Memorial for Robert Hermann

Peter E. Caines, Phillip Griffiths, Gabrielle Hermann, P. Robert Kotiuga, Arthur J. Krener, Emma Previato, Alan Weinstein, and Peter Woit

Introduction

P. Robert Kotiuga

Robert Hermann was born in Brooklyn, New York, on April 28, 1931, and died in Belmont, Massachusetts, on February 10, 2020. He earned a BA from Brown in 1952 and a PhD from Princeton in 1955 under the direction of Donald Spencer [15] with a thesis entitled "The differential geometry of symmetric spaces." He was a Pierce instructor at Harvard (1956–57), researcher at Lincoln Labs (1959–61), Lecturer at UC Berkeley (1961–62), Associate and Full Professor at Northwestern (1962–67), Professor at UC Santa Cruz (1967–69), and Professor at Rutgers (1970–77).

Robert Hermann wrote or coordinated over 30 books and over 100 journal articles, dealing primarily with Lie groups, differential geometry, mathematical physics, control theory, integrable systems, and associated historical aspects. He had a propensity for trailblazing both in the great outdoors and in mathematics by finding significant new applications of what most would consider pure mathematics. In order to reissue books published by prominent publishers and develop some of his more speculative explorations, he started Math Sci Press whose green and blue volumes are well known; the green series was called Interdisciplinary Mathematics, while the blue series was called Lie Groups: History, Frontiers and Applications. Along the way, he had visiting appointments at UC Berkeley (1963–64), UC Santa Cruz (1966–67), CRM Montreal

Figure 1. Bob and his sister Lila at a family reunion in August 2003.

Figure 2. Bob with wife Lana and son Chris, circa 1973.

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(1972), Boston University (Physics) (1973–74), Harvard (Physics and control) (1975–79), and MIT LIDS (1979–85). He was also a Member of the IAS (1969–70), an NRC Research Associate at the NASA Ames Research Center (1975–76 and 1984–86), a Research Associate in the Center for the History and Philosophy of Science, Boston University (1985–91), and Research Professor, Boston University (ECS Eng.) (1991–94). In 1980, he formed the association for Physical and Systems Mathematics.

The most informative personal remembrances of Robert Hermann come from people who enjoyed his company 30–70 years ago. However, the subset of these people who can write about his multifaceted trailblazing are fewer and fewer. For this memorial we have a disparate group of contributors who can testify to the scope of Robert Hermann's activities.

P. Robert Kotiuga

Remembering Robert Hermann

Phillip Griffiths

Bob Hermann was a singular figure in the mathematics community. In addition to his own work, he thought about and forcefully advocated what mathematics should be done. Aside from Weyl, Bob was as early as any mathematician I know of in recognizing and bringing attention to the connection between geometry, especially differential geometry, and physics. And not only did he push these connections, he acted on them. His books on Lie groups and differential geometry are written with the expressed intent to be accessible and useful to a wide audience including physicists.

Bob argued against the then prevalent division of mathematics into pure and applied. And again he practiced what he preached. He was one of the first to bring differential geometry, especially that in the style of Élie Cartan, into control theory. Both through his own work and through those who he interacted with, Bob's influence in this field was of substantial significance.

Finally Bob was, to use an inadequate cliché, a big thinker. His interest lay more in the major ideas of his many areas of interest and in their interactions than in the necessary but to him less compelling technical aspects of a subject. Not shy and, from my experience, never bashful about expressing a point of view, Bob played a special and unique role in the mathematic community.

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Phillip Griffiths

Reflections on My Dad

Gabrielle Hermann

I used to think I was nothing like my father. I wasn't particularly gifted in math, wasn't an avid reader, and am not an introvert. However, typical of most adult children, with every passing year, I've noticed that I'm more like him than I realized. For instance, living amongst socially restrained Germans has nudged me to appreciate, even embrace, the benefits of an introverted existence. Since moving away from the US, reading has become a significant way for me to engage with my world and, as a consequence, with my dad. After all, I had a father who was thoroughly immersed in books and his own intellect. He loved his family very much, but there was never any doubt that math was his life's passion. He had a lot of knowledge to impart, the trick was getting him to talk about it. Eventually, I figured out that the only way to get him engaged was to talk about math/physics, politics, or history.

