Recalling James Serrin

Howard Levine and Hans Weinberger, Coordinating Editors

Photo by Patrizia Pucci.

Jim Serrin in his backyard.

James Serrin was born in Chicago on November 1, 1926, and grew up in Evanston, Illinois. He did his graduate work at Indiana University under the direction of David Gilbarg. He received his doctorate in 1951, with a profound thesis on the hydrodynamical theory of cavitation.

In the next few years he wrote several papers on cavitation, some very influential papers on compressible flows, and an important paper on the

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Harnack inequality for elliptic equations. These papers very quickly established his reputation as a rising star in the area of partial differential equations. This reputation led to his being selected to write the article "Mathematical principles of classical fluid mechanics" for the *Handbuch der Physik*, VIII/1, Springer, 1959, pp. 125–263, which is still a standard reference in the subject.

Jim Serrin served as a Fine Instructor at Princeton University in 1951–1952 and as a C. L. E. Moore Instructor at MIT in 1952–1954. In Boston he met and married Barbara West, who remained his companion and helpmate for the rest of his life.

Jim came to the University of Minnesota in 1954, and with the exception of numerous visiting positions, he remained there for his entire career, even after his retirement in 1995. At Minnesota he served as head of the School of Mathematics in 1964–1965 and was appointed Regents' Professor of Mathematics in 1969.

Jim Serrin was the recipient of many honors. He received honorary doctorates from the University of Sussex in 1972, the University of Ferrara in 1992, the University of Padua in 1992, and the University François-Rabelais at Tours in 2005. He received the George David Birkhoff Award in Applied Mathematics from the American Mathematical Society in 1973. He was a member of the National Academy of Sciences and the American Academy of Arts and Sciences, and was a foreign member of the Finnish Academy of Sciences.

Jim Serrin was president of the Society for Natural Philosophy in 1969–1970. He served on the Council of the American Mathematical Society from 1972 to 1974 and also was a member of three AMS committees. He was a coeditor of the *Archive for Rational Mechanics and Analysis* from 1969 to 1986. He was also on the editorial boards of many other journals. He gave a multitude of

invited addresses, including two at International Congresses of Mathematicians.

During his teaching career, James Serrin directed the research of twelve students.

Serrin published almost two hundred papers. His research activities lasted until his death, and two of the manuscripts are still in the publication process. He was also a joint author with Patrizia Pucci of the book *The Maximum Principle*, Birkhäuser, 1952. A book *The Selected Works of James B. Serrin* is in the process of publication by Springer, Basel.

Donald Aronson

Jim Serrin was a truly great mathematician and a wonderful person. I first met Jim in 1953 when I was a graduate student at MIT and he was a Moore Instructor. He was teaching the graduate course in partial differential equations. I had become interested in PDE from the lectures of I. J. Schoenberg at UCLA in the summer of 1951 and was subsequently completely turned off by the course I took at MIT in 1952. For reasons I cannot recall, I decided to attend Jim's elegant lectures in 1953 and was totally captivated. This was a crucial turning point in my career. I had hoped to do a dissertation under Jim's supervision, but he left MIT too soon.

Jim's presence in Minnesota was a very large factor in my decision to come there. I continued to learn from him by attending some of his lectures, such as his beautiful courses in differentiation theory and boundary layer theory. Eventually we collaborated, and that was another aspect of Jim's influence. He was a very fastidious and lucid writer, and I hope that some of that rubbed off on me.

Collaboration with Jim was not easy. Although we mostly saw eye-to-eye mathematically, we had seemingly endless arguments over phrasing and notation. However, it all worked out in the end. We wrote two papers on divergence structure parabolic equations. One, which I suspect has never been read, concerns a maximum principle. The other was a derivation of the Harnack principle and has proven to be quite useful. For example, it is one of the main ingredients in my derivation of the Gaussian estimates for the fundamental solution of linear divergence structure equations. These two papers were Jim's only forays into the parabolic realm, but he continued his groundbreaking research on elliptic equations and the calculus of variations.

Jim was friendly and gregarious, and I miss the wonderful hospitality shown by Jim and Barbara. Although we usually disagreed on politics, we shared, in addition to mathematics, many interests

From left: Hans Weinberger, Grisha Barenblatt, Don Aronson, Jim Serrin.

Photo courtesy of Don Aronson.

in art, music, and literature. We will not see his equal any time soon, and I certainly miss him as a friend and colleague.

Alberto Farina

I met James Serrin in June 2008 in Perugia (Italy). He invited me to visit him in Minneapolis in October 2008, and we immediately started working together on our first article. This was the beginning of our collaboration and of our friendship. After James's passing, I realized that we had exchanged more than five hundred emails. I wish to share with you some he sent me (written around Christmas 2008).

This is the way I remember you, James. An outstanding mathematician, of a fine elegance, full of energy and enthusiasm, always pursuing excellence. A man who lived and worked with the respect of the people around him: family, friends, and collaborators. A person sensitive to the beauty of life and of the surrounding world.

