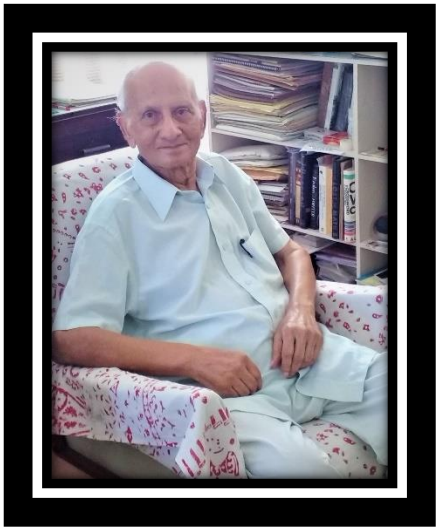
Professor S. Naranan



April 17, 1930 – 28 November, 2019

Alas, another pioneering High Energy Cosmic Ray Astrophysicist, Prof. Sundaresan Naranan, is no more with us. He breathed his last on 28 November, 2019. His daughter, Mrs. Venil Sumantran, tells me that they were surprised since he was recovering from a mild chest infection.

Prof. S. Naranan was born on April 17, 1930 in Kattupputtur, a village near Tiruchi in South India. He grew up in Berhampur, Odisha. In 1953, Naranan married Visalakshi Sundaresan, who, beyond her B.Sc , had diplomas in Teacher Training and Library Science. She was a devoted wife and mother of three daughters,Vidya, Venil and Mati Her demise in 2013 was keenly felt by Naranan and his daughters.

Nobody can tell his own story any better than he himself. Prof. Naranan wrote a short account of his Scientific Career in his website – a kind of mini autobiography, you may say, - I shall include here a few excerpts from that account:

"My Education

> *I studied in High School and College (undergraduate) in Berhampur Orissa) and obtained my B.Sc. degree from the Utkal University in 1948. My four years at the Khallikote College are memorable for the inspiring teachers in Mathematics, Physics and Chemistry. Prof. K.N. Sundaresan, my father taught Mathematics, which became my favorite subject. Unlike other universities, Utkal had no 'main' or 'subsidiary' subjects; Mathematics, Physics and Chemistry carried equal weight. So, for my M.Sc. degree, I had a choice of all the three subjects. I chose Physics over Mathematics because M.Sc. (Physics) offered better career prospects in late 1940's (soon after India's independence in 1947). I obtained the first rank in B.Sc. mainly because I scored high in Inorganic Chemistry.*
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> *There is an interesting background to above. I had picked up an Inorganic Chemistry textbook from a waste paper vendor. The book by Caven and Landor was an eye-opener. It propounded the subject in the framework of the Periodic Table of Elements, which is Modern Physics. I concentrated on reading the book, ignoring the syllabus as taught in the college. It*

just happened that the question paper that year was attuned to the methodology of Caven and Landor, unlike the question papers in the preceding years. The examiner (who had also set the question paper) specially referred to my high score at the University Academic Council meeting. I knew about this from my father who was also a member of the Council.

I got admission to the M.Sc. (Physics) of the Benares Hindu University (BHU) in 1948. But at the time of admission, I was told that my admission was cancelled because I had not sent the fees in advance by post (money order). I had indeed sent the fees by post and fortunately I had the acknowledgment receipt from BHU as proof. When I met the Head of the Department, Prof. B. Dasannacharya, he sympathized with my predicament and created an extra seat in M.Sc. (Physics) to accommodate me (raising the class strength from 12 to 13). He complimented me saying that I deserved admission more than anybody else in the class. But for the magnanimity of Prof. Dasannacharya, I would have joined perhaps, M.Sc. (Chemistry) at BHU and my whole scientific career would have taken a different direction.