Bob was born in Brooklyn, NY, in 1931 to Jewish parents. His father, Boris, was the 10th and last child of an immigrant Ukrainian family. His mother, Alice, was born in South Africa to an Austrian Jewish family, but she grew up in New York. Boris worked with his brothers as a traveling salesman for dental equipment. Bob's parents

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Figure 3. Bob with his daughter, Gabrielle, at her graduation in 2005 from the Fletcher School, Tufts University.

divorced when he was four years old, leaving him and his older sister, Lila Freedman, to fend mostly for themselves. With his mother in and out of mental hospitals and his father consumed with the shame and resentment of a failed marriage, instability came to rule their life. He and Lila were moved around from California to New York, depending on the parent who had custody. During his early teen years he lived with his married sister in Wisconsin. Intellectual pursuits came to define both Bob and Lila's lives. Lila got her PhD in English, eventually becoming the long-time Director of Publications at Yale. After skipping several grades, Bob graduated high school at age 16, and then hiked across the country.

Bob became a father when he was in his mid-40s, so I never knew him as an adventurer, just as an avid day-hiker. But that image of him as a teenager fearlessly setting out across the United States inspired the kind of parent I wanted to be. In my 30s, after marrying an outdoorsy German who could ensure I couldn't get myself hopelessly lost in the woods, we started taking our children on long-distance hikes. On one of those trips, I realized that my father had silently modeled how to live and work while maintaining a close connection to nature. Almost every day he would go for a long walk in the woods or a swim in a lake. He would go for extended periods to our cabin in New Hampshire, where he would spend his days writing and hiking. It took me until my mid-20s to figure out that I wanted nature to be a part of my life in a similar way to my father.

Around 15 years ago, my dad marveled to me that he had lost his interest in reading fiction or watching movies. I couldn't relate since watching movies and reading novels were how I often spent my free time and reading nonfiction gave me little pleasure. These days, however, I find myself reading the same type of books as my father. How can aspects of our parents come to define us, when we stopped living with them decades ago? Especially when that parent was mostly a mystery to us as a child. Of course, there are some passions I have always shared with my father. A love of good food and learning foreign languages come to mind. My Dad spoke French, Dutch, and German.

During the last seven years, Bob was confined to a wheelchair. Nevertheless, wherever he went he would always have a book tucked into his chair with him. Books about math, physics, politics, history, or Jewish studies were his constant companion. Up until the last years of his life he kept himself occupied with thoughts about math and writing math books, despite his having advanced dementia. I hired a retired engineer to help him put these dementia-corrupted fragments of thoughts down on paper. For many years, my weekly calls with him revolved around how his "book" was going and how he was going to get his ideas "funded." Even in his old age, he never lost his boyish enthusiasm for math and physics. What a gift he was to us all.

Gabrielle Hermann

Bob Hermann: Pioneer and Friend

Peter E. Caines

I met Bob Hermann in the late seventies, when I was a faculty member in the Decision and Control group of the Division of Applied Sciences at Harvard. Bob was visiting from somewhere at the time (a typical state for Bob) and it was the golden era of differential geometric control theory of which Bob was a pioneer. Bob and Arthur Krener had published their classic paper on the topic in 1977 and were key players in the research vortex which had developed at

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Harvard. My collaborators and I were then working on stochastic control systems, and the climate was such that Bob and I and others organized an after-hours informal seminar series on systems, control, and mathematical physics.

As the other contributions to this memorial demonstrate, Bob was a seminal thinker. His combination of energetic creativity, independent scholarship, and a disinterest in conforming, permitted him to make fundamental contributions to differential geometry, systems and control, and thermodynamics, all of which supplied topics for our hikes in locations such as Yellow Stone National Park and New Hampshire. As an illustration of their impact, Bob's results in differential geometry were used in non-linear filtering theory for partially observed stochastic systems in Riemannian manifolds. And I would like to add that my own work on thermodynamic control systems was formulated within Bob's contact geometrical setting for the subject.

In Montreal, my wife, Anne, and I, and later our children, Hanako and Kiyoshi, became close family friends of Bob, his wife, Lana, and their children, Chris and Gabrielle. Their hospitality at home in Brookline and on vacations in New Hampshire was wonderful for its generosity, flow of ideas, and plain family fun.

Bob was a real original; he was a feisty, warm, and brilliant man, and a true friend whom I shall greatly miss.

