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EMINENT WOMEN SCIENTISTS RELIVE THEIR JOURNEY IN SCIENCE

> Azadi <sub>Ka</sub> <sup>Amrit</sup> Mahotsav



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> INTERNATIONAL WOMEN'S DAY SPECIAL

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## Dr Rohini Godbole is currently a professor at the Centre for High Energy Physics, Indian Institute of Science, Bangalore. She has worked on different aspects of particle phenomenology over the past three decades, in particular on exploring different aspects of the Standard Model of Particle Physics. Her work regarding hadronic structure of high-energy photons outlined a variety of ways in which to study it and has had implications for the design of next generation electron positron colliders.

SCIENCE

REFLECTIONS

**ON A LIFE IN** 

(8 MARCH 2022)

INTERNATIONAL

WOMEN'S DAY

**SPECIAL** 

She is an elected fellow of all the three academies of science of India and also The World Academy of Sciences (TWAS). Dr Godbole is also a much sought-after communicator of science and an avid supporter of women pursuing careers in science and technology. Along with Ram Ramaswamy, she edited the book *Lilavati's Daughters*, a collection of biographical essays on women scientists from India.

Among the accolades and awards she has received are Padma Shri (2019); Honorary doctorate, IIT Kanpur; Satyendranath Bose Medal of INSA; Devi Award of the *New Indian Express* Group, and Ordre National du Mérite by the French government.

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Was invited to write an article for the special issue of Science Reporter on the occasion of the International Day for Women, based on my Journey in Science. I first thought to myself about the possible starting point of this journey, one obvious candidate being the admission to M.Sc. (Physics) at the Indian Institute of Technology at Powai almost 50 years ago. But on reflecting a bit more I think the seeds of a life spent in learning, doing and teaching science were sown much before, in my childhood itself. So I will start at the beginning, which as advised in the song sung by Julie Andrews in The Sound of Music, 'is a very good place to begin'!

I was born five years after India attained its independence and raised in a typical middle class Maharashtrian family, where education and knowledge were highly valued. My late mother who would have been 96 years old today, had she been still around, was promised by her father that he will make sure she finishes her school before he would think of her marriage and he would respect her wishes of marrying a person with at least a Bachelor's degree! This too at the insistence of his wife, my grandmother, who herself had studied till the fourth grade and read voraciously! Needless to say he fulfilled his promise.

I also had the great privilege of spending my childhood in Pune where the first 'girl's' school was founded by Savitribai Phule in 1848 and Mahadev Govind Ranade started the first 'female English school' in 1884. So it was not a surprise that my three sisters and I were always encouraged in pursuits intellectual and educational from the word go.

In fact, I was a student in the historical 'female English school', which came to be called His Highness Chintamanrao Patwardhan (H.H.C.P) High School or Huzurpaga. At home I grew up in an atmosphere listening to couplets from Sanskrit classics from my parents along with their morning cuppa and my glass of milk. Dinner times were spent discussing, among other things, literature/politics/history/theater/music and even economics. While all this excited interest in activities intellectual and taught me logical thinking, an ingredient essential to a career in science, neither the school nor my surroundings exposed me much to science. The only exception being the Sunday afternoons where my father would read out some popular science news/articles from the Times of India, as I could not yet read/write English having started to learn the subject only in the seventh grade and studying in Marathi medium. I remember hearing from him about the report of something called 'quarks' suggested by Gell Mann and Zweig. Little did I know at that time that they would become my life-long passion.

The real seeds of my life in science were sown when I decided to appear for the State Scholarship Examination which used to be conducted at the state level in seventh grade and only 10 scholarships used to be given. The examination had a paper in General Science. Since in my venerable and very highly reputed girls' school we used to be taught only 'Home Science' till the seventh grade, it This positive experience taught me that one should insist and argue logically for a change in the system, once one is convinced that it is desirable. It has a chance of succeeding if people in positions of authority are reasonable.

was not a surprise that no student from my school had got this scholarship.

I wanted to appear for it and my school teachers agreed to teach me outside the school hours and on holidays. My math teacher (Mrs. Sowani) asked me to come to her house as her husband (Bhau Sowani) was known to be an excellent science teacher. Not only did he teach me things that I needed to know to succeed in the examination (me getting a scholarship 1 INR less than my school fee and feeling mighty proud about it!) but he opened my eyes to the world of science in general. He pointed me to a popular science magazine called *Srishti Vigyan* in Marathi and arranged for the older issues by talking to the publishers. Discussions with him nurtured my interest in Mathematics and encouraged me also to participate in science essay competitions.

