Deepak Kumar (1946–2016)

The morning of 26 January this year came to us with the tragic news that our colleague Prof. Deepak Kumar was no more. On the evening of 25th while driving back from JNU campus to his residence in Noida he had developed uneasiness. His son immediately took him from the road to a nearby hospital where in the early hours of 26th he breathed his last. Even on the day before, he was in his office in the School of Physical Sciences, JNU where he has been working for last twenty eight years.

Deepak Kumar was born in New Delhi on 1 April 1946 to parents Iqbal Behari Lal and Kashmiran Pyari. He grew up in Delhi where he had his schooling. He studied in the Stephens College of Delhi and obtained his B Sc degree with honors in 1965. He completed his Master's degree in 1967 from the Physics Department of the University of Delhi. The same year he joined the Graduate school of the Department of Physics in University of Pennsylvania, USA. There he worked for his thesis on theoretical condensed matter physics under the guidance of A. B. Harris and obtained his Ph D degree in 1972. Soon after completing his degree he returned to India and joined the Physics Department of the University of Roorkee. He taught and pursued a very active research programne with several colleagues for next sixteen years in University of Roorkee. In 1985, JNU started building up its new School of Physical Sciences. It was aimed towards having a programme with emphasis on research in areas of Condensed Matter Physics. Several scientists, at an early stage in their career at that point, joined the University during these years. In 1988, Deepak Kumar started working in JNU as a Professor. He remained associated with the School of Physical Sciences till the very last day of his life. He has heavily contributed to the research and the teaching programme of the University for twenty eight years. The faculty of the School had recently nominated his name to the University for Emeritus Professorship.

In his doctoral research with A. B. Harris in University of Pennsylvania, and also with B. I. Halperin, P. C. Hohenberg, in Bell Labs, Deepak Kumar studied the theory for the dynamics of an Antiferromagnet at low temperature. The propagating disturbances in the spin lattice or the spin waves are similar to the phonons of the nuclear lattice. His work demonstrated that spin waves in antiferromagnets are well-defined elementary excitations, which interact weakly at low temperatures and long wavelengths. This analysis, using methods developed by Freeman Dyson and others, obtained the corresponding low temperature transport properties of the system. A key aspect of this work lies in linking the microscopic description with the long wavelength macroscopic hydrodynamic behaviour of the antiferromagnet. Indeed it was these two approaches, often adopted in theoretical condensed matter physics, that Deepak Kumar time and again explored in his research of the later years.

Following his return from US, during his years in the University of Roorkee, he worked on a number of different topics. In collaboration with A. Mukherjee, Vijay Kumar, S. K. Joshi, he worked on surface segregation in random alloys. Using a classical thermodynamic approach, the free energy of a semi-infinite binary alloy was constructed. Its minimization in a Bragg–Williams type approximation obtained the variation in the composition of the alloy from the surface into the bulk, and thus demonstrated the surface segregation process.

In 1984, P. W. Anderson and his collaborators presented a hierarchical model, involving constraints at different levels, and obtained from it relaxation behaviour similar to that of glassy systems. In the same year M. Mezard and coworkers demonstrated the hierarchical structuring of the pure states of an infinite-ranged spin-glass model. Soon after these works, in 1986, from University of Roorke, with Kamlesh Kumari, Deepak Kumar made an important contribution. They presented a spherical model of Ising spins, placed on sites arranged in a cluster hierarchy. The critical exponents for a ferromagnetic transition in the system were shown to be non-universal, while for antiferromagnetic interactions, the system has no transition, demonstrating that condensation cannot occur in localized systems.

During his initial years in New Delhi, he studied microscopic models of hopping conduction in a system with Coulomb interactions. In a paper with his student S. Lamba, he calculated within the linear-response regime, the conductivity and the dielectric functions in terms of the density–density response function. Using a generalized master equation approach, the dynamics was formulated in terms of a random resistor network. The dc conductivity of the network was calculated in an effective-medium approximation. At low temperatures the relaxation is slow, so that electrons hop in a frozen charge background and sense the Coulomb gap. With increasing temperatures the relaxation gets faster and the Coulomb gap is alleviated leading to Mott's behaviour showing $T^{1/4}$ temperature dependence. He pursued in the later years his interest on discrete models and transport in simple systems. With G. Santosh and R. Ramaswamy, he studied transport and phonon renormalization in a chain with transverse and longitudinal vibrations, worked with R. K. Brojen Singh, on self-consistent study of localization in thin films and with another student V. Malik on thermodynamics and excitations of Coulomb glass. With his student A. Tripathi he worked in recent years on the behaviour of velocity correlations and mobility in single-file diffusion.