Peter E. Caines

Robert Hermann, Geometry, and Mechanics

Alan Weinstein

Looking back over my own work in differential geometry and mathematical physics, I am reminded of the enormous influence of Bob Hermann's work in these areas. Among the topics and works which I have cited, covering a wide variety of subjects, are:

- His book, *Differential Geometry and the Calculus of Variations*, 1968 [5], for a clear presentation of the Lie derivative formula on differential forms, among many other things.
- His theorem that, for any proper Riemannian submersion with totally geodesic fibres, the holonomy group is contained in the isometry group of the fibres [6].
- Fundamental results in Poisson geometry, including the singular foliation by symplectic leaves, and references to work of Lie which anticipated the basics of the modern theory [7], [8], [9].
- A proof of the formal linearizability of actions of semisimple Lie algebras around any fixed point [10].

Bob's many books were basic references to me. Paul Chernoff and Jerry Marsden wrote a very thorough review of some of his books [11]. Although critical in many ways, Chernoff and Marsden also express a real appreciation, shared by many colleagues and students, of the great value of Bob's books for introducing mathematicians and physicists to each other's language and concepts in the area where the subjects overlap.

I also enjoyed meeting with Bob from time to time, and I still enjoy looking back over our personal correspondence. He was certainly a unique figure in our world!

Alan Weinstein

Remembering Bob Hermann

Arthur J. Krener

I first met Bob Hermann in the spring of 1968, when I was a fourth-year graduate student at Berkeley, two years before I had started working on my dissertation with R. Sherman Lehman. He had been a postdoc with Richard Bellman at Rand Corporation in the fifties and they had worked

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Figure 4. Bob with his first grandson, Alex, aged 2, who was visiting from Germany in 2008.

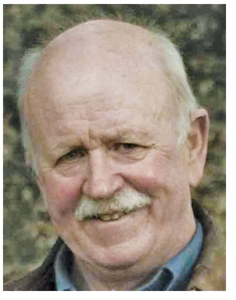
on continuous linear programming, linear programming in function spaces. At any frozen time, a continuous linear program is a standard linear program. Bellman and Lehman found through examples that the solution to a continuous linear program tended to stay on the extreme of the frozen time linear programs, jumping from one extreme point to another as the feasible sets evolve. My thesis topic was to confirm this phenomenon.

I thought that this was a problem in functional analysis and I took advanced courses in this area. But Lehman had a serious auto accident, followed months later by a stroke, so I was on my own. There were plenty of distractions in Berkeley in the sixties, and I was easily distracted. But I continued to work on the problem, and I came to realize that it was not a functional analytic problem but a differential geometric one. A graduate school colleague told me that I was trying to prove a bang-bang theorem in optimal control, a field that I knew nothing about. In my second year, I had taken a course in differential geometry from S. S. Chern. He was a wonderful teacher; I still have my notes from that course. I learned about the Lie bracket and the Frobenius Theorem from Chern and I was sure they had something to do with my problem. I went to Chern with a vague idea about a theorem that might exist and asked him about it. He told me that he did not know but I should talk to Bob Hermann who was visiting the Berkeley Physics Department.

I went to Bob's smoke-filled office with my faithful dog Hogan. (It was a different time then.) When I posed my vague question to Bob he knew what I was looking for. He pulled out the galley proofs of his soon to be published book, *Differential Geometry and Calculus of Variations* [5], and showed me Chow's Theorem. It was very close to what I needed. Bob gave me great encouragement and a few years later I proved my bang-bang theorem using an extension of Chow's Theorem. I don't think that I would have been able to do it without that encounter with Bob Hermann.

A few years later, I was a postdoc with Roger Brockett at Harvard and Bob came around regularly. One day Bob suggested that we write a paper on nonlinear controllability and observability. We did and it was chosen by the IEEE as one of the Twenty-Five Seminal Papers in Control in the Twentieth Century.

Bob Hermann saw connections between different branches of mathematics and physics better than anyone I know. He was a very generous person who greatly influenced my career and that of many others. He will be greatly missed.



Arthur J. Krener

Robert Hermann and the Geometry of Complete Integrability

Emma Previato

Robert Hermann became interested in the interface of integrable systems and PDEs in the mid-seventies. His review of G. L. Lamb, Jr.'s, *Elements of Soliton Theory* [4] exhibits his typical talent for identifying the main ideas, in such a diverse field (which progressively became broader and more diverse, as Hermann continued to devote both pedagogical and original work to it). I read Lamb's book around the same time, at the beginning of my work on a PhD thesis, on the recommendation by my advisor, David Mumford. I never had the privilege of meeting Hermann, despite us both attending the Santa Barbara conference "Solitons and Coherent Structures" in 1985.

