In this issue

George Sudarshan and the theory of weak interaction

As I thought about it, as I beheld it in my minds eye the goddam thing was sparkling, it was shining bright... I felt that it was the first time, and the only time in my scientific career, that I knew a law of nature that no one else knew. It was not as beautiful as Dirac's or Maxwell's but my new equation for beta decay was a bit like that. It was the first time I discovered a new law, rather than finding a more efficient method of calculating somebody else's theory... I felt all the thrill of a new discovery. I thought now I have completed myself.

Such were the effulgent words used by Richard Feynman, one of the great scientists of our era, when in 1958 he constructed the (V–A) theory of the weak interaction. He felt that the Creator had revealed one of His laws to him through a direct hotline. It also puts into perspective the importance of this discovery and gives us a feel for the achievement of George Sudarshan (a 26-year-old graduate student at Rochester with Robert E. Marshak) who had made just this discovery some time earlier.

It is stated by experts that the chirality invariance derivation of the (V–A) theory in the original Sudarshan–Marshak paper has stood the test of time, while, in contrast, the Feynman–Gell-Mann version derived from the two-component Klein-Gordon equation has been found to be field-theoretically wanting and had therefore to be discarded. We reproduce the two original papers [from the Proceedings of the Padua Conference (1957) and *Physical Review* (1958)] on **pages 65** and **76** so that the *cognoscenti* can decide for themselves.

On **page 60** we publish the moving lecture by Marshak relating the story how George Sudarshan, at just the age of 26, made this remarkable discovery and the sad account how due to a series of events he did not receive the credit due to him. Marshak, one of the greats in particle physics, George Sudarshan's professor and thesis adviser, in this gracious and self-effacing tale gives the lion's share of the credit for this discovery to 'young' George. Says he: 'George — your mastery of Cartan's *Leçons sur les spineurs*, before you left Bombay for Rochester (1955) served you well!'

When Becquerel discovered radioactivity he proposed the hypothesis that beta rays consist of electrons. Even after this was definitely established in 1948 no one had an inkling as to why an atom should emit these electrons with such different speeds. With the discovery of the neutron it was suggested that, inside the nucleus, the neutron actually disintegrates to form a proton and an electron. Using Pauli's suggestion Fermi decided that an extra particle, the chargeless and almost massless 'little one' (the neutrino), was emitted in beta decay. (It turned out to be an antineutrino!) Fermi had discovered the existence of a new force in nature normally far weaker than the force of electromagnetism but of very great importance. *Nature* rejected this epoch-making paper of Fermi's and he published it in *Ricerca Scientifica*.

It was with rare intuition that Fermi hypothesized that the beta decay was a vector interaction. Many things happened after this, including the discovery of parity violation. Physicists then classified elementary particle interaction into five kinds: scalar (S), vector (V), tensor (T), pseudoscalar (P) and axial vector (A). We invited N. Mukunda, an early doctoral student of Sudarshan, to write a Commentary to explain to us the significance of this discovery (**page 59**). If there is a universal Fermi interaction, Sudarshan and Marshak asserted, it had to be a mixture of V and A — infact (V–A), i.e. it was a vector (V) interaction along with the axial vector (A) introduced to account for parity violation.

Marshak's lecture truly shows the sadness that can envelope an young man's life, even though at the age of 26, Sudarshan makes a great discovery. Sudarshan was at that time on leave of absence from India.

It is said that Sudarshan drew the short straw once again when he did his beautiful work on coherence. Experimenters are aware of the brilliant work of Hanbury Brown and Twiss who courageously extrapolated the classical ideas of optics to the quantum domain and evolved the revolutionary concept of intensity interferometry. It took a long time for many even to accept the incredible step that these scientists had taken. Sudarshan revived an old idea which was lying dormant since the days of Schrödinger — the coherent state. A few mathematically minded physicists like Bargman did realize the importance of this concept. Sudarshan applied the coherent state to light and showed the applicability and limitations of the classical theory of light. Glauber of Princeton did this work almost at the same time. There are some who feel that Sudarshan did not get proper credit for this work too; although it must be stated that in the book edited by Mandel and Wolf (the renowned red and blue collection) both Sudarshan's and Glauber's papers appear.

Science is always presented as an activity motivated and driven by the search for truth and that it is done for its own sake. This comes home to us when one as Feynman asserts from personal experiences that, a discovery of a law fulfils a scientist. Yet the cynic might question this

and say that much of science operates and is boosted up by the race track mentality; and is based on a reward system of priorities, recognition, etc., that the dog-eat-dog philosophy pervades the market-place of science. Marshak has adduced many detailed reasons why Sudarshan did not receive due recognition in any big way. We in India can add another one—that George was young, not well known and from a far away country. One is tempted to ask in what way George himself has been influenced by all this. Those of us who know George are aware that he has maintained his unique insight into physics and his unique sense of humour. He makes (often!) philosophical statements (as the ones quoted by Mukunda). Yet one strongly suspects as with Subrahmanyam Chandrasekhar, that these early events did leave their mark on George, though in a different way.