Few years down the line after I learnt some English, I also recall reading wonderful books on the lives of famous scientists/innovators such as Marie Curie or Nicola Tesla or Thomas Edison. I wish some were available in Marathi so that I could have read them earlier and also that books such as *Bose and his Statistics* or *Saha and his Formula* were already available then. Be as it may, it is the last three/four years of my school that opened my eyes to science and my first steps in science were taken. Perhaps, it is not a surprise that I ended up being a theoretical physicist as never in all the time spent at the school did we do many experiments or prepared any science exhibits.

Further, while I was an enthusiastic and successful participant in oration, debating, etc. on behalf of the school, edited the school magazine and wrote essays in Marathi/English on all kinds of things there were never any science related activities to participate in. I should add here that in the last year of my school in an essay 'reforms that may be introduced in my school' I actually wrote, "Isuggest that General Science be taught to enable us to compete better in competitive exams" and also further bemoaned the lack of equipment and experience in the science laboratory in school. What was good is that the school actually implemented my suggestions. Looking at it as an outside observer now, I am happy with this positive experience that taught me that one should insist and argue logically for a change in the system, once one is convinced that it is desirable. It has a chance of succeeding if people in positions of authority are reasonable. These experiences did perhaps influence the steps I took when I worked for the issues of 'Women in Science'.

After leaving the school, receiving the National Science Talent Search (NSTS) scholarship of the Indian Government (a precursor of today's KVPY) was one of the major milestones in my journey on the path of science. When I entered college I knew I did not want to do a professional course but wanted to do a PhD and be a professor. I wanted to do a degree in Mathematics. I guess I did not know much about being a researcher at that time, but one of the college teachers had lit the lamp of the excitement about mathematics.

Another reason for appearing for NSTS examination was that while one was mandated to do pure science if one received the scholarship, there was no bar on the income of the parent. Having failed to receive the state merit-cum-means scholarship (in spite of having qualified for it) as my father's (not very high) income was above a certain limit, I was excited about the chance of being able to pay for one's education as it were. Remember this was a recently independent India and the middle class was less than affluent.

The NSTS summer schools exposed me to other educational institutes like IIT (K), IIT (Delhi) or Central University, Bangalore and more importantly to some very smart, talented young students from all over India. My horizons widened. In fact, some of the NSTS scholars I met in those days have gone on to become lifelong friends, many of whom have also made spectacular achievements in the world of science. (I may mention here that Nobel Prize winner Prof. Venky Ramakrishnan and the famous Astrophysicist Prof. Ramesh Narayan, though not cosummer school students, were both NSTS scholars in Chemistry and Physics respectively.)

The summer schools and the books I could buy as a result of the book grant clearly paved the path for my journey in science. In fact, it is only because I got this scholarship that I could think of staying out of town for my M.Sc. and appeared for IIT examination. Some excellent teachers like Prof. S.H. Patil and the environment in IIT (Mumbai) influenced my moving to the USA fordoing PhD and also my choice of subject to do it in. I can say I benefitted from this general program that the GOI had started to attract young minds to science with an aim to foster development of S&T in the modern India.

I should add here that we were very few girls in this bunch of NSTS students (3 or 4 in a group of 35/40) and many of us had studied in all girls' or all boys' schools. But honestly I never felt this affected our academic interactions and exchanges, apart from the impact of the fact that the boys had more time together as they all lived in the same hostel.

Even in the class in IIT (B) we were three girls in a class of 17, but again I do not believe the gender difference affected things and nobody begrudged that the three of us were among the top five in the class. I guess all I am trying to say is that till I went to the US I neither felt nor was made to feel that being a girl student excelling in STEM was something different or unexpected. I was also lucky that my parents supported me wholeheartedly and neglected the gratuitous advice given by extended family to not send a young girl, alone, unmarried to a country like the US. Without their moral support the adventure would never have happened.

One was also busy overcoming other insecurities that seemed much more significant at the time, such as how would one measure up in IIT after having studied at a college and whether one could speak in English. The only thing that I now see as being related to my gender was the advice given by one of the mentors (who liked me and thought well of me) to do a PhD in India as he could find me a good advisor here as well. I can imagine that it arose out of a protective attitude than doubting my abilities, but still the fact remains that he advised a male student next year (who had the same credentials as I) exactly the opposite. As it happened neither of us listened to him: I went to the US and he stayed in India. As luck would have it, both of us have been successful scientists for the past many decades. I was also lucky that my parents supported me wholeheartedly and neglected the gratuitous advice given by extended family to not send a young girl, alone, unmarried to a country like the US. They could not help too much financially, so one had to take a student loan for travel but without their moral support the adventure would never have happened.

