matching condition. 1mW output green light was observed.

The small size and simple structure of the diode laser enables a direct coupling of the pumping radiation to the laser without any complex optics. But to obtain good overall electrical efficiency, the thermoelectric cooling, which is necessary to stabilise the operating wavelength of the laser diode, must be considered as well. It is of major importance to check the performance of these laser crystals as a function of the diode wavelength.

In our laser experiments, only end pumping was employed, but side pumping is necessary for scaling to higher powers. This allows pumping by arrays of diode lasers. It remains to be seen whether the efficiency of side-pumped devices can approach that of end-pumped devices, with near diffraction limited output beams. One possible approach to pump with diode arrays in a small volume is to couple the pump power from each individual diodes to the gain medium through optical fibers. It is very difficult to produce consistent and reliable intracavity frequency doubled lasers due to their intrinsic complexity. Solid state lasers have nonlinear cross saturation properties because of standing wave effects in the laser cavity. Combining this with a nonlinear output coupling gives a system with two coupled nonlinearities. As the strength of these couplings are varied they lead to bistability, oscillation and ultimately chaotic amplitude fluctuations.

Despite these problems, recent developments in diode pumps solid state lasers have not only made these lasers efficient alternatives to flash lamps pumped solid state lasers but they are also going to replace gas and ion lasers in several applications.

Rakesh Kapoor

# We Interview . . . .

**Dr R Chidambaram, Chairman, Atomic Energy Commission & Secretary, Department of Atomic Energy visited CAT during February 1996. He saw the booster synchrotron in operation and also visited various labs. Following is an excerpt from his interview with the Newsletter editorial board:**

Q. CAT is about to complete 10 years. What do you think of the progress made till now?

Since the ten years of its inception CAT has made excellent progress under the dynamic leadership of Dr Bhawalkar. A very significant advantage in CAT is the low average age of the scientists working here, compared to other units. Therefore, they still have a lot of potential to achieve higher goals. The balance between science and technology maintained in laser programme is an ideal mix. The working atmosphere is very open. Both things together means scope is there for everyone.

Q. In your opinion, what should be the future goals of CAT now?

CAT should be working in the forefront of laser science for example developing new kinds of lasers. In this context, one should not worry too much about technology (buy it wherever possible or develop an alternative). On the technological development side, we have to note that after liberalisation the multinationals are looking to India as a big market. So they also have a vested interest in preventing us from developing technology on our own. To this end, tricks like labeling technologies strategic to prevent us from buying them, are used. But once the same thing is developed here the sanctions are removed. Therefore, we have to develop capability for making every component so as to be able to bargain from a strong position. In this context the development of synchrotron radiation source at CAT is an important step.

Q. Since the R&D work done in labs like CAT does affect the market, what should be the level of interaction between institutions like this centre and the Indian industry?

We should work in the frontline research areas because that governs the development of new technology. The responsibility of making industry aware of this fact rests with R&D labs. They have to reach out to industry, not vice versa. A good example of this kind of interaction are the chemical and drug industries in India. R&D centres should contribute their knowledge to bring our industry up to internationally competitive standards. Once the technology is available to them, the cheaper labour and good management practices in India would ensure economic competitiveness. We also have a big advantage in the excellent software expertise available in the country. What we have to ensure is that before transferring the technology to industry from R & D centres, it should be brought up to a level where it can compete with established brands in quality. In this context, the development of laser fluorimeter, medical lasers and $CO_2$ laser at CAT is a step in the right direction.

Q. A lot of resources are invested in national facilities.

What should be their role in the present science and technology scenario in India?

CAT is going to have India's first synchrotron light source which is envisaged as a national facility which can be used by researchers from all over the country. For the amount of money to be justified, CAT should also work on sensitizing researchers and industry on potential uses of the synchrotron in this respective areas. All efforts should be made to facilitate collaboration from different users. A good example is the Dhruva reactor, which came in great demand after the Inter University Consortium was started.