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I found several features of integrability in Hermann's review of Lamb's book that I had not grasped so deeply. He, as an expert on Lie groups, views two properties as the pillars of integrability: the "Lax-pair representation," and H. D. Wahlquist and F. B. Estabrook's theory of prolongation structures of non-linear evolution equations, the latter put in a context of connections that allow for the construction of a hierarchy of potentials and pseudopotentials. The Lax pair in turn brings about a spectral curve, of finite or infinite genus, and its Jacobian (roughly speaking, the angle variables of the fiber of a completely integrable system). Hermann then wrote an expository book on the theory, in two parts, *The Geometry of Non-linear Differential Equations, Bäcklund Transformations, and Solitons*, in the series Interdisciplinary Mathematics, which he created and produced via the Math Sci Press, Brookline, Mass. In turn, K. K. Lee's enthusiastic reviews of the two volumes in MathSciNet (see [2]) is an overview of what Hermann brought to the field in terms of expertise and insight; Lee's chapter-by-chapter summary is a very helpful guide to the necessary background.

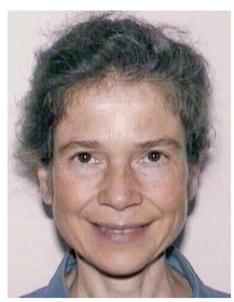
As for original research in integrable systems/PDE, Hermann's main contribution appears to be in the area of control systems; unfortunately I am not an expert, and again I refer readers to a MathSciNet review by Chris Byrnes, which is both beautiful and informative [1].

Putting it all together, what is the algebraic geometry of integrability? Let's start with the question, "what is integrability?" In a classical Hamiltonian system, the motion of a particle is described by a Hamiltonian function $H(p, q)$ depending on position and momentum. Separation of variables allows for a fibration by tori, swept by the angle variables, over the space of action variables. Integrability means that the motion is linear (at least locally) in the angle variables. For a non-linear evolution differential equation, such as Korteweg-de Vries,

$$u(x, t) = u_{xxx} + uu_x$$

(working as I do in complex algebraic geometry, the constant coefficients that appear in the traditional formula are irrelevant), the Hamiltonians are functions of u and its x-derivatives, they commute with respect to the symplectic structure and define the tori swept by the angle variables. What is a soliton? It is a wave-like solution that retains its shape (the peaks superimpose linearly) as time approaches infinity, aside from perturbations at infinity, and a phase shift. For me, what ties it all together is the theta function. For a hyperelliptic spectral curve, as is the case for KdV, the second and higher logarithmic derivatives (along one of the translation-invariant vector fields) of the theta function on its Jacobian generate the function field of the whole Jacobian. Integrability as I understand it are the addition formulas satisfied by this function, classical in genus one, where it is the Weierstrass $\wp$-function. As Mumford says in [13, IIIa.10], "at the risk of precipitating some confusion in notation," let's call this function $\wp$ in any genus. It is in fact called "Klein's sigma function," and the vector field that corresponds to the x variable in KdV conjecturally is the derivative that plays the role described above. Integrability then could be defined as "effectivization," or explicit solution, to a non-linear PDE. The growth of the theory set in motion a search for criteria of non-integrability, which yielded powerful results by the use of another tool dear to Hermann's heart, Galois theory. But this is a story for another day.

When it was time for writing up my thesis in this area fertile with unexpected connections, I asked—timidly—my advisor, "maybe I should refrain from being philosophical?" and he replied emphatically (joking, but not quite) "Absolutely! Do not be philosophical." Robert Hermann's opus, if it didn't tell us anything else about him and his legacy, shows that he, with his dream of bringing all of mathematics and physics (and engineering, according to Byrnes, loc. cit.) together in a huge, buzzing network, absolutely was philosophical. This may not be the cleanest attitude for a scientist (cf. Marsden's MathSciNet review of [12]), and personally, I am grateful to my advisor for modeling the purity of a cut crystal, but it holds great beauty and inspiration.