The second year of M.Sc. (Physics) was mostly devoted to a research project.I worked in Spectroscopy under the guidance of Prof. R.K. Asundi, a highly respected and venerated spectroscopist. The students had a rigorous introduction of hands-on experimental techniques in spectroscopy before the project assignment. It was a great learning experience in experimental Physics. Once, I had measured the wavelength of a spectral line and got an answer that differed in the first decimal place – a very small error – from the value written alongside the line on the glass plate. I checked and rechecked my calculation When the discrepancy persisted, I mentioned it to Prof. Asundi. He found out that my value indeed was correct and tallied exactly with the value given in reference tables! He remarked that I deserved a Nobel Prize – not entirely in jest or mockery as I learnt later – because Prof. Asundi considered precision in measurement as very important.

I got the top rank in M.Sc. (Physics), but missed the Gold medal for all the subjects put together; the medal went to a brilliant student in M.Sc. (Mathematics). Usually M.Sc. (Physics) topper got the gold medal too. But I was happy to learn that I had the record for the highest marks for the M.Sc thesis (198/200). I think the record still stands because BHU changed the syllabus from the following year, removing the requirement of research project and also increased the strength of the M.Sc. (Physics) class about three-fold.

My Research

I worked in the Tata Institute of Fundamental Research (Bombay, now Mumbai) for 42 years from 1950 to 1992. The first half of my research career was devoted mostly to Cosmic Rays (Experimental). Research in Cosmic Rays was truly an adventure, working deep underground in Kolar Gold Fields (KGF), under water (Sathanur dam) and in an abandoned Railway tunnel (Khandala). I also worked in mountain stations (Ooty).The depths to which we went down in KGF ranged up to 3 km (10,000 ft.), even greater than the altitude of Ooty 2.2 km (7200 ft.). B.V. Sreekantan and I first started the work in KGF in 1951. I was the last candidate to be registered with Dr. H.J. Bhabha as guide for Ph.D. My Ph.D work was based on a cloud chamber experiment to study the interaction of high energy muons capable of penetrating about 300 ft. of rock before entering the cloud chamber located in an abandoned tunnel in Khandala, between Mumbai and Pune. The experiment clearly established that muon interactions with matter, even at high energies, are fully consistent with their behavior as 'heavy electrons'. No interaction other than the 'electromagnetic', was required, as suggested by some earlier experiments. This was a confirmation of an earlier prediction of Dr. Bhabha. In an incisive analysis of the 'penetrating' component of Cosmic Radiation in 1937, Dr. Bhabha had concluded that it is consistent with being composed of electron-like particles about 100 times heavier than the electron. Muons were discovered later that

year and they behave like heavy electrons. From 1954 I started working at Ooty, first with cloud chambers and later with Extensive Air Shower (EAS) arrays of plastic scintillators to study the interactions of High Energy Cosmic Rays (> 10 eV). EAS experiments were also started in KGF in 1962 with muon detectors deep underground in coincidence with an EAS array on the surface."

The EAS array consisted of about 20 plastic scintillators and a couple of water Cerenkov detectors. The latter was quite new at that time and developed as a cheap large area charged particle detector. It consisted of a circular clean water tank of about 3m diameter and 1m deep to which a wavelength shifter was added. When a charged particle passed through it, Cerenkov light is emitted and collected by photomultipliers. These detectors were operated at two underground levels of 1000 and 2000 ft deep in coincidence with EAS array on the surface.

Here I would like to mention a few details of his work on EAS studies in collaboration with me.
We were 5 members in the group at that time; B.V. Sreekantan, S. Naranan, B.K. Chatterjee, G.T. Murthy and myself. We started an air shower experiment on the terrace of the C block of the TIFR building with 5 liquid scintillation (toluene) detectors and, I think, 2 neutron monitors. My first assignment was to build a 300 V power supply, which was required for all the electronics built from vacuum tubes those days. Dr. Naranan helped me in this project.

My next assignment was to help Dr. Naranan in building a mechanical computer to analyze the data collected from that experiment. It was an ingenious device originally designed by MIT, USA, which we tried to replicate. I enjoyed working with him on this project. To analyze the data further, he developed a punch-card system to sort the data. We used it extensively.

