IWSA NEWSLETTER

The official publication of the Indian Women Scientists' Association

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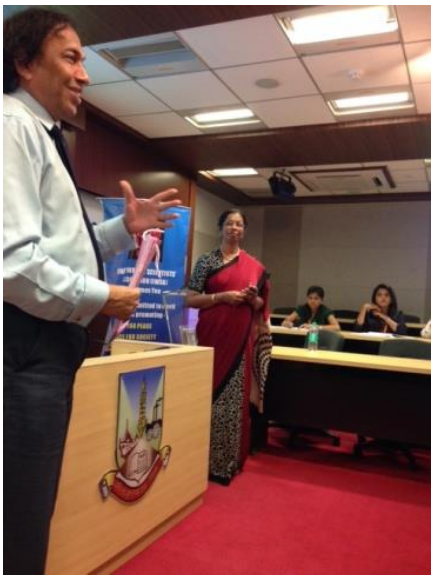
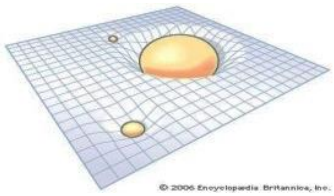


National Technology Day

International Yoga Day

2016 INTERNATIONAL YEAR OF PULSES



Gravitational Waves

BRANCHES

Roorkie 1979 . Hyderabad 1979 . Pune 1980 . Nagpur 1982 . Kolhapur 1982
Delhi 1987 . Kalpakkam 1987 . Baroda 1988 . Lucknow 1997 . Amravati 2010



Inauguration of Science Nurture Program by Smt. Latha Pillai, Principal, Sainath English School, Vashi, on 18th July 2016.

Popular Science lecture by Dr. Dimple Dutta at SIES College, Sion, 18th June, 2016

Popular Science Talk by Prof. B.S. Mahajan at SIES College, Sion, 25th July 2016.

From the Editor's desk

Dear IWSA Members,

The 68th UN General Assembly declared 2016 as the International Year of Pulses (IYP). The IYP 2016 aims to heighten public awareness of the nutritional benefits of pulses as a part of sustainable food production aimed towards food security and nutrition. In order to raise awareness about the important role of pulses in sustainable food production and healthy diets among our members, we have a review article on "Functional, nutritional properties and health benefits of pulses" by Dr. Sonali Gaikwad and Dr. Shalini S. Arya of Food Engineering and Technology Department, Institute of Chemical Technology, Mumbai.

On 14th September 2015, the two Laser Interferometric Gravitational Wave Observatories (LIGO) located at Hanford, Washington and Livingston, Lousiana, U.S.A. instruments received the gravitational wave signal from the merger event of binary black holes which occurred 1.33 billion years away in a distant galaxy. As this was the first ever evidence of the existence of the stellar mass binary black hole system, this observation of gravitational waves created great excitement among the scientists and science lovers all over the world. Dr Archana Pai, School of Physics, IISER Trivandrum, is sharing this excitement with us in her article on "GW150914: The First Symphony from the Universe by Black-Hole Binary Merger@1.33 Billion Light Years."

Besides these two exciting articles, in this Newsletter, we are presenting to you detailed reports on the various activities of IWSA. We bring you the reports on celebration of International Yoga Day at IWSA Headquarters, participation in the National Technology Day at Kalina Campus, Mumbai, Science Nurture Program, Training of Nursery Teachers, Hobby Classes for tiny tots and Pottery workshop. Several popular science lectures were held in various colleges of Mumbai and Navi Mumbai. There are also interesting reports on the activities of the various branches of IWSA at Delhi, Nagpur, Pune and Vadodara. I hope that all of you will enjoy reading about these reports and the scientific articles in this Newsletter.

With best wishes
Shyamala Bharadwaj
shyamala.bharadwaj@gmail.com

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Editorial Board

REQUEST FOR UPDATING OF CONTACT DETAILS OF MEMBERS

President's Message

Dear IWSA Members,

I have been unwell for some time and hence not very active since June '16. But IWSA has been bubbling with activities, thanks to the other EC members, and thus, I have a lot of information to share with you. The summary of the activities are published in this edition, yet I would like to highlight a couple of IMPORTANT matters.

Firstly, I would like to thank all of you members who braved the heavy, showers and attended our AGBM on July '16! There were 2 branch convenors also, from Pune and Baroda, who attended the AGBM and it was very nice to exchange ideas for more productive, futuristic plans. But I wish there were more local members willing to come to the IWSA-HQ on a Saturday afternoon (July 16th), enjoy the monsoon and mark their attendance for the AGBM. Better luck next time.

The Triennial conference on `Sustainable development in India: Role of science & technology" is shaping up very well in the hands of our capable convenors. July 31, 2016 was the last date for concessional registration – a few members have already done – but I am sure our working (earning) members will have no problem to do it any day at any cost. We have exciting speakers already ready for the invited talks. All members who can contribute to the different strands should hurry up and send the abstracts ! Please look up conference website for all relevant details: http:///www.iwsa.net/conference2016/index.php.

Our association is doing well in all its other projects and programmes. I entreat all of you to attend a few of them so that you can keep abreast of our activities. We would very much appreciate your inputs and suggestions for improvements.

Best wishes to all members.
Devaki Ramanathan
President, IWSA
devakir66@yahoo.com

Reports from Head Quarters

IWSA Popular Science Lectures

In the past four months IWSA conducted eight popular science lectures in Mumbai and Navi Mumbai to reach out to college students and to inculcate scientific temper in them. Four of these lectures were sponsored by BRNS,

National Technology Day Lectures

On the occasion of National Technology Day, Indian Women Scientists' Association (IWSA) conducted four lectures in collaboration with University of Mumbai at the Virtual Class Room, Phirozha Mehta Bhavan, University of Mumbai, Kalina, Mumbai on 10th May, 2016 from 9.30 am onwards. These lectures were attended by 50 selected students from all over Maharashtra and preserved at the University Virtual facility for further use. The students very much appreciated the whole proceedings. Dr. Devaki Ramanathan, President, IWSA spoke about IWSA's efforts to take science to the student community. Dr.Niyati Bhattacharya, Chairperson, IWSA Board of Trustees was also present on the occasion.

1. Dr. Dhanya Suresh of Radiation and Photochemistry Division, BARC spoke on "Light based technologies – for existence and exploration." Light in the UV-Vis region of electromagnetic spectrum is the most fundamental to the existence of life in earth in the present form. Our understanding on the nature and properties of light has improved in the last century, which is converted to many useful applications in various fields such as energy, communication, medicine, entertainment etc. In the talk Dr. Dhanya focused on the basis of interaction of light with matter at the molecular level and several applications based on light absorption and fluorescence of molecules as well as applications of advanced spectroscopy in improvising our probing methods, allowing us to explore a wide range of space and time. The specificity and selectivity of absorption and consequent processes such as energy transfer are made use of in the treatment of jaundice in babies and photodynamic therapy of cancer. The high sensitivity and easy detection possibility of fluorescence has led to many applications in crime investigations, pathogen detection and sensing and diagnostics in biological systems. Many Nobel prize-winning developments of advanced spectroscopic techniques, single molecule fluorescence, ultrafast femtosecond spectroscopy, laser induced fluorescence spectroscopy etc have tremendously contributed towards understanding and mimicking natural phenomena such as vision and photosynthesis. In the backdrop of dwindling fuel sources, development of technologies for utilising the solar energy is seen as the major option for future. Understanding of the atmospheric cleansing via OH radicals, the key species in the atmosphere, involves light, and the OH radicals, as low as 10^6 molecules per cc have been detected and quantified by laser induced fluorescence. The knowledge has led to development of many products for cleansing the interiors and self-cleaning surfaces. The spectroscopic techniques are also very useful in probing the species and phenomena occurring in the upper atmosphere. The various ground based and satellite based space stations including India's recently launched Astrostat are equipped with probing instruments covering all the wavelength ranges of electromagnetic radiation, continuously giving us information about interstellar

clouds, planetary atmosphere, distant galaxies etc.Dr. Dhanya dealt with all theabove aspects in detail.

2. Ms. Saly T. Panicker of Desalination Division, BARC spoke on “Environment – Friendly adaptation of water treatment technologies suitable for rural and coastal areas”. Drinking water with physical, chemical or biological contamination has harmful effects on human health. Surface water is normally infected with disease-causing organisms and ground water at certain locations contain high loads of dissolved salts, including toxic elements. With the increasing demand for water and the depleting ground water tables, it has come to a level that, alternate resources for drinking water are to be explored. The two options possible are rain water harvesting and conversion of the highly saline seawater to drinking water, with the help of appropriate technologies. Rain water harvesting is feasible only when it rains and has got limitations as far as storage is concerned. On the other hand, sea is an unending and free resource of water. Bad quality water can be made potable by effecting suitable water purification processes such as, filtration or distillation and membrane based desalination (salt removal). These systems need significant amounts of energy in the form of heat &/ electricity. Burning of fossil fuel for power production is a key contributor towards global warming and climate change. Power production utilizing environment friendly renewable energy sources is an alternate solution in such situation. Generating energy from renewable sources also would help in providing off-grid, stand-alone water treatment systems for rural areas, which are not electrified. The most useful renewable energy sources are sun and wind. They are inexhaustible, free and cause no pollution to the environment. This talk dealt with the effects of poor quality drinking water on human health, effect of climate change on drinking water quality, the impacts of conventional power reactors towards global warming/climate change, the techniques for making impure water potable and the use of renewable energies for this purpose. She shared her experience in developing potable water in some rural areas of Maharashtra.

3. Dr. Shyamala Bharadwaj, Former Senior Scientist, Chemistry Division, BARC spoke on “Hydrogen Technology for meeting future energy demands”. Energy plays an important role in social, economic, industrial and technological development of any society. Due to increasing population and rising living standards, there is an increase in energy demand worldwide. In a developing country like India, energy sector is further more important owing to its large population. Hence there is a need for development of alternative energy sources both nationally as well as internationally. Lot of research is going on in this field; people are looking for new CO2 free energy systems. CO2 free energy systems are important basically due to the following two reasons. Firstly, the gap between energy demand and available energy sources will increase in future because the demand will keep on increasing due to various reasons like increasing population, industrial growth etc. but there will be decline in production of conventional fossil fuels. Consumption as well as production of all types of fuels has increased in recent times but for each of the fossil fuel rise in consumption was much more as compared to rise in production. These trends raise an alarm about possible energy crisis in near future. There are various reports

suggesting that global energy demand may increase so rapidly that it cannot be met by available fossil fuels, nuclear and hydrothermal energy.

As of now most of the world's energy requirement for electricity generation and transportation etc. are met by combustion of fossil fuels like oil, coal and natural gas. Due to their finite resources and the irreparable harm that they cause to environment, there is a need to look for cleaner alternate primary energy sources. Some of the promising non-polluting renewable energy sources are like Nuclear, Solar, wind, geothermal and biomass etc.