My decision to apply to the US was also influenced by a scholarship that the American Association of University Women (AAUW) (if I recollect right) was offering for doing PhD in the US. I finally did not get the AAUW scholarship, but the entire exercise of getting an admission in a US university was started because of wanting to apply for this scholarship. I ended up applying to five places, receiving admission with varying amount of financial aid in three of them and finally joining the State University of New York. So here a program introduced to increase participation of women in education/research helped me indirectly!

The time in the US was full of the usual challenges, anxieties and also the rewards in the life of a PhD student. The world was not as global as it is now. So indeed life in the US was full of quite a few unusual experiences. I can truly say that these enriched my life. A young host family consisting of an Indian particle physicist turned nuclear engineer Debu who was working at a nearby national laboratory and his American wife Catherine indeed provided me a lot of moral support when it was necessary. Mentoring from Debu was really useful as he knew my field of research and even the faculty at the University rather well. But it was also the first time that I became aware, to some extent, of the issue of gender in science during my interactions

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with the girl students at the University who thought that doing physics hampers your chances of getting a good boyfriend. But even then I saw it more as in issue of the American environment and not really relevant to myself.

After finishing my PhD, to some extent the feeling of home sickness and also to some extent the dreams of making contributions to Indian science and society, led me to my decision to come back without any post doctoral experience, in spite of an offer of a position in Europe and a possible promise of one in the US. A good post-doctoral experience can have a defining impact on the life of a young scientist. In that sense my decision to come back without any of it was perhaps immature. Luckily the action did not impact my scientific journey adversely. It is only now when I look upon those decisions from a distance that I see that some of the mentoring I received then might have been influenced by my gender.

A big difference in the career of a scientist as opposed to other professions is the early period after getting the degree of PhD during which you have to create your own research niche. This essentially defines one as a researcher. After working for three years at the Tata Institute of Fundamental Research (TIFR) as a Post Doctoral Fellow (PDF) where I was the first woman PDF to join the Theoretical Physics group, I worked at the University of Mumbai for about 15 years, two of these being spent in Germany.

I cannot say that life was simple in these times but it was full of challenges, hard work and yet exciting. The support of some of the erstwhile collaborators at TIFR, the friendships with the young student and PDF community in TIFR, their belief in my desire and ability to create my own place in the field played a crucial role during these times. The unwavering support of my family and no pressure to 'settle' in life, respecting my decisions was crucial in this period. Equally important was the moral and Institutional support of my senior mentor in the Department of Physics, Prof. Rangwala, who appreciated my strong desire to continue research at high level even in the not so well-endowed university environment.

Did I experience gender bias in this journey? On meeting a scientist in Europe for the first time I heard that 'he had seen papers by my husband'. Of course he had not realised that he was talking about papers written by me as I had no husband at that time! I was also told by a senior professor on a seminar visit to a University in Germany that he always thought I was a mani A day in my life those days had may be more than 24 hours and the journey in science consisted of going to the university department in the first half of the day and teaching, following it up with a journey to TIFR and then back home late in the night. The informal nature of scientific collaborations when different scientists are interested in seeking answers to the same questions also helped in my continued collaborative work with friends in and outside India.

I was somewhat late in getting off the block but was lucky to have hit upon some interesting ideas that made a lot of impact. The whole hearted appreciation of the work by the community reflected in invitations to give talks at conferences (no matter small or big), give lectures at special topic schools for PhD students, etc. bolstered my confidence no end. The confidence that some senior members of India's particle physics community giving me these responsibilities at a young age, was a source of great encouragement. For any scientist, young or old, this appreciation by the community brings far more satisfaction than any awards or rewards could bring.

But slowly those too started coming my way when I was the first woman to be elected fellow of the Indian Academy of Sciences in its physics section. I would be remiss if I do not state how one enjoys the high one gets when one uncovers how a small piece fits in the big jigsaw puzzle, which others had missed or when one has been able to charter some new direction of scientific investigations which some others find worth following, even though in the end it might lead to a dead end.

Did I experience some gender bias in this journey? Somewhere along the way on meeting a scientist in Europe for the first time I heard that 'he had seen papers by my husband'. Of course he had not realised that he was talking about papers written by me as I had no husband at that time! I was also told by a senior professor on a seminar visit to a University in Germany that he always thought I was a man! These amused me more than anything else. On reflection I now see the gender unfriendliness of some of the experiences I had as a young scientist still trying to find her way.

