LNS NEWSLETTER
LABORATORY FOR NUCLEAR SCIENCE

Volume 11, No. 2
June 22, 1993

THE SUPERCONDUCTING SUPER COLLIDER -- PHYSICS AT THE CUTTING EDGE

Interview with Jerome I. Friedman, who shared the Nobel Prize in 1990 with Henry W. Kendall and Richard E. Taylor for their work on the discovery of the quark. This interview was with Jean Flanagan of the Laboratory for Nuclear Science. The interview is about the Superconducting Super Collider and the importance of basic research.

FLANAGAN: Why should the U.S. build the SSC?

FRIEDMAN: The U.S. should build the SSC for a number of reasons, but the most important of these is that this project is necessary to advance a fundamental science. We know that the Standard Model, which is quite a successful model, is incomplete. The Standard Model doesn't tell us why particles have mass or the origin of mass and it doesn't explain the many parameters that appear in this model. The Standard Model also doesn't necessarily define the origin of CP violation. It doesn't tell us the ultimate size of quarks.

The current machines do not provide sufficient energy to answer a number of these questions and so we have to use higher energy. If you want to investigate Nature at smaller scales you must use a higher energy. The SSC is also being designed for an energy at which we are quite sure that the question of symmetry breaking will be clarified.

When you survey the history of particle physics you will find that the reason the accelerators were built generally ended up being less important than what the accelerator ultimately uncovered. The physics uncovered can be totally unexpected when compared with the reasons for building the accelerator.

FLANAGAN: What is symmetry breaking?

FRIEDMAN: Symmetry breaking is the idea

that if you look at the equations of the basic theory they are symmetric and, in fact, they have zero mass objects in them. When we look at Nature we find much asymmetry in the forces. The forces are not symmetric and we have a whole range of masses. We believe something causes the symmetry to break. It is called spontaneous symmetry breaking and that has been discussed in terms of the concept of the Higgs particle.

Now the Higgs particle represents a very simple mechanism. The idea is that there is a field in the vacuum called the Higgs field that causes the symmetry breaking and that this field gives the particles their mass. You find oscillations of the field that are equivalent to having particles and these are the so called Higgs particles. Certainly we are looking for the Higgs particle, but this may be much too simple an explanation for the actual mechanism of symmetry breaking. It may be much more complicated. For example, the Higgs particle may be a composite system or it may not exist at all, in which case the symmetry breaking is caused by a new kind of force that is quite strong. Whatever the mechanism is, some convincing arguments have been made by a number of people, that the energy range of the SSC will clarify whether it is a simple Higgs particle or a more complicated mechanism. So that is an important issue that will be investigated.

FLANAGAN: **What other reasons are there for building the SSC?**

FRIEDMAN: It is important for young people because it is a tremendous intellectual challenge. Young people become excited about understanding the universe and about science in general. It is a very important part of our culture to understand these issues at the deepest level possible. In a certain sense, that which most differentiates us as creatures on the earth are those things that have to do with our intellect and trying to understand what it's all about.

FLANAGAN: **As Weinberg[1] says, trying to get a sense of what reality is?**

FRIEDMAN: Yes, in a certain sense, but basically it is what makes humankind different. We have insatiable curiosity. We want to understand everything. Here's a device that allows us to probe very deeply into one kind of phenomena. Now there are, of course, many other different important areas of science that we want to examine. In biology, for example, we want to examine how cells work. If we want to understand the most basic building blocks of Nature we must use high energy accelerators. We have no other way of doing it. In a certain sense a very important part of our cultural and intellectual heritage is to attempt to understand these issues.

FLANAGAN: **Many people talk about the spin-offs of the technology developed at the SSC. How can this technology be applied to everyday life?**

FRIEDMAN: One has to be very careful about how one talks about this. Spin-offs and technology transfer come from some of the solutions to specific technology problems in a project. One has to meet new technological challenges and learn how to build things in very efficient ways. For example, the SSC will have 10,000 superconducting magnets. To figure out how to build these magnets in the most efficient manner they have developed new techniques of making high performance superconducting cable of great uniformity. Superconducting magnets are used in magnetic resonance imaging devices and will have applications in other types of systems. If you learn things like this in the development of a big accelerator the technical spin-offs will be very useful in many other areas.

Until the problems are solved you can't be sure of what the applications will be, but in the past many of the spin-offs of particle physics have been very useful. Particle physics detectors have been used for medical diagnosis, and particle physics accelerators are used for medical diagnosis and therapy. The synchrotron light source, which uses an ordinary electron synchrotron for achieving synchrotron radiation, has been used in condensed matter physics. It has also been used to make very high density micro-chips, and for biological and chemical research. This accelerator was invented for research in particle physics. Later it was found that the electromagnetic radiation from this accelerator was extremely valuable and that it has many different applications. The whole history of this is now clear.

The SSC is being built now. We don't know what all the applications of the new technology will be, but if history is a guide, there will be many of them. The challenges of the machine are really immense. For example, this machine will produce 100 million collisions a second, each collision will have hundreds and hundreds of tracks. These big detectors have to register the tracks, make calculations on the kinematics of the tracks, store those events that are useful, and do this is at a rate of 100 million per second. It will require enormous calculational power and require developments both in hardware and software for computers. Also the electronics has to be extremely fast and radiation hard.

Many things like this will come out of the SSC. To give you a small example of what has been done, there was a group that was trying to develop plastic light pipes that are radiation resistant, that is, they don't darken when exposed to radiation. Because the SSC will be a high intensity machine and the detectors themselves could be damaged by the radiation, they found out how to make plastic that will not darken when radiated. This has enormous applications in medicine for the reason that when instruments like syringes were sterilized in the past they were sterilized by very toxic gases, really a great nuisance and not very good for the environment. Now they find that because they can make radiation resistant plastic they can sterilize these things with radiation. Now we have a new way of sterilizing plastic. Many things like this will develop. Another example is that there will be great applications for fiber optics systems. Fiber optics are used in the detectors.