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Date: 21 Dec 2008 13:25:02 -0600 [21.12.2008 20:25:02 CET]
Dear Alberto,
We are now in Montana in the mountains, in the middle of a snowstorm (beautiful, but making us temporarily isolated). I am still thinking about the counterexample for Theorem 3 [...]
Buon Natale!
James

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Date: 22 Dec 2008 20:40:02 -0600 [23.12.2008 03:40:02 CET]
Dear Alberto,
In the interest of saving time, I decided to write the file for Example 7 (Section 8) now instead of waiting for the full file to arrive later […]
The mountains remain absolutely beautiful for Christmas.
All best wishes,
James

————

23 Dec 2008 20:50:55 -0600 [24.12.2008 03:50:55 CET]
Dear Alberto,
Here in the mountains with snow everywhere, I can't stop thinking of the paper!
In fact, to obtain a complete counterexample for Theorem 1 we should still treat the case of Example 3 when [...]
Have a very nice Christmas!
James

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Date: 24 Dec 2008 14:50:41 -0600 [24.12.2008 21:50:41 CET]
Dear Alberto,
Yea, I thought you might have been away from your home. I hope you are having a nice time with your family, as I am. Concerning the remaining case of Theorem 1, I have made one kind of progress, […]
Barbara joins me in wishing you "Merry Christmas".
James

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Date: Mon, 29 Dec 2008 15:31:09 -0600 [29.12.2008 22:31:09 CET]
Dear Alberto,
Everything looks good. […] Great progress!
James
PS: I will be in the office Wednesday morning.

The result of this correspondence was the joint paper "Entire solutions of completely coercive quasilinear elliptic equations", *J. of Differential Equations* **250** (2011), 4367–4408.

Avner Friedman

Jim Serrin was more than a friend, more than a colleague. He set high standards scientifically and personally. His research was characterized by crisp theorems and elegant proofs. He was very supportive of me throughout my career, especially in my early years. I remember our first meeting in 1958 at Indiana University, where I was a lecturer. Jim had graduated from Indiana University seven years earlier and came for a short visit unbeknownst to me. There was a knock

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on my door one afternoon, and in he came and introduced himself. "Are you THE Jim Serrin?" I asked in disbelief and awe, having read some of his amazing papers already as a graduate student.

It is impossible to review here, even very briefly, Jim's seminal contributions to mathematics and its applications. So let me just say a few words about his very early work. Jim received his Ph.D. in 1951. In 1952–1953 he published four outstanding papers [1]–[4] on free boundary problems that arise in fluid mechanics: cavities formed by fast-moving bodies in an infinite body of fluid and jets bursting from a nozzle into the air. These topics were very active research areas in the early 1930s but thereafter remained dormant until Jim revitalized them with the above four papers. Jim introduced new variational approaches and new comparison principles, including the "under-over theorem" and the "single intersection property". As it turned out, around 1980, W. Alt, L. Caffarelli, and I used these two theorems in a crucial way to establish the existence of the "infinite cavity problem". Between 1953 and 1980 Jim wrote many other important papers in fluid mechanics, PDEs, and differential geometry.

For years the University of Minnesota meant to me Jim Serrin. He and his gracious wife, Barbara, often hosted dinners to which young, and later on not-so-young, faculty were invited. Dinner at the Serrins' included stimulating discussions on all topics, such as mathematics and mathematicians, politics and politicians. Jim usually held the minority opinion; I thought he liked the role of arguing against the common wisdom. And his arguments, especially in politics, were always based on well-documented sources, although not necessarily unbiased. Jim's library was impressive in its breadth, from books of art, to science, to history. In fact, when we first arrived in Minnesota he hosted me and my wife in his home, and I got a chance to leaf through his rich selection of books in the library where we slept.

Over the years I became increasingly aware of Jim's important contributions not only in PDEs but also in many other areas, such as Navier-Stokes equations, minimal surfaces, surfaces of mean curvature, Prandtl's boundary layers, and singularity of solutions, to name just a few. His papers developing the mathematical principles of fluid mechanics [5] and thermodynamics [6] are classics. Jim loved mathematics; mathematics was his life. He will be missed, but his legacy will persist.

References

[1] Uniqueness theorems for two free boundary problems, *American Journal of Mathematics* **74** (1952), 492–506.

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[4] On plane and axially symmetric free boundary problems, *Journal of Rational Mechanics and Analysis* **2** (1953), 563–575.

[5] Mathematical principles of classical fluid mechanics. In *Handbuch der Physik*, vol. VIII/I (1959), Springer-Verlag, pp. 125–263. Russian translation: Foreign Literature Publishing House, Moscow, 1963 (265 pages).

[6] Foundations of classical thermodynamics. Lecture Notes, Department of Mathematics, University of Chicago, 1975, 223 pages.

Giovanni Leoni

During my college years I spent one month studying English at the Evergreen State College in Olympia. It was such a fun experience that I decided to do my Ph.D. in the U.S., thinking (yeah, I was that naive) that it would be the same. So I asked my undergraduate advisor (in Italy you write a thesis for your bachelor's), Patrizia Pucci, for advice. She told me that she was working with a professor in Minnesota and that if I wanted she could contact him. I still remember when she said, "But keep in mind that Minneapolis is very cold," and I thought, "How cold can it possibly be?" I know better now.

