Nobel Voices Video History Project, 2000-2001

Interviewee: Norman Ramsey
Interviewer: Neil Hollander
Date: June 27, 2000
Repository: Archives Center, National Museum of American History

HOLLANDER:

Doctor, if you would be so kind as to introduce yourself to us.

RAMSEY:

Yes. I'm Norman Ramsey, a physics professor at Harvard University.

How big of an introduction do you want from me?

HOLLANDER:

[inaudible]

RAMSEY:

I'm a physics professor at Harvard University who's done particularly large amount of work on magnetic resonance. I actually did the first Ph.D. thesis on any kind of magnetic resonance and then developed improvements. Before this, I worked originally with I. I. Rabi, who's the inventor of the very first magnetic resonance experiment.

Then I made an improvement of that, which is particularly useful for atomic clocks, and that's had a great application, still is having great applications, because at the present time, time and frequency, they're closely related. Essentially, time, if you have a swinging pendulum, time is the number of swings of the pendulum. The frequency is the number of swings per second so that in that fashion if you have a good clock, you also have a good frequency meeting to the same. These are the most accurately measured physical quantities that exist, and, therefore, it's very valuable to express other quantities in terms of those.

HOLLANDER:

Could you give us an example?

RAMSEY:

Well, an example of it is, it used to be that the second fundamental unit of time used to be defined in terms of the rotation of the Earth, to make sure that the sun was overhead at Greenwich at noontime every day. But as soon as you have atomic clocks, it's apparent that the Earth rotates very irregularly. Winter is a little different than the summer. It depends on a variety of things, unpredictable things, and that makes it a very poor definition of the second. So now the second is defined in terms of the number of oscillations of a cesium atom.

HOLLANDER:

[inaudible] the Nobel led to you or you were led to the Nobel?

RAMSEY:

It's a part of being a—it's only part of the work I was doing. I was doing work. I was, in fact, initially, not interested in clocks. I was interested in accurate measurements of properties of atoms, molecules, and nuclei. On the other hand, it became apparent that this would make a superb clock. So I was also interested in the applications, and there's been tremendous number of applications. I mean, one I just mentioned.

But I'd say now the unit of length, the most fundamental of units of measurement, which used to be defined in terms as a distance between two scratches on a platinum bar kept in Paris, now is defined as the distance light will travel in a certain amount of time. Now, that is what used to be called the velocity of light. In fact, now the velocity of light is given by definition. It's used in defining [unclear].

HOLLANDER:

Doctor, can you ratchet back a little bit, all the way back? Why are you a scientist and not a poet or a writer or a plumber?

RAMSEY:

Oh, because I think it's more fun for me. I mean, I think the one poem I ever wrote in my life that I can remember, even that was on a scientific track. Well, I'll even tell it to you. This was written when I must have been about eight or something. I don't know the age. I had to write a poem. The poem was "I had a watch that would not run. To take it apart I thought would be fun. To take it apart was easy enough. But when I put it together, it had too much stuff."

HOLLANDER:

Was there a moment or event or something that happened [inaudible]?

RAMSEY:

No, I think it was a little more gradual. In fact, at the time I was even a student, even up through college, the subject of physics wasn't what you thought of as a profession, at least not in the United States. It didn't occur to me that I could. Now, it's true somewhere in, oh, when I was probably in grade school, I happened to find one of my father's—my father had done some chemical engineering—a chemical engineering book. It had an introductory chapter on the atom, very elementary form, the form that Rutherford and Bohr had developed. It was about that time. I was absolutely fascinated by it, really interesting, I mean, you could even think to talk about it. This interested me, but even then I didn't realize this was something I could do as a study.

So when I finally went to college at Columbia University, I was initially a pre-engineer. I was going to go into engineering. So that would be what we studied, structures, maybe teach me how to put my watches together. Then they at that time, the engineers, were always very anxious to do everything by tables. All you had to do was follow the instructions in the table, and that wasn't what I was into. I wanted to understand where the tables came from.

So I made a switch to mathematics, and I was a mathematician as an undergraduate. Then the math department gave me a scholarship to Cambridge University. Just about that time, I discovered that not only did I love physics, but it's even a job that I could do. So that I actually told the math department, a little to their disappointment, I'd be happy to accept their appointment, provided they let me use it to convert from math to physics, which they did. They were very kind about it and let me do it.

