Women in Physics and Mathematics

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Women in Science
An Indian Academy of Sciences Initiative

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ICTS summer School on Mathematics and Statistics

May 9, 2018,

ICTS, Bangalore

Plan

1) Origin of the idea of this colloquium and preliminary remarks

2) Inspiring stories of women of physics and mathematics from early history upto middle of 20 th Century. *What do we learn from the stories?*

3)What is the current situation?

Have the issues changed? ***What needs to be done?***

Origin of the collquium

Solvay Conference 1927

Only one woman

Mme Marie Curie

ICTP conference 1960

single woman but not

a physicist

Two photographs in the building of German Physical Society

Lise Meitner, 1878-1968.

Why discuss issues of women in science?

Number of women doing science small world over

Is that necessarily bad?

Yes..it is certainly not the optimal use of humanity's intellectual potential. Diversity can only be good for science, as for any creative activity.

Changing economic realities mean, at least in India, that the number of women participating in science is going to increase.

Important to discuss what efforts will make this more efficient and more effective!

Some myths, some biases...

U.S. Supreme Court Chief Justice Roberts (2015)

"What unique perspective does a minority student bring to a physics class?"

Tim Hunt (Nobel Prize winner 2011: Physiology and Medicine) (Interview in 2015)

"Let me tell you about my trouble with girls … three things happen when they are in the lab … You fall in love with them, they fall in love with you and when you criticise them, they cry."

Why focus on physics and mathematics?

We are a long way from gender equity in science! Numbers are small across all disciplines.. but some are more unequal than others!

i.e. the numbers are even smaller in physics and maths generally compared to other disciplines.

Harvard President: Larry Summers

"Women lack capabilty in Mathematical and Physical Sciences"

Women's day slogan 2018!

#Pressforprogress

There is hope to fullfil such pledges if all scientists – natural and social scientists together -- discuss and try to look at the issue like a scientific probelm.

Needs to be discussed at all fora, all levels and NOT necessarily only on special occasions!

About myself

I am a Theoretical Particle Physicist.

My work deals with theories of interactions among the fundamental constituents of matter : quarks, leptons and gluons.

Currently I am engaged in studying theoretical issues that can be probed in the experiments being performed at the high energy frontier at the large hadron collider **LHC** at **CERN**. Theoretical physicists use maths to unravel secrets of nature and understand the laws governing all the phenomena in the universe!

About myself: context Women in Science (**WiS**)

1) An invited speaker (among 9) at the first IUPAP International Conference on Women in Physics held in Paris in 2001 & **involved with the IUPAP group on Women in Physics since then.**

2) One of the editors of the INSA report on 'Science Career for Women in India brought out in 2004 .

INSA: Indian National Science Academy

(IUPAP: International Union of Pure and Applied Physics)

About myself: context Women in Science (**WiS**)

3) Chair of the **WiS** panel of the Indian Academy of Sciences and Indian National Science Academy and Member Joint Panel of all the three academies for 'Women in Science'.

4) Author of survey-report: '*Trained Scientific Woman Power*: **what fraction are we losing and why**?'

About myself: context WiS

Co- Editor (with R. Ramaswamy) of two books to encourage girls to take up Science:

1) Lilavati's Daughters : Women in Science in India

(Publisher: Indian Academy of Science, 2008)

2) A Girl's Guide to Life in Science:

(Publisher: Young Zubaan, 2010)

Now being translated in various Indian Languages

Can be seen at

http://www.ias.ac.in/womeninscience/

References

I have collected information over the years from various sources. But at present I will list one or two sites which have a lot of information.

Women in mathematics:

1) agnesscott.edu/lriddle/women/chronol.htm

2)womenshistoryabout.com/od/sciencemath1/ss/Women-in-Mathematics-History.htm#step1

References

Women in physics:

