Interviews of the Margaret MacVicar Memorial AMITA Oral History Project, MC 356
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Elsa Garmire – class of 1965
Interviewed by Sharon Lin, class of 2021
June 15, 2019

MIT Libraries

Margaret MacVicar Memorial AMITA Oral History Project

Elsa Garmire (PhD Physics, 1965) was interviewed by Sharon Lin (SB Electrical Engineering and Computer Science, 2021) at her home in Santa Cruz, California on June 15, 2019.

Dr. Garmire is a physicist in non-linear optics and lasers, and an advocate for women in science and engineering. She earned her bachelor's degree in physics at Harvard University in 1961 and went on to earn her PhD at MIT under Nobel Laureate Charles Townes – the first woman anywhere to earn a PhD in laser physics. She later worked as a Senior Research Fellow at Caltech and became a Professor at University of Southern California. In 1995 she went to Dartmouth College as Dean of the Thayer School of Engineering, the first woman dean of any research school of engineering.

A pioneer of laser light shows, Dr. Garmire worked with filmmaker Ivan Dryer to develop the *Laserium* brand laser shows. She also holds nine patents on devices to enhance optical communications, including lasers and waveguides, has co-authored over 250 journal publications, and advised 30 PhD and 15 master's theses. In addition, she has advised government policy through advisory roles for the Department of Energy, the Department of State, the National Science Foundation, and the National Academies' Committee on Science, Engineering and Public Policy.

Before retiring in 2016, Dr. Garmire was the Sydney E. Junkins Professor of Engineering and Dean of the Thayer School of Engineering at Dartmouth College. She had previously been the William Hogue Professor of Electrical Engineering and Director of the Center for Laser Studies at the University of Southern California.

Dr. Garmire was elected a member of the National Academy of Engineering in 1989 and the American Academy of Arts and Sciences in 1996. She is a fellow of the Institute of Electrical and Electronics Engineers (the first woman fellow ever elected to IEEE in Southern California), the American Physical Society, the Society of Women Engineers (SWE) and The Optical Society of America (where she served as president in 1994).

As she notes in this oral history, Dr. Garmire is writing a book about nonlinear optics for engineers, and then hopes to write about her life, including her experience as a woman in science and engineering.

LIN: I read a bit about your upbringing in Buffalo, New York. Can you tell me a bit about your childhood?

GARMIRE: I was born in 1939. Just to set the time, it was one year to the day after Kristallnacht; I hate to have that be a history as part of my life. That was in Germany, where they destroyed the Jewish area, the ghetto. The only reason I bring that up is it was just before the Second World War. It was when the Nazis were in power. Things were going to be happening. That helps me remember how history works.

As you said, I was born in Buffalo. But we left before I was two because my father joined the Army; he was interested in serving in World War II. He was of German extraction, and I think he was interested in seeing what he could do to help our side. We moved to Huntsville, Alabama. He was a chemist. He was the first member of his family – the youngest of 10 kids – to go to college, and went all the way through to get a PhD in chemistry. He went to work in the Army Chemical Corps at the beginning of the war, so we were there for that.
The only real relevance to my family, I suppose, of the move to Alabama is that my mother was absolutely miserable. It was a horrible for us in the South. She wasn't happy in Dayton, either.

I was her second child. I had a sister who was two years older than me, and that was not a particularly joyous time in certainly my mother's life. As a two-year-old, I didn't care. But then we moved when I was four to Dayton, Ohio, because my father was asked to work there on some of the chemical aspects of the Manhattan Project. That's when I started school through the first grade.

Then, it was really very hard for my father to find a job as a PhD chemist after World War II. He wanted to be a professor, but available jobs were at too low a salary to support a wife and three children. Eventually, we moved to outside of Gary, Indiana – a little town called Munster. My father had a job for a while, but it was very unsatisfactory, so he decided to start a company. The chemical 24D had been discovered; it was a wonderful weed killer. That's before they knew all the dangers to the environment of chemicals. He set up a company where they were making it in our barn. We lived on a farm in the farmhouse; the actual farmer lived in town and came out to do the farming. But it was a delightful place for a child because we had a tree and a horse and a few other things out there. I got to relate chemistry to bad smells, but also to success.

But my father's company went bust, like many companies do, and he got a job working with the design of the chemistry building in the new Argonne National Laboratories. We moved to Hinsdale, Illinois, where I took third grade and up.

So I grew up, essentially, in a suburb of Chicago and went through the Hinsdale schools. I graduated from high school in 1957. If you go to any movies of the '50s, that was exactly me, with great big skirts. My mother made me a great big skirt, but she wouldn't let me have a poodle on the skirt, like was really popular. [LAUGHS]

LIN: Were you always interested in science and engineering?

GARMIRE: When was I interested in STEM? I probably always grew up with it. My mother was the old-fashioned kind of woman: "I don't understand any of those things!" I remember being upset with her that she didn't seem to care what happened when the light switch turned the lights on. My older sister was "my mother's child." She loved the homemaking skills. My father had no sons and so took me under his wing to be "the boy," the technical one. I did the gardening chores with him and spent as little time in the kitchen as I could get away with.

My father's hobby was photography, especially developing and printing his own (black-and-white) photographs. My favorite activity was to join him in helping expose, develop, and print. I love the smell of these chemicals – still, to this day. As far as STEM is concerned, my father was definitely conflicted; on the one hand, he had a traditional German background and expected that women should take care of the house. On the other hand, he loved chemistry. He knew only a couple of technically competent women, but respected them. Eventually, when I was in high school, he arranged for me to meet a woman he was working with and highly respected. I was excited about it, but very disappointed to find her old and not very attractive. I can't say it was inspirational.

The biggest STEM inspiration was my summer jobs when I was in high school and college. My mother arranged with a personal friend (who she knew from her hobby, playing in an orchestra – a chemist at University of Illinois Medical School in Chicago) to get me a job as a lab assistant. I worked there two summers, carrying out laboratory experiments. Everything fascinated me – except the smell of the chemicals. It was also a growing-up experience, as I took the commuter train and then bus to get to my job.

This was followed with two summers at Argonne National Laboratory, where I was in a ANL-wide program for students to work in the summers as laboratory assistants. I was in the Physics Deptartment, which had become my technical interest. The first summer, I worked with the Mossbauer Effect and the second summer with the health effects of radiation. Both jobs were fascinating and cemented my interests in physics forever.

By the way, my first “formal” realization that I wanted to go into STEM was in sixth grade. In an effort to increase the number of students who would into those fields, the federal government put out a pamphlet, for all sixth graders interested in science, describing various jobs that would be available. The jobs listed began with technician, then teaching, and finally PhD researchers. I was smitten by the latter category – the white coats, the idea that I would have “Dr.” in front of my name, just like my father. Of course, the researcher shown was a man, but that didn’t deter me at all.

Continuing on with my life, I had a sister that was born when we were living in Dayton, so there were three of us. My older sister was two years older, and my younger sister was five years younger. My older sister and I didn't particularly get along. But I was pretty close, and still am, to my younger sister, who became the successful orchestra professional musician with a career that my mother always wished she’d had.

Why am I telling you all this? I'm trying to set a context. I'm planning to write a book, the story of my life, and I need it to have some point to it. I've been thinking about what's the point of this book. What I've realized is that I was one of the first women in many places in my career. But I wasn't like the first women that had to fight really hard before they made it, such as Millie Dresselhaus at MIT.

[Professor Dresselhaus, a pioneer for women in science and engineering who was also a pioneer in carbon science and carbon nanostructures, was associated with MIT for 57 years. She held professorships in two departments, Electrical Engineering and Physics. Among numerous other distinctions, she was awarded the Presidential Medal of Freedom in 2014.]

LIN: Oh, of course.

GARMIRE: Millie Dresselhaus was God to me, as was Marie Curie. These were the people that were way up above me technically and very, very successful. Another person that I feel that way about was Esther Cornwell [author of the seminal textbook, High Field Transport in Semiconductors; known for her research on how impurities affect the transport of electrons in a semiconductor], who had a lot to do with understanding semiconductors. They were ahead of me by about 10 years. Two other woman I came to know blew me away when I found out that they’d been physically abused by their husbands whom they had to leave – in one case, secretly and changing her name!

I have thought a lot about where I came along in this realm of females getting ahead. By the time I was at Harvard, Harvard had only one female professor [Cecilia Payne-Gaposchkin, British-born American astronomer and astrophysicist]. Millie was the first female professor at MIT, at least in electrical engineering, I think. Wasn't she the first female professor?

LIN: I know she was one of the first—

GARMIRE: Something like that. [Dresselhaus was MIT's first female Institute Professor.] But I was of a different generation. I was the next generation, and because of my upbringing, sort of the middle class, comfortable, with a PhD father, I didn't have any passion to do anything. I just wanted to be a good daughter. I was well behaved. And I was also very competitive (being a second daughter!), so if I was going to do anything, I wanted to be the best. I studied hard in high school and ended up being valedictorian. There were actually five of us that were valedictorian, but that's all right. I was one of them. And I got into Harvard. That was the big deal. Well, in those days, it was Radcliffe, so I got into Radcliffe. Nobody in the history of my school had ever gotten into Harvard.

LIN: Why did you apply there?

GARMIRE: Because it was the hardest school in the country to get into. I decided to major in physics. Why? Because it was the hardest major I could do. Math was also difficult for me. I wasn't turned on by it. I was really interested in the physical world and how things worked. I sort of bit the apple in terms of when you start physics, you want to really know all the way down to basics, how do things really work? So intellectually, I was very interested in physics. And, of course, Marie Curie was my idol. You know, I hadn't heard of—

LIN: Millie.

GARMIRE: Millie. At that time, she wasn't all that well known.

I can still remember going to interview for my application to Radcliffe. This will just sort of set the tone for some of what I'm getting at here.

First, I had to go buy a suit; I didn't have a suit. And, of course, I couldn't find a suit to fit me. This is the other thing I haven't mentioned. I was 6 foot 2. I still am 6 foot 2, which is very unusual for a female. It certainly was 50 years ago. I felt like an outsider; I wasn't really like a typical girl. I started off from the very beginning of being very atypical, first of all being tall, then being interested in physics, which was not something girls did. If I went to a party and said I was

interested in physics, they'd say, you know, “Oh, my god,” and walk away. [LAUGHS]

And then, truly, I don't think my father wanted me to go be a success, because he was from a very strong German background. And Germans felt women should be housewives. Just as an example of that, once I was a housewife and had a child, I was working at Caltech, and my parents came to visit me. They did it by driving out from Chicago and arriving at 2:00 in the afternoon. They were upset that I wasn't home with the baby. They had never realized that I was going to have childcare, you know? It was just not something that they'd thought of. So I didn't get inspiration from home, but I did get a desire to succeed.

