NASA SCIENCE MISSION DIRECTORATE
ORAL HISTORY PROJECT
EDITED ORAL HISTORY TRANSCRIPT

LINDA R. BROWN
INTERVIEWED BY JENNIFER ROSS-NAZZAL
PASADENA, CALIFORNIA – 10 MAY 2017

ROSS-NAZZAL: Today is May 10, 2017. This interview with Dr. Linda Brown is being conducted in Pasadena, California, for the Science Mission Directorate Oral History Project. The interviewer is Jennifer Ross-Nazzal, assisted by Sandra Johnson. Thanks again for taking time this afternoon to meet with us. We certainly appreciate it.

BROWN: You're welcome, my pleasure.

ROSS-NAZZAL: I'd like to start by asking you to talk about your interest in science as a child.

BROWN: I was really more interested in math, in terms of what I could have access to. There weren't so many things on TV. We got our first TV when I was seven years old, and we got it to see the coronation of the queen of England [in 1953]. That motivated my family to do something.

ROSS-NAZZAL: Oh yes, that's a big event.

BROWN: Yes, that's right. I always enjoyed math in school. That was the thing that I really liked. Later the courses exposed me to science, and I found how things worked was interesting

to me. I went out to my father's workbench and sometimes manipulated the tools there, because I just thought that was fun to do. Then, when I was a preteen, I got interested in reading. I liked things that were mysteries, and I liked things that were histories. I went to astronomy after reading about mythology. I wandered into the other part of the library and read about the lives of astronomers.

One book was *The Sleepwalkers [A History of Man's Changing Vision of the Universe* by Arthur Koestler (1959)], [that] really shook me up. I thought, "Wow." To see this progression of thought and understanding of nature and the universe, I thought that was pretty special. That made me think about being a teacher. I had an opportunity to tutor someone in high school in math, and I really liked that experience as well. In the end, when I went to college, I decided I would try to major in physics. That was the progression for me in terms of interest.

ROSS-NAZZAL: I imagine you were one of very few women in your program at that point.

BROWN: Yes. In the beginning physics class, there was at least 100 students, and there were 3 of us [women]. But I had gotten used to being in situations where I didn't care so much about what other people thought. "Oh, well, I like that. I'll do that." In high school, women could play basketball. We had six people on the team. Three of them had to stay on one side of the court, the other three on the other. So you played defense, or you played offense. You couldn't cross that line.

ROSS-NAZZAL: Were you on the basketball team?

BROWN: Yes, I played. Our school had a pool because we were about 20 miles from Lake Erie [in Ohio], so there were a lot of opportunities. They had a pretty good sports program for women, as well as the guys.

ROSS-NAZZAL: That's pretty unusual for that time period.

BROWN: Yes, that's right, it was. The population was like 15,000. It was very small, yet they did have a physics class. I only learned later that only about one-fourth of the country had high school physics. I was just shocked. How could you not learn physics?

ROSS-NAZZAL: Your small community offered that, that's interesting. So you ended up teaching, and you moved to Rhode Island, which I thought was an interesting move from Ohio.

BROWN: That was "I'm going to get out and see the world" time. Also the fact that there were fewer job offerings in [teaching] physics than I had really realized. That one came up first and I thought, "Well, Ohio was nice for a while, but gee whiz, I can go live on the East Coast next to the ocean."

ROSS-NAZZAL: Yes, it sounds nice.

BROWN: It was near the Connecticut border; it was a nice location. I could take the train to Boston [Massachusetts], I could take the train down to New York [City, New York]. I had a

friend or two in both places. So that was my "see the world"—or at least see part of the East Coast—time.

I really did enjoy teaching; I really did enjoy physics. Chemistry I wasn't so prepared for. I was learning it as the year went on, but then eventually I ended up with two physics classes and two algebra II classes. That was just fine, that was nice.

ROSS-NAZZAL: Quite a mix.

BROWN: Yes. By the third year, I decided this was not a community I wanted to stay in. Rhode Island was special in the way that they encouraged their teachers to get masters' degrees. That was unusual at the time.

ROSS-NAZZAL: Yes, that's very unusual.

BROWN: I don't know what states are doing these days. I had encouragement to do that, and that gave me a reason to leave and seek something else.

ROSS-NAZZAL: So you decided to move south where the climate was much nicer, warmer?

BROWN: Yes. I applied to Georgia Tech [Georgia Institute of Technology, Atlanta], Purdue [University, West Lafayette, Indiana] and Florida State [University, Tallahassee]. Georgia and Florida State offered me funding, which I needed. I couldn't do that without. I thought well, go warmer [to Florida]. It was near the Gulf [of Mexico], so that was a fun thing to do.

As I got acquainted with people and groups, I had the experience of going to the upwelling of a spring that turned into a creek and then turned into a river. People would go there on weekends and bring inner tubes, [some] filled with cases of beer, and boats and just float. They just would all jump in, and then let the current carry them down to a certain point where there were people waiting to pick you up and take you back to your car.

ROSS-NAZZAL: Sounds nice.

BROWN: Yes, that was a nice combination, I really enjoyed that. The other part was that my dad decided to retire, and they moved near Cape Kennedy [Cape Canaveral, Florida]. That was another motivation, to get back closer to them, even though it was a few hundred miles away still.

ROSS-NAZZAL: Sure, it's not like Tallahassee is that close, but of course much closer than Ohio. Why did you decide to pursue the PhD at that point?

BROWN: In the graduate program you took a test. The low grade said "goodbye," and the high grade [I received] was to skip the master's and get a PhD. I thought okay, since it came with financial support. I just saw that that was going to get me a different range of opportunities.

ROSS-NAZZAL: Were you thinking of going into academia at that point? Or were you thinking of working for the government?

BROWN: That was one of the things. I didn't know what I was going to do, but I thought that credential and that extra knowledge was important to have for changing my direction and my career.

ROSS-NAZZAL: That was a time when the women's movement was really gathering a lot of steam. Were you interested at all in that? Or was that just on the sidelines as you were pursuing your degree?

BROWN: I wasn't involved, but I was interested. I didn't go out and burn my bra or anything like that. Yes, I was quietly supportive I suppose. We had small groups, clusters of women in the same activity and would get together and talk about things. It was a time of realizing that there was more potential in us than we had been encouraged to think about.

ROSS-NAZZAL: Right, more than becoming a teacher or nurse or a wife.

BROWN: Yes, that's right.

ROSS-NAZZAL: Were you also one of the few women in your PhD program at that point? Or were there other women pursuing that same field?

BROWN: I think there was one other [woman] that I connected with. It was a relatively small department. Florida State had been a girls' school, and then they became coed. They recruited a former [employee] of the National Bureau of Standards [now the National Institute of Standards

and Technology] to come start a physics program [Earle K. Plyler]. He was a spectroscopist, and he was very encouraging of everybody. He would come and talk, he'd show interest. "What are you doing? How's your work going?" That was really good. My major professor was a very nice person who was very encouraging as well, so I just slowly absorbed things.

ROSS-NAZZAL: How did you get interested in spectroscopy?

