# *In Touch with God: An Interview with Paul Halmos*

*Don Albers*

**Don Albers** is Associate Executive Director and Director of Publications of the MAA. He has done dozens of interviews with mathematicians and has published *Mathematical People* with Jerry Alexanderson and *More Mathematical People* with Alexanderson and Constance Reid.

In a few months, Paul Halmos will be 88. Sixty-six years ago he received his Ph.D. from the University of Illinois under the direction of Joe Doob. His contributions to mathematics over those 66 years have been substantial. He is an exemplary writer, teacher, editor, and research mathematician. He has the awards to prove it, too: the Chauvenet Prize, the Lester R. Ford Award (twice), the Pólya Award, the Steele Prize, the Haimo Award for Distinguished College or University Teaching, and the MAA's highest award, the Gung-Hu Award for Distinguished Service to Mathematics.

He was born in Hungary, and came to the United States when he was 13. Five years later he earned his B.S. in mathematics from the University of Illinois. Upon completing his doctorate in 1938, he spent two years at the Institute for Advanced Study as an assistant to Johnny von Neumann. While there he began writing *Finite-Dimensional Vector Spaces*, the first of his 17 books. It was published in 1942 and is still in print 62 years later! The fact that most of his books are still in print is further testimony to the quality and staying power of his writing. He also has written 122 papers and served as editor of *The American Mathematical Monthly*.

He has held positions at Chicago, Hawaii, Illinois, Indiana, Michigan, Santa Barbara, and Santa Clara University. Now retired from Santa Clara University, he and his wife Ginger reside a few miles from the campus, where they maintain two apartments, one for mathematics and one for basic living.

In this interview, done in 1990, Halmos talks about the best and worst parts of being a mathematician, cats, the law, doing mathematics, the root of all deep mathematics, and smelling mathematicians. *Maverick Mathologist*, an earlier interview, done in 1981, can be found in *Mathematical People* or online at www.maa.org/Halmos.

## The best part

**Albers:** What's the best part of being a mathematician?

**Halmos:** No answer is going to roll off my tongue—I have never thought about such a question. What comes first to mind is being alone in a room and thinking. When things go wrong, the weather is bad, or my cat is sick, I enjoy being alone in a room, making marks on paper or fiddling with my Macintosh, thinking even about silly little calculus problems. I almost always wake up in the middle of the night, go to the john, and then go back to bed and spend a half hour thinking, not because I decided to think; it just comes. And I might think about a calculus problem or some more genuine research level mathematics. But that's a joy. What's the best part of being

a mathematician? I'm not a religious man, but it's almost like being in touch with God when you're thinking about mathematics. God is keeping secrets from us, and it's fun to try to learn some of the secrets. Everything else is fun. It was fun when I was young to try to get to be a big-shot by going to meetings, by taking committee assignments seriously, by working at them, eventually by becoming a sub-junior member of the Council of the AMS, and then it was fun to have been a big-shot on the Council and other things. And it was fun to go to meetings, meet people, hear new ideas, and exchange ideas. I used to say that I enjoyed teaching, and maybe I still do, but I'm somehow less sure of that than I used to be. Sure, when I was in my twenties and tried to inculcate some calculus in those recalcitrant students, I didn't enjoy every step of it. But it seems to me that more often I ran into people who wanted to know things, and more often I ran into people who were properly prepared. Now they are neither curious nor prepared. So teaching has become less the good part of being a mathematician.

Thinking, being in contact with the mathematical world, being a member of an 'in' group are good parts. Learning mathematics is always extraordinarily hard work. I can't easily read mathematics, I can't listen to lectures. The only thing I enjoy is a kind of mathematical gossip, when people sit in easy chairs with their feet up on something and tell me their mathematics; then I can learn.

**Figure 1.** Halmos with Pizzicato. "[Cats] look nice, they're interesting, they're loving, they're lovable, and somehow one is in touch with another soul."

