Obituary note

K V L SARMA (1937–1997)

Kuruganti Veera Lakshmana Sarma (K V L Sarma) of Tata Institute of Fundamental Research, Mumbai passed away on 28th September 1997, due to heart attack. He was born on 26, October 1937 in Ongole, Andhra Pradesh. After MSc in Andhra University, Waltair, he joined the Training School of the Atomic Energy Establishment, Mumbai in 1957. This was the first batch of what is now known as the BARC Training School. He started working in TIFR soon after. He went to the University of Wisconsin, Madison, USA where he did his Ph.D. work (1963–67) under the supervision of Professor Vernon Barger and was a Research Associate of Professor R E Cutkosky at Carnegie–Mellon University (1967–69). He then returned to TIFR where he continued to work until the end.

Prof. K V L Sarma's scientific work was in the field of Theoretical High Energy Physics and spanned the following areas: transverse momentum distribution in hadron scattering at high energies, Regge pole models, total cross sections of hadrons, multiplicity distributions, neutral current weak interaction, Kolar events, deep inelastic scattering and structure functions, neutrino physics, charm physics, B physics.... A few highlights of his work are as follows:

Hadron scattering at high energies

In 1963, Sarma and D S Narayan [1] pointed out that the differential cross section of hadrons showed little variation with energy when plotted against p_T. This was the first attempt to extend the empirically observed universality of transverse momentum distribution to elastic scattering. This work immediately attracted wide attention and was an ingredient in the construction of the famous '*Orear Plot*'.

In his Ph.D. thesis, Sarma constructed a Regge-pole model for describing the charge exchange and hypercharge exchange reactions in πN and KN scattering. This then grew into a comprehensive version in collaboration with D D Reeder [2] and it became a quite popular model for comparing experimental data on cross sections and final hyperon polarizations in meson–baryon scattering. Renninger and Sarma [3] developed a Regge-pole model to describe the high-energy production of Δ (1232) and they also extended the model to the production of Σ (1385). Experimental results that came a decade later [4] were in absolute agreement with the prediction of the Renninger–Sarma model.

Total cross sections was a topic of continuing interest to Sarma. He continued to work and publish on this, during the 60's and 70's. His Panchagani lectures [5] provided a comprehensive review of the subject and was much liked by the total cross sectioners.

Making use of the factorization of the Regge residues, Sarma and V Singh [6] deduced a lower bound on the total cross section for photon–photon scattering at high energies.

Remarkably enough, the bound gave values close to the measured ones for c.m. of energy $W > 6\,\text{GeV}$ and showed a gentle logarithmic increase in W.

Neutral current

The first model-independent analysis of the neutral-current data on the inclusive neutrino scattering was done by G Rajasekaran and Sarma [7] in 1973, immediately after the experimental discovery of the neutral-current weak interaction. Their relations (called 'Master Formulae' by J J Sakurai) determined the neutrino-quark chiral coupling combinations $(u_L^2 + d_L^2)$ and $(u_R^2 + d_R^2)$ for the neutral current. This analysis was actually the first step in determining the neutral-current couplings in the neutrino-quark sector, which ultimately paved the way to establish the Standard Model of High Energy Physics.

This, as well as other related work were published in *Pramana*, which had limited circulation and was not well-known outside India. Nevertheless, the work attracted wide attention and was cited in several papers. Sarma was quite proud of this (and I too was).

KGF experiment

Around 1975, the Kolar Gold Fields group reported some events suggestive of the decay of a massive long-lived particle which was produced in ν-interactions. In 1986, using an improved detector, the group announced detecting more events possibly from the decay of a particle of a few GeV mass and nanosecond mean life. Sarma and collaborators [8–10] spent much effort trying to interpret these tantalizing events in terms of several theoretical scenarios. It remains an unsolved problem to this day.

Deep inelastic scattering

The experimental discovery of the EMC effect prompted the construction of the *gas model* by Sourendu Gupta and Sarma [11]. They assumed that a nucleon in the nucleus has a small probability (≈ 0.1) to deconfine spontaneously into the constituent partons and that these partons form a noninteracting gas of quarks and gluons at a temperature $T\,(\approx 50\,\text{MeV})$ in the nuclear volume.

The gas model gave rise to many interesting consequences in regard to the A-dependence in hard scattering collisions and these were put in perspective in a recent review by M Arneodo [12]. Some of the consequences were studied in two Ph.D theses (of Sourendu Gupta and K Sridhar).

Later, R S Bhalerao and Sarma [13] developed a phenomenological model for the structure function (somewhat like the above gas model), by assuming that the nucleon comprises of non-interacting fermions and bosons in thermal equilibrium. A special feature of their model is that the *finite volume* of the nucleon is taken into account.

Neutrino physics

The paper of G V Dass and Sarma [14] on atmospheric neutrinos was one of the early papers on this subject which has gained considerable importance in recent years. They studied the possible depletion of the flux of upward-going neutrinos due to neutrino oscillations. This effect has now been seen in the super-Kamiokande experiments.

