First IEEE Milestones in India

The work of J.C. Bose and C.V. Raman to be recognized

By IVAN BERGER 7 September 2012

Technological achievements in India are being honored with **IEEE Milestones in Electrical Engineering and Computing**

Photos: SSPL/ Getty Images

(http://www.ieeeghn.org/wiki/index.php/Milestones:IEEE_Milestones_Program). The first millimeter-wave communications experiments, by J.C. Bose [left], and the molecular scattering of light, discovered by C.V. Raman [right], are to be recognized in Kolkata, West Bengal, on 14 and 15 September.

RADIO WAVES

Two years before Guglielmo Marconi's long-wave radio demonstration in England, Sir Jagadish Chandra "J.C." Bose demonstrated millimeter-wave radio in Calcutta (now known as Kolkata). Bose (1858–1937), born in what is now Bangladesh, was a versatile scientist, working in physics, biology, botany, and archeology. After graduating from St. Xavier's College, in Calcutta, he studied medicine for a year at London University, left because of poor health, and in 1881 entered Christ's College, Cambridge, in England, to study physics under Lord Rayleigh.

After graduating in 1884 with a natural science tripos (an honors baccalaureate), Bose returned to India. A year later, a recommendation from Rayleigh got him the post of professor at Presidency College, in Calcutta, the first Indian to hold that title there. The college's British administrators offered him only one-third the salary of its European professors. Bose protested by taking no salary at all for several years until the college recognized his value and raised his salary to match his European peers, retroactive to the start of his professorship.

During his 30 years at the college, Bose conducted research and engaged his students' interest through extensive scientific demonstrations. It wasn't easy, because the school had no lab facilities. Bose was, however, given the use

of a 2.2-square-meter room, and he devised his own equipment with the aid of a tinsmith.

Between 1894 and 1900, Bose performed pioneering research on radio waves and generated waves as short as 5 millimeters. His work predates that of Marconi, who is most often associated with the development of radio. Unlike Marconi, who sought to commercialize his work with radio waves, Bose was interested in radio purely as a scientific endeavor.

Bose also developed equipment for generating, transmitting, and receiving radio waves and used it to demonstrate the waves' properties.

He also experimented with galena, a form of lead sulfide, to make an early type of semiconductor diode, using it as a detector of radio waves. Galena detectors were at the heart of the reliable and inexpensive "crystal sets" that helped make radio popular until tube radios began supplanting them in the 1920s.

In the early 1900s, Bose did further pioneering work, this time in animal and plant physiology, another longtime interest. His contributions included his invention of the chrestograph for recording plant growth in increments as small as 1/100 000 of an inch. Another device he developed demonstrated the effects of electromagnetic waves on living and nonliving matter.

Bose, who believed strongly in the free exchange of scientific knowledge, lectured frequently in Europe and the United States on plant physiology and the effects of electromagnetic waves on living and nonliving matter.

In 1917 he founded the Bose Research Institute, in Calcutta, one of India's first scientific research institutes.

Bose was the first Indian scientist to make a name for himself in the western scientific world, and he received many honors. He was the first Indian to lecture before London's Royal Institution (1897). He was knighted by the British Empire in 1917 and became the first Indian member of the prestigious Royal Society of London in 1920.

On 14 September, his experimental work on millimeter-band radio is to be recognized when a plaque is placed in the corridor of the A.J.C. Bose Auditorium in Presidency College's main building.

RAMAN EFFECT

Unlike Bose, Chandrasekhara Venkata "C.V." Raman (1888–1970) was already well known among physicists when he first visited England in 1921, thanks mainly to his work in acoustics, especially in the sounds and vibrations of Western and Indian stringed instruments. But it was his interest in optics, and his curiosity on his trip home to Calcutta about the sea's deep blue color, that led to the IEEE Milestone.

Realizing that the sea's color resulted from light scattering, Raman turned his mind to that phenomenon when he reached home. "It seemed, indeed, that the study of light scattering might carry one into the deepest problems of physics and chemistry," he later wrote.

While supporting himself as a civil servant in the Indian Finance Department, he used the laboratories of the Indian Association for the Cultivation of Sciences (IACS), where he and his protégé K.S. Krishnan exhaustively explored the

scattering of light as it passed through various substances. In 1928, they discovered that when monochromatic light passed through a substance, a fraction of the scattered light that emerged was of a different color than the original beam, and that the color varied with the substance.

The experimental results, published in the Indian Journal of Physics (which Raman had founded two years earlier), touched on the phenomenon's quantum implications and stated, "We are obviously only at the fringe of a fascinating new region of experimental research which promises to throw light on diverse problems relating to radiation and wave theory, X-ray optics, atomic and molecular spectra, fluorescence and scattering, thermodynamics, and chemistry."

Widespread recognition followed immediately. Raman's results were published in Nature in 1928, he was made a knight of the British Empire in 1929, and he was awarded the 1930 Nobel Prize in Physics. In his acceptance speech, he said his discovery had "practically unrestricted scope in the study of problems relating to the structure of matter."

"We may also hope," he said, "that it will lead us to a fuller understanding of the nature of light and of the interactions between matter and light."

He was right. Spectroscopy, based on what was called the Raman effect, soon became chemists' principal tool for nondestructive chemical analysis, applicable to liquids, gases, and transparent solids. It can be used to analyze not only stable substances but also the spectra of the most transient chemicals. For those reasons, Raman's discovery was named an International Chemical Historic Landmark by the American Chemical Society and IACS in 1998.

But the Raman effect is also applied to electronics and communications, used in lidar (the optical analog of radar), in frequency conversion, in long-distance quasi-lossless transmissions schemes, nonlinear optics, and Raman amplification for optical communications. The phenomenon is of interest in engineering, nonlinear physics, and applied mathematics. IEEE plans to honor Raman's discovery as a Milestone in Electrical Engineering and Computing on 15 September. The commemorative plaque will be placed at the entrance of the IACS.

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