Path integrals, Les Houches, and other adventures of Cécile DeWitt-Morette FREE

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scales or adequately long time scales to address OIF's efficacy in storing carbon. How much additional atmospheric CO_2 would be removed, and how long would it be sequestered? Might the blooms include harmful algae, or could biochemical processes produce methane or nitrous oxide—more potent greenhouse gases? Michaels is among a group of 16 scientists who have publicly asserted that it would be premature to sell carbon offsets for OIF unless the method is shown to remove CO_2, retain it for a quantifiable period of time, and have acceptable and predictable environmental impacts.

Accelerated weathering

Raindrops contain some CO_2, so that the drops constitute a weak carbonic acid. Over geologically long time periods, weathering by rainfall dissolves rocks such as magnesium silicate, with magnesium and bicarbonate ions washing eventually into the oceans. The bicarbonate ions can combine with calcium to form calcium carbonate. When the calcium carbonate sinks to the deep ocean, it is sequestered for more than 1000 years, and the carbon is eventually recycled through Earth's mantle.

The oceans absorb about one-quarter of the CO_2 added annually to the atmosphere. The absorption is dependent, among other factors, on the alkalinity of the oceans' surface layer. As atmospheric CO_2 has increased, so has the acidity of Earth's oceans.

One of several ideas to accelerate the natural weathering cycle is to increase the oceans' alkalinity. For example, House and others have proposed a scheme to remove hydrochloric acid electrochemically from the oceans and to neutralize it by reacting it with silicate rocks. To offset the output of 1 gigaton of carbon per year—one-seventh of today's annual global emissions—House estimates that his weathering scheme would require a seawater flow rate equal to that of 100 large sewage treatment plants and the consumption of about 10 gigatons of basalt rock.

The enormous scale of such geoengineering schemes helps to underscore the importance of getting things right. **Barbara Goss Levi**

Path integrals, Les Houches, and other adventures of Cécile DeWitt-Morette

Entrée to Paris got Cécile DeWitt into physics. Working with great physicists kept her in the field.

One of the first things Cécile DeWitt-Morette said to me was that she wished she was better known for her science. Instead, if people know of her, it tends to be as founder of the Les Houches School of Physics in France. Her involvement in Les Houches—which continues today, 57 years later—may even have been used to harm her research. For example, she says, in the 1980s, she had a grant proposal turned down with the comment that she was "busy raising children and doing administrative work."

DeWitt was born in Paris, France, in 1922. She went to the US in 1948 for a postdoc and has since split her time between the two countries. She recently recounted to PHYSICS TODAY how she chanced into physics thanks to travel restrictions during World War II; how she met Frédéric Joliot-Curie, Paul Dirac, Richard Feynman, Erwin Schrödinger, Louis de Broglie—who was her PhD supervisor—and other physics giants of the 20th century; how she started Les Houches as a self-imposed condition of marrying fellow theoretical physicist Bryce DeWitt; and many other adventures on her way to her present position as professor emerita at the University of Texas at Austin.

PT: Why did you go into physics?

DEWITT: You've opened a can of worms, but I'll give it to you.

I wanted to go to medical school, but that was during the war, and there were several issues why I couldn't. I got my BS in 1943 in physics, math, and chemistry at the University of Caen in Normandy. Then I wanted to do something a little more exciting. I wanted to go to Paris. Because it was wartime and Caen was in the coastal zone, I had to ask for a pass. And the only reason I could give to look reasonable was to say I was getting my MS in physics. I knew that if it were on my pass, I'd better do it, so I signed up for a course in quantum mechanics. I had vaguely heard the term, but it sounded good to me, and it sounded very good to the German officer.

To tell you how bad the course was, in two semesters of quantum mechanics, I do not recall hearing the word "Hamiltonian" once. But it was my condition to have a pass, so I stuck to it.

I was shuttling back and forth between Paris and Normandy, and the exam for that course turned out to be on D-day, June 6, 1944. At that point the Allied bombing was terrible. I mean, they were bombing all the trains, all the stations. Everyone around me said I shouldn't go to Paris for an exam that I didn't care about.

