Lalit Kumar Pandit (1932–2006)

The well-known theoretical particle physicist Lalit Kumar Pandit (called Panditji universally by his Indian physicist acquaintances) passed away following a cardiac arrest on 23 May 2006, while visiting his elder son in Boston, USA. This is a discernible loss to India's theoretical physics community, which will mourn the demise of one of its valued members.

Born into a Himachali Pandit family in 1932, Lalit Kumar was the fifth of the nine children of Pt. Chandu Lal and Smt Kalavati Sharma. Pt. Sharma was employed at the Archaeological Department of the Government of India, which functioned for six months of the year at Shimla and for the rest at Delhi. Young Lalit attended the Harcourt Butler Senior Secondary School, which also worked at Shimla and Delhi for six months each, and stood first in the 1948 Secondary Board Examination as well as in the all-India entrance scholarship examination conducted by Delhi University. The latter result led to a fully funded (tuition plus boarding) scholarship that enabled this member of a family of humble means to enrol at the elite St. Stephen's College, Delhi for the B Sc Physics Honours course, which was actually conducted by the University of Delhi. He graduated in 1951, again topping the list and securing a further full scholarship of two years to complete his M Sc in 1953 from the same university. Thus for five years he received training in physics under the tutelage of India's stalwart professors of the time such as Daulat Singh Kothari and Ramesh Chandra Majumdar. After his M Sc, Panditji spent a year working as a research fellow under Majumdar. In 1954, he won a Government of India full educational scholarship to go to Zurich, Switzerland for the pursuit of his doctoral studies at the university there.

At Zurich, Panditji chose to conduct research in the newly developing area of high energy particle physics. He was guided by the distinguished quantum theorist, Walter Heitler (author of the book *Quantum Theory of Radiation*), working under a group headed by Wolfgang Pauli. The last-named impressed the young doctoral student so much as to leave in him a lifelong sense of reverence for the great physicist. Panditji's Ph D thesis, written in 1957, comprised a number of both static and dynamical calculations in pseudoscalar meson theory. While the static ones computed the anomalous magnetic moments of nucleons, the dynamical ones addressed the electron–proton scattering process at high energies. These calculations represented some of the first instances of the utilization of the covariant integration method (applied with a cut-off) pioneered by Suraj Gupta. Also, while at Zurich, Panditji wrote a review

on the properties of linear vector spaces with indefinite metric. This subject was timely in the wake of the use of such spaces in the covariant handling of the gauge-fixing problem in quantum electrodynamics. A major emphasis in the said article was on the general lack of reality of the eigenvalues of a Hermitian matrix and the consequent non-orthogonality of the corresponding eigenvectors in such spaces. All categories of this behaviour were in fact systematically studied in this paper.

Returning to India in 1958, Panditji accepted Homi Bhabha's invitation to join the Tata Institute of Fundamental Research (TIFR), Mumbai where he stayed till his retirement in 1992. During his first few years at TIFR, he worked on the properties of K-mesons in collaboration with Samarendra 'Dada' Biswas, proposing different methods for determining their relative parity with respect to other baryons. He did spend some time in 1960 as a postdoctoral visitor to the Istituto di Fisica at Padova, Italy, collaborating with Nicola Dallaporta to explore the internal symmetry properties of baryons. These were studied in relation not only to baryonic mass differences, but also to the interactions of the baryons with π- and K-mesons.

The three years from 1963 to 1966 were spent on a visiting assignment at the University of Rochester, USA. Panditji's initial work there concerned various mathematical properties of the newly proposed internal symmetry group SU(3). This was done in collaboration with Narasimhaiengar Mukunda, who was there at the time. Together they developed computational techniques utilizing irreducible tensors of the said group. Methods were found for determining the direct product of two general irreducible representations of SU(3) and for the computation of some of the associated Clebsch–Gordon coefficients. In essence, a spinor calculus for SU(3) was developed. Afterwards, Panditji did some renowned work with the famed Rochester particle theory group led by Robert Marshak. The most notable result, obtained together with Vishnu Mathur and Susumu Okubo, was a soft pion theorem (also derived at the same time and independently by Curtis Callan and Samuel Treiman, Princeton University) on the weak three-body semileptonic decays of the strange and charged pseudoscalar mesons $K^{\pm}$. This theorem utilized both Richard Feynman's Partial Conservation of the Axial Vector Current hypothesis as well as the SU(3) $\otimes$ SU(3) algebra of hadronic weak and electromagnetic currents, proposed by Murray Gell-Mann. The result was hailed as a major breakthrough since neither perturbative field-theoretic nor S-matrix methods, developed earlier, could be applied successfully to such a low-energy, weak process involving strongly interacting particles. Then a new idea came from Panditji and Riazuddin with a certain amount of prescience. They proposed the existence of a unitary transformation (rather akin to the famous one due to Foldy and Wouthuysen) between two sets of quark fields that are now known as current and constituent quarks. This was a precursor to what later came to be known as the 'Melosh transformation'. Other interesting works emerged from collaborations, of which Panditji was a member, pertaining to hyperon magnetic moments and to the mass difference bet-

ween the short- and long-lived neutral kaons – calculated by current-algebra techniques. Because of all this success, Panditji was invited to talk about applications of the algebra of currents at the Coral Gables Conference of 1966. Given the fame that he had acquired at that time, Panditji could have easily accepted a job offer in America and stayed on in that country. But a strong sense of patriotism and a commitment to build up a good school of researchers at TIFR made him return to his homeland.