Sarma [15] published a critical survey of recent results in neutrino physics in 1995. This contained a balanced discussion of all the experimental data up to the end of 1994 and was acclaimed by the neutrino physicists. The entry of our group at Chennai into the field of atmospheric neutrinos was very much influenced by this survey.

B physics

G V Dass and Sarma [16] outlined a comprehensive programme to determine the fundamental parameters characterizing the B–$\bar{B}$ oscillations in a model-independent way, directly from experiments. They [17] proposed experimental tests to probe possible violations of the quark selection rule $\Delta B = +\Delta Q$. A lot more work was done by them, in the general area of B physics.

I shall briefly describe one contribution since it was in fact Sarma's last paper, completed just a few days before his death. Actually this paper is exceptional and atypical of Sarma's work. It deals with controversial issues concerning foundations of Quantum Mechanics, which Sarma generally avoided. Probably, Sarma made an exception in this case since the question that was asked could be answered directly in terms of experimentally measured quantities. Dass and Sarma [18] studied the Einstein-Podolsky-Rosen correlation implied by the entangled wavefunction of the B^o–$\bar{B}^o$ pair created in $\Upsilon(4S)$ decay. The analysis uses the basis provided by the mass eigenstates B_1, B_2. Using data on the inclusive dilepton charge ratio, they show that experimental data are close to the expectation of Quantum Mechanics and is nearly 8 standard deviations away from that of complete decoherence. Earlier, Bertlmann and Grimus [19] used the B^o, $\bar{B}^o$ basis in this context, but Dass and Sarma showed that the choice of B_1B_2 basis leads to a much stronger result.

K V L Sarma was an excellent teacher. Apart from teaching graduate courses at TIFR, he taught in Summer Schools and the DST-supported SERC Schools on Theoretical High Energy Physics where his pedagogical skills were very much appreciated by students.

I would like to stress three chief characteristics of K V L Sarma, his scientific integrity, his ability to plan and work out his theoretical research in close contact with down-to-earth experimental data and his stress on the sanctity of experimental results. I have seen very few theoretical physicists who laid so much emphasis on experiment. One may even call this his credo: *Experimental result is Truth.* I have been very much influenced by him on this point.

To these, I would add a basic human quality which he had in abundance, his warm-heartedness and generosity. All his friends and collaborators along with his family (wife, daughter and son) miss him very much. In his untimely death, we have lost a good physicist and a good man.

References

[1] D S Narayan and K V L Sarma, *Phys. Lett.* **5**, 365 (1963)
[2] D D Reeder and K V L Sarma, *Phys. Rev.* **172**, 1566 (1968)
[3] G H Renninger and K V L Sarma, *Phys. Rev.* **178**, 2201 (1969)
[4] M C Goddard *et al*, *Phys. Rev.* **D19**, 1350 (1979)
[5] K V L Sarma, *Advances in High Energy Physics* edited by V Gupta and V Singh (TIFR, Bombay, 1979), vol. 3, p. 451
[6] K V L Sarma and Virendra Singh, *Phys. Lett.* **B101**, 201 (1981)
[7] G Rajasekaran and K V L Sarma, *Pramana – J. Phys.* **2**, 62 (1974); (E) **2**, 225 (1974)
[8] G Rajasekaran and K V L Sarma, *Pramana – J. Phys.* **5**, 78 (1975)
[9] K V L Sarma and L Wolfenstein, *Phys. Lett.* **B61**, 77 (1976)
[10] A S Joshipura, G Rajasekaran, V Gupta and K V L Sarma, *Pramana – J. Phys.* **33**, 639 (1989)
[11] Sourendu Gupta and K V L Sarma, *Z. Phys.* **C29**, 329 (1985)

[12] M Arneodo, *Phys. Rep.* **C240**, 301 (1994)
[13] R S Bhalerao and K V L Sarma, *Model for the Nucleon Structure Functions* (paper under preparation in 1995)
[14] G V Dass and K V L Sarma, *Phys. Rev.* **D30**, 80 (1984)
[15] K V L Sarma, *Int. J. Mod. Phys.* **A10**, 767 (1995)
[16] G V Dass and K V L Sarma, *Int. J. Mod. Phys.* **A7**, 6081 (1992); **A8**, 1183 (1993)
[17] G V Dass and K V L Sarma, *Phys. Rev. Lett.* **72**, 191 (1994); **E72**, 1573 (1994)
[18] G V Dass and K V L Sarma, *Two-particle correlations and* $B_o - \bar{B}_o$ *mixing*, hep-ph/9709249
[19] R A Bertlmann and W Grimus, *Phys. Lett.* **B392**, 426 (1997)

G Rajasekaran

Institute of Mathematical Sciences
Chennai 600 113, India