FLANAGAN: So it's a good point for having big science

FRIEDMAN: Yes, that's right. Whenever you build something on the technological edge you learn many things that have applications and use in many other areas. That is why these very ambitious projects are extremely valuable to society in addition to the basic reason for which we build them.

FLANAGAN: It seems that there have been many links over the last few years between cosmology and particle physics. As a particle physicist, what do you expect to show cosmologists at the SSC?

FRIEDMAN: The particle physics phenomena that will be produced at the SSC will reproduce conditions that existed in the very early universe, the first 10^{13} seconds after the birth of the universe. The energy density produced at SSC would be like the conditions in which the universe actually evolved. If you want to understand the evolution of the universe, you have to understand the conditions in which it came about. It is based on the Big Bang Theory and I don't think anybody, at this point, has any other theory that is as compelling. No theory other than Big Bang can give you any acceptable description of what occurred. Now it also turns out, even Alan Guth's inflation theory makes use of the so called Higgs potential, so again even some of the cosmological developments use properties of the vacuum that are related to what we are looking for with the SSC.

FLANAGAN: I think that it's very difficult for the average person to understand why, in a country such as ours, that there are homeless people on the streets and all kinds of money is being spent on other things.

FRIEDMAN: I agree that there are many issues, many problems, but there are different ways of helping human beings. We have to take care of the homeless and the hungry, but is not the SSC versus the homeless. It is the whole budget. There is a much bigger domain of budget issues. It is an issue, which of course, is brought up by political people who don't want to support the SSC. We still make B2 bombers and nuclear submarines in response to a cold war that no longer exists.

FLANAGAN: I guess part of what you're saying is that we are still having problems changing over to a peace time economy and our government is still motivated by cold war logic.

FRIEDMAN: Yes, the budget still is not what it should be. What you want to do is take the funds for military R&D and put it into civilian R&D. It is important to keep the technology base going. The military budget has had one important aspect in addition to security. It has kept the level of technology in this country at a very high level. The question is, what happens when you stop making all these weapons. Obviously, without a cold war, we are not going to need the same number of weapons. In order to maintain high technology there must be investments made in other things. There are many things that one can do. We have to make choices. We are making a mistake if basic research gets wiped out just because the nation primarily supports the development of the applications of science. Basic research, in addition to utilizing technology of all kinds, drives technology. Technology just doesn't develop on its own.

FLANAGAN: **Do you look at the SSC as a new type of exploration?**

FRIEDMAN: It's a continuation of the old explorations. If you had a research submarine you go to certain level and start to examine what's going on. If you then can go to a level that is ten times deeper you will see other things. In the same way, the SSC is a continuation of a voyage that will go much further. The scale makes it totally different, in the sense that we can see very different phenomena; however the tradition of asking questions and seeking to understand is exactly the same.

FLANAGAN: **How do you recommend educating the public about science, about physics, and about the SSC?**

FRIEDMAN: I think the way to do it is to have people in the field write, talk and interact with the public and tell them about the SSC. Providing information is essential. We must give talks in the schools, give popular lectures and write articles for newspapers. It is the only way.

FLANAGAN: **A physicist I interviewed told me that he thought that physics was the closest thing to religion that you could study. What do you think?**

FRIEDMAN: It is correct that both physics and religion ask fundamental questions, but if anyone thinks you can find the ultimate answer in physics, I think that person will be disappointed. Physics will go only a certain distance and beyond that no one will ever know. Metaphysics still will have plenty of room to exist. Religion is totally different. Religion relies on belief whereas physics is based on observation. Religion tries to answer questions about things we don't understand -- at least that is part of its function. All science seeks to do that, but science has to stop at some point. When physics stops, it stops because it has exhausted the realm of observed phenomena. Religion does not have this constraint.

FLANAGAN: **Physicists have been viewed as the leaders of science since the second world war. Do you see that continuing?**

FRIEDMAN: I don't want to say leader. I don't want to have an elitist's point of view about physics. Physics is a very important subject. But I don't want to make any statements that somehow physics is more important than other areas of science. I'd like to take the point of view that it *all* has to go on. We want to understand matter in all of its forms, both inorganic and biological and at all scales. Our investigations should range in scale from the cosmos to the sub-atomic world.

-end-

[1] Weinberg, Steven, *"Continuity in Theoretical Physics,"* 46LNS46

Symposium, "On the Matter of Particles," May 15, 1992.

Awards and Honors

Naomi Makins received the Luise Meyer-Schutzmeister Memorial Award for women graduate students in physics. This award was provided by the Association for Women in Science.

Mark J. Damian recently completed a Certificate program in Acquisition and Contracting from Western New England College.

Leslie J. Rosenberg received one of the 1993 Department of Energy Outstanding Junior Investigator Awards. This Award recognizes significant contribution to high energy physics and the leadership in the field.

Samuel C.C. Ting was recently awarded Honorary Membership in the Hungarian Academy of Sciences.

LNS Barbecue

Once again, it is time for the LNS Barbecue!!! Mark your calendars for Wednesday, June 30, 1993 at 3:00 PM. Those interested in attending MUST RSVP and pay to Donna Henderson no later than June 28, 1993, Bldg. 26-505, X8-5448. The price is $4.00 per person.

Published quarterly by the M.I.T. Laboratory for Nuclear Science Communications Office, Bldg. 26-540, Cambridge, MA 02139

Director: Robert P. Redwine
Editor: Jean P. Flanagan

For further information call (617) 258-5447.