BROWN: When I was doing my undergraduate degree, I realized I really liked optics when I had the coursework for that. I also liked E&M, electromagnetism. Those were obvious connections to studying some aspect of light, so that was, I think, really the interest that I had on that.

ROSS-NAZZAL: Would you tell us about your doctoral dissertation?

BROWN: It was on the spectrum of formaldehyde. You pass light through a gas, and of course some of the gases make the light go dimmer, but it's not the same across the whole wavelength scale. You have periods where you get the same amount of light, and then you don't. The amount of light gets reduced, and that's connected to energy levels in either the atom or the molecule.

It turned out that it was kind of a puzzle, because each feature had a special identity called a quantum number. When you got a new spectrum, it was your task to figure out these quantum numbers so that you could apply quantum mechanics to reproduce the spectrum that you see. That was a challenge, that was always *the* challenge.

You had to measure the location of these peaks. Sometimes a spectrum looked like that if it was emission or absorption on the wavelength scale. [Demonstrates with fingers] Use that information to sort out the identity of each feature, and then you could have a particular calculating model to try to reproduce that. The location of the wavelengths was one aspect. The other was how big that depth was and how wide the line, the feature, was. Sometimes if you had low pressure it was narrow line. If you had a high pressure, the line got wider.

When I first started, in order to get the area of that line, we used this device called a planimeter. [Shows device.] The features were inked out on a piece of paper, on like a roll of toilet paper, that would automatically scroll as the spectrometer scanned through the wavelengths. We had to take the piece of paper and trace along the line. The device uses the length around the line, [which] can be converted it into an area; a line integral can produce an area. We took the area by hand, and we'd write it down on a piece of paper. Then we would punch it into a punch card, one feature per punch card, and go read it into a computer. It had a program that would compute the area into what we called the strength of the line. That was how I did my dissertation.

ROSS-NAZZAL: How long did that take? It sounds like a very tedious process.

BROWN: Recording the spectra took—I'd have to get into a unit. Let's say that we could record, with the device, about 100 scale units a day. My dissertation covered about 1,000 units of those. When we were doing the depths, the intensities, we would do different pressures. If you went to higher pressures, the lines would get deeper and deeper. I spent many weeks just recording

spectra. So that's how I started. Even when I first came to [NASA] JPL [Jet Propulsion Laboratory, Pasadena, California] I was doing this.

ROSS-NAZZAL: Just doing that? Oh my gosh.

BROWN: Yes, that's right. I got involved with the ATMOS [Atmospheric Trace Molecule Spectroscopy] project, which was going to fly on the Space Shuttle. That gave me access to better computer possibilities and also people who would write programs for me. So this [planimeter] got replaced with a program that would allow me to find out where they were on the wavelength scale. We had a program that, once it knew where lines were, would do an algorithm that would determine the area on its own by nonlinear least-squares curve fitting.

ROSS-NAZZAL: Saving you a lot of time, I imagine. Oh my gosh, and a lot of paper.

BROWN: Yes, that's right. The only problem was that sometimes our resolution was such that these features were not well-separated. So we had to manually tell the program, "Oh, there's two features there." There was an interactive thing between the users, so that was the big deal.

ROSS-NAZZAL: That's amazing that you were using that in the '70s.

BROWN: Yes. I don't have the ruler [anymore], but it was a fine metal ruler with lots of intervals, down to a few fractions of a centimeter.

ROSS-NAZZAL: How did you find out about that opportunity at JPL? You mentioned you took a side trip to come work at JPL.

BROWN: A former PhD in spectroscopy was working at JPL doing this type of work to support people who were observing the atmosphere with this technique, with spectroscopic equipment. They were [using] apparatus that was on the ground and also they had things that were set into balloons that went up to quite high altitudes. The balloons floated across the U.S. for a while and then came back down.

They needed spectroscopy; in fact, the agencies don't really want to support spectroscopy as lab work. They only do it because there's some remote sensing project that needs the information. So we always have to be careful about keeping our funding going. On the other hand, when they want to build something, then they turn to the laboratory people to help them design the instruments.

ROSS-NAZZAL: You had told me that you bought an orange Super Beetle [Volkswagen], as you referred to it and drove all the way across country from Florida. Can you tell us about that trip? Kind of unusual at that point.

BROWN: I made one and a half trips, because I came here [for the summer], went back, and then came again [for a job]. I would drive about I think 10 hours a day, with some breaks.

ROSS-NAZZAL: It's a long trip.

BROWN: I guess it took about five days. I-10 [Interstate-10 cross-country highway] wasn't always completed, so I would be on I-10 for a while and then I'd have to go to the side road. But I really enjoyed it. It was like the whole horizon is there, "Look at that, I'm going there." The first time, I gave my cat to people who were going to take care of it while I was gone, so the cat didn't have to go all the way that way.

ROSS-NAZZAL: It's probably a little easier. Cats really don't like to travel at all if they can help it.

BROWN: Yes. On the one trip westward, I started having a strange noise in my car about in Texas, and I thought "Uh-oh." It was going clung-clung-clung in the back. I found a Volkswagen dealer, and I only had so much [money]. I didn't have a credit card—this was [back in] the day—I was just carrying what I had. Would they take a check? The people were very nice, and it turned out to be something not very difficult to repair. They charged me only $20. I always thought maybe they just gave me a break because I was this poor woman out there all by herself traveling across country.

The other interesting thing in Texas was that I had planned to get to El Paso by the evening, and I got too tired and I couldn't make it. Just east of El Paso there was this one little town. They had a motel sign, and I said, "Oh, thank goodness." When I got there, the lights of the motel [rooms] were all on, but nobody was at the desk. I went to the gas station next door and I said, "I wanted to check in." They said, "Oh yes, the keys are all in the door, just pick a room you want and pay them in the morning."

ROSS-NAZZAL: That's an unusual setup.

BROWN: Yes, the restaurant was closed, so I ate out of the candy machine. Soda and candy, that was my dinner that night.

ROSS-NAZZAL: You can do that at that age.

BROWN: Yes, I thought "Well, so this is Texas." It was, in a sense, a labor to keep driving every day. I felt like a truck driver. There were new experiences, finding my way and going across the southern states, and then through Texas of course. I noticed in the cities in Texas there were so many Cadillacs on the road, new Cadillacs.

ROSS-NAZZAL: That's funny. So what did you think of JPL the first time that you came out? What was your impression of the area compared to Florida State?

BROWN: California had many more people around. The climate was so nice, and I rented someone's guesthouse. It was small, and it was a bit above Pasadena, actually Arcadia. So I could see the mountains really nicely, and it just seemed so fresh and clear. Although when I think back about it—when I first arrived in the summer, I was here several weeks before I realized how close the mountains were because of the smog. Then one day it cleared and I thought, "Look at that!"

ROSS-NAZZAL: It's beautiful.

BROWN: The air quality has improved so much over the decades, now you don't have that as much.

ROSS-NAZZAL: I imagine. I guess that was pretty soon after the Clean Air Act was passed.

BROWN: That's right.

ROSS-NAZZAL: You mentioned that they were doing work with balloons. Were you doing any work with that?

