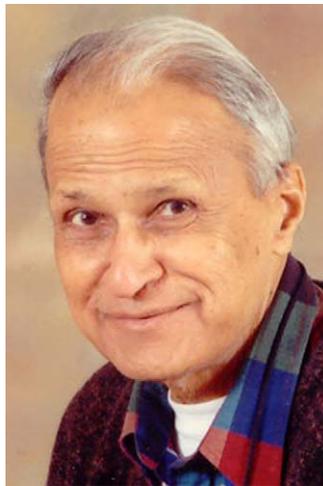


In Memoriam  
Ambikeshwar Sharma  
(1920–2003)



Ambikeshwar Sharma passed away on December 22, 2003, after a long period of illness at his home in Edmonton, Alberta, Canada. Sharma is survived by a daughter, Jyotsna Sharma-Srinivasan, and two sons, Someshwar (Raja) Sharma and Yogi Sharma.

Ambikeshwar Sharma was born in India on July 2, 1920. He received his B.A. (1938) and M.Sc. (1940) from the Maharaja's College, Jaipur, and his Ph.D. (1951) under A.N. Singh from Lucknow University, Lucknow.

Sharma held positions at Cornell, Rajasthan, Harvard, and UCLA before joining the University of Alberta in 1962, where he remained until his retirement, in 1985.

He had eight Ph.D. students: A.M. Chak (1956), R.B. Saxena (1964), A.K. Varma (1964), J. Prasad (1968), D.J. Leeming (1969), S.L. Lee (1974), Mario Botto (1975), and M.A. Bokhari (1986). In addition, he co-advised H.M. Srivastava and K.K. Mathur before leaving India.

Sharma worked in classical analysis, concentrating eventually on lacunary polynomial and trigonometric interpolation, and on spline functions, first cubic splines, then cardinal

splines, trigonometric splines, and even multivariate splines. In his final years, Sharma focused on various aspects of the Walsh over-convergence theorem.

Sharma's wide-ranging knowledge and intuition, his infectious enthusiasm and engaging personality, are reflected in his many publications (more than 200 papers) and in the fact that 56 mathematicians have written papers with him and have become his friends in the process. Among his coauthors are G. Alexits, R. Askey, E.W. Cheney, P. Erdős, G. Freud, C.A. Micchelli, T.S. Motzkin, I.J. Schoenberg, R.S. Varga, J.L. Walsh, and H. Zassenhaus.

Although he was unable to visit the Mathematics Department of the University of Alberta in his final years, his immobility did not prevent him from doing mathematics. He was up-to-date in the literature of his chosen subject, approximation theory. Fortunately, e-mail enabled him to remain in contact with friends and colleagues. He was very eager to stay mobile as long as possible.

The last conference he attended, and even gave a plenary talk at, was in the summer of 1999 in Budapest. He made the long trip against the advice of family, doctors, and friends, using a wheelchair at airports, and delivered a successful talk. He even attended the conference excursion, a further indication of his unflagging willpower.

He was an expert in the theory of interpolation. His dream for many years was to write a monograph on his favorite subject, the theory of over-convergence of complex polynomials. This theory is based on the classic result of J. Walsh stating that the difference of the partial sums of the Taylor series of an analytic function and the Lagrange interpolation polynomials of the function based on the roots of unity converges to zero in a circle larger than the domain of analyticity, although both diverge there. The project started about ten years ago, but his death prevented him from completing the work. It is our duty now to finish the monograph and thus realize his dream.

He was a person devoted to his profession and did not care much for other worldly pleasures. At the same time, he was very sensitive to his friends' problems, and did everything he could to help people. In particular, he tried to help Ph.D. students and fresh Ph.D.'s.

He was the most friendly person we have ever met. He was a credit to mathematics and, especially, approximation theory.

## 1. Recollections

*Contributed by Richard S. Varga:* I first met Ambikeshwar Sharma in the early 1960s in Professor Walsh's office at Harvard University, not knowing then how our lives and research would intertwine over the years. As we both wrote theses in function theory, it was initially easy to connect with each other's ideas and research, but I "strayed" from this area in my early years to numerical analysis, which wasn't Ambikeshwar's "cup of tea". But in 1978, he spent the first of a number of sabbatical leaves at Kent State University, where he kept Alfred Cavaretta (a Ph.D. student of Iso Schoenberg's) and me busy with ideas related to Walsh overconvergence and Hermite–Birkhoff interpolation. This was always exciting. In fact, our weekly seminars in approximation theory were inspiring to all who attended.

