Introduction to Research
Prof. Prathap Haridoss
Prof. R. Nirmala
Department of Metallurgical & Materials Engineering
Department of Physics
Indian Institute of Technology, Madras

Lecture – 47
Research in Physics

Prof. Prathap Haridoss: Hello, it's our pleasure to have with us Prof. Nirmala from the Department of Physics here at IIT, Madras. She has been a faculty here for almost a decade now. Before that, I mean she had done her PhD here and after that she has done several post doc positions she has held at IISC, at TIFR, at Ames lab in the US Department of Energy Ames Lab at Ayova. She was also at the SKKU in South Korea so and after all that she is been a faculty here. So, lot of experience in that process working with you know, research groups from across the world and also of course, with the research students here at IIT, Madras. So, it's our pleasure to have her with us today. So, welcome to this interview.

Prof. R. Nirmala: Thanks a lot Prathap, for this chance of talking to in NPTEL.

Prof. Prathap Haridoss: Sure, sure, our pleasure, our pleasure. So, just to start off with, see physics has a department as a field has been around of course, I means it is a one of the fundamental fields and so, I mean for ages people have been doing work in physics. So, if you look at it now, what would you call as traditional areas of research in physics?

Prof. R. Nirmala: Okay so, if you go back in history you will find physics starting from say, Optics, Atomic and Molecular physics and we still continue to work in these areas. And, experimental solid state physics and non-linear dynamics and we have this theoretical and computational physics and this is a very vast area, you can go from condense matters to string theory and etcetera.

Prof. Prathap Haridoss: OK.

Prof. R. Nirmala: These are some traditional areas that physics departments work with.

Prof. Prathap Haridoss: These are areas where there is probably a lot of literature, for somehow, some very long time ago and then you know when somebody starts there is a lot of stuff to look at.

Prof. R. Nirmala: Yeah, yeah.

Prof. Prathap Haridoss: Look at.

Prof. R. Nirmala: Look at.

Prof. Prathap Haridoss: So, also along similar lines if you want to look at you know new areas of research are there new areas that I have come up let's say in the last 10 years or so which lot of people look at?

Prof. R. Nirmala: So, again when I say new areas, some of these areas where were all the time.

Prof. Prathap Haridoss: OK.

Prof. R. Nirmala: But, probably we are concentrating more recently.

Prof. Prathap Haridoss: OK ok.

Prof. R. Nirmala: So, for example, high energy in particle physics it grabbed attention after Higgs boson, for example.

Prof. Prathap Haridoss: Yes, yes.

Prof. R. Nirmala: And, we have gravitation and cosmology. And, we have soft condensed matter on bio physics and quantum computation and information, quantum confinement, quantum interference and the entire set of nanoscience and nanotechnology and this involves low dimensional systems like graphene and similar 2D systems. And, quite a lot

of energy harvesting materials and quantum face transitions that happened close to absolute 0 and strongly correlated electron systems and so on.

Prof. Prathap Haridoss: Okay I mean of course, you see physics I think several of these are also some of these are your areas of expertise. I think your area, you are expert in condense matter, in rarer inter metallic, you also work on strongly correlated electron systems and also on magnetic and transport properties of materials at low temperatures, these are some. So, you are working on really on some of the newer areas.

Prof. R. Nirmala: Newer areas and of course, because it falls into experimental solid state physics I would call that as a traditional as well.

Prof. Prathap Haridoss: Ok, fine.

Prof. R. Nirmala: So there is some link.

Prof. Prathap Haridoss: Now, see if you look at physics. Again, it something that comes from high school, at high school itself students are exposed to a range of topics that get describe to them as physics. So, they are very familiar with what is considered as physics or the thought process that goes into all the things that we look at in physics and so through high school, through you know the process of getting into under graduate programs and also through under graduate programs, they all most all of them have considerable exposure to physics in the engineering field. Given this, when people come in for a Masters program or for a MS program or a PhD program. Do they still face specific challenges in settling into a masters or a PhD program with respect to the physics aspects of it and if so, what do they tend to do to you know handle such challenges?

Prof. R. Nirmala: We do have an M. Tech program and also the conventional M. Sc program under masters and the regular PhD program. So, although the students have exposure to fundamentals of physics, their core physics namely classical mechanics, quantum mechanics, statistical physics, electricity in magnetism and mathematical physics these needs to be strengthened and augmented. So, that is what we do at these

level 2. So, in the initial semesters they undergo a set of these courses, even for a PhD we have a module of foundations in theoretical physics which deals with these core subjects. And, we also have foundations in experimental physics which exposes them to a range of techniques and measurements; they also get some hands on experience doing some basic experiments.

Prof. Prathap Haridoss: OK**.**

Prof. R. Nirmala: Before they get into the actual program, even if a student registers for a PhD in a theory. He does take this other course as well. So, the person going to do a PhD in experimental physics will also be taking the fundamental theory course.

Prof. Prathap Haridoss: OK.