## The worst part

**Albers:** What's the worst part?

**Halmos:** Whew! I wasn't expecting that. The first thing that comes to my mind is self-contradictory. The worst part has to do with the best part—a part of the best part that I did not yet mention: competitiveness. I like competitiveness. I am competitive. I want to beat the other guys. At the same time, I don't like it. Of course, that's not unique to mathematics, it's the same in many human affairs. There are some people who have talent, but who are so competitive, that although I can learn something from them, I don't want to. What else is a bad part? It's a little bad—I wouldn't put it into the worst part—that we are so unrecognized by the world. If you say you're a physicist, even relatively uneducated people have some idea of what you're saying. If you say you're a scientist, everybody has some idea of what you're saying. If you say you're a mathematician, even physicists often don't know what you're talking about. And the oft-suggested remedy for that, that we should write a lot more propaganda, tell a lot more people what mathematics is and prove to them that it's useful and challenging and interesting is something I've always deplored. I think in our first long chat I went on record as saying I'm not for PR in mathematics, but it would be nice if the effect that the PR people want to achieve had already been achieved.

**Figure 2.** Halmos at age 13 in Basel in a rather spiffy outfit

**Albers:** How prominent do you think competition is in the mathematical community?

**Halmos:** All pervasive. Everybody, all levels, all the time.

**Albers:** Do you think it differs very much from, say, physics?

**Halmos:** Physics, I'm sure, does not differ. Other disciplines, I can't be sure. One of my friends who wrote a lot was a historian, to be sure a historian more or less of science, and he gave me an idea that in his business the same competitiveness existed. Yet mathematics is different from all other forms of human endeavor in the sense that it is (well, except for some of the arts) the only thing that a person does all by himself. Therefore, this competitive aspect of the profession might be greater in mathematics, but that's a dim feeling.

**Figure 3.** The freshly minted Dr. Halmos in 1938

## Halmos and the Law

**Albers:** What other careers do you think you might have been good at?

**Halmos:** I wasn't expecting that question, either, but I'm ready with an answer. I was always interested in law. I took some courses in law, not many, two or three or four in the course of my life, separated by years, and I used to daydream about how some of the reasoning in law is like mathematical reasoning and how I could make a serious project out of it, a contribution by making it completely mathematical. That is not original with me. Things like that exist. People have tried it. I think by and large they've failed, though I cannot off-hand think of a reference.

In a complicated trial, lawyers want to establish that someone is guilty, and in order to do that, they call this witness. For that witness it is necessary to establish credibility, and to do that, they have to cite a certain piece of history, and so on. It seems to me that this is a theorem to be proved and a sequence of lemmas that are necessary to prove it. The lawyers, the good ones, know this and you can almost hear them say 'theorem, lemma, proof, . . . ' and so on. To a layman the whole thing might seem to end in a fizzle after a long sequence of steps and corollaries. The very last thing is a piddly little sentence that was just needed to fill the gap, but this little last thing proves

the first, great, big thing. That is exactly how mathematicians proceed. Incidentally, it's bad exposition when they proceed that way, but they often do. They state a big theorem and at the end of 30 or 300 pages at a trivial level they finish the proof of the big theorem. And that parallel called my attention to the similarity of the logical attitude of lawyers and mathematicians. That's one field.

The other field is perhaps more related to mathematics, and that's linguistics. And there, too, people have tried and to some extent succeeded and to some extent failed. Languages have always interested me, too.

**Albers:** When did law first enter your thoughts?

**Halmos:** Before I went to college, I thought of going to law school.

**Albers:** Do you remember what motivated your decision to go the other direction because we know you didn't really start in mathematics either?

**Halmos:** Maybe you know. I no longer remember anything. I just somehow oozed, like a bit of jelly, into mathematics. I was just good at solving algebra problems in high school and moderately good at solving calculus problems in college. I was too unimaginative to stop school, so I went to graduate school. The next thing I knew, I was a mathematician.

**Albers:** As I recall, you originally started out in chemical engineering.

**Halmos:** That was just a silly, temporary, mistake. I liked math, and as a kid that meant engineering.

**Albers:** For what it's worth, in the now fairly large collection of mathematicians that we've interviewed, the field that many of them started in was chemistry.

**Halmos:** I offer one explanation that wasn't in my head 50 years ago. Chemical formulas, balancing them, are lovely things. The only things I remember from my freshman years in college and year or so in high school was the beauty of chemical formulas and Euclidean geometry with statements in the left-hand column and reasons in the right-hand column. Those were good, hard things that you could trust.

## Practice, practice

**Albers:** The image that you project in writing and giving public addresses is thorough professionalism.

**Halmos:** I regard that as one of the nicest compliments. When I want to pat myself on the back, I don't say I'm a great mathematician, but I say I'm a pro.