This is how I met James Serrin. When I started my Ph.D. in 1990, I had no idea of who he really was. Looking back I guess it was a blessing. If I had known that my advisor was one of the outstanding analysts of this century, my interactions with him would have been quite different. Instead, in my blessed ignorance, for me he was just a really kind gentleman. He and Barbara quickly became a second family for me. I often had dinner at their beautiful house. Jim loved history and art and had been in Italy several times. It was a pleasure listening to him. Well, I quickly learned never to discuss politics with him. He knew people considered him a reactionary, and I think he enjoyed shocking them with his statements. When he would go "overboard", I would just smile and nod, and eventually Barbara would change the conversation with an affectionate/exasperated "Oh, Jimmy."

I liked his witty/quirky sense of humor. There was still a child inside him. I was foolish enough to tell him that during my college years I worked as a swimming instructor, and, as a result, every summer until I graduated I almost drowned in his swimming pool because he wanted to time how long I could swim underwater. While Barbara often

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swam with me, I never managed to get him into the pool! I have very fond memories of my years in Minneapolis.

I often wondered why Jim did not have more Ph.D. students. It is hard for me to judge him as a Ph.D. advisor. Looking back at my experience with my own students, I think I was much more independent. I would often stop at his office to say hi, tell him what I was doing, and to show him my progress, but I never went to him when I was stuck on a proof. Pride, I guess.

But I still learned a lot from him, especially simplicity and elegance in mathematics. I think his love for art and beauty affected his taste in mathematics. While his papers could be technical, whenever he would talk with me or give talks, he would always start with a simple example that still contained most of the difficulties of the general problem.

At one of the symposia to celebrate his birthday (can't recall if it was his sixty-fifth or seventy-fifth), I was asked to say a few words about him. I am terrible at giving public speeches, but I do remember that I said something like, "If I learned an ε of math, I owe it to you," at which Jim stood up and said laughing, "What do you mean? I taught you this much math" and he spread his arms wide, "and you only learned an ε?" It was the funniest moment of that day!

A few years after I went back to Italy, I changed my area of research and moved to calculus of variations. Since I did not have as many chances to meet Jim at conferences, I started sending him and Barbara a gift every Christmas, usually something that I brought back from Italy. As soon as they got it, they would call me and we would spend a nice time catching up. They would both tell me I should stop, but we all knew I would not. Last Christmas, instead of a phone call, I got a long letter from Jim. Something had changed.

I last saw Jim in June. I went to Minneapolis for a summer school, and Irene Fonseca and I took Barbara and Jim out for dinner at their favorite restaurant. Jim's mind was as sharp as usual, but his health had deteriorated a lot and he looked very frail. When we were driving back, Irene and I looked at each other and said, "This will probably be the last time we see him alive." Sadly, we were right. This year there will be no Christmas gift.

I love you, Jim.

Howard Levine

In the fall of 1969, I joined the University of Minnesota mathematics department as a green and timid assistant professor. I was in awe to the point of being terrified of Jim and the other PDE giants in the department, but with respect to Jim,

these fears were unfounded. One day he asked me to referee a paper that had been submitted to the *Archive for Rational Mechanical Analysis*. I gave him the report a few days later. After reading it carefully, he set down his glasses, looked up at me, and said, "You know, Howard, the *Archive* does not have a refereeing system. So with your permission, I'd like to send this fine report to the authors, mentioning that you wrote it and that the authors should acknowledge your contribution to improving their paper." That gesture of generosity turned out to play a pivotal role in my life, not only professionally but also personally. But that is another story.

At Minnesota I attended a number of his lecture series, including those on his papers "The swirling vortex" and "The problem of Dirichlet for quasilinear elliptic differential equations with many independent variables". The lectures were an inspirational lesson as to what could be done in mathematics if one set one's mind to it.

He followed the careers of young people whom he felt had promise whether they stayed at Minnesota or went elsewhere. Over the years he invited me to several conferences he organized on elliptic and parabolic equations, further proof that my fears had been unfounded. Then he paid me the ultimate compliment of asking me to collaborate with him and Patrizia Pucci in working on the stability-instability dichotomy for semilinear hyperbolic equations, a collaboration that resulted in four articles. He was also instrumental in helping many fine international mathematicians secure positions in the United States, perhaps the best known of whom is Grozdena Todorova, now at the University of Tennessee.

I can only echo the remarks of others in this article: he was not only an outstanding mathematician but also a good friend.

Lawrence Markus

This casual note is dedicated to the memory of my dear friend, Jim Serrin, who was my colleague and mentor in the School of Mathematics at the University of Minnesota for over a half-century. In our boyhood and youth we shared many similar experiences, although we never met until we were both established members of the Minnesota faculty. For instance, we both attended primary school in Evanston near Chicago, graduated from mid-western universities, and began our careers with postdoctoral appointments and faculty positions

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in various eastern "Ivy" universities. Furthermore, we both had serious professional interests in diverse physical sciences and engineering subjects, particularly in the foundations of mechanics and thermodynamics. At the University of Minnesota we individually found congenial interdepartmental cooperation within the Institute of Technology.

