B. V. Krishna Murthy (1938–2022)

Dr B. V. Krishna Murthy or BVK for those close to him, passed away on the evening of 10 April 2022 at the age of 84 at Chennai, where had lived since 2001 after superannuating from Indian Space Research Organisation (ISRO) as the Director of the Space Physics Laboratory of Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram. It is a great loss to Indian science (atmospheric and space science), and a personal loss to me. I have been fortunate to be associated with BVK since 1973 in several capacities – as my Ph.D. mentor, a superior officer and leader in several state-of-the-art projects of ISRO, a colleague, an adviser, a collaborator and above all, as a well-wisher. Here I share a few scattered thoughts on BVK and his contributions to the evolution of space and atmospheric science research in ISRO in general and Space Physics Laboratory (SPL)/Space Physics Division (SPD) at Trivandrum in particular.

BVK has been an integral part of the space and atmospheric research programmes of ISRO and VSSC even before their formal initiation. The establishment of Thumba Equatorial Rocket Launching Station (TERLS) in 1963 by the 'father of the Indian space programme' Vikram Sarabahi, sowed the seeds for India's space programme. Thumba's proximity to the geomagnetic equator set a unique natural laboratory for various geophysical processes to take place high above in the atmosphere (in the ionosphere, a broad region extending from about 80 km above the surface of the Earth) and TERLS was designed to make rocket experiments to study the equatorial ionospheric processes. To supplement the rocket experiments with continuous ground-based data on the state of the ionosphere, a few ground-based experiments were also initially set up in TERLS.

Next, there was the necessity to intelligently synchronize these activities and fortify them with newer research components from the ground as well as using rocket experiments for their long-term sustenance. For this, BVK was hand-picked in 1967 from National Aeronautics and Atmospheric Administration-Goddard Space Flight Centre, USA (where he had been working as a postdoctoral researcher) by none other than Sarabhai, through the offer of a physicist position at Space Science and Technology Centre (SSTC), which was established along with TERLS.

Accepting this offer, BVK joined SSTC and TERLS in 1968. By then, the Space Physics Division was also established with its main office housed in the Flora Villa building in TERLS, with the few ionospheric monitoring instruments already in place along with a few research scholars and supporting staff. BVK started functioning as the Associate Head of SPD (the Head being Prof. P. D. Bhavsar at PRL).

In SPD, BVK initiated new scientific experiments for studies of the ionosphere, along with his colleagues, as well as jointly with other scientists, mainly from PRL. The major efforts included in-house development of scientific instruments for the measurements of ionospheric absorption, high-frequency phase-path, relative ionospheric opacity meter and topside sounder experiment for studying the topside ionosphere using sounding from the ISIS (International Satellites for Ionospheric Studies) series of satellites. This in a way was the earliest attempt to use satellite data for ionospheric studies in SPL. BVK also initiated the development of rocket payloads, the ionization gauge experiment flown aboard RH-560 from Sri Harikota range being the first of these. However, these did not yield the expected thrust due to several teething issues in space technology, including consistency in rocket performance, onboard systems and data collection. In parallel, BVK provided thrust in ionospheric research, and started guiding research students, leading to the build-up and diversification of ionospheric research.

Then came a big opportunity in the form of the ISRO–NASA joint venture in proving the feasibility and establishing satellite-based television (TV) across India through the SITE (Satellite Instructional Television Experiment) programme, under which the US satellite ATS-6 (Application Technology Satellite series 6) was loaned to India for a period of one year from August 1975 to July 1976. Taking advantage of the potential of this satellite, which also carried on-board a multi-frequency coherent radio beacon experiment (RBE) along with the TV links, BVK took up the project of radio beacon studies from Thumba to understand and model the regular and disturbed characteristics of the equatorial ionosphere, which have application in trans-ionospheric communication design over a wide frequency range from HF through VHF, UHF to SHF. Under this, a 22-channel coherent RBE receivers system working on 40, 140 and 360 MHz and their modulations was designed and developed totally in-house employing the phase locked loop principle (perhaps for the first time in VSSC then). It was used for measuring the total electron content of the ionosphere using the principle of polarization rotation (Faraday rotation) due to change in the electron content along the ray path during the morning and evening hours, when the ionosphere goes through its diurnal production and loss cycles. Again, the amplitude of the signal at these frequencies was used to observe and record the radio scintillations (pseudo random fluctuations of the amplitude of the signals) produced by the ionospheric irregularities acting as random scatterers. These scintillation data were used for in-depth studies of the characteristics of these irregularities, their spectral characteristics and the processes leading to their formation on the one hand, while their fading characteristics were used to model the effect of these irregularities on satellite to ground communication channels. The grand success of this project was recognized both nationally and internationally.

There was a total solar eclipse in 1980 and BVK was quick to see its potential to study infrasonic pressure perturbations caused by the supersonic movement of the Moon's shadow. For this, a set of infrasonic sensors were developed, again totally in-house, and deployed along the path of the eclipse, in addition to the one at SPD (where the eclipse was only partial), forming a mini network. In fact, this was the first coordinated field experiment carried out by SPD.