**Albers:** I mentioned to Jerry Alexanderson that you had told me that you had rehearsed your talk for MAA's 75th Birthday several times, and Jerry said, "Well, it really shows, doesn't it?" Do you practice in the privacy of your home or office—in front of a mirror? I don't think many mathematicians would do that, and it may show that they don't.

**Halmos:** It's an old gag that it's very hard work for an actor or any other public performer to be spontaneous. I try very hard in my writing and in my public speaking to be spontaneous, by which I mean that I prepare everything to within an inch of its life. It's not always fun to give the same performance over and over again, but I have done it a few times, and I noticed how it improves each time. I know how to time the laughs. I know when to shrug my shoulders and throw up my hands and grin and look sad and so on. It's all ham acting, and it's important, not because people will pat you on the back and applaud you, but because it contributes to communication. I say things better if people understand them better. My recent talk, "Has Progress in Mathematics Slowed Down?" involved condensing the 2 hours and 20 minutes (I timed it) that it

would have taken to present my entire Monthly article to 29 minutes. I practiced that talk at least 20 times, sometimes just by sitting here at my desk and reading it out loud and other times by doing the same thing but recording it on a cassette recorder and then listening to it and making notes as I listened as to what required change, and what I had to say more clearly. Preparation is vital and important and an indispensable part of professional life. You say that not many people do it. I wonder. One of the greatest ham actors was Emil Artin. Von Neumann was less of a ham and more sure of himself. He thought he could get away with things. He thought he could think them up on the spur of the moment. And much of the time he could, but I saw him give bad lectures and get badly confused—rarely, but it did happen. Preparation, including rehearsal, is vital, and I think your surprise over my practicing may be unjustified.

**Albers:** Does practicing extend to your writing as well?

**Halmos:** Yes, even if somehow less so because the pressure is less and you have more time to write. When you're preparing a talk, you might have six months' notice. And also in the talk, you're publicly exposed. But I feel that the kind of changes and revisions I make, going round and round as I do are the same when I prepare a talk or an article.

**Figure 4.** Halmos at age 36 in Gainesville looking quite dapper

**Albers:** How about in writing? How many drafts do you usually prepare before you feel that you're there?

**Halmos:** That's an unanswerable question because there isn't something called Draft 1 and then Draft 2 and then Draft 3. There is something called Draft 1 all right except I prefer to call it Draft Zero. And then I change a sentence, and then I change a paragraph, then I change a page, then I have to change two pages, and it's unclear when it becomes a different draft. Every single word that I publish I write at least six times.

## Doing mathematics

**Albers:** I want to talk about how you do mathematics and how you did it. Has it changed over the years? Did you do it differently at 30 than you did at 40 than at 50 than at 60 than at 70?

**Halmos:** Most of the questions that you ask or imply I don't know the answers to. I don't know how I did it when I was 20, which was when it mattered. That's when I started. I remember improving. I remember at 28 or 30 thinking, 'Gee, now I know how to do this better than I did back then.' What do I do? The hardest part of doing mathematics for me is finding a question. When writing my Ph.D. thesis with Doob, he had to tell me the problem. He was sore at me for having to tell me the problem. He knew that a good mathematician thinks of his own problems. I don't know when that came along, but I think it came along quite early in my life, and it certainly has been increasing if anything. I feel joyous, I want to run up a flag and sing, when I think of a question. Never mind the answer; the answer will come or something will come. That's something I've been saying for many decades.

Then what do I do? Well, from here on I'll have to be either vague or cliché-ridden. I look for examples. Since a lot of my work has been operator theory and infinite-dimensional Hilbert spaces, and since the most easily accessible part of that is matrix theory and finite-dimensional vector spaces, I start by looking at a 2-by-2 matrix. Sometimes I look at a 4-by-4 matrix. That's when things get out of control and too hard. Usually 2-by-2 or 3-by-3 is enough, and I look at them, and I compute with them, and I try to guess the facts. First, think of a question. Second, I look at an example and then third, guess the facts. I felt better about the other questions you asked me, whether I had thought about them before or not, because I hear myself speak. On this one I just hear an ocean of clichés, everybody has said these things, and I can't add much to them.

**Albers:** It is hard for most mathematicians to explain what their subject is to non-specialists for some very obvious reasons, not the least of which is language, if you're outside the field. How would you describe, let's say to a freshman or sophomore high-school student, how a professional mathematician really does his subject?