So that was by the time I—then I had the very good fortune, my scholarship was to Cambridge University in England, which at the time was probably the strongest place in the world in fundamental physics. I mean, Lord Rutherford, who did the Rutherford war atom, was the head of the department there. Burak, who was very fundamental quantum mechanics, was doing his greatest work at that time, officially in the mathematics department, and I took his courses. A variety. Eddington, Fowler, and Cockroft who did the first—later did the—I guess he was already done the first nuclear interaction with artificial accelerators.

HOLLANDER:

Did you come into contact with Lord Rutherford?

RAMSEY:

I came into contact with Rutherford. I was not there—when I went there, I had two options. The one was that I could, if I'd wanted, start doing research on a Ph.D. thesis. But the level of the undergraduate training in England and in the United States was quite different at that time. Basically the undergraduates then and now spend a good deal—half or more of your time is spent on general education courses and only a certain fraction

on physics. Whereas the students in England who are undergraduates, if they were physics majors, they did nothing but physics so that they had the equivalent of what is in America is sort of the first two years of graduate school they had there before they entered.
So if I'd gone on to my research, I never would have gotten the training. I wouldn't have gotten the education. I wouldn't have learned quantum mechanics, for example, which is fundamental to almost everything in the world, particularly in physics things. So I felt a little bit foolish. I worked two more years, worked quite hard, studied very hard, learned a lot, and but I got the same degree. I got another bachelor's degree. Many people, I have friends who have multiple doctor's degrees. I have multiple bachelor's degrees, which is even rarer.

But then it turned out fine because after I got my bachelor's degree, I went back to Columbia, and I decided to work with I. I. Rabi, who was their leading physicist. I said I wanted to work on molecular beams. I had learned about this subject and the work he had done. He said, you know, he'd be happy to take me on as a graduate student, but he wasn't very optimistic about the field of molecular beams, because he had done measurements reasonably accurate to 2 or 3 percent accuracy. It was going to be difficult to do them much more accurately. All's you do is you measure magnetic moments by bending the beam in an inhomogeneous magnetic field, and it was hard to measure the inhomogeneity very accurately. But I wanted to do molecular beams, so he said fine.

I started on one project, and about a month and a half later, he invented the magnetic resonance method, the first one of the same magnetic resonance method that I used for MRIs, NMR, for the very first one of these. So I had the good fortune of doing the first Ph.D. thesis using magnetic resonance. That made it also very much easier to get your degree, because, in fact, one of my very good friends ended up by doing the last Columbia Ph.D. thesis not using magnetic resonance, and I did the first one using it. It's much easier if you've got a new method in the world in front of you, and it worked very well. I was very lucky.

HOLLANDER:

[inaudible]

RAMSEY:

Well, it's a wonderful award, and it's a real surprise. In the first place, it should not be overestimated. There are a number of very, very good people who deserve the Nobel Prize and don't get it. One of my friends who just recently—is on the boat now, who recently got [unclear], when being interviewed by some students who said, "What is the key thing for winning the Nobel Prize?" and he very appropriately said, "Well, if you're given the choice between being brilliant and being lucky, choose lucky." And that is true to a certain extent. It's true not merely on getting the Prize, but it's also true on the research you do, as witnessed by having been involved in these first magnetic resonance experiments with Rabi. That was luck to a fair degree. Now, it was also—I had into my two years' study in Cambridge, I learned that he was doing fascinating work even before magnetic resonance. But, in fact, it's luck. But sometimes I like jokingly to say, some people are luckier than others, which means do you take advantage of the luck when you have it. I've had, I think, good luck and also, on the whole, taken fairly good advantage of it.

HOLLANDER:

Can you draw a line between your research in magnetic resonance and something we're using today?

RAMSEY:

Oh, there are lots of things. First place, things that we are using today, coming back to the magnetic resonance, magnetic resonance imaging depends on the same magnetic. Now, we did not invent magnetic resonance imaging. It took some thirty or more years to develop from the first magnetic resonance. NMR, which is a variety of magnetic resonance that works with condensed matter, is the most powerful technique of chemical analysis. Its invention was really a separate thing, but it was, in turn, based upon the magnetic resonance we did.

Now, I invented the so-called separated oscillatory magnetic field, which enables us to make measurements more precisely. My purpose for doing it was wanting to study the properties of atoms and molecules, but it turns out that since these lines are so stable, the frequencies are so stable, it also means it can make the most accurate clocks, and they're clocks that are good to an accuracy of one part in 100 million million. It takes I've forgotten how many centuries, thousand centuries, for two clocks to get out of step by even one second.

