Arun M. Jayannavar (1956–2021)

Arun M. Jayannavar, known to his friends either as Arun or simply Jayannavar, passed away in Belgaum on 22 November 2021. He had recently retired from the Institute of Physics (IoP), Bhubaneshwar, where he was a senior professor.

He was a close friend, collaborator and mentor to many, including the three of us. He was also an outstanding physicist. He was awarded the ICTP Prize in Solid State Physics, in honour of Nevill Francis Mott, in 1996. He received the Shanti Swarup Bhatnagar Prize in 1998, and the G. D. Birla Award for Scientific Research in 2004. He was an elected fellow of all the three Indian science academies. He served on a large number of national scientific committees, while also holding a number of administrative positions at the Institute of Physics, including that of Director.

Arun Jayannavar did his undergraduate degree from Belgaum in 1976. He then went on to do a master's degree at Karnataka University, Dharwar in 1978. He completed a Ph.D. at the Indian Institute of Science, with N. Kumar and E. S. Rajagopal. This was the beginning of a fruitful and long-lasting collaboration with Kumar, who Arun held in the highest respect. One outcome of this collaboration was a paper entitled 'Non-diffusive quantum transport in a dynamically disordered medium', which was one of Arun's most cited papers. Jayannavar and Kumar studied quantum motion in a dynamically disordered medium, finding that a quantum particle in the continuum would exhibit super-diffusive motion rather than the diffusive behaviour obtained in a lattice description of electron motion, a surprising and counter-intuitive result.

He then spent some years at ICTP, in Trieste, returning to Bangalore in the period 1984–1987, before going on to a Humboldt Fellowship at Ulm, Germany. He joined the Institute of Physics, Bhubaneswar in 1991 and would go on to become its Director in the period November 2009 to May 2013.

Arun, very unusually, moved with great ease between problems in both classical and quantum physics. With E. S. Rajagopal, he worked on the very classical problem of the elastic properties of Se–P glasses, in parallel with his work with Kumar on quantum transport. A bit later, in another example of Jayannavar's versatile ability to move between problems in quantum transport, statistical physics and the properties of materials, Kumar and Jayannavar were to write a well-cited paper on the temperature dependence of the c-axis resistivity of high-T_c layered oxides. Here, they interpreted electrical transport along the c-axis of high-T_c layered oxides in terms of coherent interplanar tunnelling between neighbouring layers that was blocked by repeated intra-planar incoherent scatterings, showing that this approach gave the same temperature dependence for the c-axis resistivity as that for the in-plane resistivity.

With a number of students in the decades from 1991 to 2001, Arun explored problems in mesoscopic physics, notably with his students Pareek, Singh Deo, Gupta, Joshi and Benjamin. A long collaboration with a friend of many years, Mangal Mahato of the NEHU, Shillong, led in another direction, the investigation of the unusual properties of stochastic resonance in driven systems.

He described his own interests as: classical and quantum transport in random media, non-equilibrium statistical physics, the physics of mesoscopic and nano systems as well as stochastic processes and their applications to physical, chemical and biological problems. Through much of the first decade of the 2000s Arun would switch between problems in mesoscopic quantum physics, including the Aharonov–Bohm effect, current magnification, dephasing in quantum mechanics and tunnelling times, and problems in non-equilibrium statistical mechanics, including the study of ratchet models, stochastic thermodynamics, fluctuation theorems, entropy production and stochastic engines. This was an unusually productive time. It was not unusual for Arun to write more than 12 papers a year, usually with one or at most two students but also singly-authored, keeping up a pace that few could match.

With one of us (GIM), and his student Debasis Dan, he wrote a paper on the modelling of two-headed molecular motors, entitled 'A biologically inspired model for two-headed Brownian motors'. This paper extended the usual simple physical modelling of molecular motors in terms of a single particle (a motor head) in a fluctuating ratchet potential, to two connected heads, each experiencing an anti-correlated potential. For some two-headed molecular motors, their enhanced processivity and speed had been attributed to the enhanced flexibility of the neck region. We introduced a spring between the two heads to model the neck linker region. We found that the model we devised provided a novel mechanism for enhancing current over the single particle case in some regimes, via a 'pulling effect'.

Arun's deep understanding of areas such as stochastic resonance and molecular ratchets allowed him to quickly grasp the importance of the emerging area of stochastic thermodynamics, starting in the early 2000s. This had begun with the works of Jarzynski, Crooks, Seifert, Sekimoto and many others. Arun trained several students and postdocs in this area and wrote a number of well-cited papers on the Jarzynski equality, fluctuation theorems in the presence of magnetic fields, and the functioning of molecular engines. One of us (A.D.) began collaborating with Arun around this time and remembers the excitement that we all felt about the new developments. It was always an absolute pleasure to talk about these with Arun. We never wasted any time – discussions always moved quickly to the blackboard and Arun would have a never-ending stream of insightful questions.

S.B. first met Jayannavar when, as a Ph.D. student, she was looking for new problems in mesoscopic quantum transport to build up her thesis. The interactions led to several fruitful collaborations, including a study on quantum current-magnification, an effect related to but distinct from the Aharonov–Bohm effect, and several studies on the Hartmann effect of tunnelling time and related questions. Later, to better

understand feedback control of noise in spin valves, we performed a series of studies on fluctuation theorem and stochastic entropy production in macrospin. Jayannavar's approach to doing science was always hands-on and earnest. He would keep calling until a problem was completely worked out and written. He had very close relationships with students at IOP and elsewhere. He often referred to students as his friends, and the students used to feel the same.

He was a generous and open-hearted collaborator. A special characteristic of his was his perpetual interest in learning new things. He brought a child-like enthusiasm and energy to all he did and that joy was infectious. He stayed very much the same throughout the many years that we knew him. He would call, often late at night, to discuss problems in physics, a by-product of an unusual working style that flowered later into the evening as opposed to more conventional times.

All of us have experienced the warmth of the Jayannavar household through the years. He and his wife Maya were generous and affectionate hosts, giving freely of their time and effort to make a visitor comfortable. We have also had the pleasure of watching their children, Pallavi and Prasant, grow over the years that we knew them.

Arun became the Director of the Institute of Physics in November 2009, stepping down from that position to return to his professorship in May 2013. These were difficult times for the Institute, which he navigated as best as he could. His main advantage was that he could be seen as non-partisan. This, however, meant that he would often have to mediate between strongly opposed points of view, and the attendant stress did nothing good for his mental and physical health. In the last few years of his life, he suffered from persistent health issues, exacerbated, no doubt, by his own lack of attention to them.

His interests in the past year or two turned to pedagogy and to the writing of popular-level articles. One area he was interested in was quantum biology and he read up extensively on that field, convinced that the understanding of where quantum mechanics fed into biology might provide unique insights into how coherence was maintained in such systems. The second was the concept of emergence. The idea of emergence as being central to scientific thinking across many fields was his favourite. He wanted to present such ideas in a way that they could be understood even by a high school student. He wrote extensively during this period, often calling us up to discuss the finer points of an article he was writing or simply urging us to collaborate on one or the other new idea he had.

He motivated a generation of young students, at the Institute of Physics and elsewhere across the country, leaving a deep impression on those who met him, even if briefly. His many honours sat lightly on him. His respect for the work and abilities of others was clear and always present. He did not feel in competition with them, always emphasizing the virtues of collaboration and the development of a mutual joy in understanding something new. What we'll remember is his kindness, generosity and the example he set in how to think about physics, at any time and under any circumstance.

He will be missed.

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