I A Brief report of the Lecture Workshop

The three-day lecture workshop on Nonlinear Physics, sponsored by the Science Academies' has been successfully organized by the co-ordinator Dr. T. Kanna under the guidance of the Convener Prof. M. Lakshmanan, F.N.A.Sc. F.A.Sc., F.N.A., TWAS, at Bishop Heber College, Tiruchirappalli, Tamil Nadu, during the period 23.01.2014 – 25.01.2014.

DAY I 23.01.2014 (THURSDAY)

1. Registration

The registration of the candidates to participate in the Science Academies' lecture workshop on Nonlinear Physics was done by 9a.m. on 23.1.2014 at the AC seminar hall of our college. A total of 166 participants (61 pre-registered candidates from the neighbouring institutions, 77 students (M.Sc., M.Phil. and Ph.D.) and 28 faculties from our institution) have been registered for participation in the lecture workshop. Duly filled-in registration forms were received from the participants and the registration materials (notepad, workshop file, pen and ID card) including a detailed schedule of the workshop were provided to them.

2. Inaugural Function

The inaugural function of the workshop took place at 9:30a.m. on the first day. Following the welcome address and honouring the chief guests, a brief introduction to the Lecture Workshop was given by the co-ordinator of the workshop. The Principal of our college (Dr. D. Paul Dhayabaran) delivered the Inaugural Address. Professor M. Lakshmanan delivered Convener's address in which he explained the details of various activities of the three Science Academies' of our country (Indian Academy of Sciences-Bangalore, Indian National Science Academy-New Delhi and The National Academy of Sciences, India-Allahabad). He has highlighted the Science Academies' support to organize Lecture Workshops and Refresher Courses. He has also mentioned that through Summer Programmes the Science Academies encourage the post-graduate students as well as teachers to do project works with the Fellows of Academies.

After a high tea the lecture sessions started.
3. **Lecture I:** [Prof. M. Lakshmanan](#), F.N.A.Sc. F.A.Sc., F.N.A., TWAS  
Centre for Nonlinear Dynamics, Bharathidasan University, Tiruchirappalli.  
*Title: Introduction to Nonlinear Dynamics-I*

The lecture was focused on the fundamental aspects of Nonlinear Physics. After giving an introduction to the forces and the role of Newton’s second law in describing the dynamics of a physical system, the lecture dealt with the dynamics of oscillators. First the notion of nonlinearity and the nonlinear dynamical systems were discussed. Then some of the tools involved in studying the nonlinear dynamical systems were explained.

After the first lecture there was a tea break for 10 minutes.

4. **Lecture II:** [Prof. M. Lakshmanan](#), F.N.A.Sc. F.A.Sc., F.N.A., TWAS  
Centre for Nonlinear Dynamics, Bharathidasan University, Tiruchirappalli.  
*Title: Introduction to Nonlinear Dynamics-II*

The second part of Professor Lakshmanan’s lecture dealt with nonlinear oscillators. Particularly, the lecture was focused on the famous Duffing oscillator. A nice theoretical and numerical demonstration of the bifurcation phenomenon in the Duffing oscillator was performed. Following this, the notion of chaos has been explained. In particular the period doubling route to chaos has been discussed. Then an introduction to integrable systems and soliton theory was also given by the speaker during the lecture. The two lectures of Professor M. Lakshmanan have motivated several young students as well as faculties.

5. **Lecture III:** [Prof. M. Daniel](#)  
Centre for Nonlinear Dynamics, Bharathidasan University, Tiruchirappalli.  
*Title: Application of Nonlinear Physics in Spin Systems*

After lunch, the first lecture was given by Prof. M. Daniel. This lecture gave a valuable insight into the application of nonlinear physics in the area of fast growing science – Spintronics. A pedagogical introduction to the magnetic systems was given first. Then the lecture was focused on the contribution of nonlinear processes in revealing the exciting dynamics of magnetic systems. For this purpose, the Landau-Lifshitz equation has been derived systematically and the role of additional interactions has been discussed in detail. The spin reversal/spin-switching concept has been explained.
6. Lecture IV: Dr. P. Muruganandam  
School of Physics, Bharathidasan University, Tiruchirappalli.  
*Title: Application of Nonlinear Physics in Bose-Einstein Condensates: Fundamentals*

The final lecture of the first day of the lecture workshop was given by Dr. P. Muruganandam. His lecture was on the fundamental aspects of Bose-Einstein condensates. A systematic introduction to the historical development of Bose-Einstein condensates and their experimental realization were given. Then, the derivation of Gross-Pitaevskii equation as the governing equation for BEC in a trap was made along with an extensive explanation of various kinds of traps. The formation of soliton in BEC has been discussed.

