Professor Wiedeman on Synchrotron Radiation

The second School on the use of Synchrotron Radiation in science organized by the International Centre for Theoretical Physics (ICTP) and the International Centre for Science (ICS) was held from 25 October to 19 November 1993. The School was particularly important because it represented for many scientists from developing countries a rare opportunity for getting acquainted with up-to-date investigation techniques offered by synchrotron radiation sources in general and by the Trieste synchrotron facility in particular [see Newsletter *Vol.3, No. 3, July-September 1991, p. 20: "Interview with Luciano Fonda"]. In fact, the Trieste Synchrotron Laboratory headed by Nobel Laureate Carlo Rubbia was officially inaugurated on 26 February 1994 by the Prime Minister of Italy, Mr. Carlo Azeglio Ciampi, who was accompanied by (TWAS Associate Fellow) Professor Umberto Colombo, Minister of Universities and Scientific and Technological Research. In the following interview, Professor H. Wiedeman from Stanford University and Lecturer in the School, explains the many advantages resulting from the use of Synchrotron Light Radiation.*

Q. Professor Wiedeman, you delivered a lecture in the course on the applications of Synchrotron Light Radiation. Could you please describe these applications to high technology, chemistry, physics and, possibly, to environment?

R. Synchrotron radiation is basically an electromagnetic radiation which is emitted in a wide spectrum of wave lengths, from microwaves to the X-ray regime. Electromagnetic radiation has been used in the past hundred years in many disciplines as an ideal probe to investigate on metals, chemical compounds, atoms, surfaces, biological molecules and these investigations were made mostly with rotating anode X-ray tubes.

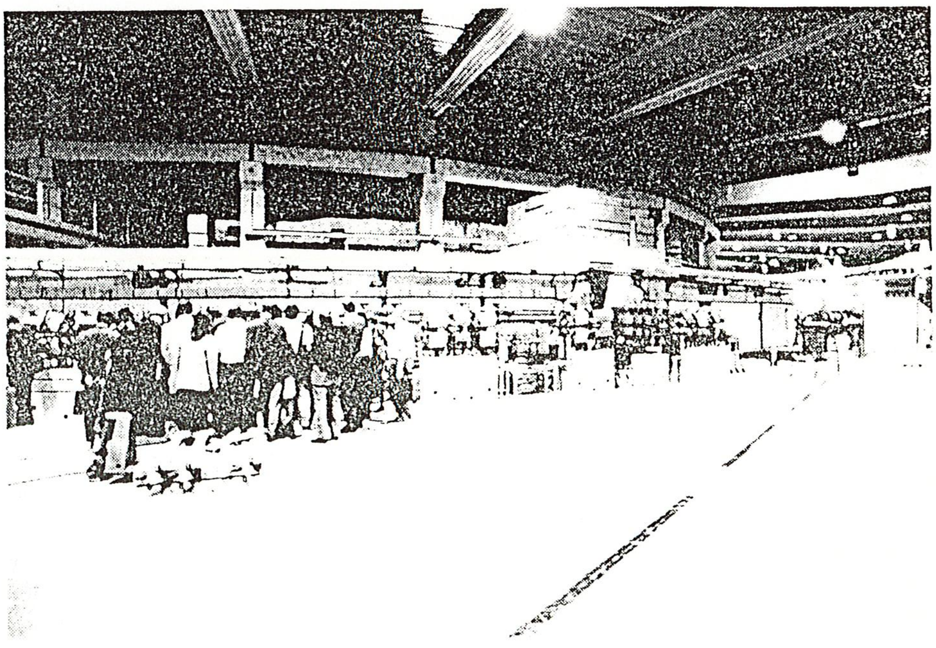
With the development of synchrotrons, new sources have become available. They can produce much more intense synchrotron radiation than ever before and that allows now the investigation of materials which require a large flux. One can investigate, with much more sensitivity and resolution, solutions, very small impurities in metals and many others. Such techniques are now being used in the existing synchrotron light radiation laboratories in fields like materials science, surface physics, chemistry, biology, medicine, geology, industrial applications, industrial fabrication, technology and environmental sciences.

To be more specific, in high technology, it becomes more and more important that very pure materials be produced. There is nowadays a great effort towards the miniaturization of electronic devices, but the smaller the structure becomes for such devices, the more important it is that impurities in the materials are eliminated. In order to eliminate them, one must be able to detect them and so, for example, in high technology, one application of synchrotron radiation is the development of processes for the fabrication of smaller and smaller integrated computer chips with such a degree of purity that these devices can be mass produced in a very reliable way. This implies that it must be possible to test these processes and this can be done with synchrotron radiation.