But for some applications like transportation purpose where Fossil fuels are extensively used, there it is highly desirable to replace fossil fuels by a more environment friendly energy carrier. Hydrogen seems to be the most suitable option for this purpose due to its favourable properties.

Dr. Bharadwaj said that in future there will be shift from today's carbon based economy to hydrogen based economy. The ultimate hydrogen economy is expected to have the following features (i) low-cost production of hydrogen by water splitting in a thermochemical process by using nuclear or solar heat, and (ii) oxidation of hydrogen in fuel cells to generate power with very high conversion efficiencies. In her talk, the research efforts aimed at hydrogen production from water splitting cycles was discussed along with brief accounts of research efforts on hydrogen storage and utilization in fuel cells.

4. Dr.Susan Eapen, Trustee, IWSA spoke on "Agricultural Biotechnology: For food, feed and environmental security". She said that agriculture is important because if humans have to survive in this planet, they have to consume food. In future, due to increase in population coupled with limited land, water and other resources and changing climate, we need to increase agricultural production to meet the increase in demand for food. In 2022, India will surpass China in population and hence we have to adapt all new technologies to increase food production. She said that before 1960s, there was a shortage of food in India and due to Green Revolution there was an enhancement in food production in the country. The year 2016 has been declared as the "Year of Pulses" by the United Nations. Pulses are the major source of proteins for the vegetarian population and there is an urgent need to increase the productivity of pulses. Since time immemorial, man has been selecting and domesticating plants and as a result the present day crop plants have evolved. Various methods of plant breeding like plant introduction, selection, hybridization and mutation breeding based on genetic principles in the 20th century has resulted in the development of several high yielding crop varieties. She recalled that mutation breeding in BARC has led to the development and release of several crop varieties in groundnut, mustard, sunflower, soybean, pigeon pea, mung bean, urad bean, cowpea, rice etc. which are currently grown nationwide. It is essential to incorporate novel technologies like plant biotechnology for introduction of novel traits into plants to develop high yielding and climate proof plants. Enhancement of micro-nutrients like Fe and Zn in edible parts of crop plants can also be achieved using

biotechnological approaches. Plants can also serve as a source of pharmaceuticals and they can be genetically engineered to produce important secondary metabolites.

Plants can also be utilized and improved for remediation of organic and metal pollutants. She also dealt with development of bio-pesticides, organic farming, developing food chains, water conservation by drip irrigation and adapting SMART agriculture practices for improving crop productivity leading to food security.

5. **BRNS Sponsored IWSA Popular Science Lectures at SIES College, Sion on 18th June, 2016.**

A popular science lecture was conducted on Saturday, 18th June, 2016 at SIES College of Arts, Science and Commerce, Sion, Mumbai. Dr. Dimple Dutta, Senior Scientist, Chemistry Division, BARC delivered a lecture on Molecular Symmetry and Point Groups.

Symmetry plays a central role in the analysis of the structure, bonding, and spectroscopy of molecules. In this lecture, Dr. Dutta explained in detail the basic symmetry elements and operations and their use in determining the symmetry classification (point group) of different molecules. The symmetry properties of objects (and molecules) may be described in terms of the presence of certain symmetry elements and their associated symmetry operations. The symmetry elements were discussed with reference to molecules having each type of symmetry. The method for deducing the point group of a particular molecule was also discussed in detail. Few applications of the point groups in deducing properties like chirality and polarity of molecules were highlighted. The audience consisting of B.Sc. and M.Sc, students and faculty members participated enthusiastically in the discussions during the lecture.

6. **BRNS Sponsored IWSA Popular Science Lectures at SIES College, Sion on 25th July, 2016.**

Prof.Bakhtaver S Mahajan, Secretary, Board of Trustees, IWSA, gave a talk on "Ethics in Science and Technology" at SIES College, Sion, on 25 July, 2016, under the BRNS lecture series programme. The audience consisted of students and faculty from BSc and MSc classes. She dealt in detail on the many aspects of Ethics as applied in the domain of Science and Technology, and took the students on an exciting journey as if they were working in a laboratory. Students were engrossed in the talk lasting more than two hours, as they also grappled in groups with numerous situations dealing with varied ethical problems.

7. **BRNS Sponsored IWSA Lecture on 28th July, 2016 at Pillai's College of Architecture, New Panvel.**

The talk was delivered by Prof. Rupa Agarwal, Associate Professor at the National Institute of Fashion Technology (NIFT), Kharghar, Navi Mumbai. Title of the talk was- "Designedly ways of doing Research". Prof. Rupa Agarwal is trained as an Architect and Industrial designer. She is presently pursuing her doctoral studies at the Industrial design Centre, IIT Bombay. Her research area deals with integrating sustainability approaches in design teaching.

Prof. Rupa Agarwal was introduced to the audience, by Dr.Lalitha Dhareshwar, Secretary, IWSA. She also informed and invited the audience to participate in IWSA's forthcoming Triennial conference on "Sustainable development in India-Role of Science and Technology".

In her talk, Prof. Rupa Agarwal deliberated on the fairly new field of 'Design research' as compared to the research traditions of other established disciplines. Design is popularly identified as a domain of work related to 'action' and 'doing'. This is not to say that design is skin deep. It certainly is deeper. What are in those depths? How do we explore those depths through research, was the focus of the talk. Being a fairly new area, design research is fraught with challenges both from within the design community and outside. In discussing these challenges, we discover initiatives, innovative approaches and future prospects of design research.

8. **BRNS Sponsored IWSA Lecture cum Demonstration on Yogasana for Women.**

Indian Women Scientists' Association (IWSA) celebrated International Yoga Day on 19th June, 2016 by organizing a lecture cum demonstration on Special Yogasanas beneficial for the health of women, by Smt. Sucharita Chatterjee and her team from BARC Yoga Circle, Anushaktinagar. This was one of the Popular Science Lecture Series, supported by BRNS and was conducted at IWSA campus, Vashi.

The sessions gave special attention to knee pain, back pain, hypertension and other lifestyle related diseases. There was a special talk on Desktop Yoga for office goers. Audience participated in these demonstrations and had a chance to experience peace with a beautiful glimpse of meditation. A talk on Yogic Diet was also presented. This talk covered important points on healthy food habits required for a healthy living recommended by Ayurveda.

Science Nurture Program

Indian Women Scientists' Association (IWSA) has been striving for the last few years, to reach out to selected students from less privileged background, in teaching SCIENCE to standard VII and VIII students, by adopting innovative methods, under the Science Nurture Program.

In this academic year also, IWSA started conducting classes for students of VII and VIII standard of English and Semi-English medium schools of Maharashtra Board. IWSA would broadly follow the syllabus, however, these classes are meant to encourage the students towards practical application, thinking and a deeper understanding of the concepts of subjects. Subjects are made interesting by conducting experiments at the IWSA Laboratory and through videos. Students are also being nurtured by giving individual attention.

This year along with Science, Mathematics and English are also being taught, as these subjects are of great importance for communicating scientific ideas in the most appropriate manner.

The Science Nurture program was inaugurated by Smt. Latha Pillai, Principal, Sainath English School, Vashi, on 18th July, 2016. A Science quiz was held on this day and some interesting experiments were demonstrated.

The classes started formally from 19th July with 22 students in Class VII and VIII. Ten of the IWSA members are working hard as the teachers for Physics, Chemistry, Biology, Mathematics and English for the Science Nurture classes.

Training of Teachers (TOT)

The inauguration of the 21st batch of teacher's training was held on 18th June 2016. Ms. Usha Banerjee, CEO St. Jude India, Child Care Centre was the chief guest. The ice breaking session was held on 20th June 2016 and regular classes began from 21st June 2016. Puppet making workshop for the TOT students was conducted by Mr. Katta Babu. In this workshop, the students learnt the art of puppet making, script writing and voice modulation.

The Indirabai Padhey Nursery reopened on 20th June, 2016 with twelve students.

An orientation programme was held on 30th June 2016 for the parents of Nursery school and day care centre. Dr.Varsha Varma of IWSA health care centre spoke to the parents on "Let the rains not dampen the spirits of your child". The talk was well attended and appreciated by the parents.

IWSA: Committed to a Greener Environment

The Indian Women Scientist's Association which was established in 1973 has been quietly working for the cause of women and children in Navi Mumbai. This non-profit organization with a membership of over 2000 enthusiastic women runs a hostel, a crèche, health care centres, a science laboratory and a library. Situated in the sector 10-A area of Vashi, it is surrounded by temples of knowledge and worship. It also boasts of a well-tended

garden with a variety of plants including both the fruiting and flowering varieties. Their commitment to improve the environment, prompted the members to conduct gardening work- shops for children and adults which received a very positive response.

Workshop on Making Tray Garden for Children

The first work-shop for tiny tots between the ages of three and eight was conducted by Mrs Vijaya Chakravarty, a landscape designer and Mrs Shobha Ramana an educationist on the 29th of April, 2016 from 9 am to 11 am. Held in the immaculately maintained hall where IWSA runs its crèche, the little children created 'Fun Gardens' in trays. The themes included a Forest Garden, a Farm and a Dinosaur Park. The eager participants were seen engaged in activities like planting, besides choosing artifacts like rocks and animals to embellish their trays. Despite their young age, they interacted well, asking and answering questions regarding the importance and care of plants. Some of the parents and grandparents who had accompanied the children looked as animated as the little ones, proudly forwarding pictures of the completed fun gardens to their near and dear ones. After posing for photographs, the kids walked home with an attractive tray garden in their hands.

Workshop on Balcony Gardens

The second workshop for adults, conducted once again by Mrs Vijaya Chakravarty and Mrs Shobha Ramana revolved around the theme, 'Balcony Gardens.' Notwithstanding the intense heat and humidity, gardening enthusiasts from all over Navi Mumbai eagerly flocked to the main hall of IWSA for the workshop. Held on the 30th of April, 2016 between 2 pm and 5 pm, the workshop began with an audio visual presentation which focused on optimal utilization of small spaces, water conservation, organic gardening methods and the basics of design, to name a few. Mrs Chakravarty, then, led the participants on a walk around the garden, not only identifying the plants but also giving useful information about them. The last part of the workshop included the creation of 'Hanging Baskets.' Here each participant got actively involved in the various steps that go into the making of a Hanging Basket, right from lining the basket, selecting the plants and the actual potting. The intentness and enthusiasm of the participants was infectious and the end result was a lush Hanging Basket along with interesting ideas related to creating gardens in balconies.

Pottery workshop at IWSA

Pottery workshop in association with Rupali Madan, Director 'ERA for women', was held from 9th May to 26th May, 2016 in 9 sessions. In this workshop the 15 participants were trained for terracotta clay, pinching, coiling, jewellery, hand work, wheel work, sculpture, firing etc.

The guidance of professional potters like Deepa Parab, Mahesh and Kavita Thakur was very useful.

The workshop was concluded and the certificates were given by Famous artist,
Mr .Ashok Mulye and Sudha Barshikar.