Since Jim and I were near-neighbors in Minneapolis, it was natural that we frequently shared the drive to the university. During these times we carried on a continuing conversation about the cosmos according to Newton and later Leibnitz (the foundational problems we considered belong also to Einstein's special and general relativity)—for instance, the physical reality of uniform motion with constant velocity: relative to the family of inertial observers, but the absolute nature of rotational motion seems mysterious.

We introduced the concept of locally Newtonian spaces, as distinct from global Newtonian space, and used these ideas to try to reinterpret the phenomena of the anomalous angular velocity of some spiral galaxies (an alternate explanation to the existence of dark matter) and further the cosmological red shift (in place of expansion). We never attained the complete mathematical theory we sought and so did not publish our partial results, which we euphemistically entitled "The General Theory of Everything Else". However, I did record some of our ideas in a preliminary Research Report of the School of Mathematics, *Cosmology of Classical Mechanics* (1991).

Bryce McLeod

I first met Jim Serrin at a meeting at the University of Edinburgh in 1968. The UK Science Research Council (as it then was) was anxious to stimulate the study of differential equations in the UK and had organized a 2-week meeting to be addressed by three mathematicians of international standing in the general area of differential equations, the audience to consist of mathematicians from all the UK universities. One of the three invited speakers was Jim Serrin, who delivered a course of lectures on the Navier-Stokes equations, then a major research interest of his. I found the lectures fascinating. My interests until then had been almost exclusively in linear problems, particularly the spectral theory of the Schrödinger equation, but Jim's lectures opened my eyes to the richness of nonlinear problems. In particular, one of his lectures was on similarity solutions (i.e., solutions which are solutions of ordinary differential equations), and he concluded with a number of unsolved conjectures. I was lucky

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enough to be able to see how to solve one of these. I mentioned it to Jim, and this was the beginning of a fruitful collaboration and, more importantly, of a lifelong friendship. Jim was at that time visiting the UK frequently, particularly at the University of Sussex, and I naturally invited him to Oxford. He and his wife, Barbara, stayed with us, and our wives formed an instant bond (it was not difficult to like Barbara), which again has lasted ever since, and in due course extended to our families, particularly reinforced when my son Kevin became a research student of Jim's.

For all this closeness, the fact remained that we were on opposite sides of the Atlantic, so that we did not meet as often as we would have liked. But we did spend one sabbatical leave at the University of Minnesota and lived in a house which essentially backed on to the Serrins', and this gave us an opportunity to experience to the full the Serrin hospitality. Jim was not a practicing artist as his brother Dick was, but one could not enter his beautiful home without realizing that this was a man whose artistic taste was impeccable. From the elegant dining room to the gorgeous library above, this was testimony to a true sense of style, and yet any suggestion that this might lead to an atmosphere of stiffness or formality was instantly dispelled by Barbara's charm and efficiency. An evening spent with them was just a family evening spent in beautiful surroundings. Once (I cannot remember the exact details) the Serrin family wanted to celebrate a family occasion in England and asked if they could use our house for a few days, to which we readily agreed. Of course, our house was incredibly scruffy by comparison with theirs, but I have always treasured the fact that if they chose it, then it must in some way have measured up to their standards.

Jim would not have been Jim without his eccentricities. There was of course his ceaseless war against airports and airlines (particularly NorthWest). His only difficulty was that without their aid he would not have been able to maintain his continuous international journeyings. But even his criticism of these (and others) was eased by a sense of his own extremism. Having offered a particularly damaging comment, he would look at you quizzically, as if to say, "What do you think of that, then?" And from Barbara there would come an exasperated, "Oh, Jimmy!" Jim was a great mathematician, a great character, and a great friend. Eunice and I, and all our family, will miss him very much.

Jim Serrin, Haim Brezis (back row), Bryce McLeod, Bert Peletier, Paris, 1998.

Photo courtesy of the Serrin family.

Kevin McLeod

I arrived in Minneapolis in August of 1978, fresh from completing my undergraduate education in England and knowing almost nobody within a radius of several thousand miles. It was my great fortune that I did have some connections: my father had often worked with James (Jim) Serrin, and our families had previously met both in England and in the USA. Jim met me at the airport and drove me to the Serrins' beautiful house in south Minneapolis, a house that was to become my second home during the time I spent in Minnesota, as the Serrins (Jim, his wife, Barbara, and their daughters, Martha, Elizabeth and Janet) were to become my second family.

Some of my fondest memories from the next six years are of the conversations around the Sunday dinner table, with Jim at the head, sometimes listening intently, sometimes gently guiding or questioning, and sometimes being deliberately (one supposed) provocative. My first impressions of Jim had been of a quiet and unassuming man. He was unassuming, especially given his accomplishments, but I came to understand that under the quiet surface he was intensely passionate about many things: about his mathematics, of course, but also about art and music, about Italy, about politics, and about the Minneapolis airport (his house stood directly under one of the flight paths). Most of all, he was passionate about his family. His love for Barbara and the girls was deep and abiding, and they in turn adored him.