BROWN: No, I was totally in the lab. Running different gases, measuring them, and creating lists of numbers as to where you would find the spectral feature and how strong it was, its intensity. I did that month after month, and then when we had enough we would start analyzing and applying quantum mechanical models to see if we could reproduce that. Then I gave a calculated list to the people who wanted to do remote sensing on different molecules.

My dissertation had been formaldehyde, which they were trying to find in their data at the time. Someone in Japan had worked on that region. It was a pretty hard region to understand. People were quite good at finding one isolated vibrational state, and there were models that were working for that. But when they got to some of the other types of molecules, where there were multiple vibrational states close together, that was more difficult. The one vibrational state would move things around for the others. It was very complicated. I eventually found the

identities of seven different bands in that region, but I didn't have the tool to really do a calculation for that. I didn't have the computer code that was capable of that.

ROSS-NAZZAL: You mentioned a colleague in France did that many years later.

BROWN: Yes, so I made an empirical list of the identities and the wavelengths and the intensities of that. Then I had a scare because there was a person at Lincoln Labs [Lincoln Laboratory at Massachusetts Institute of Technology (MIT), Lexington] at the time who was developing a laser spectrometer, and he did "my region." He was publishing. But we eventually got together, because he had one type of information, and I had the quantum assignments. So we eventually had a joint effort there with that.

ROSS-NAZZAL: You could collaborate.

BROWN: That's right. But that's always been [the challenge], trying to find something that is needed and getting it done before somebody else gets it done.

ROSS-NAZZAL: Right, that's a big challenge and publishing before someone else does. So how long were you out here at JPL before you went back to finish your PhD?

BROWN: I think it was seven months, I've actually forgotten.

ROSS-NAZZAL: That's quite a long time. I thought maybe it was over a summer.

BROWN: No, then I went back [to Florida]. I had done most of the workup for my dissertation when I'd left, but there was the writing to do. Everything was typed by hand. They gave us a secretary who would type it nicely.

ROSS-NAZZAL: That's a nice perk.

BROWN: Yes, that's right. Then we'd show pictures of spectra, and those were done with a camera. It was quite labor-intensive to get your dissertation done.

ROSS-NAZZAL: I'm thinking it must have been, to include those photographs at that point. Things weren't as easy as they are today with printers and Xerox machines.

BROWN: Yes, you sent the photographs as individual things to the publisher. It was a lot of effort to just get a manuscript together.

ROSS-NAZZAL: You decided to apply for a postdoc [postdoctoral research fellowship]. Were you still thinking about maybe academia? Had you decided after you had been working at JPL?

BROWN: I decided I really liked this stuff. Then when [Robert A.] Toth came out to ask for somebody who would work temporarily, he said, "Well, there's this postdoc opportunity." He showed me the door, and that's how that worked out.

ROSS-NAZZAL: Were you hoping that it would eventually turn into a full-time position? Or were you still thinking you might go somewhere else?

BROWN: There's no guarantee. I understood there was no guarantee for a postdoc to continue. I had a sort of "I'll wait and see what happens"-type attitude.

ROSS-NAZZAL: You continued doing the type of research you had been doing?

BROWN: Yes, and I've continued that all my life. Let me sit down in front of my terminal and close the door and look at spectra, and I'm just a happy camper all day. I never really wanted to do more than that, because it was just so much fun. Each spectrum is a mystery that you're trying to solve: identifying the lines, and then applying a model that reproduces what you see, that's always the challenge.

ROSS-NAZZAL: You said you spent many years, most of your career, studying methane.

BROWN: Yes. While I was doing my dissertation, some colleagues of Plyler, who had started the physics program at Florida State, invited his former colleagues down to visit. Also, someone at JPL who was flying a balloon instrument wanted knowledge of methane in a particular spectral region. That evolved into me working on methane, because I was the lowly graduate student who could be put to work on that.

ROSS-NAZZAL: You didn't have a choice, right.

BROWN: Well, I had a choice, but the other graduate students were committed to other things, so I was the free agent at the time.

ROSS-NAZZAL: In that retirement PowerPoint [presentation] it said, "Methane is tough." I was curious what they were referring to. What does that mean?

BROWN: Light molecules are tough. It's a difficult spectrum to model. If you have a CO_2 [carbon dioxide] spectrum or CO [carbon monoxide], they're just a set of regular lines. They're well-separated from each other. But in methane, it's a light molecule and the patterns are all different as a function of the quantum numbers. They have more bands that can exist together in the same spectral region. Some of them are really big and some of them are really small, but the small ones are pushing on the big ones and stealing intensity from the big ones, so they show up a little bigger than you'd expect them to be.

It's really like a puzzle. You throw all the pieces on the ground, and then you have to go through and figure out, "This goes with this one, and this goes with that one, and that goes with that one," until you get the picture. Again, the theoretical equations to reproduce the spectrum took decades to really come together. It was really an international effort to really understand how to do those calculations [to reproduce the observations], and it's continuing.

The picture [presentation] showed that for [the] lowest, there's only two vibrational states. Then there become five vibrational states, and then there become eight vibrational states. But each of the vibrations can have multiple components. You have all those components making transitions of patterns. It's quite a maze to identify the quantum assignment, so that you

can know how to enter the information into a master calculation. The lower vibrational states are well in hand, but by the time you get up to the fourth [vibration] one, there's actually about 60 individual states that are together and affecting the intensities and the positions of each other. It's an interesting molecule type.

ROSS-NAZZAL: I had no idea. When I read that I was just curious.

BROWN: CO_2 is a linear molecule, the atoms line up [in a straight line]. Water is a bent molecule. Then you have ammonia, which has four atoms and it's got one [nitrogen] surrounded by three hydrogens. That's a more complicated structure. Methane has five atoms—the more atoms, the more problems, essentially.

ROSS-NAZZAL: You mentioned that it was an international effort, so you were working with people all across the globe.

BROWN: Yes, that's right. It became easier once the Internet got going. [Before], we'd go to the same meetings, and we'd learn about each other's work and find ways to collaborate—but by mail. Once we had the internet, it was easy to transmit things. I would record spectra of, say, a million points, and I could shoot it over to anybody in the world who wanted to work with me on the spectra.

ROSS-NAZZAL: Quite a nice change from snail mail, plus you know it arrived. At some point you started working on ATMOS. How did you get involved in that project?

BROWN: All these remote sensing projects have a house spectroscopist on hand to tell them where the features of various chemicals can be found on the electromagnetic spectrum. I was working with Toth, who was part of the ATMOS effort, and I eventually became part of that.

There's two aspects. One is that you record spectra and do the processing of the spectra and the analysis. Then you make a long list, and you make the list available to people in an electronic database. I became the person who took control of the electronic database [for ATMOS]. It's not a fun job, really. You're [often] just manipulating other people's work and you're describing it.

ROSS-NAZZAL: I was going to ask if you would talk about that a little bit.

BROWN: Yes. The fun job is taking a spectrum where you don't know the important information and working on it and solving that puzzle. The remote sensing provided the means and funding to do both.