In 2004, with R. Mehrotra of National Physical Laboratory, Delhi, he took the approach of classical hydrodynamics to study the pattern formations in melting snow. They demonstrated that nonlinearly coupled diffusion equations involving two or more fields can give rise to a rich variety of spatiotemporal structures. By considering the interplay of phase transformation and heat flow through the layer coexisting in two phases of snow

and water, a range of patterns were predicted. Strikingly similar patterns have also been seen in monolayer depositions of Pb on heated Pb–Cu substrates, indicating that the physics of the two phenomena, differing in length scales by seven orders of magnitude, is similar in the two cases.

All his life, Deepak Kumar followed a very versatile approach in his research working on different problems of theoretical condensed matter physics. On one hand, he pursued with keen interest hierarchical models of spins, microscopic hopping models of transport, study of spin glasses, and about the same time also worked on coarse grained models of classical thermodynamics as well as hydrodynamics, looking into problems ranging from surface segregation, phase transition in mixtures, heat conduction and pattern formation in melting snow. He collaborated rather extensively with a large number of his colleagues not only in the Universities where he worked, but also working in other Institutes in India. During his years in Roorkee, he collaborated with S. Dattagupta, to study the non-equilibrium susceptibility of superparamagnetic particles, with M. Barma on the critical properties of diluted anisotropic magnets near percolation threshold, and with S. Shenoy on relaxational dynamics of disordered ultrametric models. During his JNU years, he worked with S. Sarkar to study phase diagrams of binary mixtures using methods of classical statistical physics. He collaborated extensively with S. Puri and his group again on problems of classical statistical mechanics, and studied models of phase separation, dynamics, aging in ternary mixtures. And over the same years, he was also very active in research collaboration with R. Ghosh and her group on measurement problem in quantum mechanics, studying environment-induced decoherence in the Stern–Gerlach measurement, effect of decoherence on Bell's inequality. I have felt in many of the discussions, as a theorist he greatly valued linking to experiments. Thus while he worked with theoretician colleague R. Rajaraman on the nature of the flow in renormalization-group equations with respect to Umklapp processes for electrons, he also took keen interest in studying the data on magnetism of transition metal cluster compounds with his experimentalist friend A. K. Rastogi.

His contribution to science has been recognized by several organizations. He was Alexander von Humboldt fellow in Germany during 1978–79. He was elected a member of the Indian Academy of Science, Bengaluru in 1987. In 1990 he received the Shanti Swarup Bhatnagar Award for Physical Sciences from CSIR. He was Senior Research Associate of International Center for Theoretical Physics, Trieste, Italy. He was also a member of Indian Physics Association and Material Research Society of India.

Deepak Kumar was always a University teacher. All these years, even after his formal retirement from the University he never gave up his teaching and helping out the interested learner who approached him. Even on the very last day he had presented a seminar in the School. He contributed in many ways in building up of the School of Physical Sciences as it is today. He constantly worried for improvement of standards of University education, and thought of ways of getting qualified people to join University system. His article in *Current Science*, entitled 'University science set to decline: a new caste system' (25 July 2011, **101**(02), 149) is very relevant in this respect.

Being a colleague of many years, we had our offices on the same corridor. Often while walking across his half opened door, I would notice him leaning intently on his desk reading or writing something. These days the room is closed, the desk must be collecting dust. He would not be there anymore. Beyond his academic and professional achievements, Deepak Kumar's kindness and affection for others is well known to all his friends, colleagues and students. I have seen how at times of personal crisis, he contained himself, remained true to doing his duties with utmost affection. Even at the hour of most tragic incident of life the calmness of his mind, ability to face grief showed his inner strength. As I write this note, it comes to my mind in one of his felicitation programmes, while delivering a note of thanks to people present in the room, Prof. Kumar had commented that every time he completes a new paper, he thinks in the next one he will do better and attempt more perfection. So he did. Till the very last day he remained true to doing his work, teaching and learning.

A few days later a condolence meeting was held at the School. His son Sharad and daughter Jyoti were present. In that meeting his students, his children, friends and colleagues expressed their griefs, talked of their memories and of the pain of coming to term with his sudden departure. The room echoed with the eternal cry of human life, of loosing dear ones. One could still hear sounds of his grand children playing in the outside sun of the School lawn. Memories of his affection for his work, his love for science, kindness for all will remain with people who knew him.

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