Reports from IWSA Branches

1. **Delhi**

The Delhi Branch of IWSA organized a talk by Dr. Ohja on 11th August, 2016 on- “Importance of Metrology for Innovation and Quality” at the TEC Conference Room, National Physical Laboratory, New Delhi. Dr. Ojha elaborated on importance of Metrology as the “science and practice of measurement. He spoke on- accurate measurement methods to ensure quality, performance measures for accurate technology comparisons and standards to assure fairness in trade.

2. **Nagpur**

Annual general meeting was held on 8th August, 2015 during which various programs to be carried out during the year were chalked out. It was followed by celebration of the Environment Day. A talk on "NEEM - An alternative to chemical pesticide" was given by Mr. Laxmikant Padole, Centre - Neem Foundation, Gondkhairi, Nagpur. He deliberated on beneficial effects of Neem fertilizer and Neem as a pesticide in organic farming. A short documentary film was shown which showcased the ill effects of chemical pesticides with a special case study of Cashew plantation in Kerala. There were 42 numbers of participants in this program.

Celebration of Teacher's day was held on 11th September, 2015 in association with women development cell of Ambedkar College, Dr.Ambedkar College, Deekshabhoomi, Nagpur. On this occasion, an interactive session of teachers was held to express their views. The participating teachers were provided with topics on the spot and were given two minutes to speak on it. The number of participants was 50.

World Food Day was celebrated on 10th October 2015. A cookery competition was held on this occasion at Dharampeth M.P. Deo Memorial Science College, Nagpur. The program was jointly organized by IWSA and Women Cell of Dharampeth M.P.Deo Memorial Science College, Nagpur. Numbers of participants were 60.

Children's Day was celebrated on 3rd December 2015. On the occasion of children's day a drawing competition was organized for primary school children of standard 3rd and 4th. The theme for the drawing competition was "Save the environment". Over 500 children actively took part in this competition. They showcased their talent and sent a message to save environment.

Science Day celebration was held on 28th February 2016 with a lot of enthusiasm. IWSA members visited a Zilla Parishad Primary School at village Salai (Khurd) about 60 kms off Nagpur and interacted with the school children. This year being the year of pulses, our founder member, Dr. Anuradha Gadkari interacted with the students and told them the importance of protein in their daily diet. A protein food pyramid chart was given to them. A drawing competition was organized for these children and story books were given as prizes. A healthy protein snack was distributed. IWSA members visited nearby farms and planted trees and celebrated Green Science Day. Number of participants in this program was 25.

Nagpur branch of IWSA and Institute of Engineers India, jointly celebrated International Women's Day on 12th March, 2016. The theme for the programme was "Share the dias" on the topic "Work Environment for Women has considerably improved". Justice Vasanti Naik was the Chief Guest at the function. She explained how women were underestimated in the past and their capabilities were ignored, but now work environment for women is slowly improving. The speakers who shared the dais were - Dr. Rita Shah, Dr. Manisha Deshmukh, Mrs. Gauri Dhopaukar, Dr. Lalita Sangolkar, Mrs. Pranita Thakre and Dr. Anagha Nasery. They debated intensely on the above topic, some spoke for the motion, while others were strongly against it. The programme proceedings were excellently conducted by Dr. Deepti Andhare, Former Secretary, IWSA. Number of participants was 50.

3. Pune

International Women's Day Celebration was held on 8th March, 2016. On this occasion, IWSA, Pune Branch in association with Department of Chemistry, Savitribai Phule Pune University, organized a workshop on "Soft skill Development: Preparation of Scent, Spray Perfume, Room Freshener, Liquid Soap, Detergent". Total Number of Participants was 80.

4. Baroda

On International Women's Day, 8th March 2016, a talk related to women's health issue entitled as "Women Health : correlation with Diabetes" was organized at Prof. U.N. Singh Hall, Department of Mathematics, Faculty of Science, The Maharaja Sayajirao University Baroda. The aim of this talk was to highlight the best possible methods/techniques to minimize the sugar level experienced by women. The talk was delivered by Prof. Sarita Gupta Head Department of Biochemistry, Faculty of Science, and The Maharaja Sayajirao University of Baroda.

National Seminar on "Impact of Climate Change on Biodiversity" was conducted by the ISG, ISCA & IWSA (Vadodara Chapter) in association with Department of Botany, Faculty of Science, The M.S. University of Baroda, on 12th March, 2016. This seminar reported the diverse climatic changes on the endangered species of flora and fauna. There were oral as well as poster presentations by students and research scholars. There were 5 invited speakers for the seminar and 135 registered participants.

5. Hyderabad

National Conference on "Women in Science Education and Research (WISER): Challenges and Opportunities" was organised by the Department of Physics and Electronics and the Department of Computer Science, St. Ann's College for Women, Mehdipatnam, Hyderabad in collaboration with Indian Women Scientists' Association, Hyderabad Branch on 4th March, 2016. Prof. Geeta Varadan of ISRO, Department of Space was the Chief Guest and Dr. N. Rathnasree, Director, Nehru Planetarium, New Delhi was the Guest of Honour. Prof. Geeta Varadan gave the keynote address about the Evolution of Space Program in India, Dr. N. Rathnasree gave a speech on "Cutting Edge Astronomy Directions: Indian Footprint and Student Opportunities". Other speakers were Ms. Sandhya Janak, Freelance Science Journalist and Ms. Kavita Vemuri, Senior Research scientist at IIIT, Hyderabad.

Articles

Functional, Nutritional Properties and Health Benefits of Pulses: a Review

Abstract

Pulses are the seeds of legumes that are used for human consumption and include pigeon pea, cow pea, peas, beans, lentils, chickpeas, black gram, green gram and fava beans. Pulses are an important source of macronutrients, containing almost twice the amount of protein compared to cereal grains. In addition to being a source of macro and micro nutrients, pulses also contain bioactive compounds such as enzyme inhibitors, lectins, phytates, oligosaccharides, and phenolic compounds that are increasingly being recognized for their potential benefits for human health. Apart from their nutritional properties, pulses also possess functional properties that play significant role in food formulation and processing such as solubility, water and fat binding capacity and foaming. Present review focuses on, functional nutritional properties of pulses and their potential health benefits.

Introduction

Pulses are plant species members of the Leguminosae family (commonly known as the pea family) (FAO 2016) that produces seeds which are used for human and animal consumption. Pulses include dry and edible variety of beans, peas (figure 1), lentils and chickpea, and exclude oil grain legumes (soybeans and peanuts) and harvested green for food (fresh beans, fresh peas) (Adriana,2014).

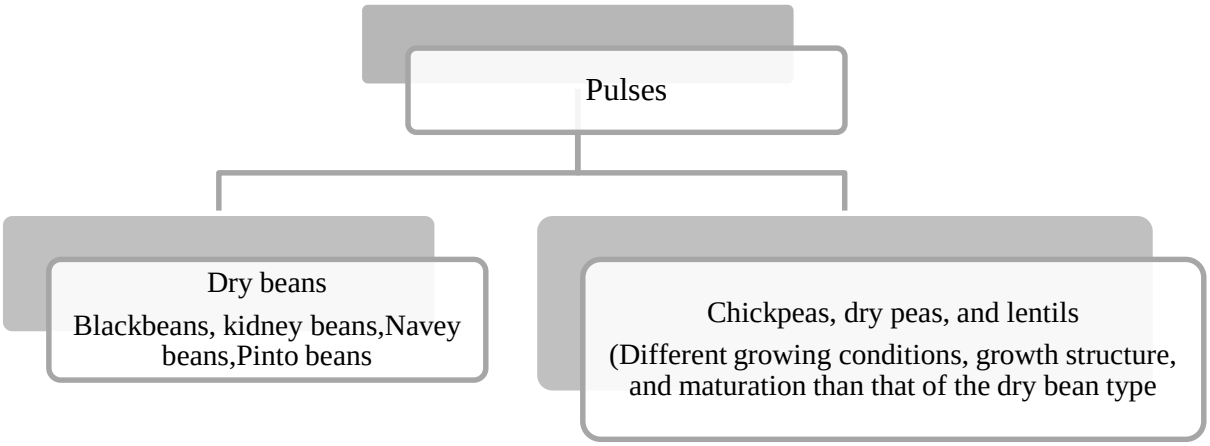

Figure 1: Classification of pulses (Rooneyet al., 2013;Ayachit, 2002)

Pulses have been a very important ingredient of the human diet and have been grown from millennia in the world. Even pulses have contributed as “balanced food” over 1000 years ago (Ayachit, 2002).Maximum numbers of pulses are mainly originated from Indian subcontinents shown in Table.1.

Table.1 Origin of Various Pulses

Pulses	Origin
Lentil (Lens esculenta)	Southwest Asia
Chickpea (Cicerarietinum)	Turkey-Syria
Pigeon pea (Cajanusindicus)	India
Black gram (Phaseolusmungo)	Indian subcontinent
Horse gram (Dolichosbiflorus)	Indian subcontinent
Green gram (Phaseolusaureus)	Indian subcontinent
Lablab bean (Lablab purpureus)	Indian subcontinent
Moth bean (Vignaaconitifolia)	Indian subcontinent
Grass pea (Lathyrussativus)	Southern Europe
Pea (Pisumsativum)	Southern Europe
Faba bean (Viciafaba)	West Asia
Cowpea (Vignaunguiculata)	West Africa

(Source: Nene, 2006).

The growing of pulses is less as compared to its consumption. The distribution and growing pulses are shown in Figure.2. National Council of Applied Economic Research (2014) reported that India is the largest producer, largest consumer and the largest importer of pulses in the world. In India pulses are grown in around 24-26 million hectares of area producing 17-19 million tonnes annually.