Emma Previato

Robert Hermann and Elementary Particle Physics

Peter Woit

As a young student trying to learn about mathematics and physics during the mid to late 1970s, much of my time was spent in library stacks trying to figure out what might

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be worth reading that I had some hope of understanding. This soon led to my noticing that many of the most interesting looking books were by the same author: Robert Hermann. My initial plan when asked to write about him for this memorial article was to begin by going back to the library stacks and happily re-immersing myself in those books, a plan that has been ruined by the current pandemic. Instead, an account concentrating on the books available (the ones in my office, since unfortunately few of Hermann's books are available online) will have to suffice.

Hermann's period of most intense engagement with the high-profile field of theoretical particle physics spanned the decade from the early 1960s to the early 1970s. Wigner's 1939 classification of the representations of the Poincaré group of space-time symmetries had shown that defining an elementary particle as an irreducible representation of this group was a powerful point of view. In 1961, the field of elementary particle physics was revolutionized by Gell-Mann and Ne'eman's discovery of a new "internal" $SU(3)$ symmetry. This symmetry commuted with space-time symmetry, and known particles could be organized into irreducible $SU(3)$ representations. This immediately raised a question that got a lot of attention: could one find a larger symmetry group that included both $SU(3)$ and Poincaré?

Hermann's first book, *Lie Groups for Physicists* [17], was written in 1965, and one of its goals was to provide physicists working in elementary particle theory with a sophisticated account of what mathematicians knew about the theory of Lie groups, Lie algebras, and their representations. One can even now get a lot out of reading this book, but the title of the review in *Physics Today* [14] was appropriate: "Not for pedestrians." In 1967, interest among physicists in this material came to a halt. The Coleman-Mandula no-go theorem [16] showed that a larger symmetry group of the kind being studied would force the theory to be trivial. The problem of how to combine internal and space-time symmetries remains fundamental and unsolved, with Hermann's book perhaps some day in the future providing someone with an idea for a solution.

Another book of Hermann's that I've often consulted is his *Vector Bundles in Mathematical Physics* [18], which appeared in 1970. While post-1967, most particle theorists had shifted attention from symmetry to analyticity, Hermann had turned to writing about the geometric underpinnings of Yang-Mills theory, a generalization of electrodynamics based on non-abelian gauge symmetry. At the time, this was not at all a popular topic among physicists, and those working on the topic took a very non-geometric point of view. The discovery in 1973 that Yang-Mills theory could provide a consistent theory of the strong interaction opened the floodgates and by 1975 most particle theorists were working on the subject, joined by many mathematicians who started to see the deep connections to geometry.

It's quite remarkable that several years earlier Hermann had, based purely on a feel for good mathematical physics, seen much of this coming and set down a detailed account of the mathematical context for the theory, one that remains useful to this day. Seeing the future of gauge theory too far in advance though meant being largely ignored when it arrived. By that time he had moved onto other things, with a wealth of books about newer ideas which will continue to inspire.

Peter Woit

Reminiscences

P. Robert Kotiuga

Those who knew Bob from the 1950s through the 1990s readily attest to his wit, charm, and insights; they have something to treasure. Robert Hermann spent most of the last 25 years in assisted living and many colleagues found it depressing to visit him more than a handful of times. About fifteen years ago, when he entered assisted living permanently, many of his colleagues lost track of him. Dealing with his lack of short-term memory was something that many friends and family had great difficulty relating to. I made an effort to talk to him about whatever I could, and it was Armand Borel's work on Lie groups and other gems from his long-term memory that came up; the IAS and the Princeton Math department of the 1950s always had a magical appeal to him.

Peter Caines first introduced me to Bob 38 years ago, while I was working on my PhD in the field of computational electromagnetics at McGill University. I was reading the Duff and Spencer work on Hodge theory on manifolds with boundary from the late 1940s, reformulations by Matthew Gaffney and Pierre Conner in the early 1950s, and later generalizations by J. J. Kohn. Little did I know that Bob and these mathematicians were all students or

Figure 5. Bob as a young adult with his father Boris and sister Lila (year unknown).

associates of Donald Spencer [15]; Bob graduated in 1955 having spent time with all of them. So, in our first conversation we finished each other's sentences on topics that few people still cared about! For the record, the first rigorous proof of the Hodge decomposition was given in 1948 by deRham, Kodaira, and Spencer in informal lecture notes prepared as a response to a request from Hermann Weyl; Weyl certainly knew the "right stuff" when he saw it.