Just to add one more thing to this story, there was a time when my mother was very unhappy married to my father and talked about it. Unhappy women back then, there were a lot of; they didn't divorce in those days. But her point was that she couldn't get a divorce because she had no skills. Her skills were playing the violin, and she couldn't support a family playing the violin, so she was really pushing for me to succeed in something. That was a real help, there's no doubt about that.

So anyway, wearing my nylons, and girdle-- [LAUGHS]

LIN: '50s attire--

GARMIRE: Everything we wore in those days, in the 1950s style-- I went for an interview to the city of Chicago, to a woman who lived in this very expensive apartment overlooking Lake Michigan. She was a Radcliffe graduate, and she interviewed me. It was sort of typical of what one expected of women in those days who had graduated from Radcliffe. Why we went to Radcliffe was to meet the most successful men we could so that we could be part of a team that would help that man to get ahead in the real world and become powerful people through being wives and doing volunteer work and all of the things that in those days counted.

I'll remind you that in those days, a woman-- My mother's name was Mrs. Ralph Meints. It was not Mel Meints. It was Mrs. Ralph Meints. You went by your husband's name – in the newspaper, for example. So that's the way I grew up.

I went to Radcliffe when it was part of Harvard. Now, Harvard has always been, and Radcliffe has been, a pretty liberal place. And, certainly, I had a nice liberal education. The interesting thing about being at Radcliffe-- I still think educating

girls separate from boys or setting it up so they're living separate from boys has real advantages, because we girls bonded very well. We all saw life in the same way. And then we left our dormitory, and we went out to the real world. All our classes were with Harvard. In my physics classes, for example, there were three girls that majored in physics and probably 70 men, something like that. That was the kind of ratio. I enjoyed it. Because I was so tall, and I knew getting a husband was the most important thing to do, I felt that I was in a place where I could meet a lot of men. [LAUGHS] That was in my thought process.

Anyway, I did all right. I didn't do spectacularly. My grades ended up to be about a 3.5 out of 4, and nobody was patting me on the back and saying, “You're doing very well.”

I do remember one particular experience. It didn't cause me to leave the field, but if I were less secure or less competitive, I probably would have. Harvard only had A, B, C, D grades; they didn't have plus and minus. This was probably junior physics – I think it was a mechanics course – and I got a B. There was one other girl in the class. She also got a B. We went to see the professor, because we both thought we'd done pretty well, and he showed us the grades on the exams. There was a whole bunch of people with one set of grades, and down at the other end was a whole bunch of other people with lower grades. And there were the two of us right in the middle. And he said, “I thought long and hard about whether I should give you an A or a B because you were separated from everybody else. And I decided to give you a B.” And I was thinking about it, you know, this idea of supporting females, wanting them to succeed; it's the least supportive thing he could have done to just have said, “Well, I think they can do better, so I'm going to give them a B.” I mean, here we were, questioning why we were there anyway, so whatever. I did hang in there, and I did like him as a professor. I guess that must have been my sophomore year.

In my junior year, I went to him and asked him if he had any special projects I could do, because I had some spare time. And he actually gave me a special project. He wanted me to build a particular apparatus that would be used in a junior lab course. It was on optical pumping, which was a new area back then. I did feel so proud of getting the chance. I read the articles in the graduate library, and it gave me a feeling that, “Well, I can get there.” So he did help me in the long run. Then I also graded papers for Roy Glauber [who later won the Nobel Prize for the fundamental theory of laser light] which was kind of nice; I could say that I had graded papers for him. And then when I was a senior, they were needing TAs for freshman physics. They'd never done it before, but they decided to take a few seniors and let them teach in the labs.

LIN: Wow, that must've felt good.

GARMIRE: Yes. So I got a chance to do that, which I had done in high school. But here I was at Harvard, as the only woman. But all of that stuff never sunk in to make me think that maybe I was better than average. I just didn't have that feeling. I liked being a student, but didn't understand being a creator – nobody had talked to me about creating things. Nobody had talked about design back then. All the teaching were strictly lectures. "Here's the professor. Believe what the professor says. Regurgitate it back on exams." I didn't have any thoughts about how I would do a career or anything, except for becoming a professor. Learning all this stuff, and then when I got old, regurgitating it back to someone else. This is to show that the learning today is done in a very different way.

I should say that I met a man in my sophomore year, and he was a physicist. We dated for several years. And, yes, in our senior year, we decided that we will marry when we graduate.

This is what everybody did there at that time. In fact, the competition was to have a bigger diamond than anybody else before graduation. [LAUGHS]

LIN: Hard to believe--

GARMIRE: I mean, really, you had to find a husband, and if you didn't, you'd be an old maid. So, yes, I found a man. He liked to go camping, which I did. He liked physics, which I did. I don't know if we had anything else in common. But anyway, he seemed to fit what I thought would be a suitable husband for me. He would become a professor.

LIN: I suppose you ended up applying--

GARMIRE: Yes. He had decided to go to MIT. He was at MIT, two years ahead of me. I knew I had to stay in Boston, so I went to see Professor Purcell, a Nobel Prize-winner for work that he did in atomic physics, and the most fabulous teacher you could ever imagine. [Edward Mills Purcell, who earned the Nobel for his discovery of nuclear resonance in liquids and solids.] I had taken a class from him when I was a junior, and I was in love with him. He was so handsome. He was absolutely everything a college girl could want as a teacher! I would stay after class and ask questions – I always seemed to have them. Atomic Physics was so fascinating!

So I went to him and I said, "I'm trying to figure out where I should apply to for college. You know, what about Tufts? What about Brandeis?" What's their physics like? He said, "Why aren't you applying to Harvard?" And I was quite

shocked. I didn't think I was good enough. And he said, "Well, what's wrong with MIT?" To start with, I thought my husband was way above me intellectually. And then, I mean, he could do problems so much faster than I could that I just didn't see that I was in the same league. But Professor Purcell convinced me, so I applied to Harvard and MIT. Got into both of them.

LIN: Congratulations!

GARMIRE: I got a fellowship at Harvard, and at MIT, I got a research assistantship. You might argue that the fellowship is at higher level and status than a research assistantship, but I thought about it and I decided that I was sick and bored with Harvard's library!

LIN: Oh! [LAUGHS]

GARMIRE: I wanted new halls to walk, a new place to be. That was the attitude that I had. I think both schools were extremely highly thought of in physics, and it was interesting to have a choice. But then I got this research assistantship during the summer, and I knew it would give me a chance to get a start on graduate school before waiting for the fall. So all of those reasons – and I suppose I didn't think of it at the time, but that my husband would be there, I'm sure – must have been part of the decision as well. At least MIT wasn't a stranger to me, because my husband had been there, and I'd visited him. I'd seen the labs and halls at MIT. So that's why I went to MIT, in a nutshell.

LIN: Did you feel supported as a woman in physics during your time at Radcliffe?

GARMIRE: I certainly didn't feel unsupported. I don't think anybody-- Well, it's interesting that the first day, I met a professor who would introduce the physics department to me. Everybody gets to meet an advisor. It was Gerald Holton [physicist and historian of science; Emeritus Professor of Physics and the History of Science at Harvard]; he's extremely famous for supporting women. He has written many articles about getting more women into physics. He was a very junior person at that time, but he must have been personally very supportive of me. I mean, I know that he was to later female students. At that time, I had no comparison, but I think that must have been the case. I certainly met those who weren't!

I also remember, just out of the blue, that when I was a sophomore, I somehow or other found a graduate student, or maybe a postdoc, to come and talk to us three women majoring in physics at Radcliffe at our separate campus to teach us about special relativity. I was very curious about it and didn't want to wait for

the classes to come. And, again, that's something that's way back in my mind. But I never really thought of it as something unusual to do. So I just did these things because they were there to be done, not to really prove anything, I guess. I was just doing it.

In fact, one more anecdote from Harvard was that I remember when I was a junior taking a class. I had climbed up a tree and was thinking about my future. I suddenly realized that I was in a solid enough place that I was going to go to graduate school. So actually, I realized that the reason I was in school was to learn. Up until then, I thought I was in school to get A's. It was a new mindset when I realized that I was there to learn. I think by the time I went to MIT, I was quite comfortable with the idea that school is to learn. I'm not sure I necessarily thought that earlier than that.

I walked in at MIT taking my first class in statistical mechanics when I was a first-year grad student – or was it quantum mechanics? A first-year grad student, and there were, what, 50 men and me? And I was wearing, believe it or not, nylons, high heels and a girdle. Why? Because all the secretaries dressed that way. Every woman I saw was dressing that way. It took me probably three or four months before I said, "Screw it. I'm going to be comfortable and wear jeans." [LAUGHS] And so, yes, it was very strange. I never met another girl in physics when I was there. I have later discovered there was one other, but she was in nuclear physics, and I never even saw her, so I was quite alone.

There were no women faculty. Millie [Dresselhaus], I heard of, but she was out at MIT's Lincoln Laboratory and I had only heard of her through the grapevine. What I did hear of, which I found very interesting and would be good for your records, is that when I think I was a second- or third-year student, MIT had decided to try to attract women to MIT.

LIN: I didn't know that.

GARMIRE: They found – I think she was a junior, an undergrad who was really attractive and really well-spoken – and they picked her to go around the country and talk about coming to MIT as a female. And I thought, "Boy, how smart they are. Pick somebody who's really attractive." They also had either gotten a grant or were just in the process of working to get the grant to build the women's dormitory.

LIN: McCormick?

GARMIRE: Yes, McCormick. It was right around that time. I think it took a couple years after that when McCormick was built, but they were beginning to move in that

direction. I don't know who was responsible or anything like that, but that's all I knew about women when I was at MIT. I do know that the first day that I arrived and walked down that infinitely long hall, I was so terrified. I had just come from Harvard; why was I scared by MIT? I was not scared coming to Harvard. When I went to Harvard, I was feeling, “I've made it. I'm, you know, one of the world's best. Oh, wonderful.” But when I got to MIT, it was a very different feeling. It was like everybody is smarter than me.

LIN: That feeling still exists!