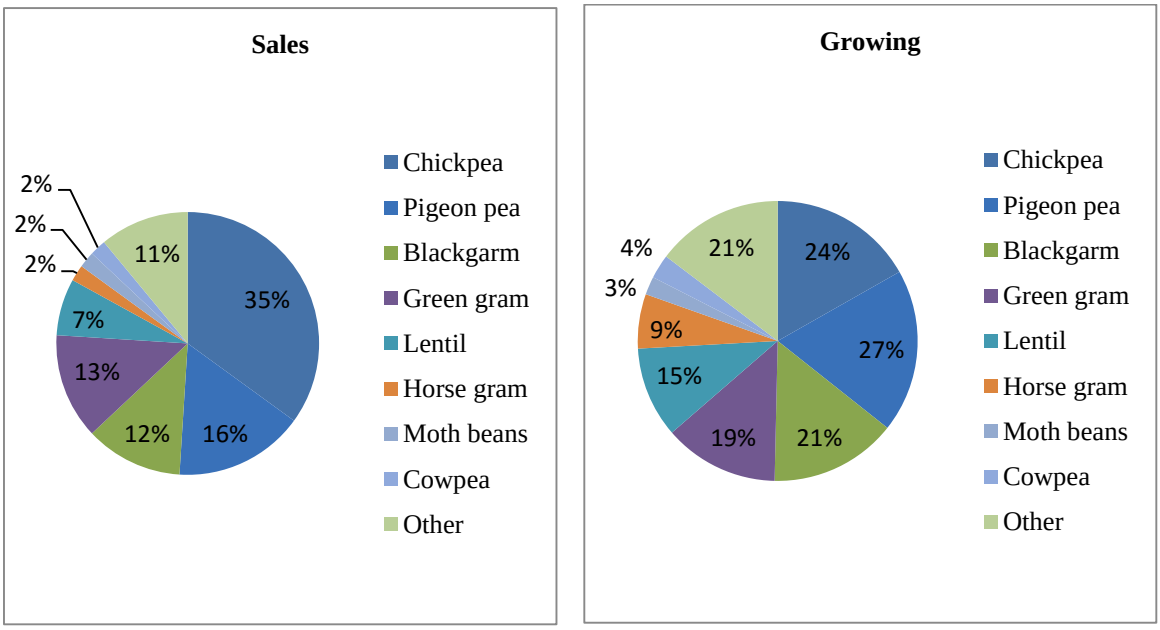

Figure.2 Distribution and Growing of Pulses throughout the World

India accounts for over one third of the total world area and over 20 per cent of total world production. For the triennium ending 2014-15 and 2015-16 the quantity of pulse production in India are shown in Table 2.

Table.2 Pulse Production of India in 2014-15 and 2015-16

Particulars	2014-15 (April-March) (Million Tonnes)	2015-16 (April-Dec) (Million Tonnes)
Production	18.40	18.32
Total Import	4.58	4.10
Availability for consumption	22.98	22.48

Sources: Directorate of Economics and Statistics (DES), Department of Agriculture & Cooperation (DAC)

In India, every year there was a gap of almost 2.5-3.0 million tonnes of pulses in demand and supply. This gap was due to higher growth of population as compared to pulse production. There was 239 lakh ha area in India at triennium ending 2014-15, mainly contributed by Madhya Pradesh, Rajasthan, Maharashtra, Karnataka and Uttar Pradesh. India mainly produces bengal gram (chickpeas), red gram (tur), lentil (masur), green gram (mung) and black gram (urad). Only legumes harvested for dry grain are classified as pulses. Pulses are the major source of protein for the majority of vegetarian population in India as well as including pulse crop residues are also major sources of high quality livestock feed in India. Pulses are vital food for the healthy diet of human. Pulses are rich source of protein, fibre, vitamins and minerals (such as iron, zinc, folate and magnesium).By increasing intake of these pulse nutrients per day can increase diet values. This review focuses on the functional, nutritional properties and health benefits of pulses.

Functional Properties

As pulse is rich source of protein it is exploited in preparation of variety of food products. Therefore processed pulse flour is considered as ingredient in various food preparations and development of food products viz., extruded products, bakery products, soups and RTE snacks. Hence, it is very necessary to evaluate its functional properties like protein solubility, water holding capacity, foaming capacity, emulsifying capacity and oil absorption capacity.

Protein Solubility

Protein solubility is one of the most important functional properties because it affects other functional properties such as foaming, gelation and emulsification. Protein solubility basically influenced by structure denaturation of protein and pH. Incorporation of pea flour proteins into products having neutral or basic pH such as diet drinks. Protein solubility also plays an important role in baked products (Miroljub Baracet al., 2010).

Water Holding Capacity

The ability to physically hold water against gravity is called as water absorption capacity (WAC). It is expressed as the amount of water that can be absorbed per gram sample. It is vital functional property in food application. Pulses are rich in polar amino acid content. These amino acid residues of proteins have affinity for water molecules (Kinsella,

1976). Pulses having different amount of amino acid content shows different WAC. WAC of different pulses could be due to the differences in the content of these amino acids. It is also known that polysaccharides, which are hydrophilic greatly, affect water absorption capacity of flours (Ghadivel and Prakash, 2006). Products made with addition of pulse flour in meat sausages, bread and cakes, water holding capacity plays important role. It forms hydrogen bonding of water and thus causes entrapment of water.

Foaming Capacity

Foaming capacity (FC) is incorporation of air bubbles whereas foam stability (FS) is defined as ability of proteins and other components. It forms a strong and cohesive film around air bubbles and greater resistance of air diffusion from the bubbles. Pulses are rich in proteins which forms interfacial film which keeps bubbles in suspension and slows down the rate of coalescence. Protein has to be very soluble to have good foaming properties. Better formability is due to rapid adsorption of air water interface during bubbling and rapid conformational rearrangement at the interface whereas for better formability form due to cohesive viscoelastic interactions (Adebowale et al., 2005).Bakery products like angel cake, different desserts and topping forming good texture due to foaming capacity. It forms stable film to entrap gases in angel cakes, whipped toppings and chiffon desserts. Chickpea, beans, lentils and pea flour has been successfully used in preparation of cakes, breads as tenderizer with higher foaming capacity (Morales-De-Leon et al., 2007).

Emulsifying Capacity (EC)

For development of food products emulsifying properties plays an important role because protein and amphoteric molecules contribute to food product quality development. Pulse flours consist of protein, carbohydrate, lipids and minerals (Ma et al., 2011; Siddiq et al., 2010. Several reports explain that carbohydrate (starch and fiber) are also responsible to improve emulsion stability because it acts as bulky barriers between oil droplets. It prevents and slows down the rate of oil droplets coalescence (Aluko et al., 2009).Combination of carbohydrate and protein from pulse interaction also impacts the emulsifying properties. Protein acts as surface active agents which form and stabilize the emulsion. This generates electrostatic repulsion on oil droplets surface. Emulsifying capacity (EC), emulsion stability (ES), emulsifying activity index (EAI) and emulsifying stability index (ESI) are often used to evaluate the emulsifying properties of pulse flours. The EC measures the volume of oil that can be emulsified by a specific amount of pulse flour/protein. EAI describes the ability of a flour/protein to form an emulsion with an estimation of the interfacial area stabilized per unit weight of flour/protein based on the turbidity of a diluted emulsion.ESI provides a measure of the stability of the same diluted emulsion over a defined time period. The ESI relates to the hydrophobic–hydrophilic balance of the protein molecule, especially on the surface. Pea flour used as thicker to increase viscosity of food product. Protein concentrates from chickpea, lentil and beans having high emulsifying capacity are used in different bakery products (Kaur and Sing., 2007)

Oil Absorption Capacity (OAC)

Oil absorption capacity (OAC) acts as flavor retainer and increases the mouth feel of food. The OAC of food proteins depends upon the essential factors like amino acid composition, protein conformation and surface polarity or hydrophobicity. As per reported data pulses vary in OAC. Variations in the presence of nonpolar side chains of proteins, which might bind the hydrocarbon side chains of oil among the flours, possibly explain

differences in the OAC of the flours (Adebowale and Lawal, 2004).In meat and bakery product, fat absorption is desirable because pulses flours helps in structural interaction and thus causes flavour retention and improvement in palatability and shelf life.

Nutritional Properties

Composition

Pulse flours are reported to vary in chemical composition. Nutritional value of different pulses varies depend on the type of pulse, cultivation method, crop growing place, quality of pulse, environment etc.The protein content in pulses mainly varies between 17-30 %. Also fat, fiber and carbohydrate varies between 1-3%, 3-7% and 55-70% respectively. Pulse protein is primarily of two types: enzymatic and structural protein. This is responsible for normal cellular activities like synthesis of structural protein and storage protein. Storage proteins are relatively small in number and accounts for about 70% of seed proteins. Primary components of protein bodies include storage proteins, salts of phytic acids, hydrolytes enzymes, cations and ribonucleic acid. Lipid content of pulses contains high concentration of lipid as compared with cereals. Lipids are heterogeneous group which included fatty acids: mono, di and triglycerides. Carbohydrate of dry pulses ranges from 28-68%. These carbohydrates include mono and oligosaccharides, starch and other polysaccharides. Total sugar represents only a small percentage of total carbohydrate. Crude fiber consists of cellular and hemi cellular heterogeneous group. Pulses are good source of minerals such as calcium, iron, copper, zinc, potassium, and magnesium. Dietary components such as phytic acid, oxalic acid, proteins, polyphones and complex polysaccharides such as starch, crude fiber and lignin are known to interact with minerals helpful for their bioavailability.

Food legumes are good source of thiamine, riboflavin, and niacin. Pulse also contains phytochemicals such as starch, phytosterols, isoflavones, saponins, alkaloids, and bioactive carbohydrates. Starch (resistant starch) is a major carbohydrate available in pulse grains, and due to its high concentration of amylose, the process of digestion and metabolism are affected. Different heat processing and cooking of pulses increases hydrolysis, incomplete starch gelatinization and formation of resistant starch with high amylose starch is thus responsible for lowering digestibility. This contributes to lower down glycemic response (Sajilataet al., 2006).Pulses containing plant sterols (phytosterol) and stanols which are helpful for reduction of blood cholesterol level. Several studies have demonstrated that pulses consumption lowers serum cholesterol and interrupts entrohepatic circulation of bile acids and increases saturation level of hepatic cholesterol in bile (Thompson.et al., 2005).Isoflavones has been isolated from fabaceae/leguminosae. Several reports available on health benefits clinical analysis for biological activity of isoflavons (Simone Rochfort and Joe Panozzo, 2007). Chemical compositions of pulses are depicted in Table 3.

Table 3 Chemical composition of pulses

Name of Pulse	Protein (%)	Ash (%)	Fat (%)	Carbohydrate (%)	Crude fiber (%)	References
Lentil	23.6 – 25.1	2.50 – 2.85	1.7 – 1.9	66.6 – 68.2	3.7 – 3.8	Sanjeewa et al. (2010) Kaur and Singh (2010)
Chickpea	21.8 – 24.9	2.8 – 3.0	6.7 – 7.6	47.4-55.8	3.9-11.2	DanutaRachwat., 2014
Yellow peas	22.37	2.84	0.94	61.21	2.07	Ma et al., 2011
Pigeon pea	20.71	3.05	3.38	64.6	0.40	Kaushal et al., 2012
Bean	20.28–23.62	3.18 – 5.0	1.52-3.62	-	0.67 – 4.59	Audu and Aremu, 2011 Siddiq et al., 2010 Shimelis et al., 2006

This is associated with reduction in osteoporosis, prevention of cancer, cardiovascular diseases and menopause. It also play natural role for plants by acting as antimicrobial component (Garcez.,et al 2000). Saponins are secondary metabolites of mixed biosynthesis and reduce cholesterol through the formation of an insoluble complex with cholesterol, thus preventing absorption in the intestine. Additionally, some saponins increase the excretion of bile acids—an indirect method of decreasing cholesterol. Majority of alkaloids from edible legumes have been reported from lupins. It enhances palatability and disease resistance. Pulses are the significant source of dietary fibre therefore glycaemic index (an indicator of the effect on blood sugar) is also low. Since they do not contain gluten, they are an ideal food for celiac patients. Pulses are an important part of a healthy diet because they are high in protein, fibre, and other essential nutrients. Additionally, pulses are rich in minerals (iron, magnesium, potassium, phosphorus, zinc) and B-vitamins (thiamine, riboflavin, niacin, B6, and folate) all of which play a vital role in health. Their high iron and zinc content is especially beneficial for women and children at risk of anemia. Pulses are also the main source polyunsaturated fatty acids (linoleic and oleic), saponins, isoflavones, butyrate, raffinose, lycopene, phytosterols etc.