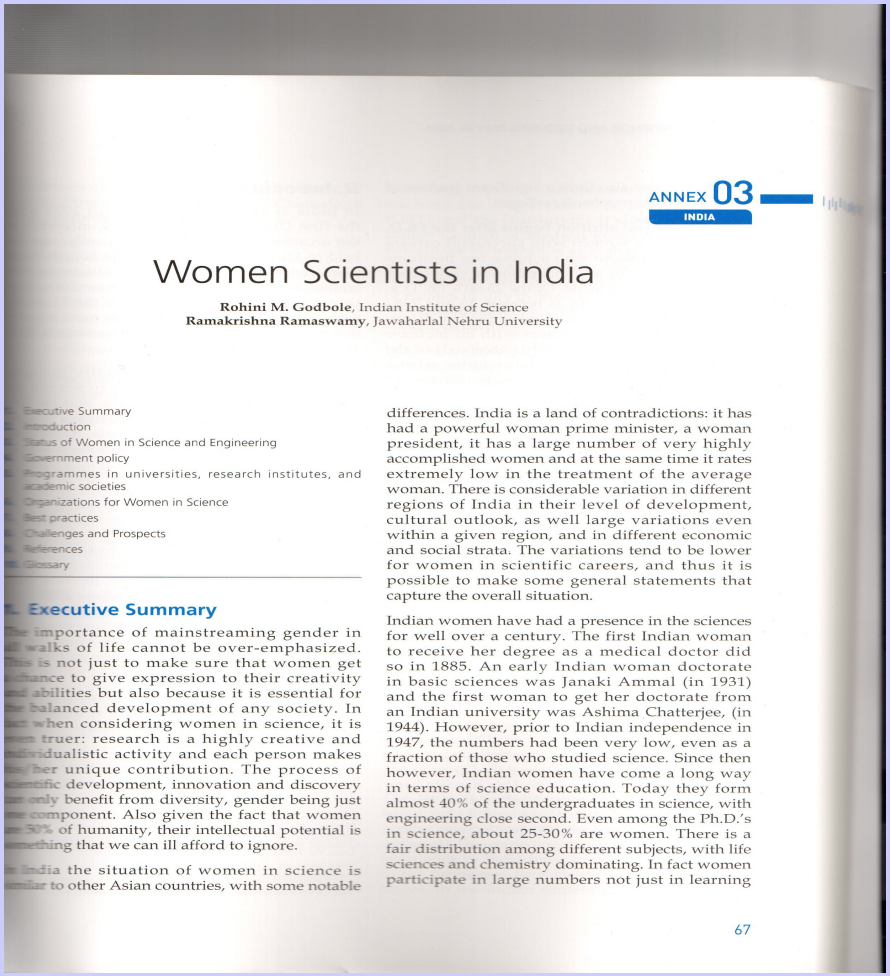
The web site maintained by APS and links from there provide a lot of information:

1) http://www.aps.org/programs/women/

2) There is also a very nice set of articles by Nina Byres

Reference

Association of Academies and Societies of Sciences in Asia: AASSA report



ANNEX 03
INDIA

Women Scientists in India

Rohini M. Godbole, Indian Institute of Science
Ramakrishna Ramaswamy, Jawaharlal Nehru University

1. Executive Summary

The importance of mainstreaming gender in all walks of life cannot be over-emphasized. This is not just to make sure that women get a chance to give expression to their creativity and abilities but also because it is essential for the balanced development of any society. In fact when considering women in science, it is even truer: research is a highly creative and individualistic activity and each person makes his/her unique contribution. The process of scientific development, innovation and discovery can only benefit from diversity, gender being just one component. Also given the fact that women are 50% of humanity, their intellectual potential is something that we can ill afford to ignore.

In India the situation of women in science is similar to other Asian countries, with some notable differences. India is a land of contradictions: it has had a powerful woman prime minister, a woman president, it has a large number of very highly accomplished women and at the same time it rates extremely low in the treatment of the average woman. There is considerable variation in different regions of India in their level of development, cultural outlook, as well large variations even within a given region, and in different economic and social strata. The variations tend to be lower for women in scientific careers, and thus it is possible to make some general statements that capture the overall situation.

Indian women have had a presence in the sciences for well over a century. The first Indian woman to receive her degree as a medical doctor did so in 1885. An early Indian woman doctorate in basic sciences was Janaki Ammal (in 1931) and the first woman to get her doctorate from an Indian university was Ashima Chatterjee, (in 1944). However, prior to Indian independence in 1947, the numbers had been very low, even as a fraction of those who studied science. Since then however, Indian women have come a long way in terms of science education. Today they form almost 40% of the undergraduates in science, with engineering close second. Even among the Ph.D.'s in science, about 25-30% are women. There is a fair distribution among different subjects, with life sciences and chemistry dominating. In fact women participate in large numbers not just in learning

India Report prepared by Rohini Godbole and R. Ramaswamy

References

Some thoughts on analysis, possible solutions:

CURRENT SCIENCE

Volume 112 Number 4 25 February 2017

GUEST EDITORIAL

Women in Science in Greek times!

(350) 370—415 (416)?

Hypatia: certainly one of the earliest known woman mathematician.

Daughter of Theon who was the last known member of the Library of Alexandria.

She created commentaries of classic mathematical works and lectured to students. Was also a philosopher.