One can also develop new materials; synchrotron radiation makes it possible to measure the properties of new materials in very minute quantities so that one can try to compose new materials even if they are available in very small quantities. One can then think about their interesting properties and decide whether or not to proceed to the production of larger amounts of these materials.

In biology there is a great effort to study, for example, the structure of DNA and in order to do so, one needs

A group of visitors at the Sincrotrone Trieste, *the synchrotron radiation installation on the hills above Trieste which has recently begun operation.*



synchrotron radiation once more. Normally, DNA decomposes while it is being investigated; its molecules are not easy to handle, but it has been found that if these molecules are irradiated in very short blasts with synchrotron radiation, the measurements can be done very quickly before the DNA biological substances decay. This has become a very important method for unravelling the structure of DNA.

It is also difficult to produce large protein crystals. Proteins can be produced only as very small crystals and therefore one needs intense radiation sources to study these small crystals. This, again, can be done only with synchrotron radiation.

In relation to applications in environment, for example, in America, at Stanford, we are just planning for a beam line or an experimental station which is entirely devoted to environmental studies. The problem which will be investigated is the safe disposal of radioactive wastes. Geologists study chemical compounds of these radioactive atoms and, in particular, their behaviour in a water environment or in any environment which is able to carry away these radioactive substances. This obviously has to be avoided. Therefore, they try to find a compound which would rest where it is placed forever: it would not be soluble in water, it would not migrate and react chemically. For such studies synchrotron is an ideal tool because one does not need large quantities of that material.

There are also medical applications of synchrotron radiation. For instance, it is possible to make cardiovascular systems, heart arteries, visible with the use of synchrotron radiation; this would be a non invasive method for looking at blockages of cardiovascular systems. For such an investigation one has to make a picture with a resolution of less than half a millimetre because these arteries are very small and one must be able to observe the blockage. The method is rather simple. A small quantity of an iodine compound is injected into the blood stream and, by using X-rays from a synchrotron, one guides these X-rays to a monochromator and one takes monochromatic X-rays at below and above the K-absorption edge of iodine Both pictures look pretty much the same except where there is iodine. Above the K-edge, the iodine absorbs much more radiation than below. And this allows to locate the blockage.

Q. I noted in your biodata that you have been contributing to the design and construction of a synchrotron in newly industrialized countries such as Brazil, Taiwan and Korea. But I see that you have been also in Thailand — a country which is less advanced than the other three from the industrial point of view and where scientists contemplate to build their own synchrotron source. It seems to me that there is quite an interest even in less advanced countries, in this way of looking at matter. What is the real benefit that these countries can obtain by using synchrotron sources? Another question which comes to my mind is why is it that there is no synchrotron source yet in Africa?

R. Newly industrialized countries were known in the past year for providing cheap labour for manufacturing. This was the case shortly after World War II for Japan and, later, for Taiwan, Korea and Singapore and now we also hear of Thailand and the Philippines. These countries started out by providing cheap labour but now, they have learnt how to produce high-tech systems. If you look to the future ten or twenty years, for these countries it will no longer be sufficient to just provide cheap labour. They will have to develop and be able to create new technologies.

Labour in Thailand is still a little bit cheaper but this will not last for ever. When the big market in China will open, labour will be cheap there for some time and the small countries around it will have to do something else. So, it is important for these smaller countries to build up on their present state of technology and take part in the development of new technologies. Japan shows how to do it: in Japan there are many synchrotron light sources. I am not saying that synchrotron light sources will solve all economic problems but they will contribute. The beauty of such synchrotron light sources is that their radiation can be applied in many areas of science, basic science, medicine and industrial applications.

An opportunity for any developing country to catch up with forefront science right away

At Stanford, a large number of industrial technologists experiment on their own products with the synchrotron radiation produced by our machine. So, as you can see, science can be very basic but it can be also very applied and immediately applicable to industrial processes. I therefore think that when we look at countries like Thailand, it will be useful for them to have, let us say in ten years, such a synchrotron light source.