Health Benefits

Nutrient and non-nutrient content in pulses have been associated with reduction of cancer risk (Dahl et al. 2012). Additionally, previous studies show that there is protective relation between pulse consumption and prevention of diseases such as cardiovascular disease (CVD) and diabetes (Iqbal et al. 2006; Winham et al. 2008).Several studies demonstrate that human studies have been confirmed by animal experiments in the field of

diabetes. Diets with low glycaemic index value improve the prevention of coronary heart disease in diabetic and healthy subjects. In obese or overweight individuals, low glycaemic index meals increase satiety and facilitate the control of food intake. Selecting low glycaemic index foods has also demonstrated benefits for healthy persons in terms of post-prandial glucose and lipid metabolism (Rizkalla S.W et al., 2002). Major health benefits associated with an increased intake of dietary fibre include reduced risk of heart disease, diabetes, obesity, and some forms of cancer (Marlett, McBurney and Slavin, 2002). As increase in consumption of soluble fibre, it will reduce serum total cholesterol and low density lipoprotein-cholesterol (LDL-C), hence help to decreases coronary heart disease mortality (James et.al; 2003, Marlett JA et.al; 2002).Also dietary fibre rich foods intake are associated with lower body mass index (BMI) (Pereira MA & Ludwig DS, 2001) which helps in reaching satiety faster and this satiating effect lasts longer because longer time required for digestion fibre-rich foods in the intestinal system (Burley et.al; 1993). Pulse fat contains almost 50-60% polyunsaturated fatty acids (PUFAs) (linoleic and oleic). Intake of linoleic acid has been shown to have a beneficial effect on serum lipids, insulin sensitivity and hemostatic factors; therefore it could be helpful in lowering the risk of coronary heart disease (Hu FB et.al; 2001).Pulses contain bioactive compounds that show some evidence of helping to combat cancer, diabetes and heart disease. Some research indicates that eating pulses frequently can help control and combat obesity as well. Pulses are dried seeds and can be stored for long periods without losing their nutritional value, allowing for flexibility and increased food availability between harvests. Since they can be used for self-consumption or as cash crops, farmers who cultivate pulses have the option to both eat and/or sell their harvest. Minor components (phytates, lectins, enzyme inhibitor, oligosaccharides, phenolic components) of pulses having protective effect like it exhibits antioxidant activity, biological, physiological activity, protect DNA damage stimulation of the immune system, regulation of lipid and hormone metabolism, antioxidant, antimutagen, and antiangiogenic effects and reduction of tumor initiation (Rocio Campos-Vega, et al., 2010).

Isoflavones content in pulses may lower the rate of heart disease due to inhibition of LDL-C oxidation, inhibition of proliferation of aortic smooth muscle cells and maintenance of physical properties of arterial walls (Tikkanen MJ et.al; 1998, Pan W et.al; 2001, van der Schouw YT et.al; 2002). .Pulses contain Phytosterols, which exhibit anti-ulcerative, anti-bacterial, anti-fungal, anti-tumoric and anti-inflammatory properties with a lowering effect on cholesterol levels (Murty CM et.al; 2010).

Application

Pulses have been successfully used in preparation of various traditional foods as well as novel products like unleavened flatbread (chapati), unleavened multigrain pancakes (thalipeeth), bakery products, instant soups, meat products, snack food like fried chickpea, lentils etc. Fibre characteristics, including hydration properties, can be modified through processing treatments, such as grinding or extrusion, to improve functionality.

Chapatti: Chapatti is staple food of India. Chickpea, pea's flour was used to increase nutritional values of chapatti by lowering glycemic index, increasing protein digestibility. Kadamet al., (2012) studied the development of chapatti and missi roti by adding chickpea flour which resulted into increased amino acid flour with improved sensory values. Addition of chickpea flour in chapatti preparation increased dietary fiber content and thus caused reduction inglycemic index and obesity (Masood Sadiq Butt et al., 2011)

Thalipeeth: Thalipeethis multigrain(cereal and legume) pancake products (Gupta, 2011). For preparation of Indian multigrain pancake viz. thalipeeth prepared by using different pulses like chickpea, black gram and green gram. These composite pulse flour having characteristics of the protein matrix, it may play an important role in determining the rate of starch digestion in thalipeeth. Higher protein in the thalipeeth reduces GI due to protein network entrapping starch granules and contains combinations of soluble dietary fiber and soluble proteins compared with others cereals responsible for reducing digestibility of legume starch.

Extruded product: Nowadays, novel use of pulses in HTST i.e. extrusion is very demanding. Pamela et al., (2014) reported that addition of 25% chickpea flour to durum wheat pasta induced a lower degree of in-vitro starch hydrolysis and of the in-vivo GI because of higher amount of indigestible carbohydrate. Substitution of durum wheat semolina with legume flour resulted to be an interesting way to increase the nutrition composition of pasta (protein, fiber, vitamin and minerals content, amino acid complementarily) while keeping the low digestibility of its starch (Lucia et al., 2014). The advantage of such a product over the traditional corn snack would be its higher protein content and superior protein nutritional quality (Batistutiet et al., 1991). According to Milan-Carrillo et al., (2000), extruded chickpeas may be considered for the fortification of widely consumed cereal-based food products. Pasta preparation is made with blends of chickpea flour (10-50%) with wheat flour. It increased in protein, fiber, resistant starch (Canadian International Grains Institute, 2007). Some finding of whole meal bread enrich with peas flour (Marcella et al., 2015) observed that addition of peas flour reduced GI. Pamela et al., (2014) reported that addition of 25% chickpea flour to durum wheat pasta induced a lower degree of in-vitro starch hydrolysis and of the in-vivo GI because of higher amount of indigestible carbohydrate.

Meat Products: Pea fractions are also used in coating of meat products like chicken nuggets, fish nuggets and chicken breast with 100% replacement of corn starch and wheat flour (Food Development Centre, 2009).

Flakes: Nutritious snack bars containing 50:50 rolled oats and lentil flakes was developed. (University of Manitoba; Ryland et al. 2010).

Conclusion

The above information shows the potential nutritional importance of pulses and its role in enhanced nutrition and health. It is a reasonable source of protein, carbohydrates, minerals and vitamins, dietary fibre, folate, polyunsaturated fatty acid (linoleic and oleic), saponins, Isoflavones, raffinose, phytosterols etc., and recommended by many major health organizations as a way to reduce the risk of chronic diseases, heart diseases, diabetes and obesity. Published data have provided indirect evidences supporting the role of pulse consumption in disease-risk reduction, but are based more on nutrient composition, and remain limited. Physico-chemical properties and functional properties of pulses are helpful for development of a variety of food products. The overall literature indicates that pulses possess many nutritive and non-nutritive factors that have been shown to possess anticarcinogenic, antioxidant, and satiating effects.

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GW150914: The First Symphony from the Universe by Black-Hole Binary Merger@1.33 Billion Light Years

On 14 September 2015, the two Laser Interferometric Gravitational Wave Observatories (LIGO) located at Hanford, Washington and Livingston, Lousiana, U.S.A. instruments detected the first symphony from the distant Universe. The symphony was nothing but the gravitational wave signal from the merger event of binary black holes which occurred 1.33 billion years away in a distant galaxy. The gravitational waves produced during this catastrophic event travelled a long distance and reached Earth on September 14 at 15:20 (IST) carrying a unique signature of its composers. This was the first ever symphony from our universe and it carried the crucial evidence of the existence of the stellar mass binary black hole system. The detection of the event has opened a new window to our universe.

Einstein's General Relativity, Gravitational Waves and Black Holes

A century ago, in 1915, Prof. Albert Einstein formulated the General Theory of Relativity. The theory completely revolutionised the concepts of Space, Time and Gravity. The Equivalence Principle states that the inertial mass is same as the gravitational mass of a body. This explains the famous experiment performed by the Italian Naturalist and Philosopher Galileo Galilei. Galileo showed that when two objects of different material/size are dropped from the tall tower (56 m height) of Pisa, they arrive at the same time irrespective their size/material. This is the direct consequence of the Equivalence Principle. This allowed Einstein to formulate the problem of the motion of a particle under gravity as a problem of geometry in the General Theory of Relativity framework.

According to General Theory of Relativity, the massive objects like (Sun or Stars) produce distortions in the fabric of space-time as shown in Fig, 1. When the central object is static, the space-time fabric is static. The particles move along a given trajectory as given by the straight lines (geodesics) of this fabric. For example, the motion of Earth around the Sun is equal to the Earth's trajectory on the distorted fabric produced by the Sun.

In 1916, General Relativity predicted the existence of gravitational waves; when a pair of stars orbit around each other in a binary orbit, the stars will produce ripples in the space-time fabric. These ripples are distortions in space-time fabric which propagate with speed of light and are referred to as Gravitational waves.

In the same year, Karl Schwarzschild obtained a solution to Einstein equations: a metric which describes the space-time geometry around a spherical mass. The Schwarzschild metric introduced the mathematical concept of a Black Hole — a compact object from which not even the light can escape. It is a great historical coincidence that both Gravitational Wave prediction as well as the concept of Black Holes was introduced in the same year exactly a century ago!

Towards Gravitational Wave Detection!

The space-time fabric described by Einstein's GR is a tight membrane. It requires large amount of energy to make small changes in the fabric. To give an example, imagine a 10 meter rod of one ton mass is spinning such that it can make 10 spinning cycles in one second. Such an object will produce gravitational waves such that for a detector located at the antipodal point (on Earth) would produce a change of 1 part in 1 billion trillion trilliontrillion! This gives an idea as how tight is the space-time fabric. Detectable gravitational waves are produced by compact astrophysical sources so that the incoming gravitational waves would be strong enough to detect with very sensitive instruments!

First Steps towards Gravitational Wave Detection

The pursuit of Gravitational Waves has been a long journey! It started in 1960's when a renowned experimental relativist from University of Maryland, Joe Weber (Fig.2) proposed a resonant bar detector as a gravitational wave detector. The detector was a metal bar of Aluminium weighing few tons and maintained at room temperature. The idea was to look for astrophysical gravitational waves in the narrow band centred around the resonant frequency of the metal bar. With the data, he published having discovered gravitational waves. The results were received with criticism as well as excitement in the field anda large number of groups developed resonant bars to detect gravitational waves.