## Prof CH Llewellyn Smith, Director General, CERN visited CAT during first week of April 1996. Following is an excerpt from his interview with the Newsletter editorial board:

Q. This is the first time CERN is planning a collaboration to such a large extent with India. How do you feel about it?

Our collaboration with India has grown slowly but steadily. It goes back many years. This collaboration has been in a number of experiments. Particularly, Indians were involved in our largest facility the Electron-Positron Collider (LEP). A group from TIFR was a part of the experiment. In subsequent experiments for example in studying collision with heavy ions, there were people from different places like, VECC, Jaipur, Bombay, Delhi, Bhubneshwar. Our job in Geneva is to provide the accelerators for physicists coming from outside say, from Oxford, Calcutta, Chicago, Madrid, or Paris. Upto now we at CERN have provided the accelerators and the experiments have been in collaboration, with collaborators more or less contributing proportional to the amount of participation. But it is becoming harder to do this because it becomes more expensive. India, I think, is the first country outside Europe to join us also in building parts of the machine. Earlier, some of the software for the CERN accelerator was written at BARC. Another example is for the LEP machine. We are upgrading it to double the energy for which we got some of the (corrector) magnets fabricated at Indore. That was a sort of trial run, if you like, for the future collaboration in the LHC machine. This is going to be a much bigger collaboration for which we are paying in a complicated way. The value of the material for the machine to be built in India is 25 million US dollars. Well, that is what it will cost to build in Western Europe. Here, depending on how much manpower is involved, it could be so much cheaper. But nevertheless it is lot of money. We are paying half of that. The work on the corrector magnets was a good trial run for this bigger collaboration.

Now the question is, does it work to have the magnets build here and use them in our machines. And the answer is yes. It works pretty well. We are ready now for the bigger collaboration.

Q. Apart from your tests on corrector magnets, now that you have visited CAT, how do you feel about things ?

I feel excited. I was very impressed in my visit. I had read about the accelerator work but I did not realise the broad range of the laser work. There are all sorts of lasers, including lasers like copper vapour lasers which are not easy to make, I was rather impressed by that. I was also impressed by the fact that more or less everything is made here. That is generating the technology and knowhow which will later go to industry. It is quite clear that to have made all these things must require great capability which we can benefit from. And at the same time you can probably benefit here by working with us.

Q. Is there any plan to transfer some technology to India ?

Well I think that will simply happen by working together. Inevitably with parts of the machine being built here, there would be people going up and down checking what is done here and Indians working in CERN. Technology transfer works by moving people. So Indian engineers installing parts of the machine being built in India can pick up other things at CERN and likewise from people visiting CAT.

Q. Does CERN has such an open structure that people going there for a specific work can get information about other areas ?

More or less, CERN was founded 40 years ago and although one of the purposes was obviously to allow to do science, which is too expensive for one country, there was also a feeling to look for something, to build bridges between the countries after the disastrous war in Europe. I think it was rather successful. I think that may be successful on world scale. The convention of CERN says absolutely explicitly that there should be no military work, every thing should be published and should be open. So all results are published of course not all technological, all scientific (are published). Everything is open.

Q. During this visit you have seen the work going on in accelerator laboratories. We would like to have your impressions.

As I said what I am impressed by is the fact that all power sources, power supplies, all the magnets, even the vacuum pumps are built here. This shows that this lab has tremendous resources and engineering capabilities. So it is rather impressive that you can build all these things.

Q. Having visited so many institutes, how do you feel about technological scene in India ?

Well I have not visited any Indian industry. So I can not judge that. But in the four places visited viz. CAT, BARC,

TIFR and Bhubneshwar, the capability in the labs seems to be rather high. But on the other hand there is also the fact that, here things have to be built which in Europe and US you would simply buy from the industry. So clearly, the (Indian) industry needs to learn, that is part of the idea of this centre as I understand.

Clearly the technical and intellectual expertise of the Indian physicists and engineers is world class. You actually have a very strong tradition of fundamental science in India. It is small but strong and a rather old and proud tradition. And we are rather proud that you chose to work with us.

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