Now, that, in turn, has many applications. There's a thing going very strongly at the present time, the so-called global positioning system, GPS, and an improved version of it known as DGPS, differential global positioning system. With the global positioning system, you can determine your location just with a small thing I can carry in my pocket. I didn't bring it with me today. I could tell where this boat was to within about a yard or a meter. If we want to do really accurate surveying, and if you take two of these and hold one in a fixed position, then you can get your location relative to that to within a half an inch or better. That's, of course, great for surveying.

It has applications all over the place. I mean, if you've been doing environmental studies, want to see what the effect is on the trees, the pine trees in Maine, from the smoke that's emitted from the smokestacks, say, in Ohio power plants, you want to go back and look at the same trees. Well, you used to have to do this by getting up and surveying, go back, be sure you got the same place. Now you just carry this pocket thing, and say where you want to go, and there it is. They also use it, now have automobiles with these on them.

The FAA, the aeronautics people, are now planning to shift in due course their basic air navigation system to GPS. Every airplane will have it, and then they'll know exactly their location and do collision avoidance by knowing where the planes are.

HOLLANDER:

[inaudible]

RAMSEY:

Yes, I suppose in some way every—yes. I think a scientist is a mixture of an inventor. He's either inventing ideas or inventing devices and/or maybe just using one, but even then, if he makes any major new accomplishment, he's inventing new ways at least of using the devices.

HOLLANDER:

[inaudible]

RAMSEY:

Yes, I think that is true, but he's also an explorer. I mean, he is exploring a different area that you're looking at, for example, looking at very [unclear], exploring the properties of atoms. We can explore properties of things even smaller than atoms. So I'd say a scientist is probably a cross combination between an explorer and inventor. I'd say he's probably primarily an explorer, but then out of his exploration he frequently makes inventions.

HOLLANDER:

Where do you see science now [inaudible]?

RAMSEY:

I think science has tremendous influence and a tremendous responsibility towards society. First place, [unclear] most of the good things we have are science-based. I mean, of the whole revolution of the last time, and that's not only including TV, but also including medicine, much of which depends on physics phenomenon. The example of magnetic resonance imaging is an example, but there are many, many others. I mean, now many hospitals, big hospitals, have to have a physicist working there, just, you know, both to keep their apparatus going and to discover new ways of using it. So the methods of exploring where you have trouble or a person is ill, as an example. Also in other things you do.

Electronics originated out of, actually, physics. Now it's going off. I mean, it's a field of computer development has done many of it, much of it by people who have only done computer development. But also the physicists did much of the original work, and many of them are still doing it.

HOLLANDER:

[inaudible]

RAMSEY:

Yes, yes, they have, and I think this is a thing we need to be cautious about. But do you remember that it is wars—wars are terrible things and they are not invented by physicists. It's true they have worked on radar, for example, contributable to the defense aspects of war, but also to offense aspects of wars, [unclear] bombing, but there was a terrible war going on. World War II, approximately 50 million people were killed. That's an enormous number. Now I would say only a fraction, a very small fraction, are killed by primary scientific or relatively new scientific weapons that would include high explosives, yes. Now, I think we have to worry about that, but the scientists I think usually are more concerned than most people about trying to control such weapons, but also war is badly [unclear].

The period I've worked some in radar, for example, in the first part of the war, the U.S. was losing the war. Well, everybody worked hard to help that, both by individual people who were fighting, but also by scientists who were developing radar.

But I think, when we need—and I think the way to avoid that problem is primarily to try to persuade society that really they have to avoid wars. This is particularly true in the case of nuclear wars, that they may even have the advantage they're so obviously disastrous that you really do have to keep avoid having them, and I think I'm hopeful that, in fact, we're doing it. In fact, we have had, I think, in the last fifty years the first time that long a period has gone without a nation using its most powerful weapon, and that's encouraging. But we cannot relax. I'm involved in various discussions currently on what can be done to make it safe.

HOLLANDER:

[inaudible]

RAMSEY:

Well, I think in the first place, I think I would feel scientists should not be dictated. Scientists are part of the general—also scientists, when they have their worries about international affairs, they're people. When they talk about science, they really know what they're talking about. Now, these two, you need the combination of those knowledges, but I think the scientist should be careful to specify what he knows at what level. Now, I think in this case what the scientist should do is devote a considerable fraction of the time, and we do, to warning people of the problem, making suggestions of what can be done to help on it, and urging things in the right direction. But on the other hand, I think it's also proper it should not be the scientists who just decide.