A consortium called International Gravitational Wave Event Coincidence (IGEC) was formed amongst these groups. The IGEC continued to improve the detectors successively. The advanced cryogenic resonant bars, operational between 1997-2003, were Allegro (Lousiana), Auriga (Legnaro, Italy), Explorer (Cern, Geneva), Nautilus (Frascati, Italy) and Niobi (Perth, Austrailia). The last data run was taken in 2003 between Explorer, Nautilus when the bars were cooled to few Kelvin degrees and were able to measure the change equal to the diameter of proton to the radius of Earth in the narrow band of tens of Hz. None of these runs gave any positive result of gravitational wave detection. Now, all the resonant bars are not operational.

Laser Interferometric Detectors

In 1970's, with the forward leap in the laser technology, scientists started pondering to use the optical interferometer to detect gravitational waves. The trio Roland Drever, Caltech, Reis Weiss, MIT and Kip Thorne, Caltech did the first feasibility studies for km arm length interferometer and studied possible noise sources. In early 1980's, prototype interferometers of few tens of meter arm length were developed in MIT, Garching and Glasgow. The National Science Foundation gave an approval to construct km arm length Laser Interferometric Gravitational wave Observatory (LIGO) detectors in Louisiana and Hanford.

The principle of optical interferometer is based on the interference of light. The base design for the interferometric detector is a Michelson interferometer. In Michelson interferometer (see Fig. 3), the laser beam is equally split in two directions by a beam-splitter. At each km-arm the beam is reflected by the mirror and sent back. The two beams are combined and collected at the photo-diode which senses the phase difference between the two interfering beams. The incoming gravitational waves introduce change in path length

based on the direction of the source and polarisation of gravitational waves which is further reflected in the phase difference.

A series of advanced technology is used in addition to the above mentioned simple design to combat the noise sources. The optics is suspended to reduce the low frequency seismic noise due to ground vibrations. Special low loss suspensions are used to reduce the thermal excitation of the suspensions. To obtain high sensitivity, high power laser is used. The change in distance measured due to the gravitational waves is proportional to the length of the arm. Higher the arm-length, higher is this change. Hence, the laser beam is folded multiple times to increase the total travel path of the laser beam. This is achieved by folding the beam using the optical cavity —- Fabry Perot Cavity. The arms are kept in high level of vacuum to avoid noise due to surrounding gas.

During the construction of suspended Michelson interferometers in U.S., world-wide network of km arm length projects started getting constructed. Amongst them is French-Italian Virgo detector of 3 km arm length located in Pisa and Japanese detector KAGRA located in the Kamiokande site.

The Hulse-Taylor Binary Pulsar

In the meanwhile, in 1974, another very important development happened in astronomy. R. Hulse and J. Taylor discovered a binary pulsar PSR 1913+16. The binary system was peculiar and was first of its kind where the observed star was a Pulsar and a companion later-on was found to be a neutron star. Later Weisberg and Taylor showed that the orbit of the pulsar was slowly shrinking over time because of the release of energy in the form of gravitational waves as shown in Fig. 4. The observed decay in the period of binary from the radio observations matched very well with that predicted from Einstein's General Theory of Relativity. For this discovery of binary pulsar, Hulse and Taylor received Nobel prize in Physics in the year 1993. This indirect evidence increased the excitement in the scientific community and the pursuit of direct detection of gravitational waves continued.

Pursuit of Gravitational Wave Detection

The initial LIGO finished construction in 2002 and took the first coincident data with 600 m GEO600 (British-German) interferometer. In the meanwhile in 1997, LIGO Scientific Collaboration was formed which expanded from Cal Tech, MIT to GEO600 scientists. In 2004, the National Science Foundation approved the construction of advanced LIGO. With reaching the designed sensitivity of the initial LIGO in 2006, LIGO detectors took the joint data with Virgo till 2007. The joint operation of these science runs did not find any gravitational wave event.

The construction of advanced LIGO started in the year of 2010. After the initial testing of the instrument, the first observation run was scheduled on 18th September 2015. The designed sensitivity reached during that time was 3-5 times better than the initial LIGO at the most sensitive frequency around 150 Hz.

Observational Features of the GW150914

Few days before the scheduled observation run, on September 14th, 2015, LIGO Livingston observed an event as shown in Fig. 5 termed as GW150914 (year-month-day) of duration of fraction of a second followed by a similar event in LIGO, Hanford delayed by 7 milliseconds. The time-frequency representation of the event showed that the frequency of the event swept from 35Hz to 350 Hz in 200 milliseconds. The event was first detected by a fast data analysis algorithm, 3 minutes after the occurrence of the event.

The event seemed to be carrying the chirping feature of a binary system. When the two stars are in the binary orbit, as they lose energy through gravitational waves, they come close to each other. As a result, they attract each other more with increase in the orbital frequency (following Kepler's law). Thus, they emit gravitational waves with increasing frequency and increasing amplitude which is termed as a 'chirp' (synonym to the chirping sound of birds). This feature was evident in the initial phase of the observed event [see Fig. 5 Horizontal panel 4]. Eventually the two stars merge following a ring down phase.

The confirmation of astrophysical origin of GW150914 required thorough scrutiny of the data. The data was compared with various environmental channels — total of 100000 in numbers. They include monitoring channels with seismometers, accelerometers, microphones, magnetometers, radio receivers, weather sensors, ac-power line monitors, and a cosmic-ray detector etc. Appropriate noise vetoes were applied based on the correlations as well as common temporal-spectral features. After doing a thorough investigation, the astrophysical origin of the event was established.

Astrophysical Origin of the Event

In gravitational wave search, the data is cross-correlated with a large number of model waveforms — a technique known as matched filtering. If the noisy data contains the similar waveform, the filtered output peaks. This happened when the model and the signal buried in the data matches in phase. For compact binary system with neutron stars and black holes, a well-defined signal models are predicted from general relativistic as well as from numerical relativity simulations. The numerical relativity simulations simulate the binary merger event on computers and obtain the merger waveforms (Fig. 6). The data from GW150914 event was analysed using matched filtering and a detection confidence was developed.

In gravitational wave search where signal might be buried in noise, a valid question is raised. What is the probability that the event is not due to chance coincidence of noise? In order to answer this, the scientists do a thorough noise background analysis. For example the two LIGOs are located 3000 km away and hence they are separated by the light flight time of 10 millisecond. If the signal is of astrophysical origin, the arrival time delay between the two LIGOs should be below 10 milliseconds else if the event is due to a random noise the delay can have any arbitrary value. A thorough background statistics is obtained which shifts the data artificially by delays greater than10 millisecond. A list of events are obtained and sorted. Based on this statistics, the GW150914 was detected with a confidence level of 5.1 sigma. This translates into probability of noise mimicking GW150914 is 1 in 203,000 years. Colloquially speaking this is equal to probability of getting heads on each toss of a fair coin when tossed 22 times in a row.

The GW150914 was confirmed to be an astrophysical binary located at 1.33 billion light years ago. It was a merger event of two black holes of masses 29 solar mass and 36 solar mass respectively. The binary merger produced a single highly spinning black hole of mass of 62 solar masses. The spin of the remnant black hole was very high (the spin amounts to 100 rotations per second). The event emitted a copious of gravitational energy in terms of emission of gravitational waves which corresponded to an equivalent energy of 3 solar mass in a fraction of a second. The peak energy of the event was few tens of the combined electromagnetic energy (in the entire band) of our Universe. The source was localised into a big patch of 600 square degrees in the southern sky. This landmark discovery by the LIGO detectors after 100 years of the prediction of gravitational waves made a history! This was the first direct detection of gravitational waves. This was the first direct observation of binary black holes of masses. Various tests were carried out on the GW150914 event looking for possible signatures of deviations from Einstein's theory of gravity. No evidence of such a deviation was found. The signal is consistent with the Einstein's theory within the experimental errors. This is the first ever astrophysical event where the strong field gravity was tested!

Indian Contribution to the Discovery

The LIGO Scientific Collaboration and Virgo Collaboration have 16 countries and close to 1000 scientists. The Indian participation in the LIGO Scientific Collaboration (LSC), under the umbrella of the Indian Initiative in Gravitational-Wave Observations (IndIGO), involves sixty-one scientists from nine institutions - CMI Chennai, ICTS-TIFR Bengaluru, IISER-Kolkata, IISER-Trivandrum, IIT Gandhinagar, IPR Gandhinagar, IUCAA Pune, RRCAT Indore and TIFR Mumbai. The discovery paper has 37 authors from these institutions.

In 2009, IndIGO consortium was formed by a group of researchers with expertise in theoretical and experimental gravity, cosmology and optical metrology, who are keen to promote gravitational wave research in the country. The consortium pursued the dream of realizing an advanced detector in India after its formation.

The current Indian gravitational wave scientific community has arisen out of intense research programmes carried out over three decades at few research institutes, with seminal contributions. The group led by Balalyer (currently at ICTS-TIFR) at the Raman Research Institute (RRI) in collaboration with scientists in France had pioneered the mathematical calculations used to model gravitational wave signals from orbiting black holes and neutron stars. The group led by Sanjeev Dhurandhar at IUCAA initiated and did foundational work on developing matched filtering techniques, technique of stationary phase approximation applied to the gravitational wave search and led the solo Indian group in the LSC in the initial era of LIGO for a decade. Theoretical work that combined black holes and gravitational waves was published by C. V. Vishveshwara in 1970. These contributions are prominently cited in the discovery paper.

Over the last decade the Indian gravitational wave community, mainly consisting of researchers trained in these groups, has spread to a number of educational and research institutions as faculty in India. For example; Sukanta Bose (IUCAA), Archana Pai (IISER-Trivandrum), Rajesh Nayak (IISER-Kolkatta), Anand Sengupta (IIT-Gandhinagar) and Sanjit Mitra (IUCAA) were trained at IUCAA during their post PhD or PhD phase whereas A. Gopakumar (TIFR-Mumbai), K. G. Arun (CMI, Chennai) and P. Ajith (ICTS-TIFR) received initial training in this field at RRI, Bangalore.

As members of the LSC, they have made contribution to the development of novel techniques to identify the weak gravitational wave signals, enabling gravitational wave astrophysics. Other Indian researchers in the LSC have expertise in precision metrology, laser and optics development, ultra- high vacuum techniques and control systems. A 3 meter prototype interferometer is being constructed at TIFR, Mumbai lead by C. S. Unnikrishnan.

Indian groups collaborated with members of the LIGO Scientific Collaboration and Virgo Collaboration and contributed to understanding the response of the detector to the terrestrial influences, the method used for detecting the signal, bounding the orbital eccentricity, estimating the mass and spin of the final black hole and the energy and power radiated during merger, confirming that the observed signal agrees with Einstein's General Theory of Relativity, and to the search for a possible electromagnetic counterpart using optical telescopes.

The discovery paves the road to the possibility of observing our universe in gravitational waves if one can locate their source with additional detectors placed far from the LIGO detectors, in a large triangle. The ‘in principle’ approval of the LIGO-India project on 17th February 2016, would help to improve the sky localisation of the future gravitational wave sources giving boost to the field of gravitational wave astronomy and, more importantly, would bring in the much needed high end vacuum, Laser, precision measurement technologies for India.

