Editorial*

B Sury, Chief Editor

It is a privilege to celebrate two giants of Indian mathematics in this issue of *Resonance*. In a departure from practice, we feature them together in the same volume. The significant role played by M S Narasimhan and C S Seshadri in the past six decades leading to mathematicians from India receiving international recognition cannot be overemphasized. Both in terms of their immense mathematical work, as well as leadership skills in institution building, their influence has straddled across the mathematical world, and they are ranked among the great mathematicians of the 20th century. Many young students in our country may not have heard the names of contemporary Indian mathematicians, and this is an opportunity for *Resonance* to introduce these two stalwarts to them.

They come from rather different backgrounds, but once they joined forces in TIFR Bombay, their partnership proved highly impactful. Some of the biographical details and the mathematical works are recalled in an article in this issue written by their lifelong friend and collaborator Ramanan. So, the narration below mainly outlines the mathematical journeys that both took—sometimes meeting and sometimes deviating.

Both Narasimhan and Seshadri were born in 1932 (the former on June 7th and the latter on February 29th), were educated in Loyola College, Chennai during 1948–1952, and joined TIFR Bombay in 1952. TIFR was founded in 1945, and they were among the first batch of research students. After joining TIFR, they ran a seminar on various topics, including material that dealt with the latest research, such as those discussed in the *Séminaire Cartan*.

Narasimhan, who was already influenced by Laurent Schwartz during the latter's visit to TIFR, followed up his postdoctoral re-

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*Vol.27, No.2, DOI: <https://doi.org/10.1007/s12045-022-1304-7>

search in CNRS, Paris under Schwartz's mentorship during 1958–1960. Seshadri was also in CNRS at the same time, and his mentor was Claude Chevalley; they continued their discussions there in algebraic geometry. Narasimhan was also interested in analytic aspects like partial differential equations and mathematical physics; some of the powerful analytic techniques influenced his research throughout his life. While in Paris, Seshadri made the first inroads to the elusive Serre conjecture, proving it for the two-dimensional case. During the Paris sojourn, Narasimhan also began collaborating with Kotake, which resulted in a famous regularity theorem for elliptic operators.

After returning from Paris in 1960, Narasimhan and Ramanan collaborated on a series of path-breaking works on universal connections on bundles. In 1965, Narasimhan and Seshadri joined forces to prove an astounding result showing that the irreducible unitary bundles were exactly the same as the stable bundles in the sense of Mumford. This work and its offshoots have continued to have a huge impact on several subjects, including physics, for the past six decades. In the decade following the Narasimhan–Seshadri paper, Seshadri continued to come up with several important generalizations. Narasimhan and Ramanan established in the late 60s, the fundamental properties of moduli space of vector bundles on curves. The stature enjoyed by the contributions of Narasimhan, Ramanan, Seshadri is indicated by the name employed by David Mumford for the moduli spaces of vector bundles on curves—he called them ‘Tata spaces’.

In joint work in the late 60s with Okamoto at the Institute for Advanced Study at Princeton, Narasimhan gave concrete geometric realizations of Harish–Chandra's discrete series representations. Narasimhan had always been bothered by inequity issues, and it was natural for him to take up the headship of a mathematics school at ICTP Trieste, Italy, where he mentored young mathematicians from Third World countries. During this decade-long phase of his career, Narasimhan left a lasting impact on researchers from countries in Asia, Africa, Europe, and Latin America. He moved to the TIFR Centre for Applicable Mathe-

matics in Bangalore in 2004. Narasimhan's generous nature and predilection for sharing ideas freely is folklore and benefited a diverse group ranging from celebrated mathematicians to young students. The large number of his joint research papers bears witness to this.

While on a visit to Harvard University on the invitation of Mumford, Seshadri proved an important special case of the Mumford conjecture on geometric reductivity. In the mid-1970s, Seshadri turned his attention to the study of algebraic homogeneous spaces and geometric invariant theory when he established, along with his students Musili and Lakshmibai, new techniques and ideas going under the name of 'Standard Monomial Theory'. These have continued to be highly influential in the subject. A characteristic of Seshadri's work is often described as 'beautiful progress on hard questions, with new ideas and deep technical skills involving modern methods'. Not many mathematicians may know that Seshadri was also deeply interested in historical aspects of Indian mathematics and edited a volume of a seminar organized jointly with Mumford. Both Narasimhan and Seshadri were institution builders even after moving from TIFR. Narasimhan had enabled researchers from Third World countries to gather and work at ICTP. Seshadri carried out his long-cherished vision of establishing a school, where bright undergraduate students are taught by active researchers through the establishment of the Chennai Mathematical Institute. Initially, this school was supported by the 'SPIC Science Foundation', and subsequently, it became an autonomous independent institution. The CMI is now flourishing as a world-renowned centre for mathematics.

It is universally acknowledged that if not for the penchant and enthusiasm for sharing ideas that both Narasimhan and Seshadri possessed, the mathematical world—especially, the Indian mathematical community—would have been much poorer.

In summary, the monumental contributions of these two eminent personages have left a lasting impact on the mathematical world. Something of their persona can be gleaned from the following words of Rabindranath Tagore which were dear to Narasimhan (I

learnt this from Nitin Nitsure):

*“I slept and dreamt that life is joy
I awoke and found that life is service.
I acted, and behold, life was joy!”*

As alluded to above, a brief description of the mathematical work of Narasimhan and Seshadri appears in an article written by Ramanan, arguably the one who is most suited for this responsibility. As the mathematics involved is highly technical, Kapil Paranjape has sketched an inviting description of the animals (including the elephant) that appear in this mathematical jungle. The classic paper of Narasimhan–Seshadri was preceded by a short one that announced these results, and it is republished here with the permission of the families.

In this issue, we also have a spectrum of other interesting articles.

In a delectable article, D Indumathi gives us a flavour of India’s home-grown experiment, the INO (India-based Neutrino Observatory), that studies the key properties of neutrinos about which we still do not know much. The INO, arguably, has the potential to be a world-class experiment.

Amit Apte writes about the work of Manabe and Hasselman, which showed the importance of understanding the complex dynamical processes which govern the evolution of Earth’s climate, work for which they were awarded the Nobel Prize in Physics in 2021. In the first of a three-part series of articles on the chemistry of antioxidants, Hussain Reddy presents the antioxidant properties of metalloenzymes. Aspects of human-microbial interaction are discussed by Rajkumar Dhanaraju and D N Rao in an article on the human microbiome. A lovely classroom note by Jayanth Vysanakere and Rajaram Nityananda poses a problem concerning the transfer of heat from a hot liquid to a cold one. Shirali continues with the second part of his series on ‘nice’ problems in mathematics, while Jagannadham et al. write about pK_a values and deprotonation equilibria of benzenonium carbocations.