But one lesson I learned during the war is that you don't know where the danger is, you don't know what it is. If it's on your agenda, you just do it. Eventually I was taking that exam on D-day, so I was not at home. And our house got the first bombs, and everybody in the house got killed.

At that point, particularly since my mother died, I felt like an adult. The days of looking for adventure were over. My family was very matriarchic, so with my mother dead, I was in charge.

I felt I better have a job. It happened that I had had, before D-day, an offer from Joliot to work in his lab. I really was not interested, but I had not yet got around to telling him no.

The reason he offered me the job, I think, is that he was a very good experimenter but he had no room for theoretical physics. And he could not ignore the letters from his theoretical colleagues. He felt that a young woman with not many degrees would just be a glorified scientific secretary. By 1944 we were not liberated, but the mail was beginning to come, and he would pass on to me letters he received—on [Niels] Bohr's liquid-drop model or the Bohr–Rosenfeld paper, for example. I had to go somewhere to learn my job. I'd heard the word Schrödinger, so I picked up a book about Schrödinger. The only thing I understood in the Schrödinger equation was π.

Part of my job was to prepare [Joliot's] lectures on the diffusion of slow neutrons. I knew nothing about it. He didn't have time to prepare his lectures because he was very busy with the government. He was a good speaker and had a lot of charisma, and he gave interesting lectures in spite of my poor contribution.

PT: You ended up doing your PhD work in Dublin, right?

DEWITT: Yes. [Walter] Heitler wrote to Joliot and wanted young people to join him and other Jewish refugees in Dublin. Joliot asked me if I wanted to go, and I said sure. Because we were still under war conditions, I needed an exit visa. Joliot asked a secretary to pre-

pare my *ordre de mission*, my mission orders. But, busy with other issues, he didn't spell out my mission. The secretary, afraid to ask for details, made up as a mission that I would go see Dirac, [Max] Born, [James] Chadwick, and others, so they could report to me what they had done during the war.

The French embassy in London either took it upon themselves, or they were instructed, to get in touch with those people and ask for appointments for me. I knew nothing about this until I got a message that I had an appointment with Dirac at his home in Cambridge at two o'clock.

He is known for not talking much. But when I arrived, he began to tell me what he had done during the war. I couldn't understand a thing. After 10 minutes, I began to see how ridiculous the situation was. So I said, "Thank you very much, Professor Dirac. I won't take much of your time. It's very nice of you to have given me an appointment."

"Oh," he said, "my wife is going to bring tea. If you have left, she will be mad at me." So of course I stayed. And he spoke nonstop until five o'clock.

After that, I called the French embassy and said, "For personal convenience, please cancel my other appointments." If they had seen me, or even talked to me, they would have realized that I didn't carry the weight implied in my ordre de mission, which was requesting help from the authorities, civilian and military, French and Allied.

PT: What happened next?

DEWITT: So then I go to the Institute for Advanced Studies in Dublin, and it's really in Dublin that I begin to like physics and to understand it. A PhD in those days in France was a very mature degree. After you had done a fair amount of research and figured out something substantial, you applied for a PhD. So the time I was in Dublin, I think it was two and a half years, whatever I was doing was in my mind material for my PhD.

The day I arrived, Schrödinger and the charwoman had both resigned their positions on letterhead of the institute. Each claimed that the other prevented her or him from doing their job. Schrödinger was very volatile. If he was annoyed at a calculation, he would crumple it and swear and throw it in the wastepaper basket. The charwoman would empty the wastepaper basket, and the next morning Schrödinger would say, "Ah, it wasn't so bad after all. . . ."

Both resignations were accepted, and so I paid my proper visit to Heitler, who was the new head of the institute. He said, "What do you want to work on?" I began to rattle something totally nonsensical, and Heitler, with a very, very nice fatherly look, said, "Would you mind if I suggested something?" So, with the good topics given to me by Heitler and being surrounded by people to talk to, that's how I really entered physics.

PT: What was the topic?

DEWITT: The creation of mesons in nucleon–nucleon collisions. But I should remind you that in those days, there were only scant data about the μ meson from cosmic rays and about the π meson from nuclear physics, and we were trying to see if they were the same thing.

PT: How did you happen to come to the US?