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Jim was a superbly polished lecturer and an excellent teacher. His courses on continuum mechanics and thermodynamics impressed me so much with the power and clarity of the arguments that I asked him to be my thesis advisor. In this role, also, he was everything I could have asked for, providing support and guidance when necessary, while allowing me to develop mathematical independence whenever possible. That independence eventually led me away from Jim's areas of research and ultimately into working in mathematics education, but Jim remained interested in my work until the end, still gently guiding or questioning and still sometimes being deliberately (I supposed!) provocative. He was a great mathematician, a great family man, and a great friend, and I will miss him greatly.

Johannes Nitsche, Louis Nirenberg, and James Serrin, left to right.

Lambertus "Bert" Peletier

Luck can play an important part in life and mine was that I met Jim and his wife, Barbara, when, in 1967, right after completing my Ph.D., I moved to Sussex University. Jim did too for the academic year 1967–1968. There, Jim became an active and stimulating presence in what was referred to as the PDE group, which then included David Edmunds, Robin Dyer, and Peter Bushell. What stands out for me were the numerous wide-ranging lunchtime conversations in which Jim demonstrated an eclectic interest and knowledge, ranging from math to history to politics and to the fear of flying.

During the course of that year Jim gave a deep course on his recent work on quasilinear elliptic equations and solved a fascinating open problem in boundary layer theory: how to explain the ubiquitous nature of the special Falkner-Skan self-similar velocity profile. This had a profound influence on my taste for problems: beautiful math used to elucidate problems in science and technology.

But Jim also fostered relations between Minnesota and Sussex: he encouraged Charlie McCarthy and Don Aronson from Minnesota to follow him and spend a year in Sussex, and I was invited to spend a year in Minnesota. Jim followed up his 1967–1968 visit to Sussex with two further long-term visits, one in 1970 and one in 1972. These visits were so inspiring to so many people that Sussex granted him an honorary doctorate.

The year in Minnesota spawned many collaborations. I learned a lot from Jim, not least how to write papers. With Jim this was no trivial undertaking: his organization of the material and style of writing were extremely rigorous, and up till this day I

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write my introductions following the Serrin blueprint. Understandably, the number of iterations a manuscript went through was near infinite. In the precomputer age this usually resulted in thick wads of paper bulging with layer upon layer of Pritt. His high standards carried over to the way he perceived his responsibilities for the *Archive for Rational Mechanics and Analysis*, which he edited for many years, together with Clifford Truesdell. He could spend long hours revising manuscripts, accepted on mathematical grounds but falling short on his standards of presentation.

Jim and Barbara were the center of an active social life. We all remember the numerous visits to the ever-hospitable elegant Serrin home on Dupont Avenue South, with its library well stocked with art books. There the PDE community frequently gathered for dinner parties and, in summer, for parties at the pool and always for spirited conversation.

In the early eighties there was a danger of losing Jim for PDE: he became very much involved in the fundamental theory of thermodynamics and the nature of such concepts as Force. Fortunately for us, in the early 1980s, the appeal of the many exciting questions surrounding the existence and uniqueness of ground states and singular solutions of semi- and quasilinear elliptic equations, and the new results of Brezis and Nirenberg succeeded in luring him back to PDE, and so began a new, extremely productive period.

Jim took an active interest in promoting the subject. He was often seen at conferences and organized a fair share himself. I remember the meetings at MSRI (Berkeley) and in Gregynog (Wales) on Nonlinear Diffusion Equations and Their Equilibrium States, as well as many other meetings, not infrequently in his honor. He actively engaged with younger mathematicians, including my own graduate students, who invariably found their way to Minneapolis.

James Serrin and Patritzia Pucci, Perugia, October 19, 1996.

Stanislav I. Pohozaev, Patritzia Pucci, James Serrin, Enzo Mitidieri, Trieste, October 1995.

I remember Jim as a central and inspiring person in the PDE community, a great mathematician, and a lifelong friend.

Norman Meyers

I came to the University of Minnesota in 1957 as an instructor. Like Jim Serrin, I had been a student of David Gilbarg at Indiana University. So, I suppose, he felt responsible for me, and I saw a good deal of Jim and his family socially.

Professionally, we wrote several papers. As I remember, he or I would bring up a problem. We would briefly discuss it, possibly in the hallway. Some time later, we would look at what we had. We did not stand at a blackboard and work together. He preferred to think it through alone. I want to emphasize that he was very generous and encouraging to me.

Jim's manner was neither cocky nor arrogant, but he had great confidence in his ability, and he was proud of what he had accomplished.

I think of him every day.

