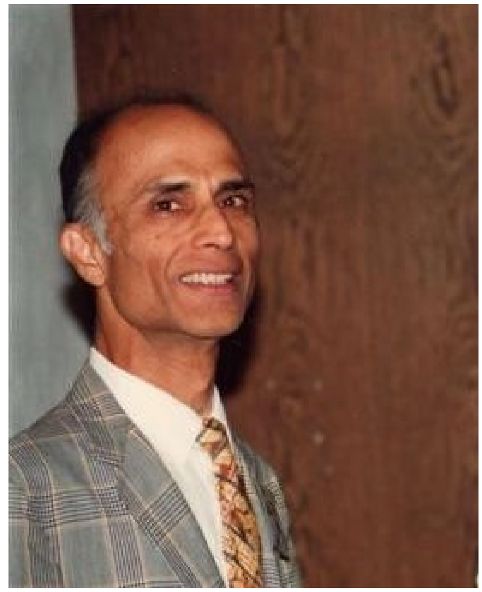
Harish-Chandra



Harish-Chandra (October 11, 1923 – October 16, 1983) came to mathematics relatively late in his career. He began as a physicist, but his interest was with the purely mathematical aspects of physical theories, so eventually he changed his professional designation to that of a mathematician. He became the most prominent Indian mathematician of the second half of the 20th century, despite having some gaps in his background. Rather than allow this to be a handicap, he merely used his imagination, vision, ingenuity, perseverance and incredibly hard work to invent the tools he needed to succeed unaware they already existed. An outstanding algebraist and analyst, he was among those responsible for transforming infinite-dimensional group representation theory from a topic found on the periphery of mathematics and physics into a major field at the heart of leading-edge mathematics.

Harish-Chandra was born in Kanpur, India, the son of a civil engineer and a mother who was the daughter of a lawyer. His early education was provided by tutors, and when he entered school at the age of nine he was enrolled in the seventh class. He graduated from Christ Church High School at age fourteen, and remained in Kanpur for intermediate college, which he completed at age sixteen. He then matriculated at the University of Allahabad, being inspired to study theoretical physics after reading P.A.M. Dirac's *Principles of Quantum Mechanics*. After graduating with a master's degree at the age of nineteen, Harish-Chandra went to the Indian Institute of Science in Bangalore in southern India as a research assistant to a leading theoretical physicist, H. J. Bhabha. While there he took lodging with Mrs. Kale, his former French teacher and her husband, Dr. Kale, a botanist and librarian, and their young daughter Lalitha. Many years later when Harish-Chandra returned to India for a visit, he found that Lalitha had grown into a beautiful young woman, and she became his wife in 1953. In 1945 Harish-Chandra moved to Cambridge in England, where on the recommendation of Bhabha, he became a research student of Dirac, who supervised his Ph.D. thesis. In 1947 he became Dirac's assistant at the Institute of Advanced Study at Princeton. Soon after Harish-Chandra abandoned theoretical physics to concentrate on mathematics. Harish-Chandra was concerned that his work lacked rigor. He later commented that this was a contributing factor to his decision to make a career move:

> "Soon after coming to Princeton I became aware that my work on the Lorentz group was based on somewhat shaky arguments… I once complained to Dirac about the fact that my proofs were not rigorous and he replied, 'I am not interested in proofs but only in what nature does.' This remark confirmed my growing conviction that I did not have the mysterious sixth sense which one needs in order to succeed in physics and I soon decided to move over to mathematics."

According to David Wells in *Curious and Interesting Mathematics*, once while chatting with Freeman Dyson, who started as a mathematician before becoming a physicist, Harish-Chandra announced, "I am leaving physics for mathematics, I find physics messy and unrigorous, elusive." Dyson rejoined, "I am leaving mathematics for physics for exactly the same reasons." At Princeton, Harish-Chandra took courses from Claude Chevalley, Emil Artin and Hermann Weyl. In 1949-50, he spent a year at Harvard to study algebraic geometry with Oscar Zariski. Harish-Chandra then became a professor at Columbia in New York (1950-63) before returning to the Institute for Advanced Study, where he remained for the rest of his life as the IBM-von Neumann Professor of Mathematics.

Harish-Chandra's years at Columbia were his most productive, mathematically, as he concentrated on the discrete series representations of semisimple Lie groups. He is also known for his work with

Armand Borel founding the theory of arithmetic groups. Before changing from physics to mathematics, he had already written a paper on infinite-dimensional representations of semisimple and reductive groups, which were not of much use in physics but had a great deal of significance in mathematics. In their work on the solvability of equations during the 19th century Galois and Abel employed the concept of a group.

Eventually, mathematicians moved away from the problem of solving equations to the study of the abstract groups. One problem they faced was to represent abstractly formulated groups by concrete means. With the rise of quantum mechanics infinite groups and matrices had to be considered. To understand very complex interacting systems of highly energetic elementary particles it is necessary to study the group of symmetries that leave the system unchanged. The groups that are most important to this problem are known as simple groups. Harish-Chandra constructed the most fundamental infinite dimensional representations of all of the simple groups and used them to represent generalized functions in these groups by means of Fourier series. Besides high-energy physics, applications of representation theory of simple groups are found in modern number theory and Galois Theory.

Harish-Chandra once attempted to express his mathematical aesthetics in a painting metaphor, "In mathematics there is an empty canvas before you which can be filled without reference to external reality." Harish-Chandra, whose health had always been fragile, had his first heart attack in 1969, and from then on his health was a major concern. He suffered a fatal heart attack on October 16, 1983 as he walked in the woods near the Institute.

Quotation of the Day: "In mathematics we agree that clear thinking is very important, but fuzzy thinking is just as important as clear thinking." – Harish-Chandra