GARMIRE: Oh, I know, I know, I know. But one of the interesting things is my first MIT exam; it was an in-class exam and a very long one. I knew I was never going to get through the whole thing, so I wrote how to solve each problem without actually solving it. Everybody else did the usual turtle thing – you know, “I'll do this problem. I'll see how far I can get.” They didn’t get very far, so my partial answers got more credit: I got the highest grade in the class! This was due to my excellent training from Harvard in how to think about physics.

LIN: Wow.

GARMIRE: At Harvard, the way they grade in graduate school is not checking your algebra; they want to see if you've got the ideas. I don't think I got the highest grade again, but at least then I did. I had a terrible time with algebra and numbers. And we were all using slide rules back in those days.

LIN: [LAUGHS] There's an image of MIT students walking around with slide rules--

GARMIRE: Yes – I had to have a slide rule. So, again, as an example of what I did to separate myself, I put a velvet slip cover on my slide rule and covered it with sequins.

LIN: Wow, that's quite a statement.

GARMIRE: Yes. I don't think anybody ever commented on it. They all knew it was Elsa's.

LIN: Right.

GARMIRE: [LAUGHS] So it was very important to me to keep the feminine side. And I had another advantage: I was already married, so I didn't have to worry about finding a husband, or dealing with men coming on to me. Also, because I was so damn tall, men never came on to me anyway. I was off scale for them.

LIN: During your time at MIT, did you interact with other women graduate students?

GARMIRE: No, never once.

LIN: Never once.

GARMIRE: Never interested in it. The idea of women getting together – things like the Society of Women Engineers – that literally didn't exist. And part of my story that we'll get to is when the women's movement came along, I got very involved in it, and I learned why it was so important to be involved. But back at that time, absolutely not.

Now, what was a positive about all of this is I was, well, let me tell the whole story. When I arrived in the summer of 1961 to start my RA, I visited with George Koster [MIT physics professor who contributed to advances in research on semiconductor materials]. He did calculations of the band structure of solid state physics. He was interested in having somebody that would work with him on gallium arsenide, and I just did not want to spend my time sitting at a computer calculating things. But he did offer me a position working with him. So you asked me, did I feel supported? I certainly did in the sense that he offered me a position. But I said I really wanted to work in an actual laboratory. The position he found for me was working with the wife of Professor Slater, who was a very famous chemistry professor at MIT. [John C. Slater, a former chair of MIT's chemistry department, did work during WWII that contributed to the development of radar.]

It's kind of an interesting story, because she had been an unmarried full professor (Rose Mooney) and head of the physics department at Tulane University. Her field was X-ray crystallography. Born 1902, she was the first female X-ray crystallographer in the United States. I happened to know Slater's family from my Radcliffe roommate, but I didn't know him. He had met her somewhere and they'd fallen madly in love. He left his wife, went to Reno, and wrote his books while he lived there for six months while getting a divorce, because it was not easy to get a divorce in those days. I know that it affected his first wife and his children. But anyway, that's beside the point. She and Slater married in 1961, just before I arrived at MIT. She obtained a research position working in her own laboratory at MIT doing X-ray crystallography of minerals, such as uranium disulfide. To me they seemed like random minerals that nobody cared about (actually, I know now that she specialized in phosphates). She was passionate about her work, but didn't explain its value to me. And she ran it like, I'm sorry to say, the old maid that she was. She wouldn't let me even go sign out a pencil from the stockroom.

[Rose Mooney Slater earned a PhD, and in 1931 published the structure of potassium permanganate as sole author, and then the structure of ammonium bicarbonate. She became a faculty member at Newcomb College. During WWII, she was appointed Associate Chief of the Metallurgical Laboratory's Structure Section, University of Chicago, becoming one of the highest-ranking women in the Manhattan Project. From "Rose C. L. Mooney-Slater," By Frank Fronczek, 2017 https://www.amercrystalassn.org/h-mooney-slater_articles.]

LIN: Wow.

GARMIRE: I had to get her signature on absolutely everything. I felt like I had no freedom in this laboratory at all. I had spent four summers working in summer laboratories, and I'd always had freedom to do things. But I didn't in her place. By October, I think, certainly November, I was extremely unhappy. I was thinking of dropping out of graduate school and giving it all up. Now, the fact is, you got paid as a research assistant the same as you did as a secretary or as a teacher--

LIN: Right.

GARMIRE: --of grade school or whatever. I figured, "Well, maybe I should look around a bit." I give a lot of credit to my ex-husband [Gordon Paul Garmire] on this. He was a lot of help to me when I was so miserable. He said, "Hang in there." Another reason I decided to hang in was that I met a woman who had been married to a professor. They'd gotten divorced, and she was now a secretary at MIT, and I saw, "Well, if I stay in school, I can either be the professor or be stuck." [LAUGHS] She was so bitter--

LIN: Right.

GARMIRE: --at what life had done to her. So I said, "I'll hang in there anyway." I went back to George Koster, who was in charge of research appointments, and he said, "The provost is looking for help." The provost's name was Charles Townes. [MIT Professor and Provost during 1961-1967; inventor of the maser, a device that produces coherent electromagnetic waves through amplification by stimulated emission; shared the 1964 Nobel Prize for Physics.]

LIN: Wow, *the* Charles Townes?

GARMIRE: I'd never heard the name. I had heard of the maser. Actually, when I was at Argonne National Laboratories, working during the summers, I had gone to seminars. And Nico Bloembergen [Nobel Prize winner from Harvard] had come

to give a seminar on the laser. What I remember about that was that he had a strong Dutch accent, and he talked about pumping the atomic levels, or bumping them. I never knew which it was. [LAUGHS]

But anyway, Dr. Townes interviewed me. He seemed to think I might be all right. He said, “Well, as long as your present advisor says that you're OK, I'll hire you.” She said I was OK, so I switched over to his lab, and it was just absolutely amazing. He took me the first day, and walked me into this empty lab. There was nothing but a table and one piece of equipment, this kind of shiny metal cylinder that was maybe a foot long and maybe four inches in diameter, and in the middle of it was a hole. This was a ruby Laser. He had purchased what I later found out was the second commercially sold ruby laser. The ruby laser was the first laser. It had been demonstrated just a year earlier by Ted Maiman at Hughes Laboratories [Theodore Maiman, an American engineer who is widely credited with the invention of the laser]. It was an optically-pumped solid-state laser that used a cylindrical synthetic ruby crystal as its laser medium.

LIN: Wow.

GARMIRE: Townes said something like: “It's yours. Do with it as you please.” Because he was provost, he was constantly up campus. His office was in hallway number four, I think, and I was in eight, so we were a long way away. I felt very excited about beginning with a new piece of equipment. I don't think anybody helped me when I began. I had a thin instruction book on the laser, and I had a very thick instruction book on an oscilloscope, because I needed an oscilloscope to monitor the laser output with a photo-cell. I read about the oscilloscope cover to cover to learn how to use it. I'd never had one before. It was very exciting to me.

So I must've been a highly motivated student. It's funny, because I don't have any sense of ownership of that part of me. I just did it because it was there to be done. There was no one helping, and that seems to be the story of my life. A great amount of what I've done is because it was there, and there wasn't necessarily anybody to help me.

Now, there's been occasions when I've certainly got important help. And the most important thing is that Townes trusted me. He didn't say, “Well, I'm going to give you a postdoc to oversee you.” And, in fact, the very first paper we published was with a post-doc from Italy, Francesco Panderese. He knew almost no English. I knew no Italian. So I had to learn to speak very slowly and simply. I put a lot of effort into it, but then I got a lot out of it. He helped me with laser experiments, investigating the stimulated Raman effect, which was very new.

Our paper came out in 1963, in my third year of research. It was the first paper pointing out that the stimulated Raman effect transferred momentum and energy to the Raman-active material in the form of coherent vibrations that could drive new frequencies.

Experimentally, what happened before then is trouble with the ruby laser as it existed when I first got it. The laser gave off a pulse of ruby light, pumped due to a flash lamp. The lamp would go off, and the ruby laser light would come out, showing as a bright red spot on a screen. It would be in a random set of pulses in time, each pulse lasting about a microsecond, and they were separated by maybe 10 microseconds each over a period of roughly a millisecond, which was the on-time of the flash lamp. You know, you can say “Fine, I see red light.” But so what? It was totally uncharacterizable. Also, it was not a nice, uniform beam like they are today. It was just random separated globs of light on the screen, so there wasn't much you could do as meaningful experiments. But then there was a very important invention that occurred, which began at Hughes Research Labs, which was what's called a Q-switch. And it was able to change this random red output into one single, very powerful pulse that lasted 10 nanoseconds – an amazing change.

Work on this had been done at MIT, at Lincoln Lab. They had developed a system for creating this Q-switch. It was a rotating prism that would use an air jet. The base had little holes in it that made the air jets. And it had a little conical-shaped base that nested in there, and the air pushed it around. And it would go “Wheeeee.” It would spin around at super-high speeds, so it would come around 100 times, 1,000 times, something like that, presenting a reflector to the laser cavity for a very short time. This made the Q-switch. It wasn't all that hard to do. It is true that it was very hard to align these lasers, because this was before there were any visible lasers. The helium-neon laser, which everybody later used to use to align lasers – a visible one didn't yet exist; it was infrared.

LIN: Oh, wow.

GARMIRE: So how did you align these lasers? We had what was called an autocollimator, which was basically a telescope that sent out circular rings of light that would reflect back. You'd get them to line up, and then you'd know that mirror was perpendicular to your beam. But getting all that to go through a Ruby was not easy. So there were a lot of technical skills that one had to invent in the early days of this.

Now, you might ask, how did we know this pulse was 10 milliseconds long? There were no nanosecond detectors back then, almost. It turns out there was one kind of detector that was a photo tube. It had a wire and a semi-cylindrical cathode. The light would hit this circular area, and then the electrons would be pulled to the wire, or vice versa. Anyway, and it would be the transit time of the electrons. It had a speed, believe it or not, a response time less than a nanosecond. But the electrical signal was extremely weak, because there was no amplification at all. But Ruby put out a lot of light.

These two things married up very well. You can't buy these kinds of oscilloscopes anymore because they're way out of fashion. But it worked just well for us. Somebody was once saying that they had done their thesis very rapidly – they were done in three weeks or something. "Well," I said, "Ten nanoseconds times how many times did I run it over the four years of my thesis? I did my whole thesis in a millisecond." [LAUGHS]

LIN: Right.