HOLLANDER:

[inaudible]

RAMSEY:

Well, I was in Washington a month or so ago, urging a nonproliferation treaty. Also, I'm very much concerned and in discussion on that now, on whether it is or isn't a wise thing to develop a missile defense. In a certain sense without having a missile defense, in some ways things are safer than if you have it, because there's always a danger that you may rely on it, and it's not reliable. That can make matters worse.

In other words, much the same as if on this boat there is a lifeboat which has lots of holes in the bottom. This can be more dangerous than if there wasn't a lifeboat here at all, because the captain might say, "Oh, we've got a lifeboat. We can take risks." But if there are holes in bottom of the lifeboat, that doesn't help. The same is true, I think, on some of the missile defense problems. It's a very subtle problem. Like many things, there are two sides to most issues. I mean, I respect people on both sides, as well.

HOLLANDER:

[inaudible]

RAMSEY:

I think dealing with the students, I think dealing with graduate students is one of the most wonderful bits of education, both for the students and for the professor, because we are working together usually on a problem. Primarily, of course, what we were doing is trying to make a discovery, and so we start off on what looks like something very interesting to do. Usually, after you start, you found something else that's even more interesting, as I did on my Ph.D. thesis. I mean, I never did do what I originally started out to do, because the magnetic resonance was more interesting. The saying is true. So that's what we're primarily doing together.

I don't think we're not explicitly directing them in one way or another, except for interests, fundamental discoveries, fundamental measurements. On the other hand, we do lots of living and working together, do lots of discussion. We talk about international problems, talk about many of the questions you've just been asking, and how can you best make sure, for example, that there is not going to be another nuclear war. I think that is one of the very prime requirements. I am somewhat optimistic we will achieve that goal because it is so obviously so disastrous to have one, that almost all people know that they will only lose by having one. So it removes somewhat the incentive to start a war using that. In fact, it discourages people from starting a war.

HOLLANDER:
[inaudible]

RAMSEY:

think a lot about fields, the different fields, there are a number of very different fields, both in physics. I mean, if you say just graduate students in general, there are other subjects. There's biology as well as physics and chemistry and so on. I would look around, see which of those subjects interested me most, really, I could be fascinated by, and at the same time had promise of interesting results, important results. And then I would probably try to find the brightest and most effective professor who would take another student on, and work with him.

HOLLANDER:

[inaudible]

RAMSEY:

Well, it depends on what is good. I mean, I don't want to pick an individual. Most any of the people on board this boat would be excellent in that regard.

HOLLANDER:

[inaudible]

RAMSEY:

What subject? I think there are two. I would divide my—I'm not sure. I think I would probably choose—I've been very lucky with the choice, and it's still a very fruitful field. I'd probably still choose physics, and I would probably still do a fair amount in atomic physics. Also particle high-energy physics is fascinating for its fundamental things, but it does have some unpleasant characteristics, in that it's apt to have long delays in getting the projects done. There are apt to be big groups of several hundred people working together. But depends on how your personality is with regard to that.

Atomic physics has had this great advantage that, on the one hand, it has led to very fundamental discoveries. I mean, quantum electrodynamics, which is the first of the successful basic fuel theories on which most theoretical work is now based, got its impetus from atomic physics on the fundamental end. On the other hand, many of the atomic physics things have had lots of practical application. For example, well, the person I was sitting at the table before this came up was Charlie Townes, who invented the laser. Now, he was an atomic physicist and he's now involved in actually the laser kind of thing for astronomy. So it's had lots of practical applications.

The atomic clock is another example. There's a new, very new phenomenon just come up in atomic physics. Well, two new phenomenon. One is so-called laser cooling. It's now possible in atomic physics to cool atoms down to the coldest temperature in the universe, colder than anything in outer space or anywhere conceivable. You can go down now to temperatures of what are called nano-kelvin. I mean, they are thousandths of a degree, less than thousandths of a degree, zero being the absolute lowest you can get. This is done by laser beams bombarding the atoms and slowing them down. Whatever the direction the atom is moving, it's pushed back.

That then has been added to these [unclear] phenomena produced for the first time only a couple years ago, so-called Bose-Einstein condensation. That's a thing that Einstein realized should happen, but it also required density of atoms and a temperature of the atoms that was totally unreachable or even inconceivable. Nobody even tried to make them.

Now with the laser cooling, you can actually produce them. This enables you to have with atoms the thing that's analogous to what you have with lasers or masers. Namely, you can have a beam of atoms who are coherent, just like an oscillator or just like a laser beam. What the application of this would be, it's too early to know. One thing that's, in fact, quite clear is that almost all of us who are involved in a new field in early times, maybe we were not very bright, but we don't think of the applications which come up later. In turns out, science very much builds one person upon another. One person maybe opens the field. Another person realizes it can be applied in a different direction.