ROSS-NAZZAL: Was that located in the payload bay of the Shuttle or was that something that the crew handled in the Spacelab that first mission?

BROWN: This was before Spacelab. It was in the bay, they had to open the bay up to do that.

ROSS-NAZZAL: I was curious if the crew had any sort of interaction with it, or if it was on its own.

BROWN: It was on its own. I wasn't so involved with the details of the instrument itself. I was involved with what the spectra looked like that came out of the instrument. It was really fun. At the time, we didn't have the ability to push data across the Internet so rapidly. It was telecommunicated down to the [NASA Johnson Space] Center in Houston and then written on a magnetic tape.

The whole team went to the monitors in Houston to see how the operation of the instrument was going and make decisions about what things should be done, if there were any changes made to the setup. Then they had one person take a load of tapes to an airplane and fly back to Los Angeles. The processing was done on our group minicomputer. I happened to be in the room when the first spectrum came out. It was like, "Is it going to be good data or not? Oh dear!" Two of us looked at it together and said, "Look at that, oh yes, it's a line. Look, look, I can see the CO_2 lines."

ROSS-NAZZAL: It worked!

BROWN: It worked. The first place we looked in CO_2, it should have been like this [demonstrates], but we saw lines that kind of looked like this. We thought, "Oh dear, is that a distorted recording there?" Then we looked at another CO_2 band in a different wavelength. It looked like it was good, but there were some extra lines there. "Why do we have those extra lines?" We suddenly realized we were seeing CO_2 in the atmosphere and some residual CO_2 inside the instrument box.

That was really kind of fun. You know the effect that if your train is coming towards you blowing its whistle, and then [when] it goes past [you] it changes the tone. That was what was happening. We saw that happening in our instrument. If we were going toward the Sun in the orbit, the extra line was on one side. Once it went past [going away from the sun], it was on the other side. Physics in action. That [interpretation] became a game. We printed out the whole spectra on chart paper and pasted it on the wall, and then people went along with their pencils and said, "Oh, that's water. Oh, that's CO_2. Oh, that's CO." They wrote down the obvious [chemicals directly on the chart paper]. Then the fun game was to look for chemicals that hadn't been clearly characterized in the atmosphere.

ROSS-NAZZAL: You were also doing some work out at Kitt Peak [National Observatory, Arizona].

BROWN: Yes, that was such a fortunate situation. The commercial spectrometer that was working at JPL was not as good as we wanted it to be. At the same time, someone who had worked at Kitt Peak to help build a very special spectrometer took a job at JPL. We heard about this instrument and how it was designed to record spectra of the Sun, but they had a lot of downtime. It really wasn't used as much. In conversation people realized all we had to do was take a chamber for the gas and a light source, and it could become a lab spectrometer for us. So we did. It took a number of years to evolve into something that was more routine, driving some equipment across the West to get some things there.

ROSS-NAZZAL: Tell us about that. You mentioned that you were taking what I would consider a fairly large vehicle with materials in it to do these experiments.

BROWN: Since it was an astronomical facility, they didn't have the ordinary things that we'd need like tight chambers to hold gas, pressure gauges and temperature gauges, lines to transfer gases from cylinders, safely—all the routine [devices] that we have. You have that one picture of me sitting in the [facility]. On the one side it shows the gas chamber, with the long tube sitting in front of this big white thing, which was the spectrometer. It was a very special design for the time.

Later, companies started selling spectrometers that were pretty good. What was special about this spectrometer was that it could do good recordings in the ultraviolet, as well as in the infrared. As we used it, new equipment was acquired, new optics were acquired so that it could go down farther in the infrared. It became a very useful instrument for a large portion of the electromagnetic spectrum for laboratory work.

ROSS-NAZZAL: I wonder if you can walk us through one of the experiments or tests that you did using that spectrometer, from setting up until you were finished. How long would a test take? What did it require you to do?

BROWN: One aspect that was very good is that we could record spectra with very good signal-to-noise in about 75 minutes. A lot of the time, if we wanted better signal to noise we would record overnight. It could operate itself without personal attention. The software was really special, because it was connected to a telescope that would just stare at one particular object for a long

period of time and integrate to build up the signal-to-noise. It was designed for that more critical aspect of making spectra.

Our job was to make the plan of what we were going to run, in terms of what chemicals and what pressures we would choose. Sometimes we would mix chemicals to make the lines fatter, which was a [pressure] broadening parameter that people needed to analyze atmospheric spectra. We'd have a plan where we would set up the cell the first day and a half and get it pumped out so it didn't have any other chemicals in it to any degree. Then, if we got started by 4:00 in the afternoon of the second day that was good. We'd keep running spectra, have a turnaround every two hours. In other words, run the spectrum, record it, check it, and in the meantime do something about changing the gas conditions.

At some point we would say, "1:00 [am], we'll go to bed and we'll let it run something overnight by itself." We ran like that for Tuesday, Wednesday, Thursday. Then Friday we tore the [gas] equipment down and took it back [home to JPL] with us. Eventually they let us leave our equipment there. A data collection session lasted a week, and we'd end up with about 20 different spectra.

ROSS-NAZZAL: How did you collect that material?

BROWN: At first it was magnetic tapes, and then eventually it was little cassette tapes. We usually wanted to have a hard copy, but eventually we could send everything over the Internet.

ROSS-NAZZAL: Made your life a lot easier. And you could fly.

BROWN: Yes, but the really important part was that we had the good knowledge of the pressures and temperatures of the gas inside the cell, so we would continually monitor that visually. We'd read gauges and record that.

ROSS-NAZZAL: You were doing this for about 20 years? Is that what I read?

BROWN: I was doing that there, I think '77 to 2005.

ROSS-NAZZAL: Quite a long time.

BROWN: Yes, but it was fun. I really enjoyed going away and doing that. It was at about 7,000 feet [elevation]. I realized I felt the lack of oxygen there, and it took me about a day and a half to get my body to adjust. I'd just walk around [feeling] dull the first 24 hours. It was outside Tucson. I enjoyed Tucson, particularly loved the [Arizona-Sonora] Desert Museum. I would always try to go there every time if I could, at least stop for a while.

ROSS-NAZZAL: Yes, it's a beautiful area. At some point, in '86 around the [STS 51-L Space Shuttle] *Challenger* accident, you and your husband decided to adopt a child. Then you ended up adopting another child.

BROWN: Yes. We have a son and a daughter, that's right.

ROSS-NAZZAL: Talk a little bit about that work-life balance, since your husband also worked at JPL and traveled.

BROWN: That's right. Yes, he was an equal partner. We were equal partners in taking care of what needed to be done for the kids. It's an exciting time when you have kids. First few years, "Oh, they're doing this," "Oh, look, look, she did that!" First words—my son wanted some extra food and he said, "More." On the other hand, my daughter—we were going out somewhere, and she wanted to wear some particular clothes she liked. I said, "I'm sorry, it's dirty." She said, "Go mall."

ROSS-NAZZAL: Oh, isn't it funny how quickly they learn consumerism?

