

lost one of the great stalwarts in the history of science, and perhaps the only scholar in the country who had such an impetuous passion when it came to engaging himself in the activities to promote studies pertaining to the history of science in any form – editing manuscripts, preparing research monographs, authoring popular books, setting up re-

search centres, preserving archives, organizing public awareness programmes, and so on.

ACKNOWLEDGEMENT. N.K.R. thanks Purushottama Bilimoria and Mayank Vahia for their useful inputs. He also acknowledges the help of Hansa Kalyani, Librarian, IAS and Christina Birdie, former Librarian, IIA.

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## P. N. Shankar (1944–2019)

We were dismayed to learn that our dear colleague and friend, P. N. Shankar, passed away on 15 April 2019. Shankar had been unwell for some time, and unable to be his usual effervescent self.

The Shankar we knew, and will always remember fondly, was sparkling, brilliant and animated. We remember conversations with him about beautiful experiments, astonishing mathematical proofs, the promise of parallel programming, the joy of building a telescope, and even about why a funny joke was not really funny.

Pattamadai Narasimhan Shankar was born on 13 August 1944 in Bombay. His early years were nomadic; the young Shankar studied in schools in India and Switzerland, obtained a B Sc in mechanical engineering from Imperial College (then in the University of London), UK in 1964, and a Ph D in engineering science from Caltech, USA in 1968.

Then Shankar did something rather curious: he took up position as a researcher in the R&D Center of General Electric at Schenectady, NY, USA, though he showed much more promise as an academic researcher in fluid dynamics. Fortunately, he quickly corrected the mismatch to become an Assistant Professor at the University of Maryland, USA, in 1970.

Almost immediately, Shankar began to glitter. In 1970, he published his first paper, on a kinetic theory of steady condensation, in the *Journal of Fluid Mechanics (JFM)*. The publication rush continued in 1971 and 1972, with five more papers in fluid mechanics and acoustic refraction, all in leading international journals, and in almost every case as a single author.

The two years (1970–72) that Shankar spent at Maryland must count among the

best in his life: he received the coveted Knapp Award of ASME in 1971, and, best of all, he met his future wife, the accomplished and gracious Priti Monteiro, who was completing her Ph D at the University.

Shankar returned to India in 1972 to join the National Aeronautical Laboratory (NAL; later National Aerospace Laboratories) at Bengaluru as a scientist; there were also overtures from IIT Kanpur, but NAL's Director S. R. Valluri proved to be more persuasive and welcoming. Shankar would go on to spend the rest of his working life at NAL, till his retirement in 2004.



Shankar's first years at NAL were – surprisingly – devoted to work on wind power. NAL had done some early pioneering work in this area and Valluri wanted Shankar to revive this effort by looking at opportunities using Savonius rotors. Shankar gave the project a perfectly good try, but somewhere along the way became convinced that wind power was not a feasible option. Valluri was not particularly amused to hear this, but allowed Shankar to change track as long as his work was relevant to NAL.

It was this happy fortuity that led to Shankar's immensely fruitful, and occasionally stormy, collaboration with U. N. Sinha. Young and confident when they started out, the duo decided to study turbulence, not inside some closed cylinder but along a wavy wall. While this work provided a splendid learning experience, and a well-cited 1976 *JFM* paper, Shankar and Sinha – always honest to the core – realized that they needed greater mathematical acumen before they could take their next steps forward. So, they teamed up with their colleague Anand Kumar to read every page, and solve nearly every problem, of the three celebrated Rudin books on mathematical analysis. It was a marvellous example of dedication and commitment to a subject they truly loved.

Shankar and Sinha went on to do more interesting work on rotational and separated flows, till NAL's new Director, Roddam Narasimha, asked Sinha to initiate the Flosolver parallel computing program in 1986. Sinha thereafter got completely immersed in Flosolver development. Shankar was not a member of the Flosolver team – although he did some work on fast solvers – but remained a strong supporter and well-wisher.

A heart-warming example of Shankar's support was when the Flosolver team suddenly realized that they needed to master PDP assembly programming, but had no guru to turn to. Shankar suggested that they ask his wife Priti, by now a teacher and researcher of great mettle and ability at the Centre for Automation, Indian Institute of Science (IISc), Bengaluru. The intense one-month teaching programme was invaluable and extremely generous.