That's why MRI is a good example. I mean, I have been involved with magnetic resonance much of my life, but it never occurred to try to do imaging of the brain as you can do now. That took a combination of magnetic resonance plus work done on CAT scans, the sort of fusion of the two fields.

HOLLANDER:
[inaudible]

RAMSEY:

Well, I tell you, this came up in two of the big panel discussions today, and rather to my surprise there was virtually unanimous agreement on the following that that was a mistake. The following is the problem, that we have a very serious problem, namely, the population is going up, the energy sources which we now use produce so-called greenhouse effect of warming the atmosphere and other pollutants as well. But we do want energy unless we want to go back and all be cavemen. Even they had to have energy. They had to burn fire. If you had the population we have now just burning firewood, we'd soon burn up all the firewood.

So that there's a fundamental energy problem and basically all sources of energy are objectionable. I mean, the fossil fuels are probably the most objectionable. That's the one we use most. Because it produces pollution and also it's a finite resource. In another hundred years we'll be out of it. Coal may last a little longer, but coal is the worst one from the point of view of that. Now, you need something, and there are other things. A lot of work is being done to help on that. Namely, there are solar cells that can convert, take sunshine and directly convert into electricity. You can use windmills, and this is being done. The windmills and the solar cells are a hundred times more efficient now than they were, or at least ten times more efficient than they were ten years ago, but they are still a long way from being able to supply the amount of energy that we can do. Also, on the whole, they're quite expensive.

So that I think the whole panel, actually, to my surprise, it surprised me, because many Germans were on the panel, I think almost all of us felt that we wish it were another way, but we don't see anything better for sure than nuclear energy. Also, the present nuclear power plants can be made extremely safe, new nuclear power plants can.

HOLLANDER:

[inaudible] what are some of the things you dislike as an individual?

RAMSEY:

As an individual?

HOLLANDER:

Yes. [inaudible]

RAMSEY:

Oh, no, there are very few things I dislike. I enjoy almost everything. I even enjoy an interview like this. [Laughs] You know, I would not go out of the way to have it. No, I think I basically have fun and enjoy what I'm doing. [unclear] things I don't. I have a little hard trouble thinking of what I might really dislike. There is something or other. Oh, once when I was in Germany as a student, I was lacking in very much funds, and I was supposed to travel on the scholarship I had. So I happened to eat at a cheap restaurant, and I really didn't have enough money for any of the items. But there was one item on the menu that looked as if it was really good. It was called cogslungo [phonetic]. I said to myself, "Lung. Language. Tongue, I love tongue. Tongue." So I ordered it. It turned out it was literal. It was calf's lung. I must admit that I think I had to eat it because that was my supper, but I did not like it.

HOLLANDER:

[inaudible]

RAMSEY:

Humorous things? Professionally? Embarrassing moments. Well, surprising moments is probably being awakened by a *New York Times* reporter and saying what do I think about getting half the Nobel Prize. It was a total shock to me. I hadn't even been thinking about it at that time. That certainly was one of my biggest surprises, very pleasant surprise, but, nevertheless, a surprise.

Incidentally, an amusing incidence, although I was not directly involved, I learned, actually, usually the Nobel Committee calls you at six a.m. New York time and tells you. But if they don't reach you, they release it to the press at seven. That's how I got it from the *New York Times*, because I'd been a visiting professor at the University of Chicago the preceding year, and my name had dropped from the telephone book, unbeknownst to me, so they couldn't reach me.

I learned only a couple of years ago that the chairman of the committee, secretary, the operator, discovered there was a Norman Ramsey in Washington, D.C., and called him up at six a.m. Washington time. A young man answered, and the chairman of the committee said, "I'd like to speak to your father."

He said, "Well, it's six a.m. here. My father's asleep. He doesn't want to be disturbed."

They said, "Well, we want to tell him he's just won half the Nobel Prize in physics," at which point the young man said, "That's very surprising, since my father's an economist." So things can go wrong on such things.

I've had a lot of amusing things happen, but I don't know that I can produce many right offhand.

HOLLANDER:

[inaudible] think of a science joke?

RAMSEY:

Not that I can think of. I'm sure I do. Usually, the ones that are most fun tend to be a little bit technical, too.

HOLLANDER:

Thank you very much, Doctor.

RAMSEY:

You're very welcome.

[End of interview]