Prof. R. Nirmala: So, that they become.

Prof. Prathap Haridoss: So, there is some uniform you know setting and they come up to and then from there they are able to. But, any particular thing like for example, is the mathematical skills, do the mathematical skills that they have. Are they sufficient in the general, you know general student community coming in for MS or a PhD or do you feel that is something that they need more work on, when they get in?

Prof. R. Nirmala: Actually, we have variety of curricular across different institutes in a country, which is why we have these courses.

Prof. Prathap Haridoss: OK.

Prof. R. Nirmala: We want to bring them to the same platform, when start from there.

Prof. Prathap Haridoss: OK.

Prof. R. Nirmala: So, if there is any lapse, I think the students get to.

Prof. Prathap Haridoss: Gets to catch up.

Prof. R. Nirmala: Yeah, catch up. Do the things.

Prof. Prathap Haridoss: OK. So, now may be if I shift focus a little bit. See, in certainly in engineering often we tend to see a little greater link between say the industry and what engineering departments do. In the case of, I mean a Science Department like physics there are, I mean there is one aspect that I mean, first of all I mean the industry anyway it looks at you know MS and PhD students as people who are specializing in a field and may be some times the exacts and since they are a specialist, it's always a little narrower field and therefore, unless the industries actually directly working on that field they may find it little less interesting to look at a particular candidate. Now, in the case of physics is this an issue and if not also, are there specific area that typical physics department work on which the industry is you know more interested in, the immediate?

Prof. R. Nirmala: I agree with you that, we work on more fundamentals often. So, this over lap may be restricted to some areas, but I would say that this area by itself is large. For example, this functional and advanced materials, comprising, optical materials, photovoltaics, solar cells and you have this organic electronics, oxide electronics, now the recent nano oxide interfaces, graphene oxide interfaces and you have magnetic memories and spintronics and I think these areas have strong over lab with industry.

Prof. Prathap Haridoss: In industry, OK. And if so, when somebody graduates with an MS or PhD, what sort of positions do they get both industry and otherwise also go?

Prof. R. Nirmala: Yeah. So, the very common place the students, now PhD students get into is Postdoctoral position.

Prof. Prathap Haridoss: OK.

Prof. R. Nirmala: So, some students also get into teaching in universities and colleges as soon as they graduate. And, the students who go for postdoctoral fellowships they come

back and teach at institutes of higher learning like NITs, ICERS, IITs and IISC and so on. So, this is teaching in research. As I said, wherever we have this industry over lab we also have some R&D positions for these students in private and government labs, like defense labs.

Prof. Prathap Haridoss: OK.

Prof. R. Nirmala: And so on so on, yeah.

Prof. Prathap Haridoss: And, you mentioned postdoc positions, in science how important is it to do a postdoc position?

Prof. R. Nirmala: I think it's very important to get this exposure and for the experience. In fact, I think positions are offer to people, who acquire enough postdoctoral experience.

Prof. Prathap Haridoss: OK.

Prof. R. Nirmala: I think it is one of the mandatory norms, if you want to get into these institutes of higher learning I mentioned. I think you should have postdoctoral experience.

Prof. Prathap Haridoss: OK.

Prof. R. Nirmala: It helps you broaden you are skills set, over all values, because during your PhD you would have concentrated on 1 specialized area and now, even in that area you can equip yourselves further that more advanced techniques and so on. And, then come back and contribute.

Prof. Prathap Haridoss: OK.

Prof. R. Nirmala: Yeah.

Prof. Prathap Haridoss: Ok ok. Of course, see you have of course, come up as I mean you have also done a PhD and then you have done several postdoc positions and then helps several postdoc positions and of course, you know guided many students by this time. So, there are certain general perceptions on, how we are supposed to you know measure a progress in research? So, we tend to at least in the more mundane way is to simply look at publications and publications. In your view, are there other ways in which you measure you know progress in research that when you look at students you say yes; in fact this person is you know moving ahead in research?

Prof. R. Nirmala: First, my own personal opinion on measuring this success of research or any work that you do is, whether the end of the day you feel good and satisfied that you have done a good days work. So, if you are going to measure the success of a research student or a research scholar, you should check when he or she graduates whether you have made some independent researcher, whether he or she is able to create a problem and also develop a methodology or a way to solve the problem. And of course, as you said the actual measure will be publications in reputed and in peer reviewed international journals, I think that's a usual way of accessing successful outcome of a PhD program, that must be there to and also this research scholar must be able to present himself or herself before expert audience.

Prof. Prathap Haridoss: OK.

Prof. R. Nirmala: More confidently his or her findings and they should be done in national and international level. One can do it by presenting a seminar or talk in a conference at these levels and also this scholar must be able to interact or by interaction I mean, discussion and collaboration with national and international level experts, so whether they have developed that independence and expertise over the years. And, also I think they should have developed out of the box thinking skills.

Prof. Prathap Haridoss: OK ok.

