

My Forays into Interdisciplinary Areas of Research

Hardev Singh Virk*

My entry into interdisciplinary areas of research was not by choice but by default. In 1970, I earned the French Government Scholarship (Bourse) to pursue my research for doctorate degree in High Energy Nuclear Physics at the university of Marie and Pierre Curie under the supervision of Prof. Max Morand, a Cosmic Ray Physicist. I started working on nuclear emulsion plates exposed to 14 GeV/c protons beam at CERN Synchrocyclotron. It was a tough job to search for nuclear interactions of protons with silver nuclei embedded inside the emulsion plates resulting in events called white stars containing all shower tracks (without any black or grey tracks) recorded by relativistic particles. Since no scanners provided to help me, I spent 6 months to collect one dozen events of my choice out of 500 stars scanned in emulsion plates. Identification of relativistic particles was another uphill task for which I was provided with an Italian make Koristka Microscope for length and scattering angle measurements. The data tapes were run over an IBM 1620 Computer to get results of particle energy and identification. My thesis "Identification of relativistic elementary particles produced in 14 GeV/c Proton-Nucleon collisions in nuclear emulsion plates" was accepted for the university doctorate (Docteur d'universite') on 26 Sept. 1972.

I was offered the choice to work in a joint collaboration, K⁺ — anti K⁺, between CERN, College of France and TIFR (Tata Institute of Fundamental Research), Bombay. I preferred to return to my parent university in India as my family had no means of subsistence in my absence. There were no high energy accelerators in India and the only alternative was to carry some proton beam exposed emulsion plates for study in India. I was not allowed this facility as Prof. Morand was going to retire just after my defence of thesis in 1972. For a year, I was sitting idle as there were no research facilities in Punjabi university Patiala. I wrote to Prof. Tolstov in Russia and he provided a stack of emulsion plates exposed to 10 GeV/c Deuteron beam at JINR, Dubna. These emulsion plates were of poor quality and I had to travel to Delhi 500 kms. on week-ends for purpose of scanning nuclear events. This arrangement was very tedious and taxing on my time and energy, hence I abandoned my dream of high energy nuclear research in India.

My Chairman of Physics department asked me to start some research activity. As a consequence, I supervised a Master's Thesis (M.Sc.) "Gap length measurements in nuclear emulsion recorded tracks" and published a paper in **Comptes Rendus** de l'Académie des Sciences, Paris. In April, 1974, I got a chance to participate in a Summer School on Radiation Biology in IISc, Bangalore. Radiation Physics and its applications was my favourite subject in later years. But I found my knowledge of Biology was almost nil, hence I dropped the idea of entering this field. Of course, I guided a Master's Thesis "Chromosome aberrations in Barley due to neutron irradiation" and got some good results.

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After the examinations were over in 1974, I started visiting universities in the neighbourhood, for example, Punjab University, Chandigarh and Kurukshetra University, Kurukshetra. Prof. KK Nagpal, a high energy physicist, was engaged in Geochronology research using fission track (FT) dating. I found his work interesting and worth

pursuing as I was expert in using the tools required for FT dating, viz., microscope, etching and track counting. Fortunately, my project for funding research in Geochronology got approved within 6 months, with the provision of two research fellows. My foray into Geochronology proved rewarding as our group was successful in dating pegmatite minerals (muscovite, biotite, chlorite, apatite, garnet, zircon and quartz), tektites, meteorites, obsidians, volcanic eruptions and ocean bottom spreading. This work resulted in 73 publications. Besides FT dating, we estimated Uranium content of samples studied as a by-product. Age determination was based on fossil and induced fission tracks; the source of both being Uranium.

Our investigations revealed that spontaneous and induced fission causes radiation damage in the matrix of samples studied. Heating of irradiated samples caused annealing of tracks and I undertook this study using heavy ion beams made available at GSI Darmstadt in 1983. Along with minerals, we irradiated glasses and polymer samples using ion beams from Carbon to Uranium over a wide range of energies. Etching was obligatory to reveal tracks of heavy ions and their length measurements in situ. Heating under varying times and temperatures (isothermal and isochronal experiments) lead us to study the Arrhenius diagrams of exposed samples. We published 126 research papers in Radiation Damage studies area culminating into empirical formulation of "Modgil—Virk Single Activation Energy Model of Radiation Damage Annealing in SSNTDs". This model, in its modified form, has been used by PB Price group in UC Berkeley during their "Space Shuttle Cosmic Ray Experiment".