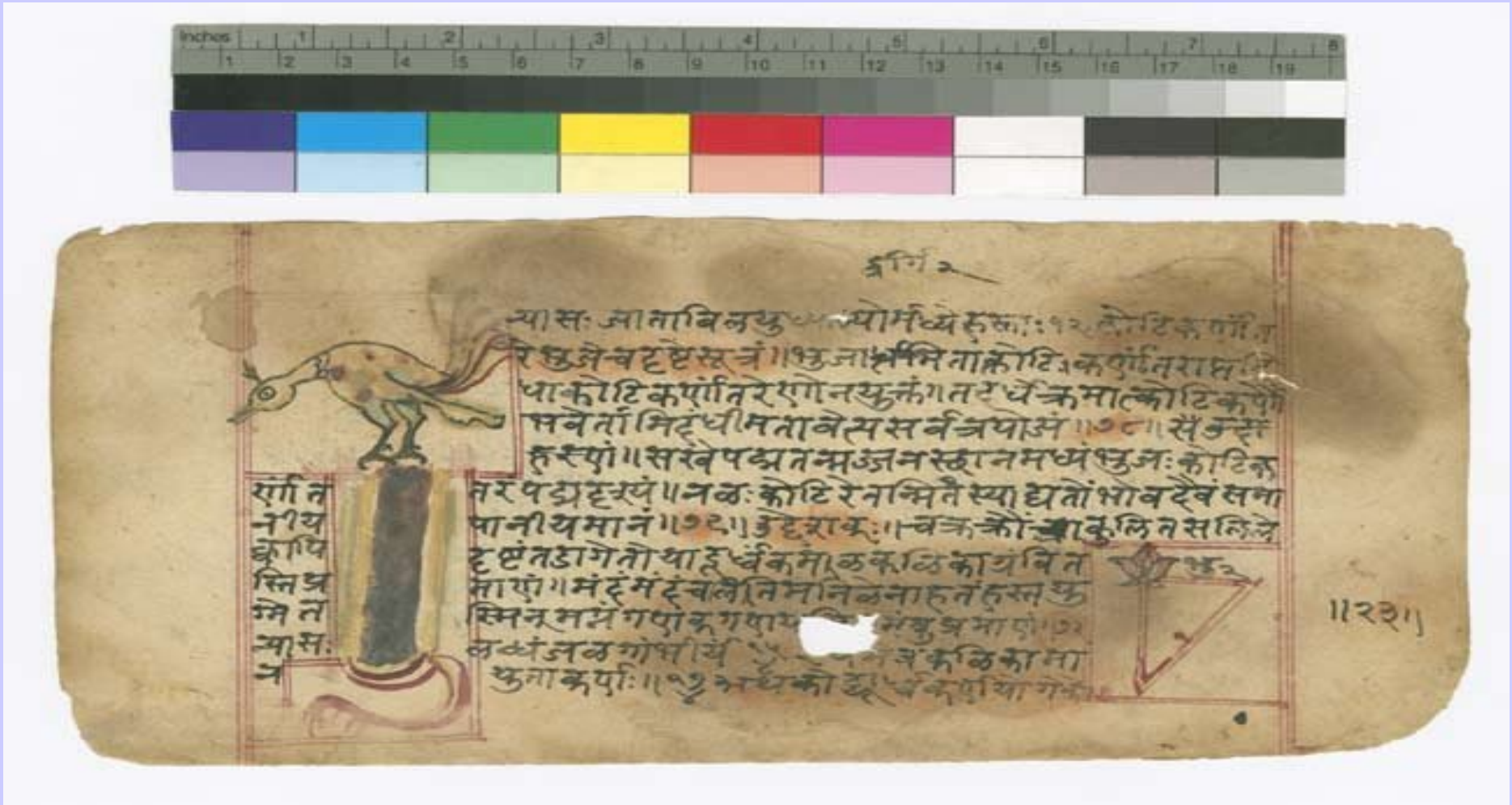
An Indian mathematician?

In the 12 th century mathematics in India was flourishing. A treatise on arithmetic written by Bhaskara-II (one copy of the manuscript in Courant Institute) is called 'Lilavatii' . In this he writes most of the probelms addressed to 'Lilavati' (the book is dated to be 1150):

"Fawn-eyed child Līlāvatī, tell me, how much is the number [resulting from] 135 multiplied by 12, if you understand multiplication by separate parts and by separate digits. And tell [me], beautiful one, how much is that product divided by the same multiplier?"

Lilavati?

The book contains many problems as verses and are often illustrated



17th century

Elena Lucrezia Cornaro Piscopia: (1646-1684)

Was not allowed to study theology because she was a woman.

(Margarete Alic)

But allowed to study Philosophy

First woman Ph.D. in 1678 University of Padua

18th Century

1) 1706-1749 : Emile du Chatelet

2)1718-1749: Maria Agnesi

3)1776-1831: Sophie Germain

4)1799-1847: Mary Anning

5)1780-1872: Mary Sommerville

6)1750-1848: Caroline Hershel

Sohie Germain (1776-1831)

Self taught. Had to fight against the family and society. **It was not proper for a 'middle' class girl to study mathematics and science!** **Lack of formal training!**

Women not allowed in Ecole Polytechnique

Used a pen name of a friend to communicate with Lagrange, Gauss.

Important work on theory of elasticity and fermat's last theorem . **First woman to win a prize from French Academy**

The family took away her candles so that she should not study at night!

Quote from Gauss:

``How can I describe my astonishment and admiration on seeing my esteemed correspondent M leBlanc metamorphosed into this celebrated person. . . when a woman, because of her sex, our customs and prejudices, encounters infinitely more obstacles than men in familiarising herself with [number theory's] knotty problems, ..."

``She [Germain] proved to the world that even a woman can accomplish something worthwhile in the most rigorous and abstract of the sciences and for that reason would well have deserved an honorary degree"

Mary Sommerville (1780-1872)

She was drawn to Mathematics by equations appearing in a fashion magazine! Father opposed studying science. She was married .

After the death of her first husband, the second husband was extremely supportive.

