Pradhan extended that proof to spin-half particles. During this period he was guiding Ph.D. students simultaneously in the area of plasma physics, atomic collisions, quantum field theory and particle physics. After 1967, most (though not all) of his papers have been with his Ph.D. students. After 1970, Pradhan's papers were primarily in the areas of quantum field theory and high-energy physics. If one looks at these papers it is clear that Pradhan never followed the current fashion, but always worked on his own ideas. Further, most of his ideas were rather novel and unconventional.

My association with Pradhan started in early 1967 when I did my post-M.Sc. review on current algebra with him. Subsequently I joined him for my Ph.D. in August 1967. Pradhan was a remarkably open-minded person. In my first meeting with him, he told me not to accept what he says, but think and accept only if I am convinced and, if not that I should argue out with him. This helped me develop our relationship where we would argue vigorously about issues. It is to the credit of Pradhan that he always took these debates and discussions in the right spirit and never took the criticism personally. I have not met many people in this country who really follow the same. This advice has helped

me immensely while collaborating with several people world over.

This was the period in Kolkata when the Naxal movement was at its peak and the situation was rather chaotic, but it was also a period full of vitality. So many creative things were happening in different spheres including movies, dramas, music, painting and science. An amazing aspect about that period in Kolkata was that even ordinary people gave so much respect to those involved in scholarship, no matter what sphere of human activity it was. I think the Naxal period had made a profound lasting impression on all those who had experienced it first hand. Many faculty and students were affected and got distracted from their research work. Pradhan saw to it that his research work never suffered. He would invariably be at his desk by 8.30 am and would work till 5 pm, six days a week, travelling 10–12 km by the famous 8B bus. We spent hours and hours during that period discussing several physics problems. He always emphasized that no matter how good you are, there is no substitute for hard work. It is this training that has helped in shaping my career. I must add that Pradhan was socially conscious and when the faculty and staff of SINP were up against a medical doctor, he too took a stand and joined the protest.

Pradhan always encouraged younger people. In 1970, when I was still doing my Ph.D., on his recommendation, in the spring semester, I was asked if I could teach the course on particle physics to the post-M.Sc. students. I gladly agreed and taught it again the next year. It was such an invaluable experience for me and helped my teaching in subsequent years.

I consider myself to be fortunate that by the time I left for Tokyo for my postdoctoral in March 1973, Pradhan and I became extremely close and even while I was in Tokyo, we maintained contact with each other through letters. His letters were always encouraging and inspiring. In August 1974, I got a letter from him informing me of his leaving SINP and joining the newly formed IOP as the founder Director. He asked me to come and join in this endeavour. I, of course, jumped at this opportunity and that started our second relationship.

It is remarkable that State Government of Odisha thought about starting a research institution for physics in the 70s. The genesis of this goes back to the more than one hundred fifty year old Ravenshaw College, which had a good physics department with excellent teachers. They inspired stu-

dents and many of them turned out to be physicists of high caliber, who occupied important positions in research institutions and universities in India and abroad. This was noticed by top physicists in the country and some of them, including Prof. D. S. Kothari suggested to then Education Minister of Odisha Banamali Patnaik to create facilities for research in physics in the state. Patnaik was a remarkable person with a vision and had carried out several administrative reforms in higher education in Odisha. He took the suggestion of Kothari and others seriously and that was how IoP was established as an autonomous institution by the Government of Odisha. It is to the credit of the politicians and bureaucrats of Odisha that all of them enthusiastically supported IOP for ten years with liberal funding and there was no political interference in either the appointment of faculty or the day-to-day functioning of the Institute. Looking at the history of independent India, starting and then nurturing of IOP by the Odisha Government is a rare event. It is doubtful if such a thing will be ever repeated again in the country.