These seminars were also interesting in a much different way. It was often a real problem to eat lunch with him at local restaurants in Kent, since he was a very strict vegetar-

ian, so we succumbed to having a communal lunch where seminar attendees all brought and exchanged their foods. This introduced me, in particular, to the wonders of Indian cooking, including basmati rice, yoghurt, and various chutneys, all prepared by his wife, Durga. Whenever we recall those “old” seminar days, we vividly recall those treats from him.

There were many papers written during those visits, and Alfred and I also visited him and his family in Edmonton.

In our joint research, he was a task master, but he had a heart of gold. He was generous and very honest in his treatment of all people, but it was his research drive which astonished us all. Even with his failing health in later years, he was intense in his pursuit of new research, and his students and collaborators learned much from his example!

Ambikeshwar, we shall really miss you!

*Contributed by Jean Sidon (Tzimbalarío):* I first met Sharma during the summer of 1973 while he was visiting Tel Aviv. When I started working in his math department during the fall of the same year, Sharma’s kindness and openness helped me feel at home. During my stay in Edmonton, his family accepted me as a member of the family, and I felt like one of Sharma’s children.

I learned from him the meaning of true collaboration. We obtained better results working together than by just working alone. I was impressed by his intuition and the way he attacked mathematical problems. He introduced me to research in approximation theory and I will never forget this debt.

I had the opportunity to meet many great mathematicians who came to visit him, including Schoenberg, Zygmund, Erdős, and DeVore. He influenced my way of thinking, not only from the mathematical point of view; I learned from him how to come to terms. He was my true mentor and one of my best friends.

*Contributed by T.N.T. Goodman:* Once when Professor Sharma was asked by a mathematician for his first name, he replied that it was ‘terrible’. Since then I have always thought of him as Terrible Sharma, but referred to him simply as Sharma, which, I hope, will not be considered disrespectful for me to do here. I owe him a great deal for, when I was a raw novice in approximation theory, he invited me to Edmonton to work with him. And work we did! On the very first evening, I caught the bus to his house and spent the first of many happy summer evenings sharing with him delicious vegetarian food and delightful mathematics. Up to the last minute before leaving for the airport at the end of the visit, we were still working enthusiastically in his house. While I profited much from Sharma’s funds of knowledge, and from the other mathematicians I met through him, it was his infectious delight and untiring energy in *doing* mathematics that has most inspired me.

Among many visits to Edmonton, one summer my wife and three daughters accompanied me and we spent a very happy time, often enjoying the gracious hospitality of Sharma and his good wife. Although mathematics was his first love (after his family) he had other interests; for example, we enjoyed an outdoor performance of Shakespeare in Edmonton, and he was fascinated by our visit to J.M. Barrie’s birthplace in Scotland. The Hawthorn tree in our garden reminds me of Sharma because during one of his visits to our home he insisted (though aged nearly 70) on hammering in the stake for its support (which still

stands firm). I will always remember his simple dignity, the warmth of his friendship, and his delight in mathematics.

*Contributed by A. Meir:* I first met Ambikeshwar Sharma at the Calgary branch campus of the University of Alberta, in 1963. He left a year later, and so did I two years later; we both joined the Mathematics Department of the University of Alberta in Edmonton.

The department in Edmonton at the time had already a very good mathematics library and considerable strength in several fields: number theory–combinatorics, ordinary differential equations, applied mathematics, relativity and asymptotics, among others. While I enjoyed working on simple-sounding combinatorial–geometric problems with Leo Moser, my background was in analysis. It was hence natural that Sharma and I soon found common interest in problems of approximation theory. Sharma was a fertile disseminator of mathematical problems: some were related to results established in earlier investigations; others were subjects of new interest, raised in conference lectures or in recent publications.

Our collaboration started with some results on quadrature and then on simultaneous approximations. In 1965–1966 we became interested (through I.J. Schoenberg, I believe) in splines and obtained our first result in this direction, “Degree of Approximation by Spline Interpolation”, which appeared in the *Journal of Mathematics and Mechanics*.

Our cooperation continued quite intensely for about the next decade. The results were included in numerous joint papers (some joint also with others) on subjects such as Tchebycheff quadrature, one-sided spline approximation, Hermite–Birkhoff interpolation problems, Ilyeff’s conjecture, etc.