Supported by John Playfair. In contact with Babbage and Herschel. Translated books by Laplace and made commentary. Her work inspired search for Neptune! **First woman (honorary) member of the Royal Astronomical Society.**

Woman of Science. She wrote about the process of Science.

Caroline Herschel (1750-1848)

Astronomer: sister of William Herschel.

Came to England to help her brother keep house!

As Royal Astronomer WIilliam Herschel asked the king to 'pay' his assistant.

So she became the frst woman who got paid for her research! Got a gold medal of Royal Astronomical Society . Contributed to searches of nebulae, clusters, comets!

Referred to herself as Cindrella of the family!

19th /20th Century

1) 1815-1852: Ada Lovelace (Developed first algorithm)

2) 1850-1891: Sofia Kvalevskya (mathematician)

3) 1818-1889: Maria Mitchell (USA) (Astronomer)

4)1867-1934: Marie Curie

5) Charles Anges Scott (British, worked in the USA)

6) 1882-1935: Emmy Noether (130 years of Noether's therorem)

7)1878-1968:Lise Meitner, theoretical physicist.

8)1912-1997: C.S. Wu, Proved parity violation exptally

9) 1906-1972: Maria Goeppert Meyer.

Ada Lovelace (1815-1852)

Daughter of Lord Byron. Encourgaed by mother. Tutored by Mary Sommerville. Interactions with Babbage and he encouraged her to write a commentary on an article by Luigi Menabrea from Turin on the 'Analytical Machine' proposed by Babbage.

This comment contained the first algorithm.

Literature has mentioned about doubts whether she did the work! Unfair!

Sofia Kovalevskya (1850-1891)

Made a marriage of convenience to get to europe to study mathematics. Did important work on differential equations . Mentor was Weisstrass. Became the first woman professor in Mathematics in Europe at Upsaala. Winner of Prix Bordin!

Unhappy and lonely personal life:

``I am as misreable as a dog. No I hope for their sake that dogs can not be as unhappy as human creatures, especially as women!''

Sometimes unfair statements about the work being Weissstrass's!

Marie Curie (1867-1934)

Marie Curie:

Life is not very easy for any of us. But what of that? We must have perseverance and above all confidence in oursleves.

We must believe that we are gifted for something and that must be attained!

Scientist par exellence: man or woman!

Got her position after accidental death of Pierre Curie who never failed to emphasize her contribution!

Emmy Noether (1882-1935)

Called a creative genius by Albert Einstein.

Did enormously important work which underpins all the theoretical physics of 20 th Century and same is true for Mathematics!

Could not get a degree for a long time because women were not allowed in the University.

First woman to get a degree from Univ. of Erlangen. Did not get a 'paid' teaching positions for 7 long years after Ph.D. In this time she was working at Gottingen and teaching Hilbert's classes.

Gave a talk at the International Mathematical Congress without a permanent position.

Emmy Noether

Charls Anges Scott : Bryn Mawr College created funds for her to come to USA to escape Nazi Germany! A woman's college!

Used to travel to Princeton Univ. To give lectures. She did not like Princeton University men professors!

Immensly successful as a researcher, teacher. Noehter boys and Noether Girls.

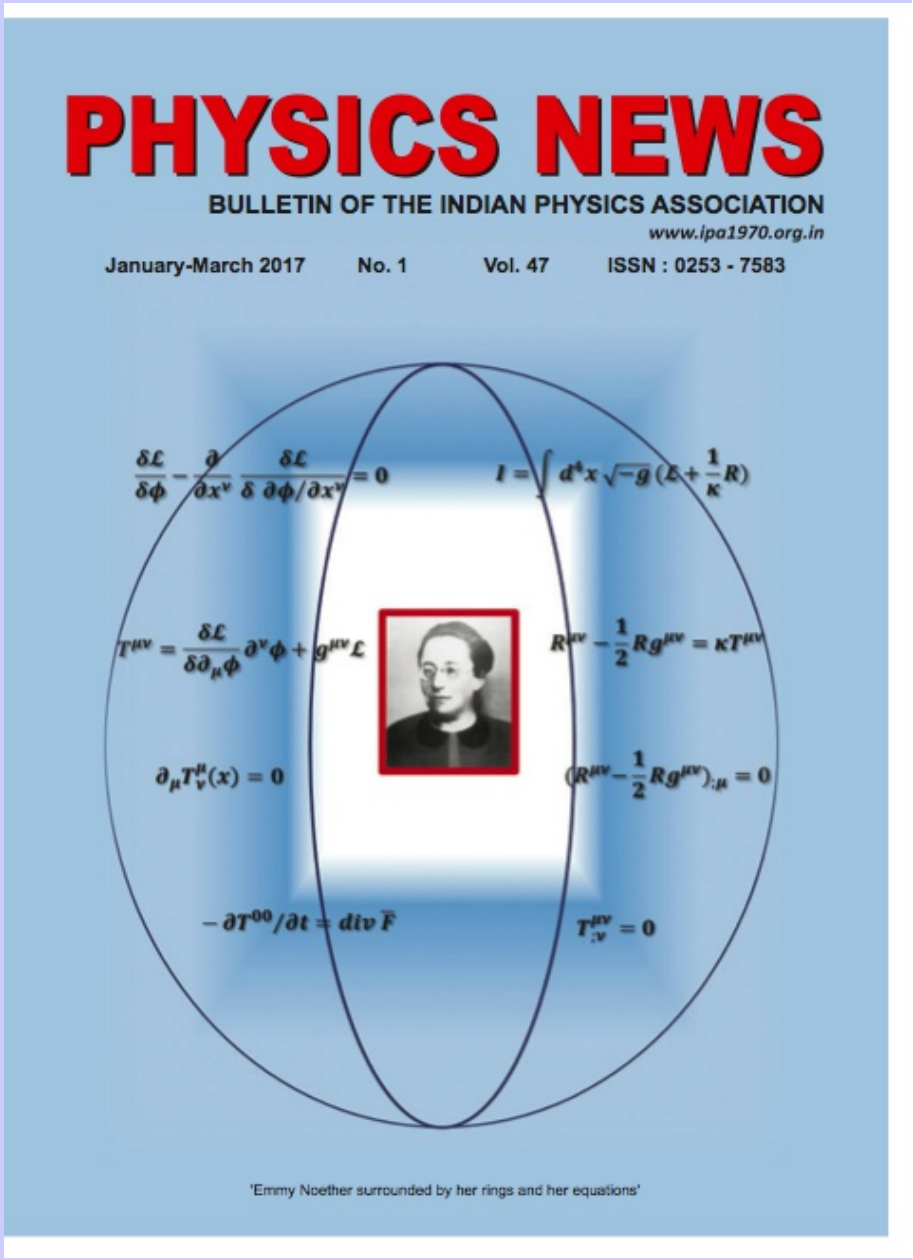
Support from family in all ways.