Our next experiment was at Ooty with much larger number and variety of detectors including muon detectors. I worked with him on setting up the neutron monitor detectors to study the nuclear active particle component. I learnt a lot from him about this detector. Study of these two components formed a major part of my Ph.D. thesis. Even though my thesis guide was Prof. Sreekantan, Dr. Naranan advised and guided me to a large extent as Prof. Sreekantan was away in MIT at that time.

He also helped me in finding a suitable lake in South India to carry out some under-water experiments in collaboration with Japanese scientists. That search took me into the interiors of Tamilnadu, where Dr. Naranan's help was crucial.

Back in Bombay, I undertook writing a program for analyzing the data collected from the Ooty experiment on the first digital computer built in TIFR using vacuum tubes. In this task, Dr. Naranan helped me a lot by discussing various mathematical and statistical procedures and algorithms in a very interesting and illuminating way. This program has, subsequently, become a bench mark program which the computer maintenance engineers used for testing the machine before releasing it for public use.

A few years later, after my return from USA, I joined the KGF air shower experiment, which was started by him. He helped me a lot in developing this experiment to its full potential.

Overall, it was a very pleasant and highly fruitful experience for me to be associated with him for a major part of my carrier. On a personal level, I almost thought of him as an elder brother. Our families also are very close to each other. In fact, I fondly remember those days in Ooty (before my marriage) when myself and Naranans were staying in the Woodville bungalow, Vishalam used to invite me for breakfast whenever she made some special dish like idlys. All in all, myself and my family cherish those fond memories, and the children (then) of the BHASKARA colony used to love the movie and video shows organized by Prof. Naranan and cherish those fond memories.

To continue with the autobiography:

"The second part of my career began in 1967 in X-ray Astronomy. X-ray Astronomy had burgeoned as a new discipline only in the early 1960's and the pioneers in the field were Cosmic Ray physicists. I worked at the Massachusetts Institute of Technology (MIT, Cambridge, USA) from 1967-1969 on the first rocket-borne experiments of MIT. Then for one year (1970) I worked on the first X-ray satellite UHURU, before its launch by the American Science and Engineering (AS&E) headed by Dr. R. Giacconi. Dr. Giacconi was a pioneer in the field and was awarded the Nobel Prize in the year 2002. MIT and AS&E had jointly carried out the first rocket-borne experiment with X-ray detectors in 1962, that heralded the birth of X-ray astronomy with the discovery of Sco X-1, the first non-solar X-ray source in the universe.

At TIFR, the rocket X-ray Astronomy program was started in 1970. Rockets were launched from Thumba (near Trivandrum) and then Sriharikota (Andhra Pradesh). Balloon-borne experiments in X-ray astronomy (20-100 keV) had begun even earlier. They were launched from the TIFR Balloon Launching Facility at Hyderabad. From 1976, I collaborated with late Prof. D. Venkatesan of the University of Calgary (Canada), in conducting balloon-borne X-ray Astronomy experiments from Hyderabad. The National Balloon Facility of TIFR at Hyderabad has the full capability of manufacturing gigantic polyethylene balloons, launching them and recovering the payload after the completion of the experiment. A balloon of volume of about 10 million cubic feet can carry a ton of payload and float at an altitude of 40 km for several hours before it is parachuted down by radio control. Late Prof. S.V. Damle was a key member of the TIFR-U.Calgary collaboration and was responsible for the design of the experiments. As the scientist in charge of the Balloon Facility, he was also instrumental in upgrading the facility with capabilities on a par with international standards encompassing all aspects of ballooning – production of balloons to recovery of payload after the flight. It is unfortunate that both Prof. Venkatesan and Prof. Damle are no more with us. For a few years before my retirement from TIFR, I was working with satellite experiments in their early phase; the satellites were launched after my retirement in 1992.