BROWN: Yes. We went to all the Boy Scouts, Girl Scouts, team sports. It's an important part of life. We really enjoyed that.

ROSS-NAZZAL: You found that NASA was amenable to you having a family and working?

BROWN: Oh, it was no problem at all. The only problem was when we were both active and needed to go to meetings. There had to be some negotiation on that sometimes. One week we both thought we needed to go to a meeting at the same time. It was really important for both of us to be at our separate meetings. My husband negotiated with his organizers to move his talk to one end of the meeting, so he could do it and then come back in the middle, and I got the arrangement to have my talk in the second part of the meeting. We managed to split that one.

ROSS-NAZZAL: Yes, that's nice. That's a good concession to make when you're both professionals.

BROWN: Being an astronomer, he had to be away more often than I did, because he would go to Hawaii to use the telescopes there.

ROSS-NAZZAL: Oh, that's not a bad gig. Did you ever get a chance to go with him?

BROWN: Yes, I did once. That's when I found out that I shouldn't be at 10,000 feet, because I really had altitude sickness. One of the worst nights of my life.

ROSS-NAZZAL: Sorry to hear that.

BROWN: He works at 14,000 feet.

ROSS-NAZZAL: Fourteen thousand feet, wow.

JOHNSON: It's a long way up.

ROSS-NAZZAL: It's very high up. Did he ever travel with you when you were doing some of your work out at Kitt Peak?

BROWN: No, he never did. We traveled a lot otherwise where meetings made it possible to turn into a vacation. The kids went to Paris when they were nine and seven. We would often take them to the [American Astronomical Society] Division of Planetary Science meeting, so they got to see people and see a little bit of what we did. Other people brought their kids, too. It was a nice little community there.

ROSS-NAZZAL: That's nice. Did either of them choose to follow in your footsteps?

BROWN: No, but they had their own talents and skills. So they're making use of that.

ROSS-NAZZAL: Sure. I wanted to ask you about some of the other databases you worked on. You mentioned working on that database for ATMOS, but you also worked on the HITRAN [High-Resolution Transmission Molecular Absorption] and the GEISA [Gestion et Etude des Informations Spectroscopiques Atmosphériques (Management and Study of Spectroscopic Information)] database. What's captured by those two databases that you were working on?

BROWN: My work for ATMOS was very specific to their needs. The HITRAN database was started in the early '70s by the Air Force. I think it was motivated because they were looking at wavelengths that lasers could pass through the atmosphere. If there was a chemical that had an absorption, that was not the right place to have the laser frequency. It was not a top-secret thing, it was done as open-literature research.

The people doing atmospheric research thought the Air Force compilation was very useful when they were trying to interpret spectra that were recorded using the Sun passing

through the atmosphere. That evolved into the HITRAN. It was a very useful thing for people to have, but the Air Force stopped funding it. So they shifted it on another organization that would be willing to support that. They ended up at the [Harvard-Smithsonian] Center for Astrophysics, which was part of the Smithsonian organization.

The GEISA was started to support European remote sensing of the atmosphere. For a while, they [the databases] were competing. One list would gain a certain molecule, and then the other list would come along and acquire that and have other molecules. The GEISA also had a system of software that was organized for the European community. It was a major project that was supported because of Earth remote sensing. For astrophysics, they started acquiring a few other molecules as well.

ROSS-NAZZAL: Were you putting data into those databases?

BROWN: Yes. Once you did the research under public money, you needed to make it all available. You'd make a list, and people would ask you for it. It just became easier to give it to the database.

ROSS-NAZZAL: They could just go out and acquire it.

BROWN: That's right. You had to describe it in the literature. From time to time, there would be a paper that came about there. Those papers had a tremendous number of citations, so that made you look good.

ROSS-NAZZAL: I wanted to ask you about your relationship and work with some of the other NASA Centers. Did you do much work at all with say Goddard [Space Flight Center, Greenbelt, Maryland] or some other Centers?

BROWN: There were some other spectroscopists that I did work with at Goddard [and Ames], but I had a lot of collaborations with people in Europe as well. The spectroscopists are a worldwide community, and we get together at meetings and find out what the other person is doing. If we see an opportunity to collaborate because we have different types of assets that would benefit each other, that's what we do. There were some spectroscopists at Goddard, but they tended to be involved in spectroscopy for other purposes. I was either working more to help astronomers or help atmospheric remote sensing people.

ROSS-NAZZAL: Did you feel a sense of competition between them? Or because they were working on such different projects that wasn't the case?

BROWN: It was more different projects. But of course one had to compete against one's friends. Organizations like NASA really don't want to pay for laboratory spectroscopy. I think it's considered a necessary evil to some. They pay for what they see they need. I was always in contact with what I call the "user community" as to what they didn't have that they knew they wanted to have.

It didn't work if I knew they needed something, but they didn't yet know it. Within what's now called the ROSES [Research Opportunities in Space and Earth Sciences] proposal system, we had to pay attention to what was ongoing in terms of research projects for astronomy

and atmospheric work. That [meant] going to meetings. Going to their meetings, as well as our meetings, was important to do.

ROSS-NAZZAL: Can you talk a little bit more about that? About how you determined what was going to be important in the future that you would have to put forward? How did you determine that?

BROWN: There were certain instruments that were going to be built and flown for atmospheric purposes. Beyond ATMOS, there was AIRS [Atmospheric Infrared Sounder] and TES [Tropospheric Emission Spectrometer]. Some of the European instruments had American co-Is [coinvestigators] as well. I would make an effort to learn about these new instruments and see what they were going to do, then see where the holes were in the spectroscopic information that they were going to need and go talk to these people and let them know. You had to be in sales as well as research.

ROSS-NAZZAL: That's tough. Can you talk about some of the collaborations that you had with the Europeans?

BROWN: Yes. First, it was people in France who were working on methane at the University of Dijon [Université de Bourgogne, Dijon], which is in the southern part [of the country], like the mustard. Methane was a hard molecule to understand. At first there was a group in England that seemed to be doing work. I did a little bit with them, but they eventually admitted that they didn't really have the right knowledge to handle the problem.

At the same time, they were competing with the Dijon group, so I stopped working with the English people and got acquainted [with the French], made new friends. Plus, they were all aware that I was doing laboratory studies in methane, so they were also approaching me. It was a lot of collaborations formed at meetings. You go and find out somebody was doing something, and [learn] there was a common interest. Then it was a matter of "How do we each get money to do work together?" Quite often that conversation would happen a couple years before I actually submitted a proposal. We had a plan, and if we both got funding then we could work together.

ROSS-NAZZAL: Can you give us an example of a project that happened to work out where you touched base, both got funding?

BROWN: I'm an experimentalist, so I would always try to work with a good theorist. The group in Dijon were people who had a program that specialized in the theoretical aspects of understanding methane, or spherical tops besides that. They noticed my work, and they invited me to come visit them for a month. I had another occasion to visit them, as well. The personnel changed over the decades. People retired, but I got acquainted with new people. Theory is really hard, and there's only a handful of people in the world that understand methane theory. I would figure out who that was and then I would go "make friends" at the meetings. Things would just evolve.