Shankar loved doing experiments. He had reasonable success, although most

would agree that his work in theoretical fluid dynamics was far more impactful. Perhaps the scientist in him loved to touch and play, record observations, and glean insight from the real data that revealed themselves. Shankar's endeavour was to start every research effort with an attractive theory, and diligently work his way to hard engineering through innovative experiments. This endeavour never ebbed.

In the late 1980s, Shankar and M. D. Deshpande attempted some experiments on liquid–vapour phase change. The going was hard, because NAL's Computational and Theoretical Fluid Dynamics Division lacked an experimental facility. But Shankar never lacked goodwill: he could enter any NAL workshop, borrow equipment and supplies from anywhere, and ask anyone for guidance. Deshpande would later say that there appeared to be 'an open conspiracy to make this experiment successful'. The research effort would result in two good publications – including one in *Physics of Fluids A* – and a slew of technical reports.

A few years later, Shankar took another shot at experimental work, this time with his younger colleague Manoj Kumar. They made measurements on the viscosity of glycerol–water mixtures; reported in their widely cited 1994 paper in *Proceedings of the Royal Society of London, Series A*. The team's original intention was to study lid-driven cavity flows using glycerol–water mixtures to vary the Reynolds number; glycerol–water mixtures are today used in a diversity of applications that Shankar could not originally have anticipated. The Shankar–Manoj Kumar team later worked on vortex rings, resulting in two 1995 papers in *Physics of Fluids*. Once again, the notable aspect was that this work was done without a proper facility; experiments were undertaken at diverse locations in NAL, and even at the IISc. As always, Shankar's immense personal popularity, significant kindness from colleagues, and some serendipity achieved the desired magic.

During his last years at NAL, Shankar returned to theoretical fluid dynamics and struck a fruitful partnership with Rangachari Kidambi. Their work used eigenfunctions – which was not such a surprise because almost all of Shankar's work after the 1990s used them. Kidambi recalls: We worked on problems that were simple to state, but also elegant, novel and 'inspiring'. In particular, their

effort led to the 'embedding method' for solving linear partial differential equations (PDEs), which Shankar considered to be his 'crowning achievement'.

Shankar's body of work – that would earn him the Fellowship of the Indian Academy of Sciences in 1992 – eventually spanned almost 50 top journal publications; about half of them either in *JFM* or *Proceedings of the Royal Society of London, Series A*. The Shankar–Deshpande 2000 paper in the *Annual Review of Fluid Mechanics*, on fluid mechanics in the driven cavity, is his most cited publication by a long mile. Shankar is also the author of *Slow Viscous Flows*, published in 2007 by Imperial College Press; the 567-page book still makes slow and steady waves.

Shankar loved to debate and argue, especially when convinced that his thought process was right and ethical. If a journal returned his manuscript for a review, he would launch a technical rejoinder with vigour and alacrity. There were occasions when Shankar would receive a referee report on a Friday afternoon and his rebuttal, complete with new calculations and examples, would be prepared over the weekend. And on Monday morning, off it would go.

Sometimes things could turn a little sour. Shankar was once briefly banned from submitting manuscripts to a prominent journal in fluid mechanics. But this hardly fazed him; he bashed on regardless, and with cheerful equanimity. We also recall that 'Oh, my God!' moment when, after a heated argument with his colleague R. K. Bera on whether a vortex sheet with elliptic loading would roll up, Shankar faxed M. J. Lighthill and pressed him to confirm if his lemma was indeed true. One does not know if Lighthill took this lightly.

Then there was the occasion, and it was not the only one, when Shankar stormed into Sinha's house to discuss some mathematical derivation. Sinha was in bed, reeling from a serious attack of typhoid, and in no physical condition to talk. But Shankar insisted on an immediate resolution of the problem.

To be fair, Shankar would admit his mistake readily, and without qualification, if he found that he was wrong. Shankar also encouraged his colleagues to express themselves freely, like himself, without having to worry about retribution or indifference. He was incredibly enigmatic, but also warmly endearing.

With Shankar there was never a dull intellectual moment.