In the beginning of 1980, SPD took a conscious decision to diversify by expanding its research domain to over the entire

atmosphere; right from the surface of the Earth to the magnetosphere and beyond; and in that process got upgraded to a full-fledged research laboratory (SPL). BVK initiated studies on atmospheric aerosols (tiny suspended particles in the atmosphere and their radiative implications). For this, he chose to employ laser remote sensing of the atmosphere; again venturing into developing the required scientific instruments, motivated by the shot-in-the-arm received by the success of the ATS-6 experiment. Thus, he became the first to develop in-house, the first pulsed Ruby lidar and the CW argon ion lidar systems in India. Extensive studies were made on aerosols using these lidar systems. BVK also initiated and nurtured aerosol and radiation budget studies in the country. He initiated the development of a multi-wavelength radiometer which became the principal method for aerosol studies. Aerosol and radiation budget studies have become a major area of scientific research in the country owing mainly to his initiative.

The 1980s also witnessed a global emphasis on atmospheric science, with the formulation the global Middle Atmospheric Programme (MAP). In line with this, India formulated a multi-agency funded programme, the Indian Middle Atmosphere Programme (IMAP) with ISRO in the lead. BVK ensured that SPL played a major part of this national programme by formulating aerosol characterization experiments at the national level, thereby taking science outside the local laboratory environment. A set of multi-wavelength solar radiometers (MWR) was designed and developed, again totally in-house, and a network consisting of five MWRs was established by looping in universities and research institutions with SPL as the nodal laboratory. This concept-proving effort became a great success during the IMAP and was readily selected to be one of major thrust experiments under the aerosol–climate interactions studies taken up by ISRO under its Geosphere Biosphere Programme, being directly monitored by the ISRO Head Quarters at Bengaluru. The success of this experiment was so phenomenal that a national network was established in a phased manner, involving universities, academia and research laboratories of various departments resulting in the biggest national network carrying out coordinated research on the regional aspects of a global issue with societal and climate implications. This network, with a series of technological updating, has become the densest network in South Asia with longest primary data on several aerosol parameters important for climate studies, and is still going strong. It stands tall in providing primary data for basic science, climate science and policy, and is also a testimony for collective teamwork and scientific capacity-building.

In the late 1990s, a joint Indo-US experiment, the INDOEX was formulated and BVK coordinated extensive participation of SPL, both from the land and aboard research cruises. Towards mid-1990s, BVK dedicated himself to research on middle atmosphere dynamics and atmospheric turbulence. Making use of data from several national facilities, he contributed extensively in the advancement of this field. He has developed methods to derive the lower atmospheric temperature profile and to estimate the turbulence parameters in the lower atmosphere from radar wind data. He has also developed a method to derive thermospheric wind from ionospheric data. In summary, BVK has been unique with respect to research in atmospheric and space science; spanning from the lowest level of the atmospheric boundary layer to the highest level of the magnetosphere, and has contributed extensively in bringing national and international visibility to SPD and SPL. Throughout his career in SPL, he strived to jive experiment development scientific research together. The number of instruments developed under his leadership for atmospheric and space research is far more that any of his contemporaries. In 2018, BVK was honoured with the national award for excellence in atmospheric science and technology.

Though a great scientist, BVK was humble and modest throughout his life; he was never after fame and never lobbied for it. BVK not only believed that one's greatness is to be recognized by others, but tried to inculcate this among all his students. He considered research as a constant pursuit for knowledge, a focused and hard work towards improving our understanding of the nature and its processes, a logical thinking, critical analyses leading to newer insights and to derive the pleasure of that understanding and sharing it with the community. He was a good teacher, making anyone approaching him with a research question to work out the answer from the first principles following the laws of physics. With his great leadership quality, anyone approaching BVK with difficulties of meeting a dead-end during their scientific pursuits in domains related to his expertise, would immediately receive from him more than one possible openings to look for possible solutions. Given his talent and success, BVK should have reached much greater heights, but he was contented in finding answers to questions and sharing the knowledge with his peers and students. He was extremely intelligent and maintained a sharp brain even in his eighties; and his advice has been greatly sought after by various scientific institutions and research bodies including NARL, SPL, numerous universities, etc. Recently he was a member of the Expert Committee to examine and prioritize payloads for future planetary missions, including those to Venus.

The atmospheric and ionospheric scientific community in India is indebted to him will ever keep a sacred position for him.

K. KRISHNAMOORTHY

Centre for Atmospheric and Oceanic Sciences,
Indian Institute of Science,
Bengaluru 560 012, India
e-mail: kkmoorthy@iisc.ac.in

Edited by S. K. Satheesh and printed & published by the Current Science Association, Bengaluru 560 080.
Typeset by WINTECS Typesetters, Bengaluru and Printed at Printek Printers, Bengaluru (Ph: 2328 7763)