**Halmos:** High-school students are too easy. Those guys I can talk to. The people who are hard are medical doctors, grocery clerks, automobile mechanics, and lawyers. People, white collar or blue, who have no idea what mathematics is like, are tough. All they know is that it's an obscene word that other people didn't talk about. To seniors in high school or college freshmen, I can explain how mathematics is done, but not the way mathematicians sometimes try, by talking about a given complex structure. That's a bunch of nonsense. You can't tell people outside the business what the actual theorems in the business are. The best you can do is to communicate the spirit of mathematics, which is: find the question, look for examples, guess the answer, and go on from there. I give talks on problems. In the course of the centuries, I've accumulated a few hundred problems. Those problems range from very fancy stuff (the fanciest things I ever knew about Hilbert spaces) down to the stuff that your mother-in-law,

the grocery clerk, and the medical doctor could understand. Just puzzles. Puzzles that please people. And sometimes they say, "How do people think of such things?" Well, that's Question 1. Where did the question come from? And then, "Gee, I don't know how to think about that. How would you ever find out?" And so you look for examples. And in these puzzle talks, problem talks that I give, in effect I reach or try to reach audiences just such as you and I described, high-school freshmen or grocery clerks, and it can be done. But it has to be done in spirit, not in detail, and done at a level that has a chance of reaching them.

**Albers:** Where do you think mathematics is going, and then closely allied to that, where do you think it should go?

**Halmos:** I have an instinctive, emotional reaction to both parts. I don't think it's going anywhere, and that's exactly where it should go. In other words, I'm giving the completely reactionary, classical, pure mathematician's answer. Mathematics just is, we nibble away at it, I don't think we direct it worth a damn, and it seems to me as silly to ask where is it going as to ask where is the dawn going. You might say it's going to the morning and to noon, but it isn't going anywhere, it just is. Of course, I know some people would say, "Well, it's going to more and more applications, going towards more and more abstraction, and it should go that way or the other way." My emotional reaction to all of those things is that it's baloney.

## The root of all deep mathematics

**Albers:** In the conclusion of "Fifty Years of Linear Algebra," you wrote: "I am inclined to believe that at the root of all deep mathematics there is a combinatorial insight... I think that in this subject (in every subject?) the really original, really deep insights are always combinatorial, and I think for the new discoveries that we need the pendulum needs to swing back, and will swing back in the combinatorial direction." I always thought of you as an analyst.

**Halmos:** People call me an analyst, but I think I'm a born algebraist, and I mean the same thing, analytic versus combinatorial-algebraic. I think the finite case illustrates and guides and simplifies the infinite.

Some people called me full of baloney when I asserted that the deep problems of operator theory could all be solved if we knew the answer to every finite-dimensional matrix question. I still have this religion that if you knew the answer to every matrix question, somehow you could answer every operator question. But the 'somehow' would require genius. The problem is not, given an operator question, to ask the same question in finite dimensions—that's silly. The problem is—the genius is—given an infinite question to think of the right finite questions to ask. Once you thought of the finite answer, then you would know the right answer to the infinite question.

Combinatorics, the finite case, is where the genuine, deep insight is. Generalizing, making it infinite, is sometimes intricate and sometimes difficult, and I might even be willing to say that it's sometimes deep, but it is nowhere near as fundamental as seeing the finite structure.

**Albers:** Seeing the finite structure brings me back to your work style. When you're thinking of problems, do you often see the problems in visual terms? What kinds of images are you holding in your head or playing with on paper? What's bouncing around in your head?

**Halmos:** I haven't the faintest idea. I remember quoting John Thompson when he was once asked what does he see when he thinks about a group. His answer was a huge German, capital G. Whether he was joking I do not know. I'm a very bad geometer.