Emmy Noether related digression

Physics News (IPA quarterly) March issue this year contains only articles by women. (IPA: Indian Physics Association)

Interestingly in the last two years there was not a single article by a woman in Physics News!

PS not just PN but Resonance of March 2017 has articles only by Women and Current Science has a special section!



Gallery will be incomplete without

1882-1935 (Ackerman Teubner Memorial Prize: 1932.)

1977-2017 (Fields medal 2014)

Pileou

Mother of Mathematical Ecology.

Did the entire research work from home, by herself and submitted it to Univ. of London. Born 1924, got first university job 1968

Started the subject of mathematical ecology: modeling of natural systems. Eminent Ecologist award in 1986.

Wrote a paper showing that Robert Mcarthur (a very eminent ecologist) was wrong . 'Correction to the McArthur formula for abudnance of species'

Pileou 1924-2016

LITERATURE CITED

Kendall, M. G. and A. Stuart. 1958. The Advanced Theory of Statistics. Vol. I. Hafner Publishing Co., New York. 433 p.

MacArthur, R. H. 1957. On the relative abundance of bird species. Proc. Nat. Acad. Sci. U.S. **43**: 293-295.

———. 1960. On the relative abundance of species. Amer. Naturalist **94**: 25-36.

Pielou, E. C. and A. N. Arnason. 1966. Correction to one of MacArthur's species-abundance formulas. Science **151**: 592.

Vandermeer, J. H. and R. H. MacArthur. 1966. A reformulation of alternative (b) of the broken stick model of species abundance. Ecology **47**: 139-140.

NOTE ON MRS. PIELOU'S COMMENTS

ROBERT MACARTHUR

Department of Biology, Princeton University

I am happy to agree that Mrs. Pielou's f rmula is literally correct, and ours only ximation. We took what amounts to an average niche subdivision and then ranked abundances; Mrs. Pielou ranked abundances and then took expectations. The distinction between these processes when applied to a single census is somewhat vague biologically and almost undetectably small numerically. Hence a graph with Mrs. Pielou's correct formula will superimpose almost perfectly on ours.

Let us hope these comments do not draw additiona attention to what is now an obsolete approach to com munity ecology, which should be allowed to die a natura death. To forestall future waste of time, I shall add tha there is also an error in my relative abundance pape (Amer. Nat. **94**: 25-36) in the first page of the appendix as Mr. Joel Cohen of Harvard University has kindl pointed out to me. Anyone interested may consult hi for the correct formulation.

19th /20th Century

The hidden figures:

1) Dorothy Vaughan 1910-2008, 2) Katherine Johnson 1918- , 3) Mary Jackson 1921-2005. 4)Mary Tsingou 1928 - .




So what do we learn?

All supremely confident of their science and also enjoyed their science.

Mentor support was essential.

Attitude of the community is not always helpful for women to conduct a career in science. ***More sociological than academic. Academia will normally bow to supreme achievements. None the less sociological biases leads to illogical obstacles. Imaginable that this can be a major cause in other cases.***

Even if academic achievements were appreciated, here seems to be a bias in recognition and awards coming women's way!

Quite a few were single or married to fellow scientists!

Indian women in Technology ISRO

India

Does that mean we have lot of women physicists and mathematicians?