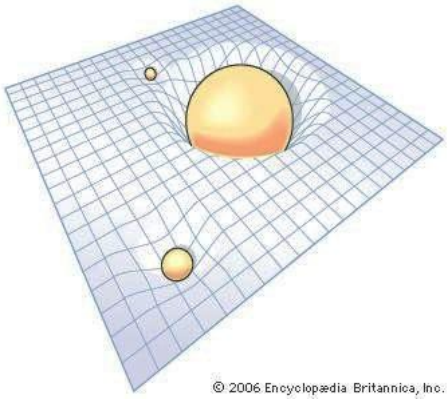


Fig1. Effect of central object on the space-time geometry

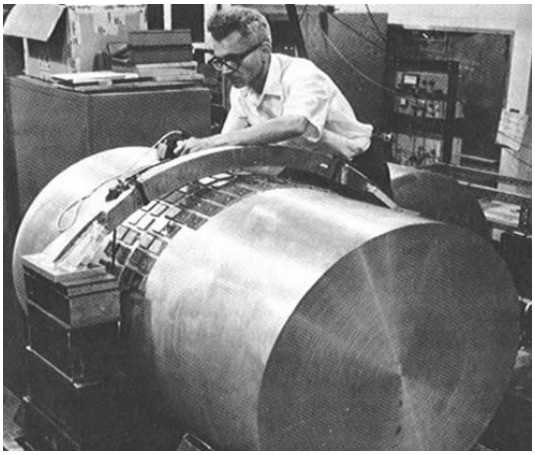


Fig.2 .Joe Weber with the resonant bar.
[Credit: Department of Physics, University of Maryland, U.S.A.]

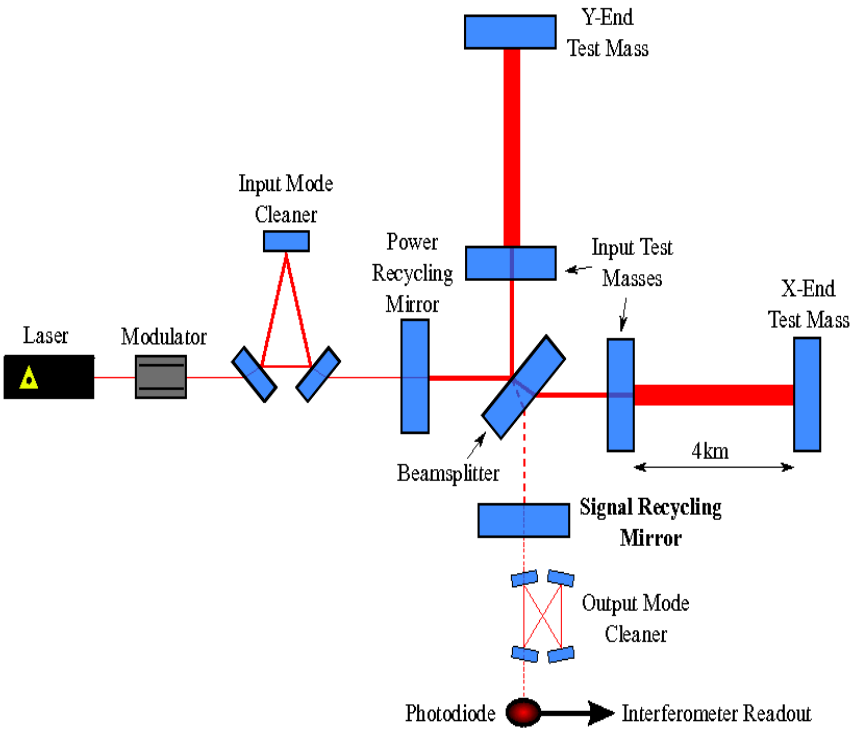


Fig3. Schematic diagram of the Optical Layout of gravitational wave detector.
[Credit: LIGO]

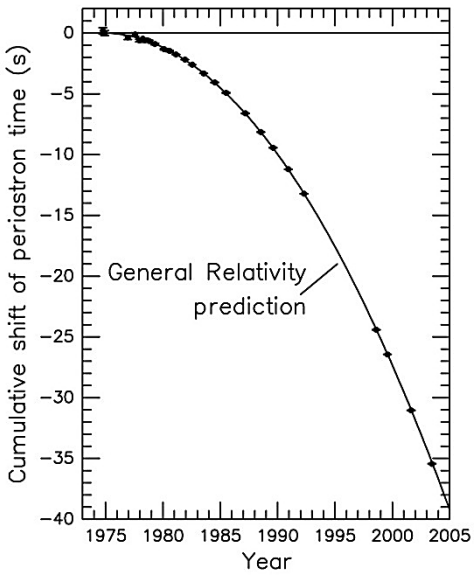


Fig. 4.Cumulative shift of the periastron time due to emission of gravitational waves. The rate this decay is 75 microsecond per year [Weisberg and Taylor, ASP Conf. Series Vol 328, 2005]

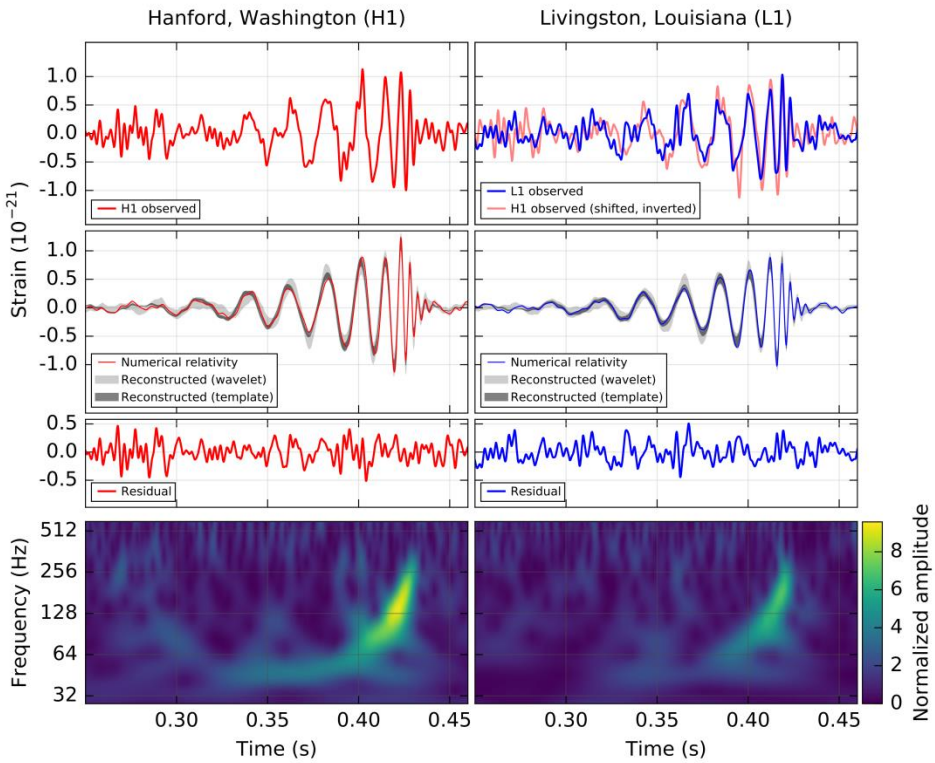


Fig.5
First horizontal row*:* GW150914 observed in both LIGO detectors
Second horizontal row*:* Reconstructed Inspiral-Merger-Ringdoen Waveforms in both the detectors. **Third horizontal row***:* Detector residual noise after removing the reconstructed signal. **Fourth horizontal row***:* Time frequency representation of GW150914. The signal swept up in frequency band as the time progresses showing clear signature of a chirp.
(Credit: LIGO-Virgo Collaboration)

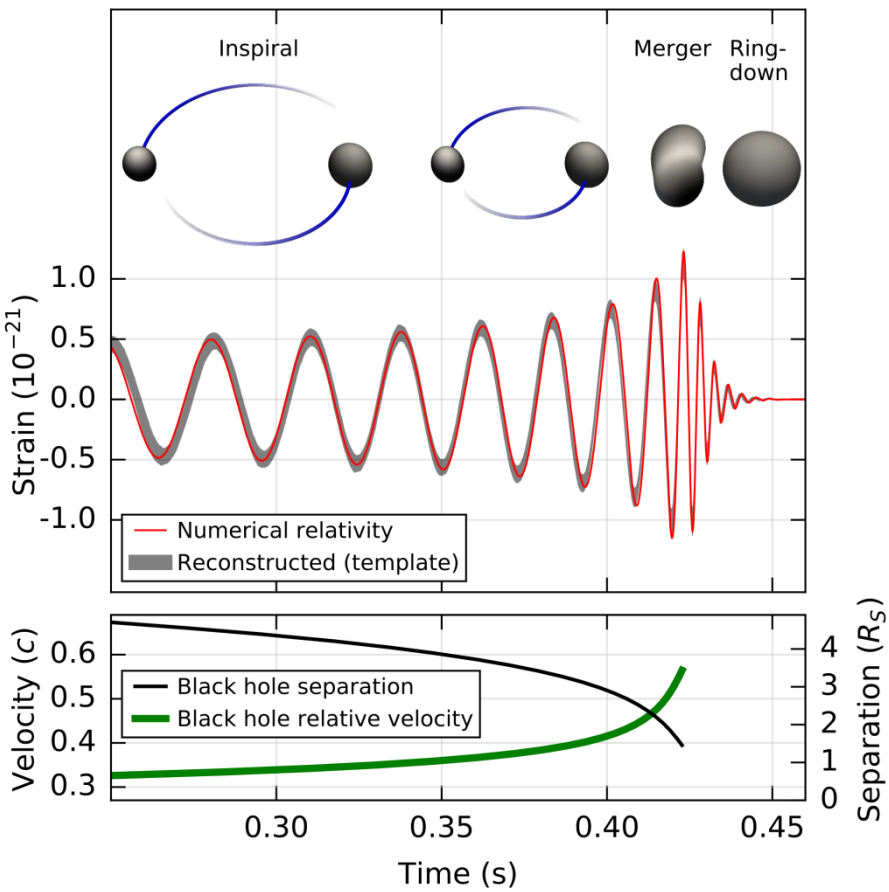


Fig 6: First horizontal panel*:* The binary phases; in spiral, merger and ring down along with reconstructed waveform matching with the numerical relativity waveform
Second horizontal panel*:* Black hole separation as well as velocity from the reconstructed waveforms as a function of time. At the closest separation, the relative velocity is as close as 0.6 times speed of light.
(Credit: LIGO Virgo Collaboration)

References:

1. LIGO Open Science Center: http://losc.org
2. LIGO Experiment webpage: http://ligo.org
3. IndIGO Consortium webpage: http://gw-indigo.org
4. LIGO India webpage: http://www.gw.iucaa.in/ligo-india/
5. GW150914 Discovery Paper: https://physics.aps.org/featured-article-pdf/10.1103/PhysRevLett.116.061102

Archana Pai is a faculty at School of Physics, IISER Trivandrum. She has done her PhD in IUCAA, Pune on Multi-detector Gravitational Waves Search with Prof. Sanjeev Dhurandhar. Subsequently she held various post-doctoral positions at some of the leading groups on gravitational waves in Europe. She secured Henri Poincare Fellowship in Virgo Group at Observatoire de Cote d'Azur, Nice. She was an INFN Fellow at University of Rome, La Sapienza jointly working on Virgo as well as Resonant Bar Group. Following which, she held a post-doctoral position in Albert Einstein Institute with Yanbei Chen where she worked on advanced interferometer designs. Her primary research interest is Gravitational Wave Detection and Parameter Estimation problems for coalescing compact binaries with Neutron Stars and Black Holes.