In the late 1960s and early 1970s, the National Research Council of Canada made special funds available for scientific conferences. Sharma and I decided to organize an approximation theory conference in Edmonton for late May 1972. We were very pleased that about 40 mathematicians attended, including A.M. Ostrowski, G.G. Lorentz, and E.G. Straus, as well as many now well-known members of the younger generation of researchers in approximation theory.

During the subsequent years, the approximation theorists at the University of Alberta have become a sizable group; a second approximation theory conference (organized in cooperation with members of the approximation group) was held in Edmonton in 1982. It had a much larger attendance and attracted people representing a wide variety of research areas related to approximation.

During all these years, Sharma worked cooperatively and effectively with mathematicians from many countries who came as visitors for shorter or longer periods. In particular, he had productive scientific connections with researchers from Hungary, India, Israel, Scotland, and, of course, the USA. Sharma was a well-liked, respected, although often passive, member of the department. As much as he could, he avoided departmental “politics” and did not like to take a stand on controversial issues. While Sharma and I were not “friends”, we had very good personal relations, and we knew each other’s families well. I remember in particular how much I enjoyed the strong Darjeeling tea Mrs. Sharma used to prepare for my visits at their home. Naturally, we spent many hours together discussing this or that problem; we had very few real disagreements. One of his amusing “policies” was not to re-check a proof obtained in the late afternoon, but leave it for the next morning. He claimed he had a better night’s sleep believing that we completed something. As any-

one doing mathematics would understand, we often found gaps in our arguments next morning.

After my retirement and departure from Edmonton, we kept in touch by an occasional letter or e-mail. The last occasion on which Ambikeshwar Sharma and I met was in San Antonio, Texas, during the last annual AMS meeting there. He was, by then, physically rather frail. We had lunch in the company of his daughter, Josna, who lives in that city, and my son, Avi, who lives in Houston. As we reminisced, we recalled that Josna used to baby-sit Avi some 30 years earlier.

*Contributed by Seng Luan Lee:* Sharma was my teacher and friend, from whom I learned mathematics, humanity, and humility. It is with a mixed feeling of happiness and sadness that I record my fond memory of Sharma, whom I hold in high esteem and affection.

I knew Sharma by name back in 1970 when I was offered a Commonwealth Scholarship to study in Canada. I wanted to study summability, and I had chanced upon a paper by Sharma and Meir on the  $S_\alpha$ -summation method, which turned out to be his only paper on this subject. I chose the University of Alberta and arrived in Edmonton in August 1971. I started to work with Sharma a year later, and the following two years were among the most enjoyable of my life. Sharma introduced me to the works of Schoenberg on cardinal spline interpolation on which I wrote my Ph.D. thesis under his guidance, and this has formed the foundation that set the directions of my research for the rest of my life into the realm of splines, wavelets, shift-invariant spaces, geometric modeling, and information processing.

Sharma's passion for and devotion to mathematics were truly exceptional and inspiring. Nothing could excite him more than mathematics. He was also an elder in the Hindu community in Edmonton, and was fondly called Sharmaji. Apart from his teaching, social, and religious obligations, Sharmaji spent all his time with mathematics. We discussed mathematics during lunch, during dinner, and even when we were running to catch a bus in the cold Edmonton winter. Very often, lunch would consist of mathematics and home-made chappatti and buns, which he shared with us. He would invite me home for dinner almost every evening. The dinners were superb Indian vegetarian cuisine prepared by Mrs. Sharma, and I enjoyed the food and hospitality as much as the mathematics. Sharmaji did not drive, and he referred to Edmonton Transit buses as his limousines. He often gave me a ride in his limousine.

The last time I saw Sharmaji was in 1995 in Edmonton. He was physically frail but mentally strong. He had to take care of Mrs. Sharma and accompanied her to hospital regularly for dialysis. We met in the hospital very often during that visit. His passion for mathematics did not diminish, and we managed to write two papers. I was supposed to visit him again in June 2003, but had to cancel the trip because of the emergence of SARS. I intended to visit him in the summer of 2004, but it was too late.

Sharmaji liked formulas and loved computation. He could compute much faster than most of us. He had a wide network of friends and mathematicians, including Schoenberg, Turán, Erdős, Freud, Ostrowski, and Straus, whom I had the opportunity to meet, and who still live in my memory. I imagine Sharmaji living in the dual space with his friends, working happily on the dual of the cardinal spline interpolation problem.