I can remember advice given to me when I was at that stage: 'your best bet is to find job in a woman's college in a mofussil area' or an exclamation 'I did not realise you were so serious about research'. May be these mentors believed truly that these were my limitations, but had I taken any of these to heart I would not be here today writing these lines. So perhaps one needs to mentor the mentors themselves and not focus only on mentoring programs for women.

Somewhere in this period I met a German theoretical physicist and we got married. The usual two body problem meant that we conducted a marriage across two different countries and continents. In fact while part of the reason to move from Mumbai to far away Bangalore was the allure of the Indian Institute of Science, part motivation was also to solve the two body problem. While the bond with IISc developed and continued strong, The percentage in permanent Faculty positions is woefully small. It falls even more when one considers higher positions of authority and decision makers. Further it also seems to fall with the perceived prestige of the Educational and Research Institutes, as is also noticed in the latest AISHE reports. The only exception seems to be the mission oriented DRDO/ ISRO laboratories. The last fact deserves some pondering over.

fruitful and enjoyable, unfortunately the bond of marriage did not. We had decided to postpone having a family till we both were in the same place and that never happened. My one regret is not having children, but I will be unfair to my nephews and nieces if I do not say that the love and affection I get from them offsets some of the regret. But this has given rise to my belief that a woman requires an extra dose of luck to be a successful scientist, have a happy marriage and a happy family. In fact many of the contributors to *Lilavati's Daughters: Women Scientists of India* also recounted the role that luck had played in their lives. If we can somehow take luck out of the equation that would be great.

The move to IISc in a senior position in the middle of my career did help professionally even if it produced its share of issues to be dealt with. In addition to research and teaching, I started getting more involved in building up activities for the particle physics community in India, being one of its responsible members, being the editor of the physics journal *Pramana* published by the Indian Academy of Sciences, writing graduate text books, etc. I set up international collaborative projects, was a member of various advisory bodies of the GOI and was also part of the committee overseeing the CERN-India collaboration at the Large Hadron Collider (LHC). In some sense this period gave me possibility to sample what I call the 'social' aspects of a scientist's duty to the science community.

What have been 'ah!' moments of this life? It is finding at the end of a long week that the predictions of a model you and your collaborators have put together agree with the data. It is being present at CERN on the day of the announcement of the discovery of the Higgs: a subject that has formed a major part of my scientific investigations and giving lectures within the hour, on the subject of the Standard Model, to summer students at CERN. It is meeting a student in the Netherlands and her showing me a video of my lecture which she attended at a school in Oran (Algeria), it is meeting a student in Beijing while travelling for the meeting of the advisory body of the Circular Electron Positron Collider in planning in China, him telling me that he had listened to my lectures at CERN in that summer few years back. It is seeing an increase in the impact factor of a journal one has been editor of or a young student telling how he still remembers a talk on particle physics that he heard from me in the library of a university department in Srinagar...I have been lucky. I have been able to savour many such moments. These are the true rewards of a life in science.

Apart from the increased engagement with activities concerning the particle physics community in India, I also got involved in the issue of Women in Science in India. The initial trigger was an invitation to give an invited talk about experiences of being a woman physicist in India, at the first International Conference on Women in Physics (WiP) held by the International Union of Pure and Applied Physics (IUPAP) in 2002 in Paris. It was the beginning of a journey on a pathway in science that I had never contemplated walking on and in which I have learnt a lot.

I had not much thought about the aspects of gender in science till then. But looking back at what I had experienced and observed in the 25 years of my life in science till then, I realised that this is a point that certainly needs attention. In my experience at the conference with my physicist friends from all across the world, I realised that our young girls of today need to have role models they can relate to and not just the great Marie Curie or Dorothy Hodgkin or Catherine Lonsdale. Great as they were, they inspire but the dizzying heights to which they rose makes one fear that this is a goal out of one's reach. This gave rise to Lilavati's Daughters: Women Scientists of India and A Girls Guide to Life in Science which consisted of autobiographical sketches of women who worked or trained as scientists in independent India. The tremendous response to the book, including its appearance in a question on KBC is testimony to the need for such a book.

I have been involved in many efforts and programs which I hope will contribute making participation of women in science equitable and effective. These include, for example, editing the above mentioned books, formation of the Panels of Women in Science of the Indian Academies, bringing out a report on Indian Women's Access to a Science Career, being involved with the Women in Science programs of the Department of Science and Technology (DST) and bringing out researched survey on why we in India lose trained scientific woman power. Experiences gained in these 20 years also helped in suggesting policy measures in the latest Science Technology and Innovation Policy. The STIP-2020, for the first time in the history of India's policy documents, includes a chapter on 'Equity and Inclusion'.