In modern day India woman physicisst of note from the period 1930 onwards to 1960 that come to my mind

Prof. Anna Mani, Head of Meteorolgy Institute,

Dr. Purnima Sinha, Central glass and ceramic research institute.

Prof. Bimla Buti, Plasma Physicist, PRL

Prof. Chanchal Oberoi, accomplished mathematician and plasma physicist, IISc. First woman dean in IISc.

Prof. Parimala, TIFR, Mathematician.

Prof. R.J. Hans Gil, Punjab University, Mathematician.

: Indian story today?:

At least in academia women are not perceived as being incapable of intellectual attainment in mathematics or science (many university prize winners in science are women). We dont seem to have our Larry Summers

But we still dont seem to be exactly inundated with women doing science!

First Current Status!

The presence of women students in Schools and Colleges high and their level of achievement high

However participation of Women in Research in Science is low, presence in high positions in academics low as well

Serious leakages in the pipeline from college to university to scientific careers

An obvious conclusion

- In India the participation of women in

  studying science

  or for that matter in

  teaching science, **at all levels**,

  is NOT LOW AT ALL.

- However, number of women

  doing science

  is certainly NOT commensurate with their participation in the other two aspects of scientific activity.

- Further it is even less when one considers decision making positions in this context.

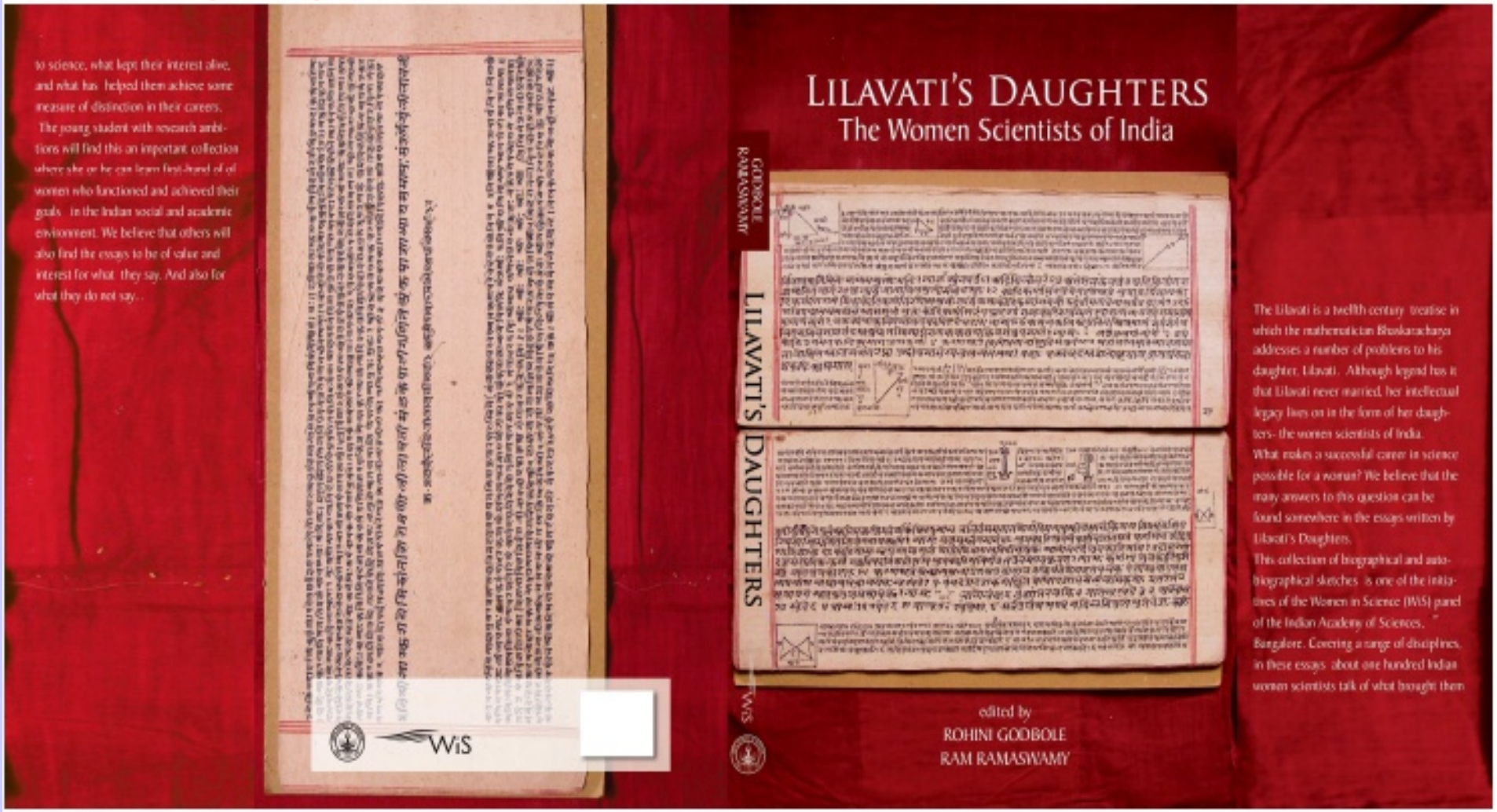
Stories from India? Lilavati's Daughters

In 2005 we brought out a book of stories of Women scientists who trained and/or worked in the Indpendent India!