**Figure 5.** Ginger and Paul Halmos at the International Congress of Mathematicians in Cambridge in 1950

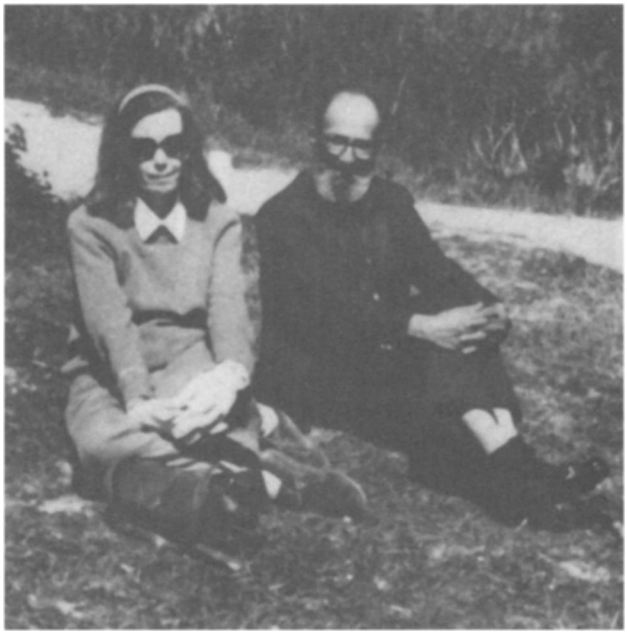


**Figure 6.** Ginger and Paul in 1973

For the calculus problem that I keep mentioning, it would have helped to see some pictures. I tried to draw them, but I'm bad at drawing them. I don't mean that I'm not artistic. I mean that I didn't see the mathematics. I didn't see whether the curve was convex or concave or whatever. And if somebody else draws pictures for me, I can't absorb them, I can't see them. Nevertheless, some kind of geometric picture seems to be necessary even for geometric idiots like myself. So to some extent, I see a picture in the plane. They're actions, they're movements, and sometimes I try to see them. I see points moving and usually I visualize a rigid translation which is not even a linear transformation. But much more than that, I think I have some kind of symbolic sense, a sense of symmetry. If there is a capital 'A' there and at the same time a little 'a' there, then the next time I see a capital 'B', I look for the little 'b.' Letters of the alphabet and mathematical symbols, and their symmetry are what I visualize. What are the marks that I put on paper? Well, I'm stuck. To a large extent they are words. It helps to slow down my mind which jumps around in a strange fashion by writing down "the question is..." etc. It helps to scribble a letter and to say small a is less than capital A, and I look at that formula, and follow it with a question mark.

**Albers:** Over the years, some moments must have been brighter and more exciting than others. Which of those moments stand out for you?

**Halmos:** Once or twice in my life when I did prove a theorem that I was struggling with for many weeks or months preceding, I remember a particular minute, or well, more like an hour that I felt good and rushed to tell Ginger about something or just plain felt unusually good. Okay, so that's one kind of accomplishment, a piece of mathematical accomplishment. Then, of course, there is recognition, the payoff to competitiveness. When you've competed and won, that can be good. I received the Steele Prize for mathematical exposition, and not long before, but some non-trivial time before, maybe a few months or even a couple of years I somehow felt that it was high time I got it. I scribbled out my acceptance of it. When I did receive it, I was pleased, and I would count that as one of my joyous moments. My secretary at the time practically fainted, when upon being notified of it, I showed her the scribbles and proved to her that I had expected it.

**Albers:** During the first half of this interview, Pizzicato, one of your two cats, rested on your lap. Is there anything about cats that especially appeals to you?

**Halmos:** Do animals have souls? People debate the subject, and I stand firmly on the affirmative. But what is it that appeals? Well, they look nice, they're interesting, they're loving, they're lovable, and somehow one is in touch with another soul. They enlarge one's life a little bit.

## Seventy-five and worrying

**Albers:** Seventy-five is approaching. How old do you feel?

**Halmos:** For some reason something like that popped into my head the other day, and I made up an epigram. Not a funny one, not a long one, but I thought it was good at the time. 'I'm older than I look, I look older than I feel, I feel older than I act, and I act about 30.' How old do I feel? People near 75 have creaks and minor aches and pains, and I have them. Therefore, sometimes I feel 85. But most of the time, although my mathematics is not that of a 25-year-old, I can think, I can walk, I can with moderation eat and drink and watch movies and enjoy people and cats and enjoy life, and I don't feel any different from how I felt (please notice that I said 'from' rather than 'than') between the ages of 25 and 65.