In India we do not have shortage of young girls studying STEM subjects and excelling. The fraction has increased steadily and over the past many decades it hovers around 30-40%. This is clear also from the reports of All India Survey of Higher Education over the past

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decade or so. In fact even the fraction of women PhDs in STEM subjects has been consistently around 20-25% over the past three-four decades. It is much smaller in institutes like IIT's but the special initiatives like supernumerary positions for girls and the Vigyan Jyoti program of the DST are improving the situation. However, the percentage in permanent Faculty positions is woefully small. It falls even more when one considers higher positions of authority and decision makers. Further it also seems to fall with the perceived prestige of the Educational and Research Institutes, as is also noticed in the latest AISHE reports. The only exception seems to be the mission oriented DRDO/ISRO laboratories. The last fact deserves some pondering over.

Balancing career and family is obviously a challenge that all the professional women, the world over, have to manage. For early career women scientists (right after their PhDs) there is an additional special challenge of the simultaneously ticking professional and body clocks, due to the overlap of the period when one should establish one's own laboratory and also start a family. This increases the need for creating support structures for young women scientists in this early period of their career and relaxing the age norms for various schemes such as the INSPIRE faculty fellowships. Many of the *Lilavati's Daughters* were successful in creating such support mechanisms.

The GOI, through the aegis of the DST and the Department of Biotechnology (DBT), indeed has put in place very welcome schemes which help women to come back to a career, after a break for family reasons. A good crèche, as recommended in the report of the DST Task Force, is now a part of many good educational and research institutes. Majority of the community (women included) seem to think that we need to take steps to handle these obvious challenges and then all will be well. These measures as necessary as they are, however, are not sufficient.

The STIP 2020 suggests additional measures such as 'dual hiring policy', 'flexi-times' or consideration of 'academic age' rather than the 'biological age', etc. These will further address the obvious challenges. But I personally do believe that more measures, addressed at the young women PhDs/PDFs, are needed. Examples are flexibility in the validity of the period of the PDF positions or realising that women-friendly measures on the campus such as creches need not be restricted only to women faculty of the Institute. The DBT-Welcome group fellowships already implement such ideas.

Perhaps an even more important challenge is the unconscious bias which arises due to our notions of what a woman should do or should not do, what women can do or cannot do. The lack of importance that the society, scientists included, attaches to a woman's participation in science both reflects and feeds these biases in our attitudes in a big way. Even the above mentioned measures to attain gender equity in scientific work force are not unaffected by them. I believe these could also be responsible for the small fraction of women in the topmost positions on the ladder and perhaps also the small share in academy fellowships, Bhatnagar awards, etc. Sometimes these invisible biases then translate into visible obstacles.

Our survey 'Trained Scientific Woman Power: What fraction are we losing and why' had concluded that while family responsibilities is one reason why women leave the scientific workforce after a PhD, the unwelcoming, cold atmosphere in the Institutes/Industry and unhelpful attitudes on part of scientists towards the young women was also a reason. I believe such attitudes also arise from our invisible and unspoken biases.

So what is needed is raising awareness of this issue at all levels. One needs to be aware of this while forming the policies as well. For example, if the 'child care leave' is made gender neutral, it will be free of the bias that child care is only a woman's duty. More importantly it will save the women from the backlash that such policies sometimes lead to.

The special chapter on equity in STIP 2020 and recommendation of developing an all India 'Equity and Inclusion Chapter' suggested therein is very welcome indeed. The chapter also contains specific policy recommendations such as mandating 30% women in all the decision making bodies. The awareness raising has to happen for all: individuals, scientists and institutions. One way to get the Institutes more involved in this effort is the Gender Advancement Transformative Initiatives (GATI) of the DST. But these efforts shall be successful only if they are not looked upon as efforts by women and for women. The entire community has to take the ownership of the effort.

It is important for all of us to realise that the efforts to achieve Gender Equity are not to be looked upon either as charity or justice for women but also as a process that is beneficial to science itself. Diversity in scientific workforce can only make the complex space of research, innovation and knowledge more vibrant and hence more productive. Women need to do science to give full expression to their intellectual abilities but science also needs women.

It is science for women and women for science. The sooner we understand this two-way street the sooner we will reach a day when we will stop talking about women scientists and women engineers. They will be just scientists and engineers who happen to be women. I dream of the day!

I wish to end with a small message to the young readers, of either gender. Be true to yourself and choose your path in life because your heart desires it, after evaluating critically your own abilities. You are the best judge to decide what you can or cannot do. Even in scientific investigations do not choose a research area simply because it is fashionable. Once you are trodding the path you have thus chosen, no obstacle is too difficult and no mountain too high. Reach for the sky. The world is yours.



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