As a public speaker Shankar was electric, fiery and magical. He could be provocative and indignant, or sweet and indulgent, depending on his mood and the nature of the audience. At one of the Flosolver conferences at NAL in the late 1980s, the discussion was getting protracted and tiresome: was Flosolver's architecture 'concurrent' or 'parallel'? Clearly irked, Shankar rose to make a heartfelt appeal to cut out the polemics and the semantics and, instead, celebrate the promise and capability of the parallel computer. But the same Shankar, at a CSIR annual meeting (to attract young students to opt for a career in science), was captivating. Shankar was practically blind on the day he spoke (he had put off an eye operation to be present). He could not see his slides, but that did not inhibit him in any way. He was utterly delightful. The children loved him.

Shankar was equally impactful in divisional seminars, even when he was not the lead speaker. Just his presence at the Friday seminars was enough to swing the discussions to something more profound and enjoyable. By encouraging juniors, and challenging seniors, Shankar ensured that everyone left the seminar feeling both fascinated and flabbergasted.

Shankar was also a marvelously gifted writer: his writing – both popular or technical – was erudite and illuminating, and written with amazing feeling and flair. The obituary of Lighthill, which appeared in *Current Science* (1998, 75(4), 405–406) is one example of his compelling and delectable ability; it was far more lucid and poignant than Lighthill's obituary published in the British daily, *The Times*.

Shankar's technical manuscripts were impeccable, often written in his slanted and stylish handwriting. More surprisingly, he was known to stop all his work for 3–4 days to improve a colleague's manuscript. Shankar would check for technical correctness, and return manuscripts with corrections and many helpful suggestions. His colleagues gratefully acknowledge how Shankar's intervention made them much better writers themselves.

Shankar had disdain for a position of authority (when he found the 'Deputy Head' nameplate on his office door, he instantly had it removed) and loathed hierarchies. His younger colleagues adored him: Shankar did not have to be

called ‘sir’, and his opinions could always be challenged. You could walk (storm!) into Shankar’s room any time and demand something to be done. In a country steeped in traditions of respectful veneration, this irreverence was a breath of fresh air.

Shankar’s generosity was unparalleled. He was known to contribute absurdly large sums of money for charitable causes. He also supported the education of a large number of school children through a trust that he ran in his father’s name. Gifting books to students gave him a special joy; given a choice he always gifted Pólya’s *How To Solve It*, because, as he used to say, ‘there’s no better way to learn mathematics’.

Shankar cared for science and did all he could to spread the scientific temper. Using the Association of Bangalore Amateur Astronomers (ABAA) platform, that he helped establish, Shankar gave talks, arranged workshops and wrote three popular books on night-sky observation and telescope building (these books were sold for Rs 5; in Shankar’s view a book had to cost less than a *masala dosa*). In 1995, when the Indian Academy of Sciences decided to launch the journal *Resonance*, Shankar could hardly contain his excitement at the impending arrival of a new journal of science education. Readers of *Resonance* will recall the wiggle which adorns its cover page,

and the footer of every page, but hardly anybody will know that it was Shankar who wrote down its mathematical expression.

There was another Shankar, beyond those mathematical equations and derivations, who aspired to touch many more corners of life’s convex polyhedron. He was, for example, a sufficiently gifted flute player – his guru was C. M. Madhuranath from the legendary T. R. Mahalingam school – with many successful public recitals. In his more youthful years, you could have seen Shankar unleash a crisp volley on the tennis court. And it was a joy to listen to Shankar talk about the film-making style of Akira Kurosawa.

Shankar loved to laugh loudly at good jokes, and laughed even more loudly if the joke was humorously indecent.

It saddened us that this laughter deserted Shankar in his last years; he was simply not himself after the sad demise of his beloved wife Priti in October 2011. Shankar tried to find new meanings in life; he even embarked on a deep study of Buddhism, but the light had sadly gone out of his life.

We should remember Shankar for his intensity and deep commitment, his meticulous scholarship, zeal to create a scientific environment around him, love for teaching young students, and support for his colleagues. If he sometimes

appeared rude in his interactions, it was because he was honest to the core and could not contain his ebullience; if he was sometimes dismissive of authority, it was because he was appalled by what he regarded as the corrosion of integrity; and if he sometimes appeared argumentative, it was because he wanted to advance critical thinking. He lived his life with intensity, verve and fearlessness. He will be missed by all who knew him and loved him.

Shankar leaves behind his son, daughter and two grandchildren.

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