Heavy Ions were used as a micro-structuring tool by Reimer Spohr in GSI, Darmstadt. During my visit to GSI in 1985, I had the privilege to work in Spohr's laboratory to learn the technique of fabricating Ion Track Filters (ITFs), also called micro-Membranes. On return to India, I was sanctioned a multi-million Rupees project, "*Heavy Ion Radiation Effects in Insulators*", by Department of Science & Technology, Govt. of India. ITFs were prepared and used for environmental pollution studies and filtration of cancer blood cells of cancer patients in Guru Nanak Hospital in Amritsar. We had collaborated with group of S.K. Chakarvarty in NIT Kurukshetra. We were not aware that application of ITFs can prove to be a stepping stone to Nanotechnology of future in India.

Before my foray into the area of Nanotechnology, I was fascinated by the study of Radon and its use as a precursor for earthquake prediction research. Radon is the most important source of naturally occurring radiation exposure for humans. For the world population, radon exposure represents 50% of the total exposure to natural background radiation. In India, only two groups had exploited Radon: AMD (Atomic Minerals Division) group for Uranium exploration and TIFR group of Prof. Rama in Geophysics. I prepared a multi-prong project using Radon for environmental pollution studies; health hazard effects to population; and correlation of Radon activity with micro-seismicity in the Himalayas. Radon and Helium were used as precursors for earthquake studies. Radon was also used for biogeochemical exploration of Uranium in the sub-Himalayan region. Our Radon studies are being used as bench mark in many states of India. Our group published 101 research papers based on Radon studies in India.

I retired in 2002 after serving 37 years in Indian universities. Just after retirement, there was no plan to undertake research projects in any area due to lack of laboratory facilities. All of a sudden, I got an invitation in 2008 to join an Indo-Russian project dealing with Nanomaterials. I had to change my plan and I joined DAVIET (DAV Institute of Engg. & Technology) Jallundhur to set up facilities in area of Nanotechnology. We started from a scratch but liberal funding was provided by the DAV Foundation to encourage and support my research activity. We prepared Nanowires, Quantum Dots and Nanocrystals of nearly a dozen materials. But our success story will be incomplete without the mention of Nanoflowers of exquisite beauty fabricated in our laboratory. My Russian collaborator wanted me to get my research patented but I believe that knowledge is for free distribution and not for sale. In recent years, nanowires and nanorods of metallic and semi-conducting materials have drawn a lot of research interest because of their potential applications in diverse fields, for example,

nanoelectronics, optoelectronics and sensors. Our investigations in Nanotechnology resulted in 38 research papers.

History of Science always attracted my attention during my student life. I studied life stories of eminent scientists in my college and university days. Philosophy of Science is another area of my interest. During my M.Sc. studies in AMU Aligarh, I developed some keen interest in Metaphysics and Greek Philosophy. It was motivated by my interaction with Prof. DS Kothari of Delhi university. Probably, my forays into comparative study of Religions propelled me into Philosophy of Science. Cosmology is my most favourite subject and I wrote my first book "Cosmology in Science & Religion".



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At present, I feel concerned about groundwater pollution studies in my home state where Uranium and Heavy Metals contamination in potable water have created health hazards leading to widespread cancer in the region. Punjab State is suffering from many maladies due to over-exploitation of soil and groundwater resources; the ecological balance has suffered an irreversible loss. Punjab Water Supply and Sanitation Department (PWSSD), Govt. of Punjab has generated lot of data on contamination of groundwater. I hope to collaborate with Scientists of Central university of Punjab located in Bathinda for preparing a mitigation plan for heavy metal contamination of groundwater.

Interdisciplinary research is need of the hour in developing countries to promote overall development of marginalized communities using scientific tools. During my groundwater surveys of rural areas, I found loss of faith in the minds of rural population in the mitigation measures undertaken by Scientists. There is a lack of scientific temper and awareness about health hazards in rural communities of India. Mass media can play an important role in dissemination of scientific ideas among the rural masses.

Last month, as a bolt from the blue, I received a communication from Florian Kongoli, the CEO of Flogen Technologies that VIRK Symposium is being organized to celebrate my contributions in the area of Interdisciplinary research during SIPS 2021 International Conference going to be held in Phuket (Thailand). I consider it a noble gesture of the organizers to honour my research during the 80th year of my life. I invite all participants of Academia.edu to join as delegates to VIRK Symposium. The link is provided in the flyer attached.

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