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.

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Preface

The series of Workshops on High Energy Physics Phenomenology (WHEPPs) has by now become a tradition which has been successful in bringing together both Indian and foreign physicists at essentially all levels, with an aim to get involved in serious collaborative efforts to focus on and solve some of the major problems in the field. The Fifth workshop in this series, WHEPP-5, was held at the Inter-University Centre for Astronomy and Astrophysics, Pune during January 12–25, 1998. The first such workshop was held in TIFR, Mumbai in January 1989. Subsequently, the S. N. Bose National Centre for Basic Sciences, Calcutta, hosted the second and fourth WHEPP in January 1991 and 1996 respectively, while the Institute of Mathematical Sciences hosted WHEPP-3 in January 1994. About 85 particle physicists and astrophysicists participated in the workshop in Pune, in which a special effort was made to focus on the emerging area of astroparticle physics.

The four broad topics chosen for the working group activity, which forms the core of the WHEPPs and was correspondingly given more time in this workshop than before, are as given below with the respective coordinators mentioned in the brackets:

1. Astroparticle physics (V Sahni and S Mohanty)
2. Collider physics and B-factories (A Datta and B Mukhopadhyaya)
3. Quantum chromodynamics (K Sridhar)
4. Physics beyond standard model (D Choudhury and S D Rindani)

The plenary talks on various topics of current interest in these areas were held in the morning sessions of the first week while the afternoon sessions as well as the entire second week were devoted to working group activity. This consisted of talks by participants on their own work or on subjects of common interest for the working group and discussion sessions on problems selected for the workshop. The results of the working groups were summarized by the group coordinators on the last day of the workshop. These proceedings contain the written versions of the review talks of common interest, covering mostly the plenary talks. The editors regret the absence of contributions from R Aleksan, G Bhattacharyya, D Choudhury, and A Stebbins, as they were not submitted by the authors in time, although it did help the editors in accepting manuscripts which exceeded the page limit substantially.

WHEPP-5 was dedicated to the memory of our colleague late Prof. K V L Sarma of TIFR, Mumbai, who passed away very suddenly on September 28, 1997, due to a heart attack. He has influenced many of us by his down-to-earth insistence on experimental data. The Indian particle physics community will miss him a lot. An obituary to Prof. K V L Sarma has kindly been submitted on our request by Prof. G Rajasekaran and is included in the proceedings.

The major financial support for the workshop came from the S. N. Bose National Centre for Basic Sciences, Calcutta. Additional funding was provided by the Tata Institute of Fundamental Research, Mumbai, and the International Centre for Theoretical Physics, Treiste. The workshop would have not been possible without the support of Inter-University Centre for Astronomy and Astrophysics, Pune, which provided the venue

for the workshop, along with all the detailed infra-structural support from the lecture halls to the guest house and from computational resources to the internet connectivity to all parts of the world.

It is our great pleasure to record here our appreciation of the support of these institutions and to thank them sincerely for it. In particular, we would like to thank Prof. C K Majumdar, Director, S. N. Bose National Centre for Basic Sciences, Calcutta, Prof. J V Narlikar, Director, Inter-University Centre for Astronomy and Astrophysics, Pune, Prof. M Virasoro, Director, International Centre for Theoretical Physics, Trieste, Italy and Prof. S S Jha, Director, Tata Institute of Fundamental Research, Mumbai, whose enthusiastic support was crucial in holding the WHEPP-5. Many individuals have helped in making WHEPP-5 a success and we would like to thank them all but special mention should be made of the valuable help of Profs A K Kembhavi, T Padmanabhan and V Sahni and Ms Snehlata Shankar, Dr S Saran and Dr V Chellathurai. Shri Girish Ogale of the Tata Institute, Mumbai managed the conference office both ably and with an happy face before and during the workshop. We would like to thank him warmly.

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