ROSS-NAZZAL: Was language ever a barrier for you?

BROWN: No, the Europeans all speak English. I have difficulty speaking any language. I've studied Spanish, German, Russian, and French. I can barely make myself known in French. I can go and order food, and I can read signs that tell you, "Oh, I take this train." Even the Russians would publish their work in Russian, and I'm actually a coauthor on a Russian paper [written] in Russian.

ROSS-NAZZAL: Are you?

BROWN: Yes, I can find my name. Eventually, the paper would be translated and appear in an English-[language] journal. That was very interesting.

ROSS-NAZZAL: How big is the world of spectroscopy? It sounds like it's a very small cohesive group, the way you're describing it.

ROWN: I suppose thousands. One of the publishing companies put out a list of the 10,000 productive scientists [based on citations of their publications]. Our group made the list. Really, many of the people who made databases were on the list. But they put us in the wrong category, so that was kind of a joke.

I made some very good friends with particularly the French people and particularly women colleagues. We're still friends. We would get acquainted for some particular reason at a meeting, or some common interest that we wrote each other about, and that's continued for decades. When I first started going to France, I wrote that I was amazed at how many more women were employed in spectroscopy [than in America]. Considering France is so—a certain

attitude of the men toward the women, I guess. In spectroscopy they did seem to thrive better in some sense.

ROSS-NAZZAL: Is that the case here in the [United] States, or is it quite different?

BROWN: There seemed to be a larger portion of the population of women involved in science than when I initially got here. These days, I think it's leveled out better. Initially, it was a little lonely when I first started going to meetings.

As I did work, I got better known. At one point I was involved in calibration standards of frequencies. Because of the fine quality of the Kitt Peak instrument, I could do that. There was a professor in Germany, and he sought me out to ask me something, discuss his work and my work and how they overlap. We were having a conversation in the hallway, and then he went back to a group of young people—which I assume was his group—and he said, "That's Linda Brown." [Pats herself on the back.] I felt like I was making some good progress at that point.

ROSS-NAZZAL: That's nice.

BROWN: Interestingly, the main meeting for spectroscopy was back at Ohio State [University, Columbus]. I had mentioned that I had classes with [K.] Narahari Rao, who was the editor of the *Journal of Molecular Spectroscopy*. When I started coming to the meetings and I happened to mention that to him, he went back and looked up my grades for his classes. Fortunately, I had gotten a B and an A, the A in optics. He was supportive of many women spectroscopists that came to the meeting. He was really a champion for us, and we all appreciated that.

ROSS-NAZZAL: Yes, that's so important. You mentioned those ROSES panels. You submitted several, and you actually received funding for most of your projects. Would you tell us about some of those?

BROWN: Toward the end I learned the scheme, which was to find out what the astronomers need, figure out which ones I can do well, and then propose—preferably with a collaborator from one of the group that needs it. Plus, my husband was quite helpful, being a planetary astronomer. I would go to his meetings and look at the posters and talk to people. That was essentially what you did to find out what laboratory work would be useful to people doing remote sensing projects, go to their meetings.

ROSS-NAZZAL: Would he also put out a call for you? Pass out your cards maybe? Tell them about your work?

BROWN: No, he wouldn't do that. I never had a card. I had [published] papers. [Before I retired] I was at JPL, and I asked my colleague to look up [how many]. The count ended up to be 181 publications.

ROSS-NAZZAL: That's very impressive.

BROWN: At first I didn't write very well, but over the years I finally learned how to do that.

ROSS-NAZZAL: I thought that was very interesting, how you mentioned that your colleagues introduced you to Strunk & White [*The Elements of Style* by William Strunk, Jr. and E. B. White], and talked about how to write an effective paper.

BROWN: Yes, that's right. Those two individuals were excellent writers. Barney [Crofton B.] Farmer was head of ATMOS and had a balloon program before that. He was just a wonderful writer. I learned from him, as well as Odell [F.] Raper.

ROSS-NAZZAL: How many people worked as spectroscopists at JPL? How many of them were there?

BROWN: We were attached to specific remote sensing categories. Bob Toth and I were with Farmer's group for a long time. There was another person who did similar work, [Jack S.] Margolis. We were an informal group. We weren't the same group.

Then, way off to the other side of the lab, were the spectroscopists who worked for astrophysics purposes. We hardly ever talked to them, it was really strange. We kind of knew each other, but when we started working at Kitt Peak taking data, one of them realized that he could do something useful with it. That was our way of getting into the other group.

Eventually, JPL decided that we needed to be in the same group, so we finally got to be friends with each other. They stayed in more the microwave region. When it came time to get our own instrument, we put it into their lab, the astrophysics group lab. That's managed to survive the change of personnel.

ROSS-NAZZAL: When you combined, is that when you became a supervisor for a short period?

BROWN: Yes. [Herbert M.] Pickett was the first supervisor, then he evolved into other tasks. They needed somebody to be the supervisor. I didn't really want to do it, but I thought, "Who are they going to ask next?" I said, "Okay, well, I'll give it a try." Fortunately, JPL [later] decided to make larger groups so they didn't need as many group supervisors.

[Break]

ROSS-NAZZAL: I was just thinking you seem so interested in the technical details of your work that you might be bored by having to do all the administrative tasks. It takes away from the mysteries that you were [solving].

BROWN: Yes, it's boring. It is. When I first started, I would take a little spectrum—we had a big long coffee table, and I'd sit on the floor trying to find assignments while I watched television. It's just really a game, a mystery, where you're trying to find the clues and put the clues together.

ROSS-NAZZAL: It's funny how you started enjoying mysteries as a child. You had also told me that you were promoted to be a principal scientist, but you had to ask to be considered.

BROWN: Yes. It'd been a lot of years since my previous—I kept getting nice pay raises, but I knew that there was this level of promotion, and I wondered why I was not being promoted.

Then I was able to read the rules, and I found that I could ask to be considered for promotion. I thought "Well, okay." So I did that. I went through the whole procedure, and got recommendations, and got [the promotion].

ROSS-NAZZAL: Do you recall when that happened, when that aha moment occurred?

BROWN: I don't recall. Brian [J. Drouin] wrote down that I was promoted in 2003, which was around the time where I was doing the group supervisor stuff. That probably had an influence on that, but I don't remember actually when it was.

ROSS-NAZZAL: We've talked about some of the work that you've done. I wonder if you could tell us—you probably worked on so many different projects over the years—but some of the planetary missions you've been involved in, or some of the remote sensing projects. Just to have your name attached with some of those efforts.

BROWN: I was never really a co-I on any of the planetary things, it was more the database things. The [NASA Astrobiology Institute] Virtual Planetary Laboratory, which is more of a theoretical group effort to understand exoplanets—that was from lots of different aspects, [such as] the possibility of life in extreme environments. They had activities where they would look at hot water pools and what life could evolve in there. Basically, I did the same old thing for them, which was to have a database of molecular line parameters of different chemicals. Or, if there wasn't the database available, collect recorded spectra wherever I could find it.