*Contributed by A. Cavaretta:* Professor Schoenberg introduced him: "We call him Sharma." So, that settled the name issue easily enough. His friendship was strong, vi-

tal, and unavoidable. That he was also blessed with such a generous spirit meant having him as a friend was a great gift.

Sharma had an excellent memory and knew the mathematical literature very well. He could always pull up some old relevant result hidden somewhere in the library stacks. He would employ the hunt and pounce method: wanting some particular paper and faced with three or four shelves of some journal, he would only need to pull down a couple of volumes before—*voilà*—there was the desired paper.

In his own eyes, his contributions were modest, although he himself was deeply interested in the challenges posed by the problems he chose. He had great respect for his colleagues in Edmonton and for the many fine mathematicians he knew worldwide. Working as he most often did with others, he seemed to take the view that he was the “medium” through which the collaboration expressed itself. And when referring to past work, Sharma always quoted his collaborator as the one who had framed the results and stated the theorems. About this, I had my doubts!

Sharing the blackboard and doing calculations with him was an adventure. He had a deep appreciation for the patterns of algebraic expressions which he could manipulate and massage with great skill. As the calculations would begin to yield, his excitement was palpable. We might take a wrong lead or some subtle error might creep into the calculation, but a restart always brought renewed energy and fresh curiosity. Learning (and relearning) was a way of life for Sharma, and it sustained him until the very end.

*Contributed by Marcel G. de Bruin:* It was in the late 1980s that I first met Sharma: during the conference in his honor and when he visited Amsterdam with his wife. Several years later, in 1992/1993, came the first visit to Edmonton *to work*. Durga’s health was already declining, and we worked on rational interpolation, both at the department and in his house at 105A Street.

Since then, many visits and days of work followed, even at the cafeteria in the hospital when Durga was undergoing dialysis. When she died in 1998, Ambikeshwar turned even more towards mathematics. His own health was also gradually causing more problems, but his mind was as strong as ever and—between our meals (cooked by Harjeet) and regular walks to the physiotherapy unit—we still worked.

But things took a turn for the worse and, after hospitalization, Sharma was taken in by his son and, finally, his age “caught up with him”. During my last visit, in May 2002, we still did some work at his son’s home or at the Mount Pleasant Care Center, but he was not longer the Sharma I knew. And then, in the fall of 2003, the e-mail messages became shorter and less frequent, until the message from his son that Ambikeshwar had passed away.

The world not only lost a mathematician but—even worse—a good man. Being with him was always special; his unrelenting striving for interesting mathematics, written down in a lucid and clear manner, has been an example for me during the years that I had the privilege of working with him. In the 1990s, the collaboration with “a colleague from Edmonton” started; in December 2003, “an elder brother” passed away.

*Contributed by Sherman D. Riemenschneider:* In early 1970 as a recent Ph.D. looking for a position, I had to decide between two universities and I chose the University of Alberta, partly out of the adventure of the frozen north and partly because Ambikeshwar Sharma was there to represent approximation theory. Sharma was a special person,

kind and generous and totally enthusiastic about mathematics. I was also amazed at his cultural and historic interests. We often enjoyed his and Durga's hospitality, warmth, and friendship.

For nearly 30 years, we were colleagues in the same department but, although our interests definitely overlapped and we would discuss many of our own results with each other, we only had two papers together. This was definitely a failing on my part because Sharma was always available to collaborate as others well document here. Even our initial collaboration didn't start out that way; it was Sharma's insistence on getting the "right" result that joined our efforts, and he was right, of course. Though our interests didn't mesh, I valued his presence and the encouraging atmosphere he provided to younger colleagues.

Our last meeting was in June 2003 as I stopped back in Edmonton after a conference in Banff. Rama and I had a very pleasant visit at his son's home where Sharma was among his books and papers busily working on his latest mathematics projects. Between tea and casual conversation, Sharma pulled out a copy of a paper in Russian and asked me to translate the results for him. Typically, while discussing with genuine interest what had happened in our lives and his since last we met, he was not far from his mathematics. I was very glad to satisfy this small request from a generous and caring man.