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Patrizia Pucci

My formation as a mathematician was greatly influenced by James Serrin, and a very large part of my research life was connected with him. I attended James Serrin's courses, beginning with his SAFA IV seminars in Naples in March 1980, but I was introduced to him by Lamberto Cesari at the University of Michigan a few months later in August 1980 during the conference on the occasion of Cesari's retirement. Professor Serrin was already a giant in the subjects of partial differential equations, fluid mechanics, and thermodynamics. His fundamental contributions, especially in real analysis and in the calculus of variations, were already well known and often cited in Italy since the 1960s. In 1981 Lamberto Cesari invited James Serrin to the conference held in Bologna to celebrate the seventieth birthday of Cesari in Italy. On that occasion, during a conversation along Via Zamboni, Lamberto told me to attend the course that James was going to deliver at the SMI school in Cortona, and at the same time asked James to propose to me some topics on which I could report at the summer school. (Presenting such reports was a teaching tool for the young mathematicians at the advanced courses in Cortona.) In August 1981 James Serrin and Lawrence Craig Evans gave courses at the Cortona summer school, and James gave me some papers on elliptic overdetermined problems and on the Mountain Pass Theorem by Antonio Ambrosetti and Paul Rabinowitz. This was the starting point of my long fruitful collaboration with James. At that time I was only an assistant professor, and in 1983 I got a position as associate professor at the University of Perugia, while in 1987 I became full professor at the University of Modena. James came for frequent visits in both towns, delivering unforgettable, exceptional lectures until 2012.

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Jim and Barbara Serrin with Hiroshi Matano in the hall of the Serrins' house. The painting is by Jim's brother, Richard.

Since those Cortona lectures, I continued to learn much from him at his remarkable seminars held year after year. I recall his masterly courses in Milan in 1982 and in Varenna in 1983. James always devoted a surprising amount of time and effort to young mathematicians, giving mathematical consultations even to people unknown to him. Between 1984 and 2012 we wrote more than forty papers and a monograph on the maximum principle together. I cite only the papers [1]–[5], which inspired other work and which we liked very much. At the end of writing one of these papers, James and I used to celebrate the event by going out with his wife, Barbara, to some Italian restaurant in Minneapolis. It was lovely to celebrate with Barbara, since without her patience, help, and hospitality I could never have written all these joint papers with James.

James very much liked to lecture in Italy, since he loved to visit small Italian villages as well as the splendid masterpieces of the famous art towns of my country. His genuine interest in coming to Italy was based mainly on the fact that his brother, Richard Serrin, has lived in Florence with his family since the 1960s. James even joined the Unione Matematica Italiana as a member from 1990 on. But also the Italian mathematical schools very much admired his achievements and invited him to deliver talks to countless outstanding international conferences held somewhere in my country. Furthermore, beyond the many prestigious honors he received for his work from everywhere, he was awarded the degree *laurea honoris causa* by the Universities of Ferrara and Padua in 1992. The Society for Natural Philosophy commemorated James Serrin in the opening address of its fiftieth meeting, held at Udine in October 2012.

My long association with him has been for me a wonderful experience. It was a great pleasure not only to see the elegance and the beauty of his way of thinking about mathematics but also, when possible, to share with him and Barbara, in moments of rest, an interest in classical music, in good reading, and in Italian art. The great master James Serrin was for me above all a steady friend since I met him in 1980. He was an enthusiastic organizer of the May conference held at Perugia in 2012 on the occasion of my sixtieth birthday, where several of our best friends and colleagues on PDEs came from all over the world and gave brilliant talks. The speakers celebrated not only me, but also James, addressing special words to him, with sincere affection and profound esteem. Even though at the time of the conference he was already not well, he attended all the talks and delivered an exceptional and unforgettable opening lecture. His presence in Perugia at the conference was for me the most appreciated gift I received for my sixtieth birthday.

James was a great mathematician and an exceptional man. His work has inspired generations of mathematicians and will continue to influence the future of mathematics. His loss is inconsolable for anyone who had the good fortune to meet him, as I had.

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David Sattinger

I first met Jim Serrin when he visited UCLA during the 1968–1969 academic year. I had read two of his articles on the Navier-Stokes equations, and we had a number of conversations during his visit. Those conversations ultimately persuaded me to leave sunny Southern California for the frigid winters and mosquito-infested summers of Minnesota.

I arrived in Minneapolis in the fall of 1971. Sometime during that first year we met in his office to go to lunch at the Campus Club, and he started complaining about the referee on a recent

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submission of his, "The swirling vortex", in the *Philosophical Transactions of the Royal Society of London.* He had worked out a rigorous theory of vortex flow for the Navier-Stokes equations, not an easy thing in itself, in which a semiinfinite vortex line meets a planar surface. He reduced the problem to a system of integral equations whose existence he could demonstrate in certain cases, and he carried out numerical computations of the solutions. The mathematical analysis itself was not in question; it was Jim's assertion that these solutions were relevant to a mathematical theory of tornadoes and his insistence on including photographs of tornadoes in the manuscript. There was also some kvetching about the boundary conditions.

It is a beautiful paper, and it epitomizes Jim's holistic approach to mathematics, combining scholarship, careful physical reasoning, pure mathematical analysis, and numerical analysis, and ultimately an attempt to relate the mathematics to an especially challenging physical problem—modeling tornadoes.

Jim worked on problems in pure mathematics as well, especially problems involving the strongly nonlinear elliptic partial differential equations arising in classical surface theory. His myriad variations on the maximum principle are rivaled only by Mozart's genius at chromaticism. His ingenuity, at times diabolical, expressed itself in careful attention to the tiniest of analytical details in order to gain a significant extension.