We would have weekly meetings that were international. People called in from different parts of the world, and the topics they discussed were really quite intriguing. They were covering what would be the conditions where life could exist, as opposed to not exist. A certain temperature range, taking the Earth model as the most likely scenario. That exposed me to a whole category of science that I normally would not hear about. I think that one was quite interesting.

ROSS-NAZZAL: Yes, it was pretty fascinating. I was reading some of the material about it and thinking it must be very exciting to be involved at the forefront of research. You also were involved in the Orbiting Carbon Observatory [OCO].

BROWN: Right, that's still in orbit now collecting data. That was to determine atmospheric chemistry that involves carbon molecules. It had an instrument that would take data over a period of time in different parts of the Earth. The first one [in 2009] failed to launch, ended up in pieces in the South Pacific [Ocean] somewhere, because a latch didn't let go. That was a sad time, but fortunately they had built a second instrument as a test. They turned that into the next instrument [launched 2014], and it's been operating successfully. There was supposed to be a third one, but it's in jeopardy with the new [presidential] administration [of Donald J. Trump].

ROSS-NAZZAL: I wanted to ask you about that because science is really a hot potato topic these days. I'm curious what your thoughts are about these opinions that have become very popular lately, especially now that we have a new administration.

BROWN: I hope those people will come to their senses. They have financial agendas that they want to place in higher than life agendas.

ROSS-NAZZAL: Do you have any concern that some of the research that you did over the years might disappear? There's a lot of concern about what's happening with the EPA [Environmental Protection Agency] and some other agencies.

BROWN: I think they don't even know I exist. All the databases that I created are being updated and improved elsewhere. I interact with people in Asia as well as Europe, and it's an ongoing thing. There's so much activity that requires knowledge of spectra at all wavelengths. It'll disappear because someone made it better. We figure that if a work lasts a decade then it was good. We don't expect that to be longer. Someone must have a reason to make some aspect of it better.

ROSS-NAZZAL: You had mentioned in one of the e-mails to me that funding was such a challenge for you, that was your biggest challenge. Would you talk about how, over the years, funding increases and sometimes it decreases? How did you deal with that up and down?

BROWN: I tried to get pieces of funding for nonspectroscopic things, little tasks that didn't take me too much away. Sometimes I succeeded, and sometimes I didn't. I really had only one year where it was critical. I had only 75 percent of my salary, so someone in management hired me to do something that I didn't want to do. I was very bad at it, but I made my best effort until I could get my own funding, either from joining some project or writing proposals.

I finally got the recipe down for winning proposals, which was go talk to people who would use it, who knew they wanted it. I also started being invited to the review panels, and that provided a lot of insight about what types of proposals and their presentation would work versus not work. I gave up on the language. I would speak about my work, and learn how to talk other people's language about my work. It was a communication lesson.

ROSS-NAZZAL: That's an important lesson learned. You said something that I thought was interesting, that one year you only had 75 percent of your salary. When you're working at JPL, you have to compete for money even for your salary? That's not provided by the Center?

BROWN: That's right. Either you have your own individual proposal or you're part of a project, so it's important for JPL to win projects. I mentioned one experience where I was part of one [team] that came in second rather than first, the FINESSE [Fast Infrared Exoplanet Spectroscopy Survey Explorer] project.

That was a whole new experience in understanding how JPL had set up groups of people, just to help win proposals. I thought "Oh, okay, I never knew about these groups." They were very good in preparing the team, telling what they were doing and how they had to present it. It was very good advice. The PI [principal investigator] hadn't really had that much experience, had been a person doing his own work in the corner, so to speak. It was a whole new change for him as well.

It was frustrating to get the help at times—"No, you don't do it that way"—but it was very interesting. I was made part of it because they were going to use spectroscopy to look at exoplanets. I was the database person who could tell them what was available and what was

needed. Then, in turn, I tried to turn that information into a proposal to do lab work. I was always on the lookout for topics that would find favor with reviewers.

ROSS-NAZZAL: Did you get money from other agencies besides NASA?

BROWN: No.

ROSS-NAZZAL: No, just NASA. Did you ever go to any launches at [NASA] KSC [Kennedy Space Center, Florida] or Vandenberg [Air Force Base, California]?

BROWN: Yes. We went to Galileo, which [launched October 18, 1989]. We have a picture of my husband having my daughter in a shoulder thing on his back, holding a baby bottle in her mouth, waiting for the launch. For OCO I went to the first one, but I didn't go to the second one.

ROSS-NAZZAL: That must have been disappointing.

BROWN: My parents lived very near the Cape when I was in graduate school, so I got to see Apollo 14, 15, and 17. [Apollo] 17 was at night. You would stand along the river there, and you would watch. This sphere of light just came out over the whole land. It was just fabulous, just fabulous.

ROSS-NAZZAL: What great memories.

BROWN: I went to one exhibit that they held in the VAB [Vehicle Assembly Building] lab [at KSC]. That was really neat to see that. They had some sort of equipment that they had to manipulate, and I got to manipulate it. I thought, "Oh, this is fun." When they began recruiting women [astronauts], I thought "It's too bad that didn't come earlier." By then I was involved with too much that I liked, and I didn't want to think about doing something like that. If it had been earlier, I might have made the effort to do it.

ROSS-NAZZAL: I was wondering about that, because that was around the time that you started coming out here [to California]. I was curious if you'd had a chance to meet any of the women, I know they did Center tours.

BROWN: Not closely, no.

ROSS-NAZZAL: It would have been an interesting field, but you certainly have made a great career for yourself.

BROWN: I was 12, I think, when they launched Sputnik. I was in Muncie, Indiana. I was born there. I went out and I tried to see it go over. I saw something and I thought that was it, but my husband said, "Oh, that couldn't have been it." Anyway, I always thought I saw Sputnik go over Muncie, Indiana.

ROSS-NAZZAL: It's a good story. You were also able to get some funding to buy a new spectrometer, which sounds like it's a pretty significant investment. Could you talk about that?

BROWN: Yes, it was. I think by then I was known to program managers because of my proposals getting funded, and I had served on some review committees. I decided "$250,000, that's a lot, but maybe [they'd support it.]." I don't know how much the program funds, but the planetary people have always had this major equipment pot that you could propose to. So I did, and I won. I found out that I had taken two years of that program to get my instrument, but thank goodness for me.

ROSS-NAZZAL: Yes, it worked out well.

BROWN: But, again, I think I had built up the right reputation and had had the right interaction with people who made decisions.

ROSS-NAZZAL: Yes, and you didn't have to travel to Arizona anymore.

BROWN: Well, I like traveling to Arizona. I missed that, although we got to fly after we deposited equipment. Several other groups would come and use it, and they had their equipment there, too. They had one whole open room where they stored equipment for people.

ROSS-NAZZAL: Very nice. I had asked you about the decadal survey that you had contributed to. You mentioned you had done some work, but it wasn't all that significant by the end.

BROWN: Yes, that's right. Have you been involved with a decadal survey operation?

ROSS-NAZZAL: No, we haven't. We've talked to some people who've contributed.