**Albers:** Do you ever worry about getting old?

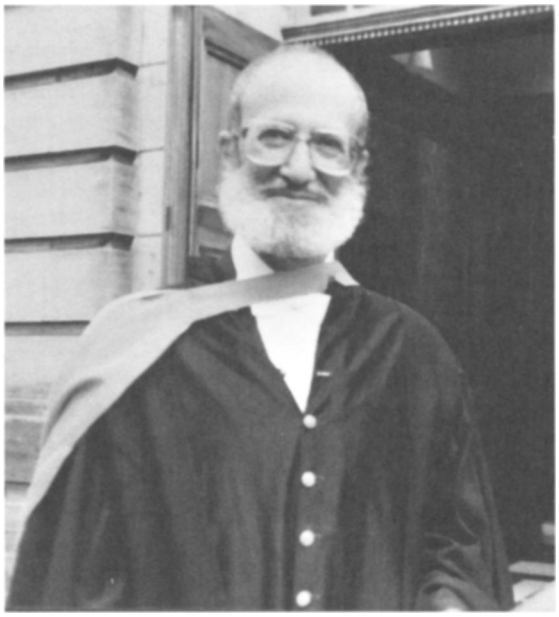


**Figure 7.** Halmos at St. Andrews in 1980 on the occasion of receiving an honorary doctorate

**Halmos:** I worry all the time. I worry about dying. Somebody tells me that I'm going to have to die sometime or other, and I resent it. And I especially resent that it might be very soon, like within five years, which is considered more than normal. It could be 10 years, or maybe 20 years, but I still resent it. And yes, I worry about various things—my brain, my eyesight. I think those are the two main things. I don't want to go ga-ga, and if I don't, I don't want to go blind either, so I can keep reading and writing. If those two prayers are answered, I'd like to be healthy enough so that I can pick up a pen and write or type or take a little walk. So I worry about those things. My father lived to be 80, and he was by no means in perfect health the last 10 years of his life, but he was not bedridden. He took tiny little walks just around his 20-foot garden, but even so, he moved, and his brain was clear. He died relatively suddenly of a major stroke, and that's the way to go.

## Father

**Albers:** We haven't talked about your father very much. Since he lived to be 80 he got to see you develop and enjoy real prominence. What did he think of your activity?

**Halmos:** We didn't pay much attention to each other. When I was eight years old, my father left his three sons in Hungary and immigrated to America as a widower, and for the next five years didn't see them. He had five years to become a citizen so that he could import his family. So, in those crucial years from 8 to 13 I didn't have a father. I had various substitutes, of course. Even before that, I didn't feel very close to him; he was a very busy medical man, and I remember somehow being ordered into his presence. I think he was being dutiful. And maybe he loved me. And then I lived in Chicago in his house for a year and a half. Then I moved away and went to college, so that takes me up to the age of about 16 or 17. He did not play an important role in my life, not that I know of, and I don't think he was all that impressed by whatever I accomplished. For one thing, it was not clear to him that I accomplished anything. He was not a rich man, but he was a medical doctor, an accepted and good one, and so he

was much richer in relation to society than you and I are ever likely to be. He knew that I wasn't and probably never would be; he didn't count things by money necessarily, but that was a symptom, an indication.

**Albers:** What's on Halmos's agenda for the future?

**Halmos:** I've been boring my friends about a book called *Linear Algebra Problem Book* ("LAPB"), which will have 50 or 75 sections and maybe 10 or 15 of them are written, and those 10 or 15 took a couple of years.[1] So at that rate, it'll be another six or eight years. Maybe I can speed up the rate. There is an actual piece of mathematical research I'm thinking about, but that's very near the beginning. And I keep doing piddling little things. Academic Press is going to publish a long scientific dictionary having thousands of pages. You know about it? They asked me to write an article of 300 words. Well, that's 300 words. This sheet of paper on which I type probably has 200 words on it. It took me 3 days to write 300 words. What do I see in the future? Well, I think I see that kind of thing continuing to come in. Extensive correspondence with, for instance, one of my very good friends, Max Zorn, who is almost exactly ten years older than I. He seems to enjoy receiving my letters.

It's hard for me to get used to the absence of pressure. I always put myself under pressure, and of course, I blamed the world. The world is putting on the pressure. Well, now I'm beginning to realize that the world is not putting on the pressure. If I never published anything, not even an elementary textbook, if I never again answered a letter, if I never did anything any more except drink my beer and watch the telly, nobody would, I think, think any the worse of me. But I keep putting myself under a little pressure and keep doing these small piddling jobs.

**Albers:** What should I have asked you about that I didn't?

**Halmos:** You might have asked about the contradiction of my having a computer. I say I don't have a computer. I have the world's most intelligent typewriter, but other people call it a computer. Although I agitated against them and denied that they have anything to do with mathematics, I am very dependent on my Macintosh.