DEWITT: One day I got an invitation to go to Copenhagen. And while I was there, out of the blue sky, I got a cable from [J. Robert] Oppenheimer, giving me a postdoc position at the Institute [for Advanced Study]. I didn't know it was a good invitation. I didn't even know where Princeton was, but I would rather say yes than no. Later I found out that Oppenheimer wanted to do something in the spirit of the Marshall Plan, so he picked two young people from Europe to give positions to at the institute.

Cécile DeWitt-Morette

PT: Why was it attractive to go to the US?

DEWITT: Why not? It was attractive for all of us. The only thing my friends and I knew was *Gone with the Wind*. That was our vision of the States.

I stayed two years in Princeton. I had, by the way, a great position, tenured, waiting for me in France. I thought I was going to Nancy—where some of the Bourbakis were [Nicolas Bourbaki was the collective pseudonym of a group of mathematicians]. But then one evening, Bryce said, "Will you marry me?" I said, "Of course not, you are a foreigner!" So he went back to physics—he always worked during the night. And I was sad, even very sad. The next morning, while I was brushing my teeth, I had the idea that if I would do Les Houches, have a summer school, for two months bring together 20 people, with no limit on nationality or age, and bring also the people responsible for interesting developments, that would be much more useful than my taking the position at Nancy. I wanted to do something for France, because I felt I had been very lucky, because as a woman, I didn't have a professional responsibility, I could do whatever I enjoyed.

There was no campus in France before this, so the idea of living together was unheard of. And professors and students were never together—to the extent that, when I was a student, the professor would enter by some doors and the students by other doors.

Anyway, after I finished brushing my teeth, I called Bryce and said, "Does your offer still hold?" Les Houches was my self-imposed condition for marrying Bryce.

PT: The first session was in 1951, and all these years later, Les Houches is going strong, year-round now.

DEWITT: Yes. Out of our first 16 years, 26 people won the Nobel Prize and two got the Fields Medal. I count only the prizes awarded to participants after their Les Houches stay. I am on the board of trustees.

PT: What did you do after that first Les Houches session?

DEWITT: We went to Bombay. Bryce was on a Fulbright [scholarship], but he was sick most of the time, so I gave some of his lectures. The doctors said he should leave India. But I was more than nine months pregnant. As soon as the baby was born, I said we have to go. So, with a week-old baby and a sick husband, and having Israeli visas in our passports, we stowed away—we couldn't fly through Arab countries with the Israeli visas, and we didn't have the money to go through Japan.

PT: What do you mean you stowed away?

DEWITT: We traveled [on] Air India, which is owned by the Tatas of the Tata Institute. The airline knew we had Israeli visas, so when we arrived in Cairo, they let us stay on the plane. In those days all the passengers had to disembark and be checked. The plane was checked, too, but the airline personnel let us stay in the toilets. It was really hot. That was my great visit to Cairo—it's the only time I've been there.

When we arrived in Paris, Bryce was so sick he went to a hotel. I thought with the baby, I better go to my family. So I got in a taxi. After a few minutes, I said, "Where is the baby?" The taxi driver had put it on top of the car in the luggage rack!

PT: Where did your career take you next?

DEWITT: We spent 15 years at the University of North Carolina in Chapel Hill. I didn't have a position there. Then Bryce got an offer from the University of Texas at Austin. The astronomy department hired me, and eventually I got a job in the physics department. I'm now the Jane and Roland Blumberg Centennial Professor, Emerita.

PT: What have been your main research areas?

DEWITT: My contributions are very often related to functional integration, both developing the mathematics and applying it to physics questions. If you move from classical physics to quantum physics, basically you have moved from finite dimensional spaces to infinite dimensional spaces. Integration then becomes functional integration.

Feynman integrals, sometimes called path integrals, are a special type in the whole domain of functional integration. At the end of his Nobel speech, [Feynman] said—I will misquote, but it's close—"You may ask me what happened to the beautiful young lady of my youth. Like all young women, she has become an old woman. She has very little attraction left in her. She has given me some good children"—meaning the Lamb shift.

The "young lady" was definitely the path integral. I was not going to let that go by. I had worked on it and proved she is not just an old woman who has nothing left in her. Here was something very interesting that had a lot of potential. So I sent him some of my work, and I wrote in the margin, "She's beautiful in her own right." He wrote back, "You only dressed her up."