We called it '*Lilavati's Daughters*'

We felt that role models are the most important things.

The book is available from Indian Academy. Department of Science and Technology supported distribution of this book to schools and colleges, **Translations to local languages are on.**



Anandibai Joshee (1865-1887)

Anandibai Joshee, the first Hindu woman to obtain a medical degree in the US at the University of Pennsylvania.

Learnt alphabets (marathi) at the age of 12! went to the USA at 17/18.

She died in Poona at the age of 22.

D Sc (1931, Michigan), Founder Fellow of the Indian Academy of Sciences.

Padmashri.

Renowned botanist and plant cytologist who made significant contributions to genetics, evolution,phytogeography and ethnobotany.

Chose to remain single!

Anna Mani, FASc, FNA, Ph.D. (submitted 1945). Worked with, India's only Nobel Prize winner in Physics, C.V. Raman. Deputy Director of Meteorological Department, Director General of Observatories in Delhi, Remained single.

Purnima Sinha., First woman Ph.D. in physics, 1956, Advisor: Satyendranath Bose, Worked in Central Glass and Ceramic Research Institute. Daughters and nieces are all successful physicists.

Bimla Buti, Ph. D., 1962, Chicago

Theoretical Plasma Physicist.

Advisor: S. Chandrasekhar

(Astrophysicist Nobel Prize winner)

FNA,FNASc, FTWAS.

President Commission C49 of IAU,

Worked in Physical Research Laboratory.

Chose to remain single.

R.J. Hans Gill, Ph.D. 1965

FTWAS, FNA, FNASc, FASc

R.J. Hans Gill in School. She dressed as a boy so she could go to a school where they taught mathematics!

Common Themes

Parental (and in-law) support.

Strong role models in schools and colleges, usually female.

Help during early career, especially for raising children.

Mentors, senior colleagues.

Chance.

These observations can then direct possible actions for retention and remove Chance from the list!

Some things are better

But some things are better than the other countries

Kathleen Lonsdale and Marjory Stephenson in 1945

First women elected to the Royal Society (1660):

In 1979, Yvonne Choquet-Bruhat was the first woman elected to the French Academy of Sciences (1666).

Florence Sabin (1871-1953), elected in 1925, was the first woman member of the NAS (1863)

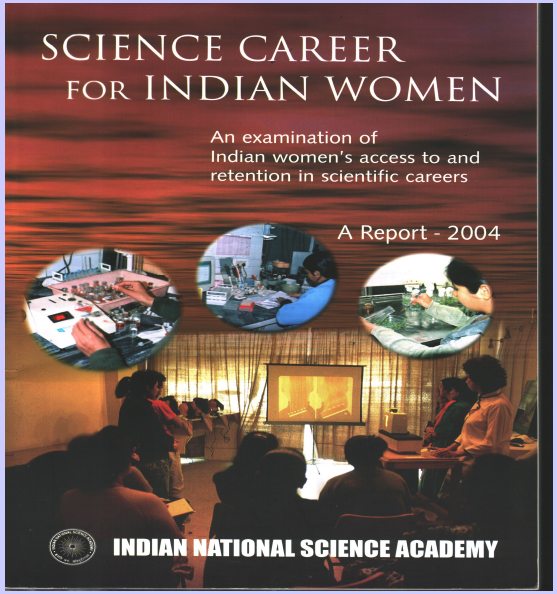
Whereas Janaki Ammal was a **Founding** Fellow of the Indian Academy of Sciences in 1934.

But first woman fellow in Physics division was elected in 1975 for one academy and 1992 in the other!

The Indian Academy of Sciences constituted a "Women in Science" panel to examine these questions in the Indian context.

url:http//www.ias.ac.in/womeninscience

The Indian National Science Academy had parallel effort, as did the Department of Science and Technology, with different emphases.



Policy changes are happening

Major policy changes are being initiated. (DISHA)
(or today some other acronym!)
Also necessary to continue analysis of the situation to identify crucial policy changes.

A personal remark:
By and large need to provide level playing field for women!

Last to last word

In conclusion, let me just assert the following. Basically consideration of how to increase the 'tribe' needs to be ALWAYS in minds of 'powers that be' and not just restricted to days like the 'International Day for Women and Girls in Science', 'Science Day' or 'International Women's Day'. Then and only then can we come up with solutions which will work for us in India. A day will come soon when we will just speak of scientists/ engineers and not their gender. The way to achieve this, surprisingly, goes through the path of being aware of the gender and gender gap for a while.

Rohini M. Godbole

Last word

You people are the architect of a world in which a woman scientist will be a scientist who happens to be a woman rather than a woman who happens to be a Scientist!!

Thank you

Lise Meitner (1878-1968)

Lise Meitner: Austrian

Could not get a degree initially as women were not allowed!