Applications Invited for Annual IWSA Awards

- **1. Dr. Shantoo Gurnani "Merit-cum-Means" Scholarship:** For girl students at the graduate levels --science stream only.

Eligiility: Girls pursuing BSc in any science stream. Students with family income of less than Rs 3.00 lakhs per annum can apply.

- **2. 'Param Udhav Gurnani' Travel Support**: For attending IWSA scientific conferences (actuals, not exceeding Rs. 2,000/-).

Eligibility: Should be presenting a paper (oral or poster). Award will be based on quality of abstract and financial status.

- **3.'Param Udhav Gurnani' Best Paper Awards:** For girl students -- best posters/papers during IWSA conferences (Rs. 1,000/-).

- **4. Nanik Gurnani 'Innovation Award':** For a IWSA member who has done innovative research in applied S&T. The application must be sent by 15th Oct. of the year with detailed bio-data, along with details of research (Rs. 5,000/-).

- **5. "Late Dr. Jayshree Daoo Award":**This award is instituted by Major Vikrant Daoo in memory of his mother. It is for a bright young woman pursuing Ph.D. in the field of Science (Rs. 18,500/).

Eligibility: Students in their second year of their PhD program can apply for the award. They should submit a two- page write up of their research proposal.

- **6. "Dr. Suresh K. Mahajan Memorial Scholarship":** This Scholarship has been instituted at IWSA, 2016, by Dr. Mahajan's student, Dr. V. Sanzgiri.

Eligibility: The scholarship will be given to a bright female student pursuing a PhD. degree in any discipline of life sciences and should be in the 2nd year of their program. The annual family income of the student should not exceed Rs. 3/lakh. This Scholarship of Rs. 50,000/ will also carry a citation and a medal. The applicants must submit a two-page summary of their Research proposal.

In addition to the above, there are several other awards instituted by generous donors, well-wishers and IWSA members. These are meant exclusively for students attending different courses in IWSA.

Please Note:

(i) Last date of application: 15 October, 2016.
(ii) Applications to be sent to: Convenor, Scholarship Committee, IWSA, with a soft copy to iwsahq@gmail.com.

Erratum

The following News item appeared in the IWSA Newsletter, Vol 43, Issue 1, January-April 2016.

"A popular science lecture entitled "Swami Vivekananda and the Tatas – A blessed combination which came as a boon to Indian scientific scenario" by ***Mataji Rev. Pravrajika Amalaprana,*** *General Secretary, Sri Sarada Math and Ramakrishna Sarada Mission, Kolkata was held on 28th April 2016 at IWSA's ICICI Multipurpose Hall at 4.30 pm."*

The name of Mataji was wrongly mentioned in this News Item.

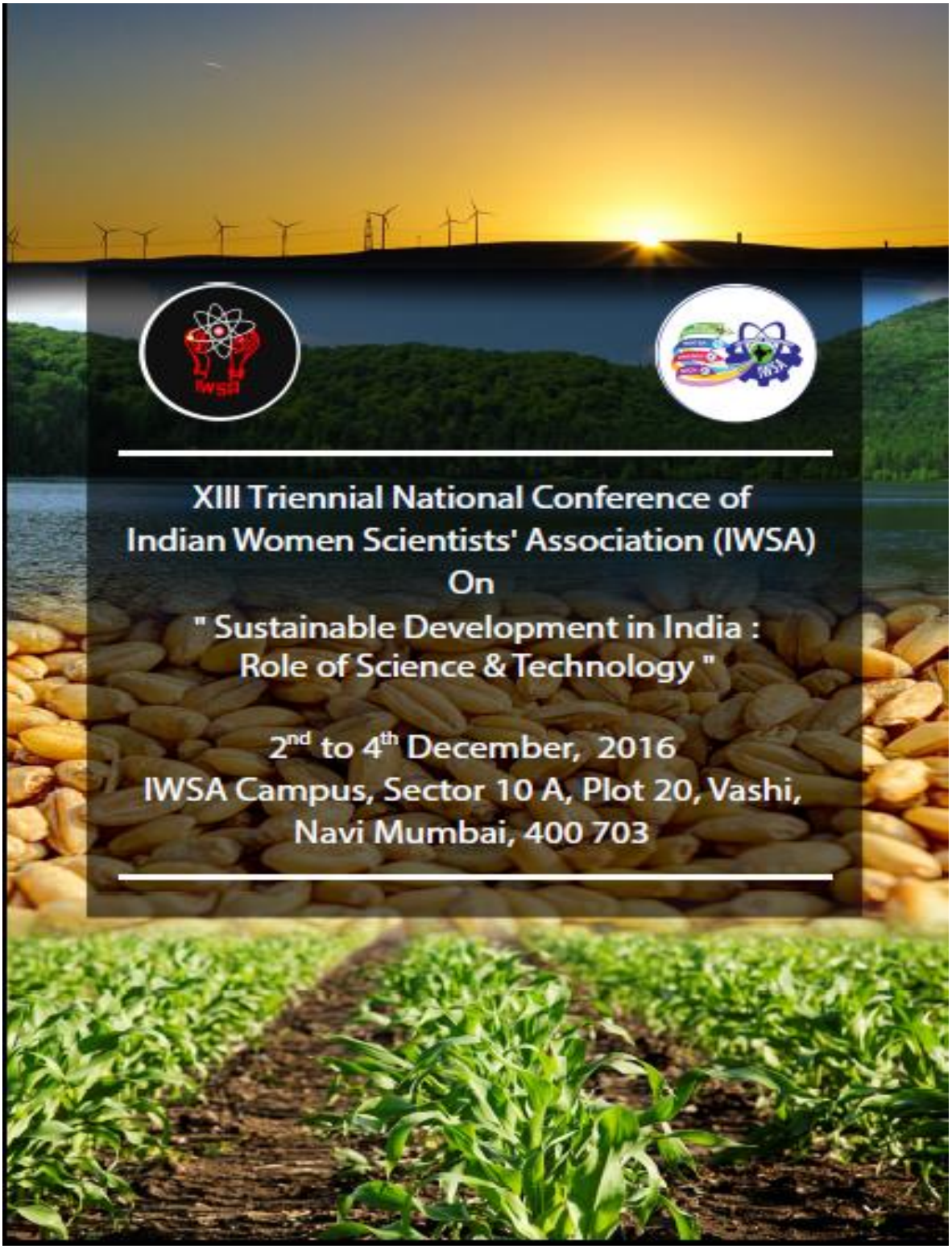
We regret the error and correct the News Item as follows:

"A popular science lecture entitled "Swami Vivekananda and the Tatas – A blessed combination which came as a boon to Indian scientific scenario" by ***Mataji Rev. Pravrajika Atandraprana,*** *Assistant Secretary, Sri Sarada Math and Ramakrishna Sarada Mission, Kolkata was held on 28th April 2016 at IWSA's ICICI Multipurpose Hall at 4.30 pm."*

REQUEST FOR UPDATING OF CONTACT DETAILS OF IWSA MEMBERS:

Members are requested to send their present postal address, telephone (landline and mobile), email and passport size photograph to IWSA Head quarters on iwsahq@gmail.com.

Branch members are requested to give the above details to their Conveners AND to send the same directly to iwsahq@gmail.com.



XIII Triennial National Conference of Indian Women Scientists' Association (IWSA)

On

" Sustainable Development in India : Role of Science & Technology "

2nd to 4th December, 2016

IWSA Campus, Sector 10 A, Plot 20, Vashi, Navi Mumbai, 400 703

The Conference Themes

ENERGY

Renewable and non-renewable sources of energy, cleaner and efficient coal technologies, hydrogen energy, biofuel energy, nuclear energy, efficient lighting, efficient transportation, energy efficient agricultural technologies, efficient use of energy, energy from waste, energy storage, rural energy, smart grids.

WATER

Sources, water availability, water quality, water purification, desalination, cleaning of rivers, lakes, use and conservation, recycling and reuse technologies.

FOOD & AGRICULTURE

Efficient agricultural production, agri-smart innovative techniques, sustainable genetic varieties of crops and livestock, agriculture and nutrition, efficient use of land, soil, fertilizers and pesticides, agriculture and balance with the ecosystem, synergy between crops, livestock, forestry and fisheries, agriculture and climate change, agriculture-food and nutrition, food system-efficient storage, packaging, and distribution.

ROLE OF NGOs IN SUSTAINABLE DEVELOPMENT

All sustainability development goals need the involvement of members of the society to ensure that expectations are understood and explained to the community at large in lay terms. NGOs have a major role to play in this activity. They are the facilitators towards sustainability, acting as the interface between the policy maker and the end user.

http://www.iwsa.net/conference2k16/index.php

Members do hurry up and Register

Workshop on Making Tray Garden for Children 29th April, 2016

Pottery Workshop 9th to 26th May 2016

Ms. Usha Banerjee being felicitated by Dr. Usha Thakare at the Inauguration of the Training of Teachers academic year.

BOOK POST

Regd. No.N.R.24208/74
ISSN 0972-6195

Pune Branch Women's Day Celebration 8th March 2016

Work environment for women is improving slowly: Justice Naik

Justice Vasanti Naik addressing the gathering while others look on.

■ Staff Reporter

INDIAN Women Scientist Association (IWSA), Nagpur Branch and Institute of Engineers India (IEI) Nagpur Local Centre jointly celebrated International Women's Day recently. The theme of the programme was 'Share the Dais' on the topic 'Work Environment for Women has considerably improved'.

Justice Vasanti Naik, chief guest of the function, explained how women were underestimated in the past and their capabilities were ignored but now work environment for women is slowly improving. Past President Date, Sanjay Raut, Secretary of IEI; Manali Kshirsagar, convenor, Anuradha Gadkari, Founder member and past convenor IWSA, Dr Seema Somalwar, convenor of IWSA were present on the dais.

Dr Deepti Andhare conducted the proceedings while Dr Bharti Ganu proposed a vote of thanks.

Nagpur Branch Women's Day Celebration 12th March 2016

Vadodara Branch National Seminar on "Impact of Climate Change on Biodiversity"12th March 2016

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