Even though IOP officially came into existence in 1972 as an autonomous research institution under the Government of Odisha, it really took off on 4 September 1974 when Pradhan joined as its founder Director. Soon, it moved to a rented building in A-105 Saheed Nagar. When I reached the Institute at Saheed Nagar in early January 1975 (the faculty interviews only took place by the end of January and I joined on 30 January 1975), there were only a couple of tables and chairs and 20–30 books in the library. It is amazing how under the leadership of Pradhan, IOP was built literally from scratch. By the end of 1975 about 14 faculty members had joined, most of them young, and the atmosphere was simply electric. Everyone was excited to be a part of building something special and Pradhan encouraged all of us to make suggestions. There were debates, discussions, and at time differences, but Pradhan took it all in the right spirit and allowed ‘100 flowers to bloom’. To bring everyone together, he saw to it that there were picnics, monthly feasts, bridge sessions and screening of excellent BBC documentaries.

Pradhan was working 24 × 7 during those days. Thinking back, I am amazed how he still managed to find time to do physics. In two months, he and I worked on two of his ideas: (i) diagrammatic technique for atomic collisions and (ii) com-

plex scale dimension plane. The first two preprints from IOP came out in March 1975, while the first paper appeared in a journal (*Physical Review Letters*) in June 1975.

Pradhan decided right in the beginning that a one-year pre-doctoral course should be started right away and those who successfully passed this course would be awarded a pre-doctoral diploma in advanced physics and be eligible to carryout Ph.D. work under the supervision of the Institute faculty members. The first batch joined in August 1975 and the programme is continuing uninterrupted till today. This programme has been invaluable both for students as well as faculty. Pradhan wanted me to teach a course on classical electrodynamics. It is well known universally that this is the toughest course to teach. Thanks to him, after teaching this course I was confident that I could teach any course in theoretical physics.

One nontrivial issue was the procurement of the back volumes and current issues of standard journals as well as books. Pradhan got addresses of the back volume suppliers in USA and by 1977, IOP had back volumes of almost all the standard journals at almost throw-away prices. With the funding available from the Odisha Government, it was possible to order most of the standard current journals. Several books were purchased from Indian sources and by the end of 1977, the Institute had a reasonably good library. Pradhan continued to do research even during those busy years as Director and wrote several papers with me as well as his Ph.D. students.

Another generous support from the Government of Odisha was in the form of donating 50 acres of land for the establishment of a permanent campus of the Institute. Further, it also gave funding for the construction. Pradhan wisely decided to erect a compound wall first, which gave identity to the Institute and saved it from encroachment. The main building and the hostel were completed by August 1981 and the Institute moved to its new campus after inauguration of the campus by the then Prime Minister Indira Gandhi on 4 September 1981. I might add here that while the building was being constructed, Pradhan was paying personal attention and everyone agrees that the main building constructed during that period is much better even today compared to all the other buildings constructed later on the campus.

By 1979 Pradhan had realized that with the available resources, the Institute cannot

do first-rate research in experimental areas and attempts were made to seek financial assistance from the Department of Atomic Energy (DAE), with the final goal being to go under the DAE umbrella. Thanks to the efforts of Pradhan and others, IOP joined the DAE family in 1985 as an aided institution like TIFR, SINP, etc.

Pradhan superannuated from IOP in January 1989. In the same year he was appointed as Vice Chancellor of Utkal University, Bhubaneswar, and occupied that position till 1991. In 1990 at the invitation of Pradhan, the Indian Academy of Sciences (IAS), Bengaluru, held its annual meeting in Bhubaneswar. It was jointly organized by Utkal University and IoP, and under the joint leadership of Pradhan and V. S. Ramamurthy, the then Director of IOP. The Academy meeting was a great success. Late Anna Mani wrote to Ramamurthy mentioning that this was the best meeting ever of IAS.

One of Pradhan's profound insights was about the magneto-electric effect. Unfortunately, he was ahead of his time. One might recall that in recent years multiferroics and magneto-electric materials have received wide attention both theoretically and experimentally. Pradhan got interested in magneto-electric materials in the early

eighties. His work on the magneto-electric effect and its connection with axial anomaly and PT symmetry is a forerunner to the present-day topological insulators. In one paper, Pradhan and I showed that the vacuum of the $2 + 1$ -dimensional quantum electrodynamics with Chern–Simons term shows magneto-electric effect. In 2006, in a paper in *Physica Scripta*, Pradhan looked at the Raman spectra of magneto-electric crystals. He was naturally attracted to symmetries and had made subtle use of them in several of his papers. Few years ago, he told me that he was looking at $SU(2)$ and $SU(3)$ symmetries and their violation in the periodic table. His study of photon confinement in an appropriate refractive index profile, viewed in the context of optical fibres, reveals his deep foresight. Pradhan's recent work on L-charge atoms and its relevance for the three-body problem, leading to an estimation of the ground state energy of helium atom and H^- ion shows his insight in connecting the classical and quantum domains.