GARMIRE: Anyway, with that fast, high-power ruby laser, there were some results that had just come out that introduced a new process called stimulated Raman scattering. And interestingly enough, this was introduced by the same group that invented the Q-switch at Hughes Research Laboratories. Robert Hellwarth [USC Physics professor whose specialty is developing materials for nonlinear optical devices] invented the Q-switch. The stimulated Raman effect was seen in his first Q-switch, and explained by Gisela Eckhardt, the only woman researcher at Hughes Research Laboratories at that time (she left lasers and moved to power electronics). The new Q-switched ruby lasers easily produced stimulated Raman effect; it was easy to see. In these experiments people were doing when I got involved in it, you just took your Q-switch ruby laser and sent it into a cell of liquid. And that liquid would respond by this stimulated Raman effect.

Is there supposed to be technical stuff in these oral histories as well?

LIN: It can be.

GARMIRE: The history behind the Raman effect is that it goes all the way back to Raman, who won the Nobel Prize in, I think, 1916 for observing some very weak light scattering. The scattered light will have its frequency shifted from the original light via internal molecular vibrations. It's an inelastic scattering, so that you come in with one frequency, and you come out with a frequency that's slightly lower. In order to see it, you've got to begin with a pretty narrow spectral line. People had done work in the past using a mercury line or a neon line. It was a

very weak effect and hard to see. But nonetheless, you could use it to measure spectra of, for example, organic compounds; if you tried to do an absorption spectrum, the lines would overlap. So Raman scattering was important, and chemists understood it. In fact, there were tables and tables of what the Raman spectrum looked like.

So I set up stimulated Raman experiments. A very interesting thing happened early on. I was doing the experiment, sending the ruby laser beam through the liquid and then measuring what came out. Now, I wanted to know what laser power went into the cell of liquid, as well as what power came out, so I took a beam splitter and sent a little bit of the input beam out to a detector. That measured the input. And then I had another detector for the output at the end of the cell of liquid. Now, in my experiments the Q-switched laser was so high power, if you weren't careful, it would actually blast the windows off your cell due to what they call optical damage. Literally, it would cause a spark, which would destroy the window. So I put a piece of paper up in front of the cell, keeping the laser light away from it, until I was ready to make stimulated Raman measurements on the cell.

I had the piece of paper in the way of the cell. I turned on the ruby laser, and I looked with this first beam splitter at what the output looked like. And, “OK, my output looks good.” So now I'm going to take out the paper and look at the output, not of the ruby laser, but of the output of the cell. But, of course, at the same time I was taking data anyway on the output of the Ruby. And when I had that cell in the optical path length, I found that the power out of the laser jumped up a factor of 10.

LIN: Wow.

GARMIRE: It just made--

LIN: That's unexpected.

GARMIRE: --absolutely no sense. I made measurements for a week, and I talked to Dr. Townes. He didn't know. Nobody knew what was going on, so we forgot about it. I thought, “Well, I'm a new graduate student. I don't know very much.” Here was this issue of lack of confidence, of, “I don't know what this is, so I'm just going to ignore it.”

And a year later, quite independently of this experiment but related to the theory that we had been doing, I worked with Townes on coming to understand that when stimulated Raman effect causes coherent vibrations occurring in the

molecules, because the laser itself is coherent, then all of the vibrations are coherent. It's as if the whole material moves with coherent vibrations. And that allows the Raman signal to be very large, which is what we were measuring. This is called the stimulated Raman effect.

Townes thought about it and realized that besides the molecular vibrations, there are also acoustic motions that can happen in the material. If you're a solid-state physicist, you know that there are optical phonons and acoustic phonons. The optical phonons are where the atoms are moving against each other, and with acoustic phonons, they're moving with each other. So, again, we published a paper that described how this theory might work if there were this stimulated Brillouin scattering--

LIN: It was newly discovered at that point?

GARMIRE: Yes. Brillouin predicted in around 1920 that Brillouin scattering would occur. Like Raman had predicted the scattering for molecular vibrations, he basically said the same thing: there's going to be scattering from acoustic waves.

After the theory, for a long time, people had trouble finding it, because the frequency shift is very small, and experiments had to have really narrow lines. But it turns out that one of our visiting scientists, Boris Stoicheff [who built the first laser in Canada], was an expert in measuring the Brillouin shifts. He was a spectroscopist, and that's what they do – they study these spectra. He helped Ray Chiao, one of the graduate students, to set up an experiment to measure this stimulated Brillouin effect in a material called TGS, triglycine sulfate. Also, they saw it in quartz.

I should mention also that Ray Chiao was a graduate student whom I got into our laboratory when I was the only graduate student. Come the second year, I met in my class this really smart student who had some ideas about lasers, and he came to talk to me. He wanted to use lasers as particle accelerators and was working on the whole theory for it.

I was very impressed. I said, “Well, you'll have to come talk to Dr. Townes,” which he did. And then Townes took him on as a student. He remained with Townes for the rest of Townes's life. They both went to Berkeley, where he became a professor, along with Townes, and quite famous.

Anyway, I don't know why I didn't think of looking for Brillouin in my liquids, but I was just set on studying this Raman. I should say that I had discovered that part of our Raman theory explained how some of the light was going to come

out at angles, in cones of light that showed up as circles on our white screen. It's called stimulated antistokes light. We predicted these cones by means of a very simple calculation. Conservation of energy means the cones have to be this certain diameter. But, they weren't: they were off by 10%. Now, you could argue, is 10% a big deal? Well, to me it was because I was a stubborn graduate student who wanted to make things work out correctly. I hadn't figured out why, but I knew it was off, and I tried all kinds of experiments to understand.

I was stuck finding the right angles, but at this point, I put in a lot of effort to get the laser into a nice single mode. You couldn't see the Brillouin shift if you had a lot of modes in the laser, so we had to develop techniques to make a single-mode laser, and it was not easy. I decided that I should get the laser to be a single mode. When I did that, the way we measured these modes is with a Fabry-Pérot [an interferometer that makes use of multiple reflections between two closely spaced partially silvered surfaces].

I put my Fabry-Pérot in the laser light to see if we had a single mode, and the line looked a little fuzzy. Now here's again where I screwed up. I didn't say, but was thinking, “Oh, big deal. I'm out of focus, whatever.” Townes is the one who said, “That looks a little fuzzy. Maybe there's something there.” And, he said, “Expand the Fabry-Pérot so you have higher resolution, and let's see what we get.” Well, it was stimulated Brillouin scattering--

LIN: Oh, wow.

GARMIRE: --just like Chiao and Stoicheff had seen, except instead of just one frequency shift, there were a dozen frequency shifts, many of them, all of equal brightness.

LIN: Wow.

GARMIRE: Well, that was not in our theory. And this is where, I believe, it was I that figured it out. What happened was that the light was retro-reflecting back into the laser. It was now in a different frequency than the laser was emitting, so it could see amplification. It went around the Ruby and came out again, very strong, and went back into the--

LIN: And it continued.

GARMIRE: --liquid. It did this any number of times. This is now a very important phenomenon used for all kinds of things. We published a paper and got a lot of

credit for it, no problem. And, of course, it explained totally what had happened to me two years earlier.

LIN: Right.

GARMIRE: I've often wondered, you know, “Could I in any way have figured it out before we knew about stimulated Brillouin and the retro-reflection, everything?”

The rest of the story is that even after we published this paper, I didn't realize that the stimulated Brillouin was an exact retro-reflection, as opposed to as if there were a mirror there, and light was reflecting off it. It was a true retro-reflection. That means a conjugation of the phase. I don't want to go through explaining that in great detail, but phase conjugation was discovered in stimulated Brillouin 10 years later, just to show you all these things I missed, right? [LAUGHS]

LIN: And you would have known at that time, since it--

GARMIRE: Well, if I had asked my question, “How come the light is going straight back, even going through a lens?” A lens would normally spread it out. But the lens focused this light down back into the laser.

LIN: Right.

GARMIRE: It's because its phase was reversed, because that's what the nonlinear process does. It's just fascinating to me that there were all these little details, which eventually got totally solved but at the time were unknown. Anyway, the stimulated Brillouin effect was discovered, and we got that paper.

Then Townes had this idea of having the nonlinearity create its own waveguide. The way that came about was that he saw a photograph of an experiment that was done at University of Rochester, where they had very high-power laser. And a focused laser beam was causing damage, like I mentioned happens, inside of a block of glass. It just made a very long track, a track 10 centimeters long, inside a block of glass. Focused light should have blown up again, after its focal point, but this was a light beam self-focusing itself all the way down a long track. So he sat down to think about it. If the nonlinear refractive index is increasing due to this nonlinearity, then it can make its own waveguide and keep all the light inside and not expand.

Townes asked Ray and me to work on this with him, and we eventually published a paper in which Ray had done the computer calculations, because

there's no analytic solution to the equation. It's a standard wave equation with a second-order nonlinearity. I analyzed the various nonlinear effects to predict what the thresholds would be.

That's, by far, our most-cited paper, because that really did introduce a new field. Having done that, we discovered that we weren't quite the first. There was a Russian who had done it first in a plasma [Gurgen Askaryan, a Soviet-Armenian physicist who discovered the self-focusing of light and conducted pioneering studies of light-matter interactions], which wasn't quite the same as in glass anyway. Since this early research in nonlinear optics, there's been 50 years and more of research that followed any one of those three areas.

I was lucky enough, all at MIT, to be able to be – perhaps not the first to discover it, but to contribute in parts to the beginning of each of these three areas: the stimulated Raman, stimulated Brillouin and self-focusing.

LIN: Fantastic.

GARMIRE: I got pregnant, and I had my baby two weeks before I defended my thesis.

LIN: Oh, wow. That's incredible.

GARMIRE: [LAUGHS]

LIN: So, essentially the biggest moments of your life. How did you manage?

GARMIRE: What happened was eventually, Townes kept saying, “You can do this experiment, and you can do that experiment.” And I said that I couldn't reach the lab table anymore. [LAUGHS] So he said, “All right, you can write it up.” Phew! I was writing it up, and I was in the last chapter, where describe the things you don't understand, what you want to do next, all that stuff. I was busy writing all that. And my baby came actually about a week later than was predicted (because they didn't know those days when it would be; they didn't have ultrasound). So two weeks after I delivered the baby, I submitted my thesis. And then another two weeks, I had a thesis defense.