There is another aspect to the whole situation and that is education. In many of these countries (and, especially ten years ago, in Taiwan and in South Korea) the majority of their bright students went abroad to get their PhD and very few came back, because of the lack of opportunities for doing experiments and participating in development. A synchrotron light source in a national laboratory provides that opportunity. Professor Yuan Tseh Lee, a chemist originally from Taiwan but who worked in the USA and won the Nobel Prize in chemistry in 1986, is now returning to his homeland. This is very significant. As you know, brain drain represents a great loss, especially for small countries. I could say that synchrotron light sources, among other types of facilities, are inexpensive as compared to the loss of young brains. The research with such a facility is mostly done by small University groups with one professor and two or three students. They collect data at the facility and return home where they analyze them. This feeds the educational process and it is high technology. It provides the opportunity for any developing country to catch up with forefront science right away and not to waste time on secondary science.

Coming to Africa, there is no synchrotron light source yet and there is no talk about it. But one must note that Africa has not yet entered in the production of high tech components like Japan, Taiwan and South Korea have. Their advantage was cheap labour, but they have learned how to use the machines. After a while they had to go by themselves and they progressed through incremental technology.

Q. You have already partially answered the question which I am going to ask you, but you might have something to add. I have seen many participants from developing countries in your audience. What is your message to them in relation to the use of synchrotron light radiation sources and, in particular, in view of the fact that in Trieste a Synchrotron facility will be operational very soon.

R. I think that this school is very valuable for students coming from these developing countries. It is a unique school where people learn about a broad range of techniques used in the experimentation with synchrotron radiation. I believe that ICTP and ICS provide here a very important contribution for the students including those from industrialized countries.

It is good that the school concentrates on developing countries because many of these are very far away from Europe, America and Japan. Here, they are exposed to the main themes in condensed form and they can study them in more details later on. Every participant has already heard about synchrotron radiation experimentation and the majority of them actually come from places where there are synchrotron light sources. They already know about these, but they need to know more about experimental techniques and that is what they can learn here.

Q. I suppose that at next school, the Trieste facility will be available and this might attract scientists from less advanced countries, from countries with no access to synchrotron sources. Then, will it be possible for those scientists to come in Trieste, make their measurements or expose their samples, go back home and analyze the results without leaving the country for too long a time?

R. Yes, this is in fact the situation at Stanford. Anybody in the world can apply for an experiment. One has to submit a proposal that will be accepted if it is scientifically interesting. Beam line time is free of charge but travel and leaving expenses must be born by other sources. That is the problem, I think, for scientists from developing countries. If they could come up with their own travel and subsistence support then they would not have to pay anything for the experimentation. In Stanford we welcome many University groups. They come mostly as graduated students accompanied by a scientist, who is usually their professor. They do their experiments in one or two week and return home to exploit them. All the data are on a magnetic tape and they analyze them at their institutes. These data are feeding the research in universities. ◆

A School For Scientific Communication: Mario Negri Sud (Italy)

One of the objectives of the Third World Academy of Sciences is to contribute to the dissemination of the results of scientific research, to provide information on and support for scientific awareness and understanding in the Third World. To reach these objectives, one needs "Science Communication". Regrettably, opportunities for getting trained in this domain are not many. There is one though with quite original features and that is the Mario Negri Sud School for Scientific Communication.

Mario Negri Sud, a Centre for Biomedical and Pharmaceutical Research, is located in Santa Maria Imbaro (Chieti, Italy) and works in symbiosis with the School of Scientific Communication. As Dr. M. Balaban, the Dean of the School, explains in the interview which follows, Mario Negri welcomes fellows who will carry out research in the laboratories and be trained in scientific communication at the same time. Other training opportunities are offered as well. Dr. Balaban also speaks about the International Federation of Science Editors and of the possibilities of collaboration with TWAS and with the Developing Countries.

Q. Dr. Balaban, can you please illustrate the purpose and the functioning of the Mario Negri School of Science Communication?

R. The School was founded because there is a need for training in science writing, editing and communication. As you well know, the reputation of scientists depend on the quality of their publications.

Nevertheless, there has been no formalizing of this type of training; there are almost no courses even within the curriculum of physicists for the budding science editor wishing to become a professional. The craft of professional editors is learnt by apprenticeship in publishing and editorial offices, or in-house, by helping colleagues.

It turns out that they are quite good editors, but there are no formal courses to help them, and this despite the fact that publishing is an enormous field in which large amounts of funds are spent.

The International Federation of Science Editors (IFSE) and other associations of editors connected with it,