During the period 1967-1990, I had spent nearly seven years in total, at several research institutions in the fore-front of X-ray Astronomy:

1. *MIT (Cambridge, USA),*
2. *AS&E (Cambridge, USA)*
3. *Naval Research Laboratory (Washington D.C.)*
4. *Goddard Space Flight Center (Greenbelt, Md),*
5. *Marshall Space Flight Center (Huntsville, AL) and*
6. *Max-Planck Institute for Extraterrestrial Research, Munich (Germany).*

Most of my work was with X-ray Astronomy satellites. The visit to NRL for one year was special because normally only US citizens were allowed to work in NRL, since NRL was a highly classified research laboratory of the U.S. Navy. Dr. Herbert Friedman, Director of Space Sciences Laboratory at NRL succeeded in inviting me as a visitor; it took nearly a year to obtain the necessary clearance from the Navy.I visited the University of Calgary several times and I wish to record here my thanks for the exemplary hospitality extended to me by Prof. Venkatesan and his wife Mrs. Bharathi.

Now I will mention my research in areas outside Physics and Astronomy starting from late 1960's. My first foray was in Bibliometrics (also known as Scientometrics or Information Science). Its aim is to study the 'Science of Science' – its growth, practice etc. A well-known law in the field was Bradford's Law. The law is about the distribution

of scientific papers in a field (say Immunology) among journals. A large number of journals carried few papers each, whereas a small number of journals carried many papers each. The latter are the core journals. The law is the forerunner of the famous '75%-25% law' in behavioral sciences. For example in Economics: in a group of rich people, 75 % of the total wealth is in the hands of 25 % of the number in the group. I found out that Bradford's Law had a very simple mathematical formulation. The number of journals carrying x number of articles is inversely proportional to x . Such functions – called Power Laws – occur frequently in Cosmic Rays. For example, the number of primary Cosmic Rays with energy E is inversely proportional to E2. This is called the energy spectrum of Cosmic Rays.

Fermi, the famous nuclear physicist and the 'father of nuclear power' had published only one paper on Cosmic Rays – a model for the energy spectrum. I cooked up a model for Bradford's Law on the lines of the Fermi model. Basically Bradford's Law is a consequence of two facts about growth of science: exponential growth in time of the number of journals in a given field of science and concurrently similar growth in the number of papers carried by an individual journal. A short paper on this model was published in Nature in 1970 and it attracted much attention, particularly in the East European countries. This model of 'back-to-back exponential growth' was extended to many other statistical laws in Bibliometrics in a subsequent long paper in the Journal of Documentation in 1971.This is one of my most cited papers.

Soon after my Nature paper was published, I received an invitation from the President of the Hungarian Academy of Sciences to join the Editorial Board of their journal Scientometrics and also act as a referee for the journal. I politely declined the offer stating that the Nature paper was the only paper I had ever published in the field.

My first leap was from Physics to Bibliometrics and then on to Linguistics, 'Indus script', DNA sequences, evolutionary genetics, all related in some way to Power Laws. Meanwhile a revolutionary development occurred in 1978 in the field of cryptography, the science of secret codes. I was drawn to it by its very innovative concept based on Number Theory. This led to fascinating studies on coding and Information Theory. A former colleague and friend from TIFR, Dr. V.K. Balasubrahmanyan also got interested and we both collaborated on applying Physics-based models and Information Theory to studies in linguistics, DNA sequences etc. We have jointly published 12 papers between 1992 and 2006 (Volume 3, L1-L12).

From a very young age (about 8 years) I had a fascination for kolam designs, the South Indian decorative folk art. Kolams are lines drawn around a grid of dots. In 2007, I found a beautiful mathematical link between Fibonaccinumbers (1,1,2,3,5,8,13 ……) and kolam designs. The connection could be exploited to produce kolams of any arbitrary size and shape using smaller modules. The recursive process made the kolam art amenable to computer-aided-design of complex kolams. I had written a long article on the subject. Recently, in a private correspondence with Martin Gardner, the celebrated leading exponent of Recreational Mathematics, Gardner appreciated the kolam work as "beautiful …..deserve to be published". Gardner wrote this letter on 22 April 2010, exactly one month before his death on 22 May 2010 at the age of 95. He had received my kolam articles only the day before he wrote to me (21 April 2010). Although my article is not published, I consider Gardner's evaluation of my work as the best commendation it can receive.My two-part article "KolamDesignsbased on Fibonacci Numbers" can be viewed on the website:

http://vindhiya.com/Naranan/Fibonacci-Kolams/

My retirement from a professional career in 1992 was actually welcome because I could focus

more on my interdisciplinary research. The time spent on this has been and continues to be rewarding. For this I am thankful to three different factors: (1) easy access to a top-class library in Matscience (Institute of Mathematical Sciences, Taramani) (2) collaboration with Dr.VKB and (3) Prof. Koehler and Prof. Altmann, two German editors of a European Journal, the Journal of Quantitative Linguistics. They wrote to us inviting our contributions to the Journal, after reading our first two papers on linguistics published in Current Science in 1992. They have greatly encouraged us in continuing to publish our work and sustain our interest in research in linguistics.

My latest adventure in research is about statistical analysis of failures in solving crossword puzzles. Ten years of patiently accumulated data showed certain regularity and the statistical function that best describes the data is known as the Negative Binomial Distribution (NBD). Just like Power Laws, NBD also occurs in many areas of behavioral science, e.g. car insurance industry. It is fascinating to realize that a model similar to one in insurance industry about car accidents, will work for the failures in crossword puzzles. I have recently found that NBD has some interesting applications in linguistics too. This paper is scheduled to appear in the Journal of Quantitative Linguistics in the second half of this year (2010).

Most of my scientific papers have multiple authors;this is a reflection of teamwork by a large group of academic researchers backed by a larger number of engineers, technicians and computer programmers. I am deeply indebted to all my colleagues and collaborators in the teams, who are too numerous to mention by name. However, I express my special gratitude to Prof. B.V. Sreekantan who was my senior colleague for nearly four decades, acted as my mentor and was the prime mover behind most of the projects I worked on in India. In my early years at TIFR, Dr. A.B. Sahiar – an expert on cloud chamber technique – was a great inspiration and I am very grateful to him. The experiment for my Ph.D was possible because of the foresight, skill and enthusiasm of Dr. Sahiar in venturing to design and build a mobile laboratory with a fully operational cloud chamber that can be towed and driven into the Khandala tunnel.A year earlier, in 1953, we had tried hard to operate a cloud chamber at a depth of about 100 ft. below ground in the KGF. The results were disastrous because of the extreme humid conditions underground. It was Dr. Sahiar's idea to operate the cloud chamber in a tunnel with overlying rock instead of underground.

Volume 3 contains the papers on Quantitative Linguistics written by Dr. V.K. Balasubrahmanyan and me in the years 1992 – 2005 (L1 – L12). Most of them would not have been written but for the active collaboration of Dr. V.K.B. The Miscellaneous group of papers (Volume 4) contains the papers written by me as the sole author. They deal with Scientometrics, Number Theory, Cryptography, Linguistics and Crossword puzzles.

My collected scientific papers in these four volumes are also available in a fully digitized format on a CD. The initiative for this came from my nephew T.V. Suresh and my daughter Venil Sumantran. The massive task was enthusiastically taken up and completed in record time by Dr. Raman Srinivasan and his team at the Tata Consultancy Services in Chennai. I am very grateful to all of them for the unique gift they have given me for my 80th birthday (17-4-2010).

14 June, 2010
S. Naranan
Chennai, India"

Thus, it can be seen that Prof. Sundaresan Naranan was a multifaceted Scientist with important contributions in subjects like Cosmic Rays, Extensive Air Showers, Particle Physics,

X-ray Astronomy, Gamma Ray Astronomy, Mathematics, Bibliometrics, Kolams etc. We very badly miss his presence among us.

RIP, Professor Naranan.

M.V.S. Rao
Formerly on the TIFR Faculty