Jim was also very interested in the foundations of mechanics and in presenting an axiomatic, deductive treatment of fluid mechanics from the basic axioms of thermodynamics and conservation of energy, mass, and momentum. He wrote many papers on the foundations of thermodynamics, especially the second law. He was strongly influenced by Clifford Truesdell, who founded the *Archive for Rational Mechanics and Analysis*, and Jim was on the original editorial board.

Jim always bought used cars and invested the savings in a superb art collection. Some of his pieces were on loan to the Minneapolis Institute of Arts, and his home on Dupont Avenue was decorated with a number of beautiful paintings, including some wonderful ones by his brother, Richard. Jim and Barbara loved to entertain, and there were many memorable parties at their home. Jim told me that human culture had peaked in the eighteenth century, and he loved Mozart, Hayden, and Handel, so I was surprised to see him once at a performance of Mahler's *Resurrection Symphony.* Jim was always full of surprises.

Juan-Luis Vazquez

Jim Serrin is one of the most prominent figures in pure and applied mathematics of the twentieth century. I had the good fortune of meeting him during my first visit to the United States in the academic year 1982–1983, with a grant from the Fulbright Foundation. This was a crucial period in my mathematical life; I was to discover life in an American university, so different from my previous experiences in Madrid and Paris. I spent in Minneapolis a long winter and short spring full of new experiences, new acquaintances, lots of mathematics, and of course all the cold weather you can imagine. My first office was on the ground floor of Vincent Hall, and the large office across the aisle was Jim Serrin's.

My research program was focused on studying free boundary problems for porous medium type flows with D. Aronson and L. Caffarelli, which I did. The open atmosphere of the School of Mathematics gave me the opportunity to converse and discuss many appealing topics with them and other renowned mathematicians, such as H. Weinberger, W. Littman, and D. Kinderleherer, who were legendary figures for me. I was immediately seized by the opportunities and challenges of so favorable a situation. With Serrin close by, discussing elliptic problems and getting interested in fluid mechanics came naturally.

One very important moment in the fall came— Thanksgiving. I did not know how special this was for American families, since family time in Spain is Christmas. I was not expecting much of a celebration for me, a foreigner just arrived. It is then that I discovered another side of Jim's character, his human side: I was invited to his house on Dupont Avenue. Thanksgiving with Jim and his family in the fall of 1982 was for me like a revelation that this visit was maybe the beginning of a deep connection with the country, which has continued ever since for me and my family.

One of Jim's most appealing characteristics for me was that he was a humanist, with deep interest in different branches of culture. Mathematics ranked paramount, and being at the time at a mature stage of his career, he was incredibly active. Talking to him meant also talking about culture, and I soon discovered his love for Italy, which was also to be a marked trait of my personal life. He talked also about politics, where he was sometimes controversial, and I learned from him the duty of arguing honestly, even against our own or another's previous firm positions if the evidence leads to it. And then, he was so family

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From left: Hans and Laura Weinberger, Jim and Barbara Serrin, Boulder, Colorado, 1957.

Barbara Serrin, Clifford Truesdell, and Jim Serrin, Venice.

James Serrin and Laurent Veron.

oriented that we have kept in contact for all these years. When I met Jim he had a solid reputation for being strict in his devotion to high standards in mathematics, as well as life. I was to discover that Jim enjoyed immensely the meetings that were organized in his honor that went on as long as he was active, which means during his lifetime, and we all enjoyed them.

The mathematics that I learned from Jim and that I often used was his early work on the regularity of nonlinear elliptic and parabolic equations. His work and writing in fluid mechanics was one of my motivations for teaching courses on the topic at UAM in Madrid and then writing my notes as a book in Spanish. His interest in thermodynamics was always out of bounds for me, but in some sense the effort I have devoted during the last ten years to understanding and using entropy functionals (in the sense of Boltzmann) for nonlinear heat equations has a relation with that topic of his.

The major common interest I had with Jim was the maximum principle, and there I had a proof of his insight and generosity. I had written a short paper in 1984 on the strong maximum principle for nonlinear elliptic equations (*Appl. Math. Optim.* **12**, 191–202) which I had more or less forgotten in subsequent years. I was then delighted when Jim Serrin, in collaboration mainly with Patrizia Pucci, took up the results as part of a series of brilliant research articles, and they gave lavish praise for that work of mine. In time their broad investigation led to the book *The Maximum Principle* (Springer, 2007), which is a basic reference on that classical subject. That paper of mine went on to be my most cited paper.

I would like to conclude by saying that for me James Serrin is a prominent example of the enlightened scientist that I found in my American experience—wise people who devote their lives to science at the highest level and to forming a community of open, critical, hard working, and

friendly minds. It is the embodiment of the happy times that I was fortunate to enjoy.

Hans Weinberger

While I had met Jim Serrin when he visited the University of Maryland in the early 1950s, I did not really get to know him until 1957. That summer there was a meeting at the University of Colorado which set the agenda in the field of partial differential equations for at least the next three decades.