PT: Did you and Bryce overlap?

DEWITT: Yes, unfortunately, because that was an area for fights. The only thing we really fought about was physics.

PT: You don't need to be married to fight about physics.

DEWITT: No, but it was touching me more. A judgment from him to me, and a judgment from me to him. It's not good to be both a colleague and a spouse.

PT: What are you working on these days?

DEWITT: I am going to do a book called "The Pursuit of Quantum Gravity: Memoirs of Bryce DeWitt from 1946 to 2004." [Bryce DeWitt died in 2004.] I will have editorial privileges, so for several issues, I can put a little note saying "the editor thinks he would have gone further if . . . ." But I'm not going behind his back, because he knew it. We've done enough fighting about it.

Another big project is "Physics at work in neuroscience, neuroscience at work in mental health." I can put people together, make an overall plan. There are no committees; it's just me. I want solutions to mental health problems, and I am interested in what physics can contribute, for example, with functional magnetic resonance imaging.

Another one that is not physics but takes a lot of time and effort on my part is a manual I've written called "IT for Intelligent Grandmothers." I want it to be a bestseller because I am going to give all the royalties to PLAN [Planned Living Assistance Network] of Central Texas, the mental health organization that I started.

PT: Is it okay to mention that your interest in mental health stems from your daughter's health problems?

DEWITT: Absolutely. She feels the more it's spoken about clearly and openly, the more it gives a better picture of mental illness—that they're not all violent or homeless. It can happen to anybody.

Anyway, of all the changes in modern life that I have seen since I was born, I could adjust very happily. But not computers. I bought all the manuals and hated them. The only way I could survive was to write my own. It doesn't say "push this button," because that changes depending whether you have a Mac or a PC. Instead, it gives the principle. It's for *intelligent* grandmothers. You don't see a child giving his grandmother a manual for "dummies."

Then there is the resurfacing of the book I wrote in 1945, in the weeks following Hiroshima. Everybody was asking, What is it? What happened? Basically, the book is a solid but quick course in nuclear physics. It's a primer, and it presented nuclear energy as neither good nor bad. It was the first book on the subject in France for the public. It begins with reactors before going to the bomb. I think that my book was just a little bit of help in the word "nuclear" not having a negative impact in France.

One of my daughters found the primer. I tried to get in touch with the publisher, but they don't exist anymore. It's an orphan publication. [The primer, *L'Energie Atomique*, will be available electronically this fall via the University of Texas Digital Repository, according to the UT physics librarian.]

I have more. I have been in touch with King Abdullah University of Science and Technology [see PHYSICS TODAY, August 2007, page 33]. I am really attracted by [Saudi Arabia's] opening of their society. KAUST also resonated with me because the newspaper article I read mentioned it would be not too far from a little fishing village on the Red Sea. They have the means to do whatever they want. Their main problem is to attract first-rate faculty and first-rate students. I know a lot of people. I think I could help because when I created Les Houches, France was similarly scientifically isolated. What I would offer KAUST is to organize three consecutive summer schools, a bit on the pattern of Les Houches. It would attract people and create a current.

Toni Feder

Iranian and US scientists keep channels of communication open

Visiting physicists and engineers are welcomed in Tehran and carry conciliatory messages from Iranian leaders back to the US.

Burton Richter told the sponsors of his recent eight-day visit to Iran that he wasn't going to go there just to talk about particle physics. The retired director of SLAC insisted that the topics to be discussed include energy, specifically nuclear energy.

But the Nobel laureate had no inkling that he would spend an hour with Gholam-Reza Aqazadeh, one of Iran's vice presidents and its top atomic energy official. The Iranian official, Richter said, "clearly was sending a message" for him to pass along to the US authorities: Iran will consider suspending its uranium enrichment program, but only as part of negotiations covering other issues of "mutual interest," including resolving the Israeli-Palestinian conflict, stabilizing Iraq and other strife-torn Middle East nations, and countering illegal drug exports from Afghanistan.

"My interpretation is that they think that we want some things from them, but they want some things from us," said Richter, "and in negotiating a package deal, they would have more negotiating