Prof. R. Nirmala: Their own thinking, the independent thinking and I think one more thing in addition to publication these days is, at the end of the day when they graduate

the students must be able to articulate their problems, the problem that they create.

Prof. Prathap Haridoss: OK ok ok .

Prof. R. Nirmala: In a manner that, it fetches them funding.

Prof. Prathap Haridoss: OK.

Prof. R. Nirmala: They can support themselves.

Prof. Prathap Haridoss: Yeah, yeah.

Prof. R. Nirmala: Yeah, because now we have plenty of opportunities in terms of fellowships and projects.

Prof. Prathap Haridoss: Sure, sure.

Prof. R. Nirmala: Projects, yeah.

Prof. Prathap Haridoss: Okay ok. So, if now this I mean, I guess to some degree we were talking of the students as they you know complete and co ahead and so on. During this stay as MS or PhD students, so one of the things that we often talk about is that, there is a lot of learning that they do by interacting with their peers.

Prof. R. Nirmala: Yeah.

Prof. Prathap Haridoss: And, also of course, interacting with their guide or adviser.

Prof. R. Nirmala: Yeah.

Prof. Prathap Haridoss: In general, in your opinion, how often should students be

meeting their adviser and what do you think it is you know is expected to happen in this process?

Prof. R. Nirmala: I would expect that this should happen every day.

Prof. Prathap Haridoss: Everyday, OK.

Prof. R. Nirmala: Yeah. So, in fact, it can be as often as it can be.

Prof. Prathap Haridoss: OK.

Prof. R. Nirmala: It is not like restricted to few times a week or so. So, I see to it I meet my students every day.

Prof. Prathap Haridoss: OK.

Prof. R. Nirmala: And I think that is good and may be more focus discussion on what has been going on can happen on a weekly basis, you can have weekly group meetings when students comes under reports more formally his or her findings. But otherwise, I think interaction must be on it should be a continuous process.

Prof. Prathap Haridoss: OK ok. So, I think it maybe sort of to conclude, what are your words of you know advice to somebody who is aspiring to do an MS or a PhD degree in physics?

Prof. R. Nirmala: I think it's humbling to be asked this question. But, I think I would say a few thinks that probably I have learnt from my experience and with my peers and so on. I think there is no replacement for hard work, I think one should develop good set of work ethics and I think one also should continuously update themselves. So, this is about the literature survey that we do with at the beginning of the research. I think it should be a very continues process and students must continuously update in their own research area and they should, now a days we have plenty of avenues for getting these updates

from international journals about the journals contents and so on. So, they must be doing that.

And, they should also connect with their peer group, by peer group I mean contemporaries, also the seniors and juniors. And, they should interact with each other and they should be a part of a discussion forum and they should participate in department level, seminars and colloquia and not only the seminars in their research area, but also in the other areas as well. And, over all they should develop the values of core physics because when you come for a PhD in physics apart from the course, specialized courses that you do in your own research area you must strengthen your basic physics. So, this means classical physics, quantum physics, electricity and magnetism and mathematical physics and statistical physics. So, I think you should get this done, if it was not done before by the time of your PhD program and when you sign up for a PhD I think you have some inner urge.

So, I am sure the scholar themselves will do some self assessment more periodically and keep growing. And, the other thing I find often in our students is this communication skills, very often research is team work not often I think always it is a team work now a days. So, I think they should develop their communication skills as well, both speaking skills as well as writing skills. When I say writing of course, technical writing is also mandatory process. Yeah, I think these are the points that come up.

Prof. Prathap Haridoss: Actually, in fact, I know and I mean you mentioned a point which I thought of very interesting about you know the fact that they should attend colloquies of even other areas and so on. In that context, how much do you think at least, for example, in IIT, Madras, we have a physics department in the midst of a engineering you know environment. Whereas, there are many other places where physics is in a separate you know environment by itself. So, to what degree do you think this has you know assisted may be let's say, the physics students who are in the Physics Department or in a campus like this.

Prof. R. Nirmala: I think there are quite some interdisciplinary programs already running. I am seeing the connections between physics and chemical engineering, physics and

methodology, and physics and e, physics and chemistry and so on. I do find interesting talks happening in the nearby department, I think one should check out and from their point of view and perspective they are presenting their results, whereas you have some view from physics.

Prof. Prathap Haridoss: Yeah, from physics.

Prof. R. Nirmala: So, I have always got some interesting points by attending talks in other departments.

Prof. Prathap Haridoss: OK

Prof. R. Nirmala: Yeah.

Prof. Prathap Haridoss: Ok so, ok great. Thank you very much for joining us, I think you have given a lot of very nice you know I think input and also a lot of advice for the students aspiring to come in. It was a pleasure having you, thank you so much for joining us.

Prof. R. Nirmala: Thanks a lot Prathap. It was nice talking to you.

Prof. Prathap Haridoss: Thank you.

Prof. R. Nirmala: Thanks.