My wife and I were newlyweds, and Jim and Barbara were there with their first daughter, Martha, who was then three or four. My wife and I were in the dormitory for childless people, while the

Jim and Barbara in their living room on Jim's 75th birthday.

From left: Elizabeth, Janet, Martha (daughters of James and Barbara Serrin), and James Serrin, 1998.

Serrins were in another dormitory, but we somehow got together. The entertainment for the meeting consisted largely of strenuous mountain hikes, but the Serrins and we found that we enjoyed more leisurely outdoor activities and had a very good time together.

This pleasant contact played an important part in our decision three years later to go to the University of Minnesota. When we arrived in Minneapolis in the summer of 1960, the Serrins were away, but they graciously let us and our one-year-old daughter live in their house until we could find more permanent housing. When they returned, we soon became fast friends, and that friendship lasted until Jim's death. The activities certainly became less strenuous and less outdoorsy, but the friendship endured.

Jim and I found that we had rather similar attitudes about mathematics. Even though we wrote only three joint papers, none of which was earth-shaking, we often discussed new results and their implications. The choice of topics for several of my papers was influenced by Jim, even though he did not work on the details. He was a good friend and a great mathematician.

Janet Sucha, Elizabeth Conley, and Martha Stack

Trying to sum up our feelings, emotions, and stories about our father, James Serrin, has been a monumental task. As one friend wrote, "Jim was an amazing man—a huge presence. Important in his work and in his life; interesting, intelligent, quixotic, fun and difficult at the same time. He will be missed, not only by his family, but a wide range of people." Already our lives feel smaller, missing his quirky smile, his joy of having family surround him, his interest in our pursuits, and his willingness to share his insights. Dad was the central cog in our family, bringing us together for many family reunions or for any excuse he could

find. Time spent together was warm, festive, and special. In his personal life our father had a love of beauty and a deep appreciation for the great works of music, art, architecture, and literature, along with a love of ideas and a tremendous regard for the life of the mind. A true and natural teacher, he inspired us and those around him to appreciate this wealth of beauty and knowledge at every opportunity, enriching our lives forever. Among the myriad of treasures he gave to his family and friends was the gift of laughter; he was always ready to tell a new joke, play a trick, or repeat a funny story. He encouraged our love for great music and great art, spending hours examining a painting or engraving (sometimes too long for a young child's attention) or lying on the floor with his eyes closed to immerse himself in a great piece of music (rock and roll not included). He shared his love of great literature and great ideas with us through his extensive library of beautiful books, and these books were works of art in themselves, crafted with rich bindings and luxuriant reprints. Our mother shared his passion for books, saying recently, "I could spend my whole life reading." He gave us the gift of feeling joy at the marvels of nature; as a young man he loved canoeing, playing tennis, orchestrating picnics, throwing a Frisbee, and taking walks through beautiful gardens. Later on he continued to enjoy driving to out-of-the-way places he'd discovered on a map or in a book. He was an avid photographer, patiently searching out the perfect composition and waiting for the ideal lighting to recreate his vision of the world through his camera lens. He found and created beauty in what he saw.

Dad gave us all a passion for travel and an appreciation for other cultures. He spent much of his time visiting foreign universities, taking us with him and giving us the opportunity of

entering into the culture at a deeper level through our experiences in foreign schools and with the many friends we have made in the worldwide math community. Our first trip abroad was to Sussex, England, when he was on sabbatical in 1967–1968. Our trip to and from Europe was almost as wonderful as being there, as we crossed on the S.S. *United States*, learning to love the joys of ocean travel and taking the time to appreciate the journey. While in England we toured extensively, visiting as many of the great houses, parks, and cathedrals as we could possibly fit into our family schedule. As his work became more recognized, his invitations to visit foreign lands increased, and we returned as a family several more times to spend semesters at Sussex and visit other European countries. He was honored to be a part of one of the first American academic delegations to China in the 1980s, to travel to the USSR, and to Poland before the fall of the Berlin wall, to name just a few.

Dad's brother moved to Italy in 1963, and after that, family reunions often took place in Florence; eventually our father began collaborating with Italian colleagues, thus combining his love of math, his love for his family, and his love of traveling. Everywhere he went, he touched people's lives through his commitment to learning and understanding. His great intellectual curiosity always made time spent in his company interesting, usually leaving you with a bit more information and insight than you had before. Still, with all his travels and among his many friends and acquaintances, his most significant relationship was with our mother, his "beautiful wife". She was his greatest helpmate and supporter, and together they created a world of friends, making connections and lasting relationships in all corners of the world. They welcomed people into their home, no matter where home was, and always made others feel at ease, sharing a cup of tea or a glass of lemonade. These friendships are the true gifts we received from our parents.

Dad enjoyed life and took what he could from every opportunity. He was committed to learning and sharing his knowledge. He was purposeful in his living and accomplished the goals he set for himself. He died at 3:30 on Thursday, August 23; he directed his death just as he directed his life, and he passed in dignity, strength, and peace. In our mother's words, "Jim and I loved each other, we had a good life together, we had three wonderful daughters and nothing but good memories."