So I went home to raise my baby. I had made no plans for my future, as was typical – this was 1965. Women were supposed to take care of their babies, so I stayed home for a couple of months. It was boring, so I called up Dr. Townes and said, “Can I please come back?” He didn't have any funding for a postdoc at MIT, but he arranged funding through another organization. At this time, which was 1965, there was a building over in Kendall Square; a new building built by

NASA. It was called the Electronics Research Center. I don't think it lasted more than five years, but NASA paid for this building. And NASA had money for scientists, so I got hired as part of NASA for one year--

LIN: Wow.

GARMIRE: --and worked, and continued to work on some of the understanding of this self-focusing effect, and sort of split my time between MIT and the NASA laboratory. We put a newer more powerful ruby laser down there as well, so we had experiments to do. We had an office in – they called it the barn, didn't they? RLE [Research Laboratory for Electronics] used to be in the World War II barracks--

LIN: Right.

GARMIRE: --before it was built. I had an office over there for a while. It was located at the end of the world, or so it seemed at that time.

LIN: Sure. It's still the same style of architecture.

GARMIRE: I thought they built a new building there.

LIN: I think they did. One of the buildings is new: building 38. And the ones around it are still old barracks style.

GARMIRE: Oh, man. [LAUGHS] Maybe they copied it. Who knows?

One other amusing – or not – story. A couple of other things happened. When I was working at the lab at MIT, I did something that I should not have done, well, really two things, I suppose. I was doing my thesis on the stimulated Raman effect, which take place in organic liquids, or at least have large effects in organic liquids, so I had little cells of organic liquids.

I didn't bother with a fume hood. We didn't have a fume hood on that floor. I was in the spectroscopy laboratory, which no longer exists but was built for the ruling engine that was run by Professor George Harrison [became Professor of Experimental Physics at MIT in 1930; later became Dean of Science; headed the Institute's Spectroscopy Laboratory; received the Presidential Medal of Freedom, in part for work he conducted for the government during WWII]. But they had built a special room that consisted of a building within a building within a building. This was in the basement of Building 6. And when you went to go into the spec lab, you had to go through four inches of foam rubber.

Then you had another door you opened, and another four inches of rubber, and you went to an inner sanctum. The ruling engine was there, floating on two layers of foam rubber. It had two floors, and our lab was up on the second floor. There was an elevator, but it was a hand-crank elevator. It was to take furniture up and down, but it was interesting to me that it was still the same old hand-crank furniture. This building was built in 1930 or something. Anyway, it had lots of history in it.

So we were up on the second floor, way in the back, and I didn't want to go find a fume hood. I would have had to leave the spec lab and whatever. I was using all these organic liquids. They smelled terrible, but I thought that was good, because it kept me from building up a lot of it, because I wasn't going to sit in the middle of smelly stuff. I was very careful to have it capped all the time. We had a very old lamp, an old fluorescent lamp, and one day, I wanted to unplug it. And I did what you're not supposed to do, was pull it from the cord rather than from the plug.

LIN: Oh!

GARMIRE: It had been cut at some point, and the two wires taped together with black electrical tape, which loses its elasticity after time. This was probably a 40-year-old lamp, dating from the 1930s. [LAUGHS] Anyway, it pulled apart. And a big spark--

LIN: A spark!

GARMIRE: The cord was called zip cord – it was flammable in those days, so there was smoke. I found out how I'll behave in a panic, which was -- I screamed, “Ray, Ray!” Ray being Ray Chiao, my pal. And he came running in. Instead of standing there screaming, like I was, he ran out. He ran right by--

LIN: The fire extinguisher?

GARMIRE: --the fire extinguisher, down the stairs, found another one, came up, and put it out.

LIN: Wow.

GARMIRE: I can't remember if we called the fire department. But I was thinking about it as we were talking about this NASA ERC. In the basement, I was doing experiments on an unusual material called stannic tetrachloride or stannous tetrachloride – I forget my chemistry. It was one of those two that is very reactive in with water.

I had made a cell of this very carefully in a fume hood. I brought it in, set it in front of their laser, but I forgot that their laser was 10 times more powerful than the one we had over at MIT.

LIN: Oh, no!

GARMIRE: And sure enough, it blew the windows off the cell. And hydrochloric acid vapor started streaming up out of the cell, which was the result of water vapor getting into this cell. And what do you do? [LAUGHS] We did what we could. We ran out of the room and shut the door, turned off the air-conditioner and called the fire department. They came in, and they put on masks and went in there. Then they came back out, and said, "Yeah, you got your room full of a very dangerous vapor. Now, what do we do?" They didn't know what to do. But about this time, a chemist walked by, and he said, "It's very simple. Flood the floor with water." And the hydrochloric acid vapor went right out into the water. The firemen knew how to do this with water. The result was that all of the stainless-steel optical equipment was rusted by the hydrochloric acid. So they remember me-- [LAUGHS]

LIN: As the one who rusted all the--

GARMIRE: They remembered me as long as that equipment lasted because the equipment was all slightly rusty. [LAUGHS]

LIN: Wow.

What was it like working at NASA? And what was the reason you eventually went to Caltech?

GARMIRE: At NASA I did the same things I was doing at MIT, except with fancier, new equipment. I trained several staff. But most of the time I still spent at MIT. I had no interactions with NASA *per se.*

My husband was going to Caltech, I'm just trying to remember why. He had gotten a position at MIT and was doing well. I guess he was in a group with other people as leaders and I think that Caltech represented a possibility of him becoming leader. Initially, he took a leave of absence from MIT; we were only going for a year. But he explored a permanent position beyond MIT. I remember I was looking for a position with him. We also interviewed at UC San Diego and the University of Maryland. Both would consider me only in the electrical engineering department because of nepotism rules. UC San Diego was just opening and we looked at an empty place where a building would be.

Ultimately, his choice was Caltech, so I interviewed at potential places around there: Caltech's EE department, Hughes Research Labs and Electro-optical Systems Lab in Pasadena (it eventually became Xerox labs).

LIN: I see. You interviewed around the area.

GARMIRE: Yes, I interviewed at Caltech with Yariv [Amnon Yariv, Israeli-American professor of applied physics and electrical engineering at Caltech]. There was another professor [Nicholas George] working with lasers at that time at Caltech in the Electrical Engineering Department. But it was quite clear to me very early on that Yariv was technically much better than he. I also interviewed at the Hughes laser research labs in Malibu, which would have been a very long commute, but I couldn't resist. It was such an important place, and they were doing just what I was doing. But they never followed through with me. That group had no women, or so I thought. Actually, I never followed through with them either. The commute from Pasadena was just too daunting.

LIN: No women--

GARMIRE: Yes, no one was particularly interested in women at that time, except as post-docs. Sometime later I applied again, but I didn't follow through. I didn't call back and say, "Yes, I liked it, I'm interested," so they assumed I wasn't interested. I probably wouldn't have been able to go anyway, because I had a child and a husband and all of that.

LIN: I did want to ask you about having a child and being able to work reasonable hours – about work-life balance.

GARMIRE: Well, my first opportunity really was very nice. I've said I hadn't planned to work when I had my baby, and then I decided I wanted to. I had to find somebody [to help with my child], and I don't remember how I found her. I think I literally put a notice up on a board somewhere – I would assume it was around Harvard, near where we lived, but I don't remember. In any event, this woman was supporting her husband while he was a student at Harvard by taking in children. She had her own three children, I think, and she took in another young child and then my baby, and was wonderful, just wonderful. So the first year, my baby grew up in a family.

LIN: That's so nice.

GARMIRE: After that year is when we went to Caltech.

You ask about being a mother and a worker, a researcher; I was not very comfortable with it. Again, growing up in the '50s, you're supposed to be a housewife and a mother, and, therefore, the most important thing to me was how my baby turned out. I was the ultimate helicopter parent, watching everything. [LAUGHS] Every time my baby cried, it was my fault, and I became a nervous wreck.

It was literally no more than two weeks before we were leaving MIT on our way to Caltech. We were going to drive cross country, camping along the way and seeing the sights. Just before we left Cambridge I experienced flashing lights in my eyes. Having worked with lasers, I immediately thought I'd hurt my eyes with the lasers. But I went to see an ophthalmologist, and it turned out that they were phosphines. They're like migraines. They're stress-induced flashing lights. People who have migraines often get these flashing lights. I get them very rarely. But if I'm under a lot of stress, they will come up. It was a sign of how much stress I was in, wanting my baby to be perfect. As we drove to California, we stopped along the way to visit my parents in Chicago, which added to my stress (wanting my parents to see what a perfect mother I was). I got to Chicago, and within a couple of days I suddenly experienced a loud noise in my head, just a [CLAPS] big bang. The hospital thought I might have had a stroke, but never found anything wrong with me. They said it was my brain flashing, like phosphines, and was the next level of stress.

LIN: I've never heard of that--

GARMIRE: My mother, who loved to be a, quote "helper" unquote, was happy to take the child, and my husband and I went off for a few days of quiet camping, so my stress relieved some. We then continued our drive. We got to Yellowstone National Park. In a very unusual coincidence, in the camping site, there was another couple from Harvard that my husband and I knew. They had two children; one of them was in one of the do-it-yourself baby walkers that were fashionable at that time. But something was a little odd. As we went over to say hi and everything, we learned that this child in the walker had Down's syndrome.

LIN: Oh, I see.

GARMIRE: Their child was slow to develop. And, of course, they were PhDs, and we were PhDs. The worst thing you could possibly have was a child that was slow to develop.

LIN: That's unfortunate.

GARMIRE: But I watched this baby roll in her walker into the picnic table and not cry, but then later suddenly realize that she was hurt. And, of course, that's the syndrome of somebody who has Down's syndrome. For one thing, they don't complain, and/or they're delayed in their complaints. And I thought, here I was, so worried about my daughter complaining all the time. But now I realized that if she were not a complainer, she'd probably have something wrong with her, like Down's syndrome. This experience just pulled away from me all my worries, you know? You see somebody worse off than you, and you realize you're not bad off at all.

That led me to [feel] much more comfort about what I was doing. At Caltech, I set it up so that I only worked six hours a day. I went to work at 10:00 and I came home at 4:00, the idea being that I could be home at the beginning of the day and the end of the day.

LIN: What did you do for child care?

GARMIRE: Back at that time, which would have been starting in 1966, it was still impossible, or let's say it was still very difficult, for a black woman to get a decent job. We were living in Pasadena, which has a very strong black community. I went to the government unemployment center, where people went to find jobs, and I sought a housekeeper. I hired a really wonderful, wonderful, very intelligent, smart, everything woman. She was warm and loving, a good cook, and kept a clean house. At the time, I didn't know that she was practically blind, but still managed beautifully.