Bob took a great interest in engineering and as the contribution of Arthur Krener shows, Bob created a geometric understanding of non-linear multivariable control theory. He was at Lincoln Labs not long after the launch of Sputnik. There he became interested in the application of dynamical systems to guidance systems and he could testify to the impetus for translating Poincaré's *Mechanique Celeste* into English at that time. We were both inspired by brilliant eccentric engineers, like Gabriel Kron, who connected disciplines in the most unexpected ways. Maverick engineers like Oliver Heaviside and Gabriel Kron got recognition in high places, but their unconventional use of mathematics left them misunderstood by their peers; Heaviside was awarded an honorary doctorate from Gottingen and Banesh Hoffman made Kron's understanding of the non-holonomic dynamics of electric machines accessible to experts in general relativity. However, the engineers that Kron inspired to talk about networks, homological algebra, and spectral sequences in one breath were primarily in Japan. They formed the "Research Association for Applied Geometry," which published the RAAG Memoirs, ... think of this as "Bourbaki for electrical engineers." It was such a pleasure to continually reexamine these trailblazing eccentrics in my conversations with Bob!

Bob's PhD thesis concerned the differential geometry of homogeneous spaces; this frames his work in mathematical physics. He had an extensive correspondence with Murray Gell-Mann which is archived at CalTech, and in the late 1950s published several key papers on current algebras. He was also a pioneer in introducing vector bundles into mathematical physics. Perhaps his most polished works which are appreciated by a wide group of physicists are more the expository books with titles like *Lie Groups for Physicists* [17]; my favorite is *Differential Geometry and the Calculus of Variations* [5]. At heart, Bob was a geometer in the sense of Poincaré; any need for intricate proofs indicated that one needed a better definition or perspective! It was because Bob cultivated such a powerful geometric perspective that he could reach out to engineers and physicists so effectively.

In May of 1984, I wanted to explore postdoc possibilities in Boston. Bob and his former wife, Lana, graciously had me as a house guest, provided I didn't mind sleeping in the basement of their wonderful Brookline home. Not only did I get to meet their children, Chris and Gabrielle, and Pepper the dog during my stay, but I slept in the heart of Math Sci Press! In this basement, I could see a century of French and German mathematics material that informed Bob's historical research, as well as the stock of Math Sci Press' green and blue volumes. Some would have sensed more than a hint of chaos in this basement, but I felt the elation of being in the well-organized wine cellar of a grand old castle!

As a postdoc at MIT, I met with Bob periodically, both socially and on campus, and it was in these contexts that I developed a sense of Bob's passion for history in more than mathematical contexts. When I joined the faculty at BU, Bob quickly introduced me to the historian of mathematics, Thomas Hawkins, and John Stachel, who brought the Einstein Papers Project to BU from Princeton, and decades later transferred it to CalTech. In the process, I obtained an enriched perspective on BU's then president, John Silber, and historian Howard Zinn. It was through John Stachel that I became a fan of the Boston Colloquium for the History and Philosophy of Science, and I acquired an appreciation of other older gentlemen like Dirk Struik; the only person I have ever heard start a talk with "Back in 1919, when I was a postdoc of David Hilbert, ..." In the college of engineering, I met Harry Moses; volume 12 of Math Sci Press' blue series was a reprint volume of the inverse scattering papers Irwin Kay and Harry Moses wrote [3]. In the 1950s, Harry was an associate of K. O. Friedrichs at the Courant Institute and he had impeccable taste when it came to bringing mathematical elegance to applied problems where the conventional wisdom was quite uninspiring. Harry had the good sense of not considering inverse scattering in terms of increasing dimension, but to only consider the inverse scattering problem in odd spatial dimensions. Later, I understood this in the context of the work of Atiyah, Bott, and Garding on lacunas of hyperbolic operators. Any approach of making the underlying ideas transparent lands one in the realm of algebraic geometry and higher dimensional residue theorems, but for one or three spatial dimensions, Harry effectively exploited the harmonic analysis on Lie groups; topics dear to Bob's heart. Through my association with Bob and Harry I was able to secure AFOSR funding to time domain antenna synthesis, and I am grateful to this day to have worked on a project that exploited such an interesting interplay of mathematical ideas. Harry and I secured a research professorship for Bob at BU which he held for a few years.