**Albers:** To what extent to you depend on your Macintosh?

**Halmos:** I spend, I sometimes exaggerate and say ten hours every day in front of the machine, but a minimum of four, and more like six every day. I live here.

**Albers:** How many hours do you work per day?

**Halmos:** I don't know what the word means. I get up early, usually Ginger and I get out of bed at 5:30, and by 7:00 or 7:30 I'm here at my desk. And some days I have classes; other days I go to seminars. Every day I try to get my walk. But I keep doing those things, including time out for an hour for lunch. The actual eating takes 20 minutes and my nap takes 20 minutes and piddling around takes an hour in the middle of the day. Well, some of that is leisure time that I spend with the gang. So discounting the lunch and the walk, I do something that people might call work from 7:30 AM to 5:30 PM which is 10 hours minus the things I've said. But course, it isn't all work. A lot of it is, as I said, correspondence. That's as close as I can come to an answer.

## Smelling mathematicians

**Halmos:** One thing you didn't ask about I want to speak about very briefly. The thing you didn't ask me about, but you almost asked me and somehow told me is that I'm a

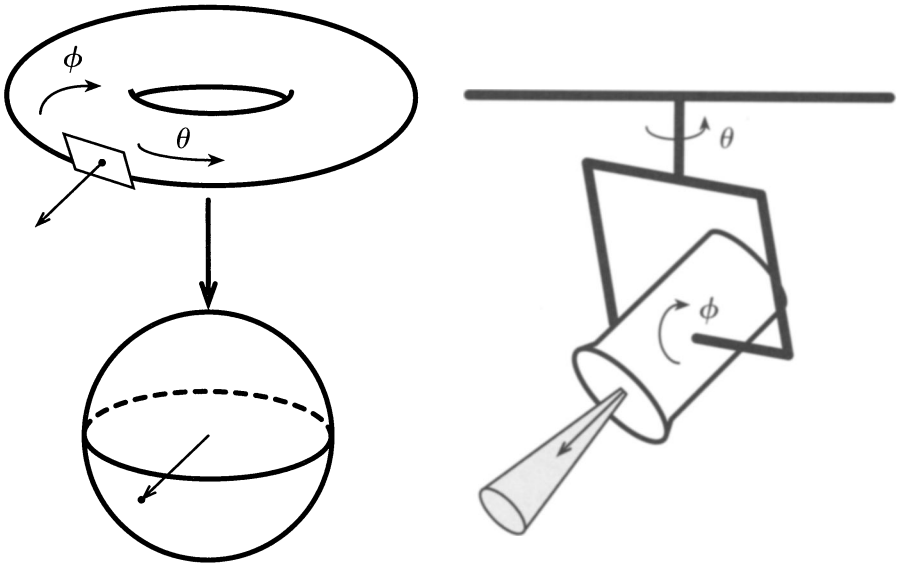
[1] *The Linear Algebra Problem Book* was published in 1993 by The Mathematical Association of America. Halmos has published three other books with the MAA: *Problems for Mathematicians Young and Old* (1991), *I Want to be a Mathematician* (1988), and *Logic as Algebra* with Steve Givant (1997).

mathematician or a good mathematician or a great mathematician or something, and I say that one of my best professional qualities, though people sometimes resent it when they learn that I think that, is evaluation. I say I can tell a mathematician, and I can smell one. I'm on record as having said, "Give me an hour alone with a student, and I can tell how good a mathematician the student will be," but better than that, give me a few minutes or an hour with a so-called mathematician and I can tell you if he's really a mathematician. And in particular, I claim I know me; I know exactly how good a mathematician I am. It embarrasses me when sycophantic admirers compare me with Milnor or Gauss—that's just plain silly.

I haven't been as prolific as some mathematicians, and I have not been as deep. I'm a mathematician and I know just how un-great I am.

This interview first appeared in *Paul Halmos: Celebrating Fifty Years of Mathematics*, Springer-Verlag, New York.

**An Illuminating Example of the Gauss Map**




The Gauss map associates to each point on the torus (or any oriented surface in 3-space), the outward pointing normal vector at that point, thereby producing a point on the sphere. Above we see that a theater light reproduces the Gauss map of a torus. Each point on the torus, with circular coordinates $\theta$ and $\phi$, creates a configuration of the theater light. The light shines in the direction of the normal vector. We hope this explanation is enlightening.

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