Back at TIFR after 1966, Panditji along with his younger colleagues started detailed studies of a variety of mesonic decays based on underlying symmetry principles such as the algebra of currents and asymptotic SU(3) as well as chiral SU(3) $\otimes$ SU(3). These led to several interesting results. For instance, the decay widths of the vector meson ϕ as well as of the non-strange and strange axial vector mesons A_1 and K_A respectively, were computed using the spectral function sum-rules proposed by Steven Weinberg. Another set of investigations led to a reasonably complete description of the four-body semileptonic decay of the K-meson as well as detailed studies of nonleptonic weak decays. The mid-sixties witnessed a real flowering of Panditji's creative talents with several papers published in the prestigious *Physical Review Letters* and an invited review article (coauthored by Vishnu Mathur) in *Advances in Particle Physics*, edited by Rodney Cool and Robert Marshak. Quite a few of the results, with the derivation of which Panditji was involved, became benchmarks for the subsequently formulated theory of strong, weak and electromagnetic particle interactions, viz. the Standard Model, to agree with. That agreement necessitated the development of chiral perturbation theoretic techniques within the later established framework of quantum chromodynamics and the electroweak theory. One can say therefore that these results paved the way for the development of those techniques. Panditji's lectures on the subject in the 1967 Dalhousie summer school, which came out as one of the famous yellow reports of TIFR, convey to the reader the sense of excitement in the field at that time. It was largely on the strength of the above works that Panditji was elected a Fellow of the Indian Academy of Sciences, Bangalore in 1976. Afterwards, his interests shifted to the algebra of bilinear quark operators on the light-cone. Again, his clear, informative and pedagogical lectures on the subject in the Dalhousie summer school of 1973 were much appreciated by all those who attended them.

Through the nineteen seventies and eighties, Panditji and his colleagues continued their studies on newly emergent phenomena in particle physics, from the J/ψ to neutral currents and heavier families, using symmetry groups such as SU(4) and $U(3)_W$. When the new revolution in high-energy physics moved the focus of particle dynamics away from global symmetries into gauge symmetries and their characteristic features, such as screening and confinement, Panditji kept track of all those developments enthusiastically. He participated in the 1982 International High Energy Physics Conference in Paris, where the Standard Model was given a canonical status. On his return, Panditji gave a colloquium on the meeting in which he said that, as an interested outsider, he could talk about 'vintage physics deliberations observed from a vantage point'.

Panditji was a wonderfully warm person and always radiated bonhomie as well as goodwill. He was a spirited teacher who infected his students with his boundless enthusiasm communicated through the frequent waving of his arms. On the other hand, he was an extremely nice individual, being gentle, considerate as well as kind and helpful – especially to younger colleagues such as the undersigned. He would go out of his way to persuade TIFR authorities to help new academic entrants into the Institute in mundane but essential matters such as housing, of which there was an acute shortage in those days. Whatever he felt to be worthwhile was pushed with elan and verve by Panditji. He would never lose his composure in any discussion, however controversial, and his smile was always a source of reassurance to his colleagues and students alike. His vibrant presence in summer schools that TIFR regularly organized over the course of two decades, was a stimulus to the students. The long walks that one had with him at the venues of such schools at Dalhousie, Mahabaleswar and Panchgani are memorable for the wise words and insightful advice which came from him.

After his retirement from TIFR, Panditji moved to Delhi and lived in his family house in Green Park. He was seen from time to time in various particle physics meetings held at Delhi. He participated with gusto in the Theoretical Physics Symposium SUJAYATA, held at TIFR in 1996 to celebrate the golden jubilee of the Institute. In the last part of his life Panditji's energy did turn inward, making him meditative and spiritual. But his enthusiasm and love for life and his cheerful demeanour remained intact and did not diminish at all. In a recent meeting held at IIT, Delhi, to consider steps to attract motivated and good students to science, Panditji was heard saying 'Show them that you enjoy doing science and they will come automatically'. He had a heart attack about eight years ago, but did rebound to active life after that. The second heart attack this time proved fatal. He was supposed to speak in the next academic semester to the students of IIT, Delhi at the invitation of Ajoy Ghatak, on the history of quantum mechanics and his personal interactions with Nobel laureates in that area. Unfortunately, things turned out otherwise. Panditji is gone. He will be missed not only by his surviving wife and three children but by all those who knew him and had the benefit of his wisdom.

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