As I mentioned, Bob's passion for history reflected his reverence for the time he spent at Princeton; not only did our discussions feature prominent mathematicians such as S. S. Chern, Hermann Weyl, Donald Spencer, and John Nash, but bigger meditations on academic work environments. Most histories of the IAS feature Oswald Veblen early on. People who dwell on social norms might focus on Oswald's wife, nee Elizabeth Richardson, in the context of more liberal German refugee academics. Bob, however, would frame discussions of the development of American universities in terms of Oswald's uncle, Thorstein Veblen, and his book *The Higher Learning in America*. As usual, Bob could reach back into history to frame what are now current debates about the corporatization of higher education.

Mathematicians live in a world where having a key definition is like Archimedes having a place to stand and being able to move the earth with a lever, or Riemann forgoing Euclid's axioms about lines and points, and having the properties of points and geodesics follow from a definition of space. Although such conceptual clarity eludes us in natural language, for the sake of argument it can be fun to assume that it doesn't. Such games can enable one to sidestep contemporary socially taboo topics in order to understand the actions of a historical character who poked at the taboos of their own time. Bob had a knack for unearthing truths this way while giving historical examples. Some might call this "unrestrained candor," but it was oxygen for Bob; the undeniable therapeutic value of playing such a game was what let his grandparents deal with pogroms.

For example, Bob talked about the impact E. T. Bell's *Men of Mathematics* had on him as a preteen in the 1940s. Although this book is often dismissed by historians on account of its cover and Bell's interpretation of historical facts, Bob was quick to point out how he grew to have a deeper appreciation of the accurate treatment of women in this book over the decades. Reopening this book as I reminisce, I now quickly verify that Emmy Noether and two other prominent women made it into a book that is supposedly about male mathematicians from Zeno to Poincaré; Sonja Kowalewska shares a chapter with Weierstrauss, and Sophie Germain comes up as the cross-dressing Mr. LeBlanc. Although many later historians dismiss this 1937 book by the text on its cover, and Bell's penchants for embellishing history, when it comes to Mr. LeBlanc, Bell anticipates and avoids being accused of writing a less than wholesome book by quoting directly from Gauss' diary. A key lesson for a preteen to learn!

This anecdote keeps on giving. Mavericks in the math community marvel that E. T. Bell wrote over a dozen technical books and over a dozen science fiction books under the pseudonym John Tane. Both Bob and Bell have been criticized for being prolific and charismatic while sacrificing rigor. However, their fans admire their forward-looking choice of topics. It is interesting that Bell's 1937 book was written when the proportion of women earning PhDs in math in the USA was at a peak. This proportion was squelched in the 1950s, as a result of several factors, most notably the GI Bill and Roy Cohn's Lavender Scare. The proportion of women getting PhDs in math did not match the level of the 1930s until the 1980s. In this way, Bob used Bell's book to contrast and compare the attitudes that pushed accomplished American women out of mathematics in the 1950s with Gauss' more enlightened actions that ultimately led to a posthumous honorary doctorate degree for Sophie Germain. This juxtaposition of attitudes from different times makes me want to revisit the correspondence between Gauss and other prominent 19th century female scientists like the American astronomer, Maria Mitchell.

In summary, Bob graduated from Princeton into the male chauvinism that characterized the 1950s and the associated cold war politics of the McCarthy era, but his lifelong fascination with international affairs was rooted in the type of European history that brought his grandparents to America and informed his research into the history of mathematical ideas. The expression of this interest was always tied to academia, pointing younger people to the academic contexts in which Thorstein Veblen, E. T. Bell, and other eccentrics wrote. Along the way, there were anecdotes surrounding loyalty oaths, the Berkeley Free Speech movement, Howard Zinn's activism, and context for John Stachel's work on the Einstein papers. These are things we now cherish in an academic world where, for decades, math departments in the USA can no longer raise their stature through hiring, as they did with German mathematicians in the 1930s or ex-Soviet mathematicians in the 1990s, or by the funding levels enjoyed at the height of the Apollo space program of the 1960s. In a time of "echo chambers" and the corporatization of higher education, where departments live and die by the ratings

Figure 6. Bob as a toddler with his parents Alice and Boris, and sister Lila (circa 1933).

administrators secure in *US News and World Report*, I feel blessed to have been exposed to the "unrestrained candor" that Bob applied to his choice of research agenda and analysis of historical fact.

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