Coined the word fission and explained the physics of the process, calculating the energy release as well as distribution of daughter nuclei. (with her nephew Frisch). Suggested experiments to Hahn who was a life long collaborator.

Her Jewish religion and gender discrimination seem to have played a role in her not gettng a Nobel Prize.

Even I as a student in the early days did not know about her role!

C.S. Wu (1912-1997)

Came from China. In the US did not join Michigan because women were not allowed through front door!

Performed an experiment which proved parity violation and played an important role in birth of the standard model Much discussion and justification why she did not get the Nobel!

My take : she deserved it!

She was much feted, honoured , respected otherwise!

Maria Meyer (1906-1972)

She was a theoretical nuclear physicist.

Her calculations for two photon transitions in her thesis were verified recently courtsey lasers.

Gave the shell model for nuclei. An important step in understanding Nuclear structure.

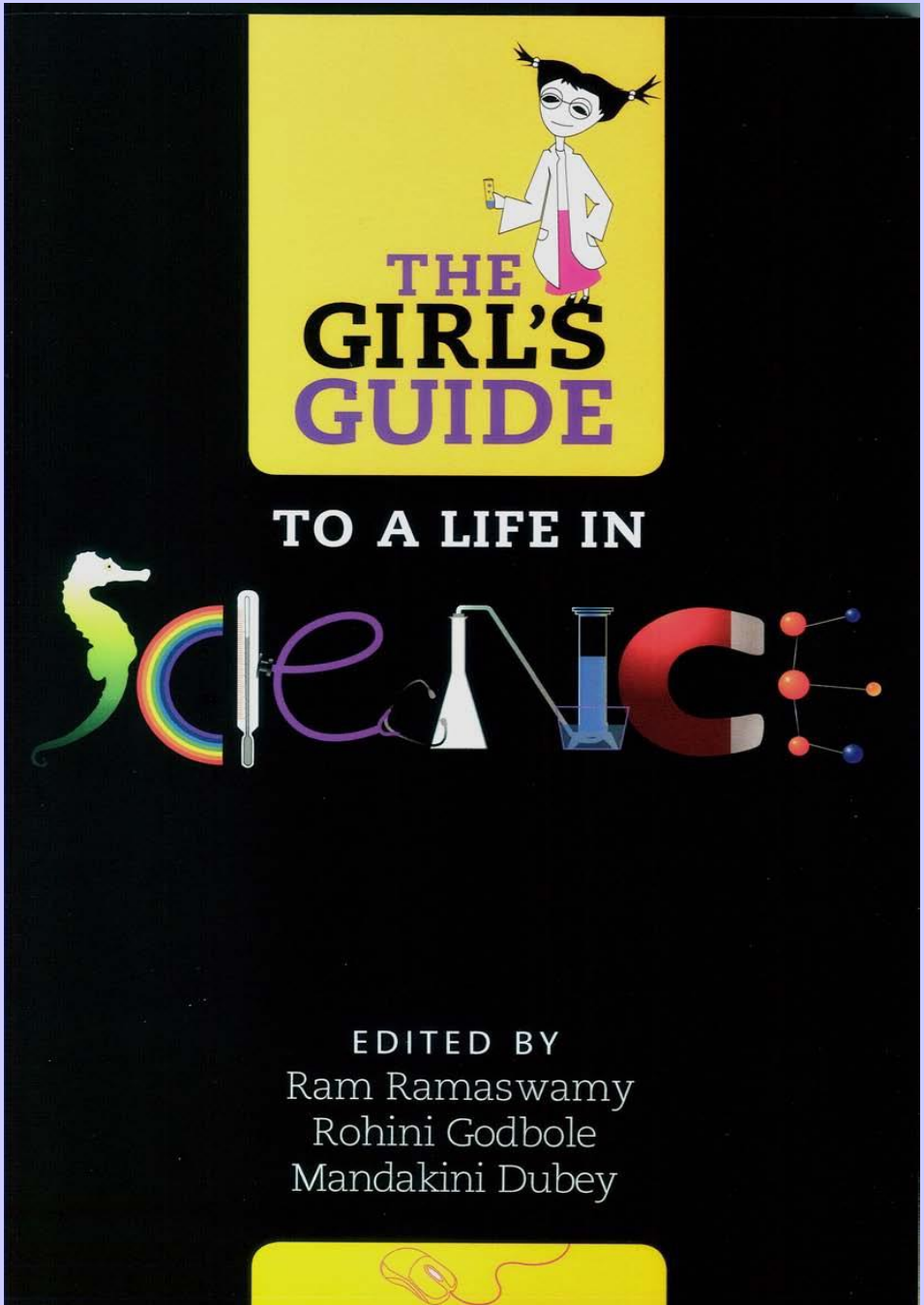
Did not have a permanent job till 1960.

Got the Nobel prize in 1963! Only the second woman to get a Nobel!

Whispers about idea being from Fermi!

I dont have any data but would like to find out whether the nepotism rule was applied to brothers or fathers!

Mentorship programs of the WiS



A new book : containsa small description of the Science done by women whose stories are in the book .

They also discuss future challenges in their area.

Stories of 25 women.