BROWN: You submit something and then they put it up, and they have a mechanism where people endorse it in the community. So I did that, and I got lots of endorsements from the laboratory folk. I thought I would get at least two sentences. I tried to put two sentences in there they could just pick up and not think about, in an "oh, by the way"-type of reference. Which I think represents the attitude that the organizations have about laboratory studies—[it's] the necessary evil.

ROSS-NAZZAL: You told us that you retired in 2016. Why did you decide to retire at this point?

BROWN: Health reasons, and also I was worried. They reorganized the ROSES groups, and they put all the laboratory people into a database-making call. It seemed like they were more interested in collecting information than creating new information. I didn't know as many people who would be reviewing. I didn't know who would be reviewing, so I decided that between the health and the uncertainty about funding it was the right time to leave. I'm hoping my junior colleague will be able to survive that. We had some funding carry over from OCO, and he'd been involved with some other projects as well.

ROSS-NAZZAL: I'm sure you passed along your wisdom that you had learned over the years.

BROWN: I tried to.

ROSS-NAZZAL: What do you think was your greatest contribution, looking back over all those years that you spent at JPL?

BROWN: I had a chance to realize something that no one else had seen yet. It's not earthshaking, but it was an aspect of our science that involved line shapes which became more and more important in what I undertook. It was how the shape of the feature can be changed by an additional mechanism. I had seen it in other molecules, and when I was using the computer screen to retrieve the information, I noticed that two water lines that were close together had an unusual shape. They had less absorption outside the lines and more absorption between the two. I said, "That looks like line mixing." So I was able to pursue that.

The understanding is still going on, but I had identified some transitions where that effect was the strongest in water. A couple years later, I went to a conference where someone was showing atmospheric spectra and where there were water absorptions. We always show the spectrum, and then observed minus calculated spectra. I noticed it didn't quite fit at those two places where I'd seen this line mixing. I thought, "Aha!"

When people do graphical comparison, observed minus calculated, they say, "Oh, the spectroscopy is wrong," if they see something not matching. There's a new effort, globally, by the people who like to do this work to create a new molecular line shape that takes into account a lot of different mechanisms more seriously than was pursued before. So I feel like I helped spark something by seeing that.

ROSS-NAZZAL: Along those lines, where do you see your field going over the next 20 years?

BROWN: I think the technology is changing. We have cavity ring-down spectroscopy, which is very sensitive. When I started, the grating spectrometers were going out the door and the Fourier transform [infrared] spectrometers and laser [absorption] spectrometers were the thing that were becoming more powerful in terms of research.

Now, I think the grating spectrometers will be a second choice as people develop these cavity ring-down instruments and other things like that with more sensitive detectors. My major professor and the people that he knew—they knew people who, to record a spectrum, set the grating, read a voltmeter, wrote down the number, changed the grating, wrote down the number, and then manually plotted that to see a spectral line.

ROSS-NAZZAL: I was going to say that looks a lot easier compared to what you just described.

BROWN: That's right. It's a technology-based instrumentation that hopefully keeps changing and allows people to do more things and see more sensitive things.

ROSS-NAZZAL: I wanted to ask if you thought gender at all had impacted your career at JPL.

BROWN: Probably, but I was a bit feisty about that. I was on the lookout for that, but on the other hand I did have managers that were better at that category than others.

ROSS-NAZZAL: How do you think opportunities for women changed at your Center over the years? You mentioned that council.

BROWN: There's more women going into the management side. The promotions are there and the opportunities, so it's clearly changed for the better.

ROSS-NAZZAL: You mentioned the [JPL] Advisory Council for Women [ACW], which you sat on for a couple of years. Would you share some details about that?

BROWN: I heard that the Director [Bruce C. Murray] had originally set it up to get more women engineers and scientists to come in, but it evolved into an organization that represented all the women at JPL. It became a place that women who had some difficulty with perhaps a personal interaction, a supervisor versus employee type of thing, could go to and get advice and help. JPL eventually set up components where such details and complaints could be handled within the organization in a just way.

This was at the beginning of the ACW's activity, and it has continued on. They sponsor seminars and events to encourage women and let women know about opportunities, or how to handle some difficult situations that might arise because of gender.

ROSS-NAZZAL: Were there any issues that popped up when you served on that council?

BROWN: I don't remember at the moment. We compartmentalized the women to handle certain things. I didn't handle anything directly myself. Things were set up so that a person with some difficult situation could go to someone that they might know and that would be close by.

ROSS-NAZZAL: You've shared with us some very important lessons learned. I wonder if there's any others that you'd like to share with us today.

BROWN: The biggest lesson is find something you like and just go with it. You'll have a happy life. Fortunately, it was rewarding financially and in terms of being recognized, having your worth recognized as well.

ROSS-NAZZAL: You seem to have found your passion in life, your calling.

BROWN: Yes, that's right. I thought I was going to be a teacher all my life, but I got happily diverted and had a much different life.

ROSS-NAZZAL: I'm going to ask Sandra if she has any questions for you.

JOHNSON: Not right now.

ROSS-NAZZAL: Is there anything else that you wanted to discuss today or that maybe we overlooked? I think over time we talked about a number of things you mentioned in your e-mail.

BROWN: Oh, there's a couple individuals that I encountered. They were spectroscopists or else organized atmospheric people. Two of them won a Nobel Prize. One was Mario [J.] Molina, who studied atmospheric chemistry and identified the problem with the ozone layer being the chlorofluorocarbons.

The other was Robert [F.] Curl [Jr.], who was aiding some astronomers trying to understand certain chemicals that seemed to be in the interstellar medium. They were made only of carbon. He used quantum mechanics to figure out how many carbon atoms would form stable molecules so they have the chain. It turned out to be odd numbers all the way up to the 60-atom carbon ball—the buckyball, the Buckminsterfullerene. It was the basis for nanotechnology, but when I knew him we'd just see each other at meetings. I felt like, "Oh, two people who know my name won the Nobel Prize."

The most interesting person was Bob [Watson]. He was working at JPL in atmospheric science and he went to [NASA] Headquarters [Washington, DC] as a program manager. He supervised the programs that I got funding from. Then he was part of the White House during the [William J. "Bill"] Clinton administration. He's the one that explained climate change to the Vice President [Albert A. "Al" Gore, Jr.] at the time. When he got on committees and when the administration changed, they wanted him to shut up. He eventually got taken off some commissions and he went back to Europe. He's had a very good career then. A few years ago [in 2012] he was knighted by the Queen [Elizabeth II].

All of them were just doing what they wanted with enthusiasm. They were pursuing science, an interesting science question. They found fame and fortune, so to speak, as a result of their unusual dedication to a problem.

ROSS-NAZZAL: Given the fact that you studied methane, do you feel like you've contributed a great deal to the understanding of global warming and climate change? Do you think that you've had that sort of impact?

BROWN: I think I've provided the information for people who evolved the understanding, yes. That wasn't my goal, I was just having fun. I aided the remote sensing effort by my research, so they could go out and get real numbers about what's happening—I think that would be my contribution to that.

ROSS-NAZZAL: Thank you very much for spending some time with us this afternoon, we appreciate it.

[End of interview]