Pradhan has authored two books. The first one entitled *The Photon* was published by Nova Science Publishers, New York, USA, while the second book entitled *Quantum Mechanics* was published by University Press, Hyderabad. He has also

edited a book based on the proceedings of the symposium on Current Trends in Physics held in IOP in 1986, and published by World Scientific, Singapore. Pradhan has chaired many committees tasked with academic evaluation of several academic institutions and has suggested a road map for their excellence.

Pradhan's contribution to scientific research and institution-building has been well recognized in the country. He became a fellow of IAS in 1974. He got the Meghnad Saha Award for Theoretical Sciences hosted by Hari Om Ashram (UGC) in 1980. In 1990, the Government of India conferred him with the Padma Bhushan. He received the Kalinga Samman in 2014 and Kalinga Ratna in 2018. He was President of Indian Physics Association (IPA) from 1983–85.

Pradhan's death is a huge loss not only to his friends, family and the IOP community, but personally to me as well since I was closely associated with him for the past 54 years.

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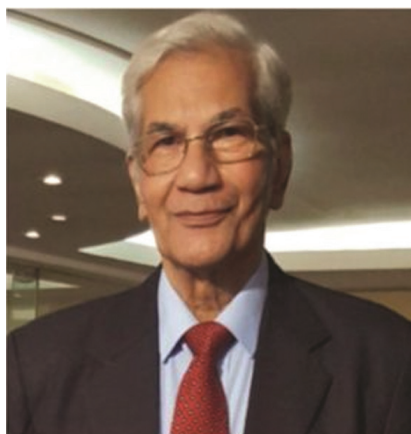
I. B. S. Passi (1939–2021)

Eminent Indian mathematician Prof. I. B. S. Passi passed away on 2 October 2021 in Mohali, Punjab. He was born on 20 August 1939 in Bilaspur, Jagadhari district, Haryana and lived mostly in Punjab.

The journey of Passi, especially as an academician, is noteworthy, being decorated with several achievements, including the Shanti Swaroop Bhatnagar (SSB) prize, the highest science award in India, in the Mathematical Sciences category.

Passi graduated from D. M. College, Moga, Punjab in 1958, and moved to Panjab University, Chandigarh, where he completed M.A. in mathematics in 1960. His first appointment was at the National College, Sirsa, Haryana as a Lecturer in 1960. In 1961, he joined the Department of Mathematics, Kurukshetra University, Haryana. In 1963, Passi was awarded the Commonwealth Scholarship to work at the University of Exeter, England, UK, with Professor David Rees, who was popular

amongst algebraists for the Artin–Rees lemma. After receiving his doctoral degree at Exeter, he returned to Kurukshetra University in July 1966, where he became a Reader in 1967 and eventually a full Professor in 1975. In 1979, Passi joined the



Centre for Advanced Study in Mathematics, Panjab University where he served as a Professor until his retirement in 2000. During this tenure, he served in the administration as well. He was Chairman, Department of Mathematics during 1984–87; Dean Alumni Relations (1990–91), Dean Foreign Students (1991–92), Dean Faculty of Science (1995–96), Dean University Instruction (1997–99) and Convener of University Programs Committee National Board for Higher Mathematics (1992–2002). Along with administrative responsibilities, he was also doing exceptionally well academically, receiving several prestigious awards and fellowships. The most prominent ones being the SSB Prize (1983) and Meghnad Saha Award for Research in Theoretical Sciences (1988). In 1986, he became Fellow of the Indian Academy of Sciences as well as the National Academy of Sciences. In 1989, he was elected fellow of the Indian National