LIN: Oh.

GARMIRE: But it didn't matter. The time I discovered she was really blind was when I came home, and there was a uniform layer of dirt all over my carpet because she hadn't known the vacuum was broken. [LAUGHS] And she had just done the vacuuming!

LIN: Oh.

GARMIRE: She could see shadows and light. She had opaque corneas, and finally she got a chance for a transplant. So she went and did that, and I had to go find others to help.

I never was able to find a very good person to help again, so when I had a second child, I actually helped set up the daycare center that Caltech still has.

LIN: Oh, wow!

GARMIRE: There were about 12 of us that worked to set it up, put a lot of effort into it. My kids then had a daycare center that they went to. But, no, it was never easy. There were always issues that you had to deal with. There was also, however, a fantastic summer camp for my kids when they got old enough, all summer long.

LIN: In the Caltech area?

GARMIRE: In the mountains behind the Caltech. They had this big old hippie bus that they drove down, and the kids would go off. It was an artist and his wife, and she made sure that things were clean and proper. They had horses, and the kids got to be very, very creative. It was a fantastic place, just so unlike the typical boring ones that you have. A very 1970's experience. It was just really creative. I don't know what I'd do now. Both of my kids have not had to deal with that. My first daughter, who got a PhD in English, worked in high-tech public relations, but had a serious issue with her kidneys. She lost both kidneys, and then she got a transplant from her husband. After that, she decided not to work.

LIN: I'm sorry she had that health issue.

GARMIRE: As you've seen, I love to talk about myself! I'm going to write a book someday. I do a lot of thinking about myself and where I am and how I got where I got, and all. That's the luxury of being retired.

But, yes, I'm just thinking about the day care that my kids have had to face. The oldest one decided to stay home, even though she has a PhD, because of these health issues, and she's been working on writing novels for the internet. She hasn't made a lot of money on it, but she hasn't tried to market them or find an agent. And the second one, her husband spends a lot of time taking care of the kids. He's trying to get a company going. If it succeeds, then they'll have money to get child care. [LAUGHS]

LIN: I guess they're involved in entrepreneurship.

GARMIRE: Yes. Right. Exactly. But it's always just around the corner, and it has been for 15 years!

LIN: Wow.

GARMIRE: I know child care is a real issue. It really is. You have to decide. You know, that's one of the things that people understand. Before you get married, you really need to negotiate how you're going to all do this, and it can go any way at all. I have a friend now who's a little older than you. Their kids are like grandchildren to us. Actually, she's my daughter's age. She was a friend of my daughter's. She and her husband have sort of alternated being home-makers. Right now, her company is going great guns and he's taking care of the kids. When his company goes, it's the other way around – and they also have a full-time person as well. So I do agree; you need to put some amount of time to your kids.

As I told my kids, I gave them all the time that I thought I could without resenting them. I wanted to make sure that I didn't resent having had kids, so I chose to work. But one of the things that happened was that it was not until I had to work (after my husband left me for his girlfriend) that I felt comfortable working. You know, I always felt like my work was – and I'm sure my husband felt that way – that my work was volunteer work, voluntary, where I didn't make much money. They held us way back in terms of the amount of money you'd get if you took a soft-money job at a university. I worked at Caltech for nine years as a postdoc, and I eventually got a title of senior research--

LIN: After nine years?

GARMIRE: Right. But I was leaving anyway, so Caltech gave me the title. I had taken a post-doc with Professor Amnon Yariv, working part time. But nine years later, my husband decided that we should take a year off, a sabbatical, and I wanted to go around the world. I wanted to prove to myself that the world was round, so we arranged for this trip. And while I was in England, I got a letter from the boss I'd been working with at Caltech saying, “Don't come back. I don't need you anymore.”

LIN: Wow.

GARMIRE: I took it very hard and wrote letters to everybody I knew to see if I could find something to do when I got back. When we got back from our trip, my husband did not move back in with me. He said, “I've been involved with somebody else for the last year. I'm moving in with her instead of you.” So I had this couple of months of just lying on the sofa saying, “I'm going to have to go on welfare. I have no job. I have no husband. I've got two children I have to take care of.” Can you imagine: PhD from MIT, graduate of Harvard, and all I could think of was going on welfare? [LAUGHS]

LIN: That's really unfortunate.

GARMIRE: I just had no feelings of self-confidence at all. But I had enough of this pick-yourself-upness that after I got over being sick – you know, stress and all that. No serious maladies, just what you'd expect.

After a couple of months, I finally wrote and called people and everyone was helpful. I decided to take two part-time jobs, one at USC in the Center for Laser Studies and one at Aerospace Corporation [a FFRC, or federally-funded research corporation] located in El Segundo [California], about an hour from Pasadena. Both of the opportunities were with people I liked and admired, so that turned out to be very good. The USC job was on soft money, and the one at Aerospace Corporation was part time, as a "consultant."

Now, this arrangement turned out to have advantages and disadvantages. One thing is that I was used to quite a bit of independence, and when you have two jobs, nobody has to know where you are. "Oh, I'm at the other place." "Right." And I managed to do interesting research both places. But I was really involved in raising money for myself at USC.

My salary was no longer quite so low, and I was expensive. I had to raise a lot of money to take care of my salary. And I thought, "Hmm, it's nice to be on the tenure track, or even better, to have tenure." What happened was my associate [Michael Bass], who was also on soft money at USC, had decided that he wanted tenure and he was going to apply for it. So I thought, "Screw it. I will, too." Ultimately, we both were given tenure, so then I started teaching and doing all the stuff that professors do. But I did it as a tenured full professor, rather than a junior professor! The advantage is I got paid a lot more. But for everything else, it was like starting out as a junior faculty member. You had to fight for students. You had to fight for money. You had to fight for lab space. You know: you start at the bottom, and you move up, and we basically had to do the same thing.

You were asking, you know, did I feel support and or not support? The man that I worked with at USC, again, was Michael Bass. He was one of the founders of nonlinear optics as a grad student, same time as I was, but at University of Michigan. We were very similar in age and status, and there was definitely a sense of competition between us.

At the same time, there was another set of issues, which I'm sure that women today face. When I'd go to a conference, I wouldn't have anybody to eat with, because nobody would want to eat with me. They wouldn't ask me to join them because that would sound like they were coming on to me. I learned early on to stand around with a group of people and just sort of say, "Can I join you?" And

usually, if you're with people, that works out. But if you're not a big sociable person, and you end up alone, you're going to be alone.

But I remember, with Michael Bass and I going out to dinner at one of these conferences, it was just so awkward, because, you know, people think you're a date. We got some wine, and it was not comfortable. [LAUGHS]

LIN: I can imagine. Were there typically other women at these conferences?

GARMIRE: Usually very, very few. In the old days, if there were, I wouldn't want to associate. There was a feeling of, "I made it." You didn't respect women – that was it. You respected men. You wanted to be a man. You were trying to be equal to the men. So I definitely had – what do they call it? – hidden bias against women.

LIN: Right.

GARMIRE: Absolutely.

But by 1971 I got involved in the women's movement. How did I get involved with that? When I was at Aerospace Corporation, I was in a laboratory where I was asked to develop an epitaxial crystal growth system for fabricating semiconductor lasers. I was given a technician, Judith Osmer, who was very much involved in the women's movement. It turned out that she was a lesbian and was living with a woman who was also at Aerospace Corporation and had a PhD in astronomy, Virginia Carter. Virginia found no future at Aerospace, which was a notoriously uncomfortable place for ambitious women. She was an interesting woman, because she went to work for Norman Lear, who produced All in the Family, Maude and other TV programs in L.A. Judy's partner was the first president of the L.A. Branch of NOW. Both were ardent feminists, and from Judy I was inspired to get involved in the movement as well.

LIN: That's interesting.

GARMIRE: This is totally irrelevant to me, but anyway: Lear's wife, who was a strong feminist, decided she would start a company to place women in good positions. So she's got this lesbian astronomer PhD. "Where am I going to put her?" And Norman Lear knew Virginia and said, "I'd like her to work for me." She became his executive assistant and took over a whole lot of what he was doing to keep his shows welcoming to feminist ideas (for example, Bea Arthur's character in *Maude*). Judith and Virginia went off to found a company, *Ramaura*, growing ruby crystals that are exquisite. But they retired 10 years ago.

Anyway, Judy got me involved in the women's movement. I read all the feminist writings, I went to all their meetings, and I marched in their marches. And I formed a consciousness-raising group. That that was a popular innovation of National Organization for Women.

The idea was initiated because we didn't have consciousness about the pros and cons of being women. And so, particularly the year or two that I was single, I spent a lot of time with other women in L.A. doing fringe-type 1970's feminist activities. I got very interested in art. I was involved in thinking about creative change.

LIN: I read about your involvement with laser art and VAD.

GARMIRE: That's one of the things that came out of it. But I was going to say that in this consciousness-raising group were women from Caltech in various roles – postdocs, JPL [Jet Propulsion Laboratory] staff, et cetera. It was really, really interesting in the sense that we really talked about who we were and how we were raised. Sure enough, one of them had been molested by her minister father. You know, just like all the #MeToo stories you read today. It really does happen. But I've lived a very isolated life; I've never had to face any of these horrible experiences. And as I said, because I'm tall, nobody's ever come on to me!

After that, I really worked very hard to support other women. In fact, I have one story that I'm happy to have recorded at MIT. I came to realize that people really are very political, and they think in political ways. And this is really what the women's movement back then was saying. The personal is political.

What you think is personal behavior is really the result of political positions of those in society, and you should start thinking of this when you get insulted, realizing that it's not you being insulted: it's all women. So the political climate is important in your interactions with people. I got to understand that. I learned how to use politics to help me in various ways. Let me give you an example of what I've done to overcome the domination of "male politics." Any woman can do this if she tries. My main professional society is the Optical Society [OSA]. I've held all the different offices. I was on the board of directors when the nominating committee came forward with three names, as they were requested to do. And the names happened to be, one, a very famous, successful head of a very large research lab at Bell Labs, which was the most highly respected place.

LIN: Right.

GARMIRE: One was a woman who had been in the field of optics for 20, 30 years, dearly loved by “ordinary” people because she was very nice and had first-class research. She worked in a very specific, narrow area which had to do with the scattering of very flat glass surfaces to understand what went on with them. And the third candidate I can't even remember, some nebbishy guy.