*Contributed by Rong-Qing Jia:* I first met Sharma in January 1983 at the Fourth International Symposium on Approximation Theory in College Station, Texas. It was the first time I attended an international conference. Sharma's research work on interpolation and splines already had a good reputation in China. I knew his name before I came to the University of Wisconsin–Madison for Ph.D. study under the supervision of Carl de Boor. I listened carefully to Sharma's talk, but I did not have personal contact with him at that time.

In 1988, S. Riemenschneider, together with Z. Ditzian and A. Sharma, invited me to visit the Department of Mathematics at the University of Alberta for one year. It was an important year for my career. As one could expect, Sharma gave me a lot of help. He made sure that I had comfortable living quarters, he lent me linen and other stuff, and he often provided me with fresh apples picked from his yard. His kindness touched every aspect of my life. More importantly, I learned a lot of mathematics from him.

Even after his retirement, Sharma was still very active in mathematical research. He was a passionate participant in the seminar on approximation theory. He knew the mathematical literature very well. I often could count on him for the precise reference related to a certain topic. He invited me to do joint research with him. I was really honored to have that privilege because I knew that he had collaborated with many great mathematicians.

When it came time to seek a replacement for Sharma, the approximation theory group at the University of Alberta recommended me to the Department of Mathematics and the Faculty of Sciences. The dean was concerned about my teaching. Sharma immediately wrote a very strong letter for me. Their efforts finally succeeded two years later. In 1991, I joined the approximation theory group in Edmonton permanently. In April 1990, while still at the University of Oregon, I invited Sharma to come and give a colloquium talk. During his visit, we completed our second joint paper, on the solvability of some multivariate interpolation problems, which was published in *J. Reine Angew. Math.*

In the early 1990s, Sharma was still able to come to his office regularly, and to participate in our seminar enthusiastically. His love for mathematics impressed his colleagues deeply. At the age of 70, he was still eager to learn about new developments in mathematics. In 1995, when his former student S.L. Lee visited him, Sharma, Lee, and I had an opportunity to collaborate. The three of us had many delightful discussions at Sharma's office and at his house. Our collaboration resulted in a paper on spectral properties of continuous refinement operators. This paper had an impact on mathematics beyond approximation theory. Robert V. Moody, a famous algebraist, cited and used our result in his study of quasicrystals, an important topic in Lie algebras and mathematical physics.

Sharma: your kindness, your friendship, your decency, and your dignity will always be kept in my memory.

*Contributed by N. Sivakumar:* I first met Professor Sharma in 1984, soon after my enrollment as a doctoral student in the University of Alberta. Having gone to Edmonton from India, and with an intention of studying approximation theory, I was quite familiar with Sharma's name. Over the course of the six years that I lived in Edmonton, I formed a close bond with Sharmaji and Maji (Mrs. Sharma), both of whom treated me with great kindness and fondness.

Sharmaji was a thorough gentleman: erudite, simple, kind, and unfailingly considerate. He also typified humility and possessed a willingness to learn from anyone, regardless of the person's age, experience, or status. I remember attending two graduate classes along with him; he was as enthusiastic as—if not more than—any of the students in these classes. His zeal for mathematics was as refreshing as it was inspirational.

Sharmaji was adept at dispensing sage advice with a wonderful twist of humour. During my stay in Edmonton, I came by a fairly large collection of mathematical books, donated by a mathematician who had quit plying the trade. Wishing to emphasize that mere possession of books wasn't enough, Sharmaji quoted a delightful Sanskrit verse translated as follows: Knowledge that remains within books is similar to wealth in another person's hands; when the time comes, neither is useful to you!

His curiosity and quest for knowledge (mathematical or otherwise) never waned. About a year before his demise he asked me to get him an English translation of the great Tamil literary classic *tirukkuRaL*, having chanced upon a reference to it in the inaugural address delivered by the (then) incoming President of India. Fortunately I was in India when I received Sharmaji's message, and I was able to fulfill his request promptly. The book I sent him also contains a brief biography (in Tamil) of the translator, who was himself a famous Indian freedom fighter. It was Sharmaji's wish that I should translate it to English and read it to him 'the next time I visited him'. I regret that this never came to pass.

Over and above all his academic accomplishments, Sharmaji was a man of genuine wisdom, which he was happy to share with one and all; his passing leaves a void that will be felt keenly by all those who knew him. Let me conclude with the following words of John Mason's. Excerpted from a poem that Professor Mason read on the occasion of Sharmaji's formal retirement from service, the words are even more apt now: "Lucknow once lost him to Alberta; But Alberta is out of luck now."

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