This was probably '78, maybe '80. I was aware that people were beginning to vote for women to lead non-profit organizations whose volunteers didn't matter much. You know: even today few expect a woman to run a Fortune 500 company. But having a woman as president of this society and that society would a safe way to give women some visibility. I mean, Harvard was finding this; when they nominated women for the board of overseers, many of them were elected, because liberals wanted to help women, so there was no pushback from women in those roles. I thought, “We can have our first woman president of the Optical Society.” So without giving it a moment's thought, I said, “I move that we go forward with all three names.”

Now, that was new for OSA. What had happened previously was that they had normally chosen one name so he (it was always a he) could run unopposed. And if I had kept my mouth shut, there's no question they would have gone with the Bell Labs guy. In fact, five years later they did, and let him run unopposed. I took this action because I was aware that out of the three names, that she would be elected. I was also aware that I was closing the door on my becoming the first woman president. So all these years I have had to be quietly proud of being the second woman president, which I think is, in some ways, has more valuable than being the first. [LAUGHS]

LIN: Right. It means it continues.

GARMIRE: Yes, you've proved it can really happen for ordinary folks.

LIN: Right.

GARMIRE: Anyway, she was elected, which is exactly what I expected. I have a very good sense for the politics of things. And that has helped me most of the time.

I guess the rest of my career really is that at USC. I ended up being very successful. Fundraising is really important; it’s everything there is. We had a wonderful president of USC at that time who liked me a lot. He was a man that was about 5 feet 2. And he would say to me, “We're the only ones that can't find clothes to fit!” [LAUGHS] So I felt totally supported. He introduced me to

people that had money, and that's how my funding started. I never was comfortable with the whole funding situation. The one place where I had comfortable money – and you can call it comfortable or not – was with the National Science Foundation. The man running their laser program told me that NSF had a special pot of money available for women. He would say, with a smile, “If I give you the money from this pot, then I'm able to fund another group.” I’d like to have complained, but instead I smiled back. He funded no women in his regular programs. Obviously, my thoughts about this are highly conflicted.

LIN: Interesting.

GARMIRE: I never had my money in competition with everybody else. It’s another part of this cloud that hangs over being part of the super minority. Now, in fact, I think my proposals were not competitive. But part of it is that I had spent nine years, where other people were building up a reputation in their own work with their own proposals, I was in the backwater as a postdoc. Not the backwater – I was at Caltech, and publishing like mad – but not doing that creative thinking about where is the next 20 years going to take us? And that's what you really need to do if you want top success. I did a lot of bullshitting about it. But it was a game to me. I didn't really, really care. And I know for sure of that truth now that I'm retired.

I don't put myself in the category of someone like Millie Dresselhaus. I'm definitely in a different category. I think it's a valuable category, and I think I've had a big impact. I've had 30 PhD students, all of which, as far as I know, are still actively working. [Except for the one who, sadly, died early of skin cancer.]

LIN: That's fantastic.

GARMIRE: I did not win the Nobel Prize, nor did any of my graduate students. But it's a constant drive, at least for me, to want to measure myself against everybody else, and I just have to shut that off. I just have to say, “That's not a way to go.”

I could say, first of all, that I've thoroughly enjoyed retiring. It allowed me to quit feeling like I had to please a boss. Now, that's part of this whole political thing. After USC, which was very uncomfortable as a woman-- It was not a comfortable place there to be, nor was Caltech. Certainly at USC, there's been a lot of this #MeToo movement. A number of people have been let go from USC, and there's been several lawsuits. I can tell you, it was really not comfortable. I was the first woman faculty member in the entire engineering school (out of

about 200 faculty). I was the only woman in my department (out of 20) for the entire 20 years I was there. But I hung in there, and I just did my own thing.

I had my own lab, separate from everybody else, after Mike Bass moved away. I could just do what I wanted, and I got my funding. At one time, I had 15 graduate students, so we had a big group, and everyone collaborated and worked together. I thoroughly enjoyed it. But I just isolated myself from everybody else, which is not good for one's self, technically, I don't think.

LIN: Right.

GARMIRE: Through a woman friend that I had met, I got called to apply for a position as dean of engineering at Dartmouth. I was at the point where I was unhappy enough at USC that I was thinking of taking early retirement. I was 52, I think, and I had looked at some other positions nearby, but none of them were nearly what I wanted.

I guess, as they say, I drank the Kool-Aid, or I caught the virus. That's the term I like, because a lot of go-go people, they reach a certain level say, “Well, now, I think it's time for administration.” I had tried to become department chair. But I was the only woman in the department and there was absolutely no way. I'm just very clear: they would not have a woman as chair. They told me so because I asked. I was asked by the Provost to become Dean of the Graduate School, but I thought of that as a thankless job and wasn’t interested.

So I looked around for various possibilities. Being dean at Dartmouth was pretty exciting – very exciting – so I went there without any qualifications for the job. [LAUGHS] I convinced them that I was so special that they shouldn't do the usual sending up three names and letting the president choose, that they should go with only me, so they did.

They were looking for a well-respected researcher. By now, I was a member of the National Academy of Engineering, so I filled the bill. But it was just like walking a tight rope: all I could see is the ways I could fail. There were a number of differences between an Ivy League college in the Northeast and a large private university in downtown Los Angeles. Dartmouth was at a cusp of deciding, were they a teaching college or a research university? There was a changing of the guard in the offices of the provost, president, and two other deans. And at the end of two years, my faculty voted “no confidence.”

Now, in that two years I had seen two things the school really needed to do. One was to organize the “selling” of their research to the world at large in a way

that made sense, and the second one was the need to double the size of the building. They thought I was crazy about both of them. They were very happy with the way things were.

LIN: Interesting.

GARMIRE: And now--

LIN: They've done both of them.

GARMIRE: They've done both – yes, exactly. So I was looking ahead, but too far ahead. Nonetheless, I did hire two people, both of whom have done extremely well. I'm very pleased about that. So, I contributed a little bit. But I stayed at Dartmouth because it was a nice rural location and well-endowed. Well, MIT is well-endowed also. You don't know what it's like to be at a poor place. USC and Dartmouth have the same endowment.

LIN: Wow.

GARMIRE: But USC is 10 times bigger. [LAUGHS]

LIN: Dartmouth must've had a lot of opportunities.

GARMIRE: Yes, exactly. We had to make budgets come out even and all of that, but there is a sense of self-confidence that comes with being very old and being very rich, or like MIT, being very smart and very rich. It's nice to be around, there's no doubt about that; so I stayed, and I did what I wanted. I had been elected to the National Academy of Engineering, so I got elected to their council. For six years, I was involved very much in the politics of that.

I kept busy, and enjoyed teaching, and continued to do some research. In the last five years, the [development of the] laser turned 50, so people started looking back. You know: “What do you remember about the early days?” Fifty years was a big deal, and nonlinear optics at 50, stimulated Brillouin at 50.

I've written a number of articles about looking back, and that's fun. And I’m trying to write a book now on nonlinear optics for engineers. Most books on nonlinear optics are physics based, and they go back to quantum mechanics and all kinds of hard-to-understand physics. I think I can explain it almost all semi-classically, and a junior engineer might be willing to do it. To me, there's something exciting about saying, “We're going to do the nonlinear stuff first, instead of linear optics. [LAUGHS]

Linear optics is filled with a whole bunch of boring stuff, and if you take a standard optics course, you memorize lens equations and all this boring ray-tracing. Here's a chance to come in at a very different place and study what is becoming very important in the field of optoelectronics today. So I – who never does anything in the usual way – am trying something exceedingly unusual. I don't care if it passes or fails. I have got Wiley to agree to publish my book, so that's what I'm working on.

LIN: That's exciting.

GARMIRE: I also have a desire to write about the story of my life. I've decided that I'm going to write it from the point of view of somebody who has the imposter syndrome. You know about the imposter syndrome?

LIN: Yes.

GARMIRE: OK, I think everybody knows that term today. Overcoming the imposter syndrome-- I'd like to talk about how, at least one way to do that, which is just keep going. [LAUGHS]

LIN: Fake it till you make it.

GARMIRE: Good.

LIN: That's totally me.

GARMIRE: Exactly. That's exactly right. [LAUGHS]

LIN: I was also reading a little bit about your policy work with Organization for Economic Cooperation and Development. How did you end up going into some policy work in the end of your career?

GARMIRE: It was very interesting. I took a year off and went to work for the State Department through a program called the Jefferson Science Fellows. The specific job that I got was working in telecommunications policy, because I'd been on lasers and fiber optics, and I'd followed telecom. I went there not really knowing very much about what I was to do. Well, I discovered that the people in telecommunications policy didn't know what the hell the telecommunications technology was. I mean, literally, they didn't know. “What is 4G? What is 3G?” Now, it's “What is 5G?” So I taught them about what spectrum means. They had

never heard of it. Their lawyers were negotiating on spectrum without even knowing what it is!

LIN: That seems flawed!

GARMIRE: It does, it does. I spent my year teaching those people more about the fundamentals of what this is all about, and it was interesting. As far as policy-making is concerned, the first thing I learned was that I had no experience in reading a 20-page report and figuring out the key information. I would go to an all-day meeting and be asked to write one paragraph on what went on.

LIN: That's difficult to do.

GARMIRE: I'm used to going and hearing 15-minute talks, a dozen of them, and I can write 15 sentences. But it's very different when you're asked to interpret everything that you've seen in its totality. Maybe that's, in fact, what I'm doing now.

The result of that year is why I've been looking at 'What has nonlinear optics done for us?' That's what my interest is in. What impact has the work we did 50 years ago had on today? Where does it show up? It just fascinates me as a question, so maybe it came out of some of that work.

I wanted to say one other thing. I've had a chance to be an expert witness on two very major patent lawsuits, which was extremely lucrative. It turns out that when you're asked as an expert witness, one of the questions will be, "How much have you been paid?" The more you've been paid, the better, because it means you're a "big cheese." One of my cases was when Litton sued Honeywell. These are two big aerospace companies. Litton sued for $3 billion.

LIN: Wow.

GARMIRE: That went all the way to the Supreme Court after we'd testified in court and the Judge threw the jury's decision out! I got called and was told," you may have to testify again," but then they settled without any more court hearings.

LIN: I see. This was an intellectual property case?

GARMIRE: It was intellectual property. I'm just putting it on the record that it can be fascinating. What I discovered there – and I did it sort of during my summer holiday – is that I could sit down and read 500 pages of testimony and just thoroughly enjoy it. I wasn't allowed to take any notes, because the other side

can ask for copies of your notes, so you have to try to remember it. The second case was *Lemelson v. Intel*.

LIN: Oh, wow.

GARMIRE: Lemelson claims to have patented everything, including ion implantation, which is required for all integrated circuits. That was another huge, huge issue. I don't know what's happened to that. They're still--

LIN: They're still fighting over it?

GARMIRE: Portions of the claims were dismissed; the remainder was settled after favorable claim construction.

LIN: That seems to be a pretty big case.

GARMIRE: Yes. The person I worked with on one of the cases was an electrical engineer PhD and a law degree from Harvard, in patent law.

LIN: Wow.

GARMIRE: I mean, you want somebody intelligent who can really tell you what's going on.

LIN: Right.

Going back to your time at MIT, did you live on campus in a grad dorm? Or did you live in an apartment?

GARMIRE: I was married, and we lived in an apartment in Cambridge. We rode to and from MIT on a motor scooter.

LIN: Oh, wow.

GARMIRE: They were popular in those days.

LIN: I didn't realize you rode motor scooters back then. Like electric scooters?

GARMIRE: No, no, no, no. A motor scooter was like a civilized motorcycle.

LIN: Oh, OK!

GARMIRE: They don't seem to have them much anymore. They're more popular in Europe. Lambretta and Vespa were the companies who made them. Do you know those?

LIN: I think so.

LIN: That sounds like a fun time. Were you involved with the student life at all on campus? Or where you mostly just occupied with the work?

GARMIRE: Yes. I worked for Scientists and Engineers for [Lyndon] Johnson.

LIN: I see. And how about your daughters? How have they grown up in a family in which science was so central?

GARMIRE: Well, one of the things that I didn't do is talk much about myself to them. In fact, I felt for a long time a tremendous schizophrenia between the mother part and the researcher part. In fact, I recently came across the letter I wrote to Yariv when I was applying for my job at Caltech as a postdoc. I said, “I have a child and I don't want a real job. I just want to keep myself occupied.”

LIN: Oh, interesting.

GARMIRE: That was the attitude in those days, at least my attitude. And maybe to some extent it was to please my parents. Maybe I didn't want them to think that I cared more about my work than anything else. Or I didn't want my children to know. My children castigate me now about the fact that they never knew much about what I was doing, or how successful I’d become.

LIN: Oh, interesting. You wouldn't talk about science with them.

GARMIRE: No, no. I just came back last week from an opportunity in New York to talk about the work I did in the laser light show. There's a museum called the Museum of the Moving Image.

LIN: Right.

GARMIRE: Oh, you come from New York.

LIN: Yes, I've seen that.

GARMIRE: Do you know the museum?

LIN: Yes, I do. It's really well curated.

GARMIRE: They had a program a week ago on the origins of laser light shows--

LIN: Wow.

GARMIRE: --and they wanted me to show the work that I did for Laserium, so I did it. My husband has been working-- I guess he's not quite done yet-- We worked together to get this light show ready, and we carried it on the airplane. We did it in New York, and we came back. But it runs on lasers that run on batteries. I want to get it running on a regular power supply and have it up on the wall permanently, because it's so easy to do and so beautiful. And nowadays, lasers don't cost very much at all.

LIN: You could buy one at Staples!

GARMIRE: [LAUGHS] Right, exactly.

LIN: Which they use at the MIT lab. It's really funny.

GARMIRE: Well, this is one that puts out 200 watts, I think. It makes paper burn, and it turns out we can make a really beautiful light show with it. These lasers are illegal to buy in the United States, but everybody does all the time. But in our house, it would be fun.

LIN: I was also curious about what it was like working in a creative position.

GARMIRE: The story behind that is New York trip is that somebody found out about my having paved the way for the first commercial laser light show. I don't know that I've got the history of early laser light shows worked out, and I don't think I can find any information that will say why I started doing laser light shows. But I was involved in an organization called EAT: Experiments in Art and Technology. They got a contract to build a pavilion in Osaka, Japan, for Expo 1970, and I was involved in working on that.

There was a laser light show there that I was not impressed by, and I thought I could do it better. I found a way to get some really beautiful laser patterns. What I can't remember is exactly the timing for all of this – it was certainly before the Sylmar Earthquake in 1971. Anyway, I made a series of laser photographs, which were laser light pattern photographs, and I decided, “What describes the essence of lasers, as far is art is concerned? They make pretty pictures. If I'm going to do art, what art am I going to do? I'm going to make

pictures of these pretty laser patterns." I made a bunch of photographs of them, either directly into the camera, or projected on a white screen. They were both black-and-white and color. I had them developed and printed in large format by a top-of-the-line commercial company. These were (analog) color prints of film negatives that I'd made of these laser patterns. Of course, this was long before digital photography!

Having done this, I then heard that there was a woman going to open a new gallery for photographers to sell photographs in Hollywood. She called it "Photosphere," and it was in a snazzy location on Hollywood Avenue. And I thought, "Hey." She was going to have an opening, and I went to look at what she framed. It was all these women with poodles and just let's say 'female stuff.' And I said, "You've got to have my lasers in your opening – it will draw the press." And she said, "All right." So I gave her a bunch of "lasergram" photographic prints to put up. Also, I had developed a little laser light show, based on moving the diffractors that made the lasergrams, and I set it up in the gallery. I was hoping to sell it for home do-it-yourself shows.
(I never sold any; lasers were too expensive.)

She did, indeed get TV coverage – or at least I did. I was on the local news in L.A., showing off my laser light shows, and a couple of graduate students in cinematography at UCLA saw it and said, "That would make a great movie." So they called me up and said they would like to film it, and I said fine. So we met at Caltech at night for two or three evenings, and they made a bunch of films of these moving abstract laser patterns. One of them (Ivan Dryer) was working as a technician in the planetarium at Griffith Park, and he said, "I would love to have this in the dome of the planetarium." We actually borrowed the laser from Caltech, took it down to the planetarium, and showed off what these patterns looked like. And the folks there fell in love with them.

Ivan Dryer and I started a company, Laser Images Incorporated. I had a friend who was an attorney, Richard Anderson, who set up the company, free of charge. I just recently came across the initial company papers again for the startup. I was initially president, but at the end of the year, my husband and I were going on leave from Caltech for his sabbatical and our trip around the world. I basically gave Ivan Dryer the rights to fully take over; I resigned from the company and let them do it. Then, by the time I came back, all hell had broken loose with my husband leaving me.

LIN: Oh, no.

GARMIRE: So that was the end of that Laser Images. I was single for about a year. A year later, I met Bob Russell. For the first year after Gordon Garmire left me, I was in love with somebody else, and slowly but surely, I decided I was in love with Bob more, and we've been married for 40 years. [LAUGHS]

LIN: That's amazing. How did you meet?

GARMIRE: The attorney I was talking about, Richard Anderson, who started our company, liked me and invited me to dinner. His wife knew Bob, liked Bob, and knew that he was newly single. So he invited me to dinner, and she invited Bob to dinner. The rest, as they say, is history.

LIN: A setup – that's really nice. I guess it turned out well, then.

GARMIRE: Yes, it turned out well – after seven years of therapy.

LIN: Well, therapy is important.

GARMIRE: Well, I should throw this in, too. I'm not the least bit embarrassed to talk about it. I have had periods of relatively serious depression. And you can argue, you know, if when I was young, maybe if I'd had some early therapy, I would have been able to get over being depressed on my own, but the fact is that I go through periods of depression that I'm not able to overcome without medication. I have been taking my "happy pills" faithfully for 20 years now and I'm very stable on it.

Depression began around the time of the divorce. I went on medication then and then I'd gotten off of it. But I met a neurophysiologist doctor in a meeting at the National Academy, a very well-respected academician. He said that anybody that reaches, you know, a certain age, will probably have to be taking the medication the rest of their life. After I went through five years of being sorry for being stuck on the happy pills and trying to imagine going off them, I finally decided, "If I'm happy and stable, why bother trying to graduate from the pills?"

LIN: Right.

GARMIRE: I'm perfectly content to continue to take happy pills.

LIN: Yeah, I think there definitely needs to be a lot of destigmatization of mental health within the scientific community.

GARMIRE: Right, right.

LIN: Especially at universities.

GARMIRE: Yes, yes. I have counseled any number of students to go get help. It's particularly hard for foreign students. Their families don't understand it and don't believe in it.

LIN: Right.

GARMIRE: It's really hard. But I know that there are serotonin effects. In fact, I just came from a talk talking about dopamine, serotonin, cortisol: that trio that needs to be balanced to run a decent life. If for some reason you're off that chemical balance, you can really harm yourself. I've not been into illegal drugs or anything like that, but I'm sure that I have some genetic issues related to depression. I can see that in some of the members of my family.

LIN: On the topic of MIT, have you had a chance to go back since graduating?

GARMIRE: Oh, yes. I've been back a number of times. It seems like there's been a lot of changes in the last few years. Probably about every five years I've gone back for some reason.

LIN: For talks, or to meet with people?

GARMIRE: Yes, to see people I've known there who have retired, or-- I guess the last time I went was for the Millie Dresselhaus party. I think it's the one before she turned 80 [in 2010]. There was one earlier that I also went to. I didn't go to the celebration of her life, after she passed away.

I'm hoping to live to be 100.

LIN: I look forward to that – to your future books and such.

GARMIRE: [LAUGHS] Well, I hope I've given MIT something.

LIN: For sure. Thank you so much for sharing your story.

GARMIRE: Well, I was interested to say a lot about the lab, because that was important, and, you know, working with Townes is something people want to know about.

I guess one other thing I should say is that I advise all of my students, when you're looking for an advisor, choose either a female one or somebody who has female children. [LAUGHS]

LIN: Did Townes have female children?

GARMIRE: He had four girls.

LIN: Aha.

I was reading about collaboration within the engineering department. I think MIT has been making a huge push in trying to make classes more collaborative and interdisciplinary. They definitely understand that it's important to get students to work with each other.

GARMIRE: Right, right, right. And I think there's no doubt that when there's money present, researchers work together and do some very exciting things.

LIN: Right.

GARMIRE: I'm not sure how often they collaborate in a sense of “together we'll be more successful than I would have been alone.”

I don't want to cast aspersions-- There's a variety of people. Everybody's different.

LIN: There’s a lot of politics.

GARMIRE: Right. Anywhere, there's a lot of politics.

LIN: For sure. Well, thank you once again for your generosity in agreeing to take part in this oral history project. We’re so glad to be able to include you.

GARMIRE: Good, good. Thank you.