**DAY II 24.01.2014 (FRIDAY)**

7. Lecture V: Prof. M. Daniel  
Centre for Nonlinear Dynamics, Bharathidasan University, Tiruchirappalli.  
*Title: Application of Nonlinear Physics in Biological Systems*

The second day, Professor M. Daniel has continued his lecture on application of nonlinear processes in biological systems. This lecture shed clear lights on various biological processes involving nonlinear phenomena. Particularly, this lecture was focused on the biological macromolecules: protein dynamics and nonlinear dynamics of DNA. Then the formation of solitons in DNA strand was explained and their dynamics were discussed. After the lecture, we had a tea break for 15 minutes.

8. Lecture VI: Dr. K. Murali  
Department of Physics, Anna University, Chennai.  
*Title: Nonlinear Electronics-I*

This lecture gave an introduction to the realization of nonlinear phenomena in simple electronic circuits. He gave a detailed description on the passive and active elements, LCR circuit and its oscillatory behavior first. Then he explained the realization of nonlinear behavior in circuit elements and how to perform such circuit operations. His lecture gave deep insight into the construction of nonlinear electronic circuits.
9. Lecture VII: Dr. K. Murali  
Department of Physics, Anna University, Chennai.  
**Title:** Nonlinear Electronics-II

After lunch, Dr. K. Murali continued his lecture on Nonlinear Electronics. He has discussed a fascinating concept of constructing reconfigurable logic gates by using nonlinear electronic circuits, particularly, by using Murali-Lakshmanan-Chua circuit. This exciting concept has attracted the students very much. Following the lecture several students interacted with Dr. Murali and he has happily clarified their doubts.

10. Lecture VIII: Prof. Avinash Khare, F.A.Sc., F.N.A.,  
Department of Physics, Indian Institute of Science Education and Research (IISER) Pune.  
**Title:** Supersymmetry in Quantum Mechanics-I

An elementary introduction was given to the subject of supersymmetry in quantum mechanics. The lecture demonstrated with explicit examples that given a solvable problem in quantum mechanics with $n$ bound states, one can construct new exactly solvable $n$ Hamiltonians having $n-1,n-2,...,0$ bound states. The relationship between the eigenvalues, eigenfunctions and scattering matrix of the supersymmetric partner potentials was derived and a class of reflectionless potentials was explicitly constructed. He extended the operator method of solving the one-dimensional harmonic oscillator problem to a class of potentials called shape invariant potentials. I would like to emphasize that his lecture included almost all the solvable problems that are found in the standard text books on quantum mechanics.

**DAY III 25.01.2014 (SATURDAY)**

11. Lecture –IX: Prof. Avinash Khare, F.A.Sc., F.N.A.,  
Department of Physics, Indian Institute of Science Education and Research (IISER) Pune.  
**Title:** Supersymmetry in Quantum Mechanics-II

As a continuation to his previous lecture, Prof. Avinash Khare has shown that any given potential with at least one bound state, one can very easily construct one continuous parameter family of potentials having same eigenvalues and $s$-matrix. He also discussed the supersymmetry inspired WKB approximation. Finally, he explained the construction of new exactly solvable periodic potentials by using the machinery of supersymmetric quantum mechanics. These two lectures will also be very much useful for the researchers who are pursuing research in the area of quantum integrable systems.  
After the lecture, we had a tea break for 15 minutes.
12. Lecture X: **Prof. K. Porsezian**, F.A.Sc. F.N.A.Sc.,
Department of Physics, Pondicherry University, Puducherry.

*Title: Introduction to Nonlinear Optics*

In this lecture, a detailed introduction to nonlinear optics was given. This includes a discussion on various nonlinear optical effects in optical fiber. Particularly, the interesting second harmonic generation process, self-phase modulation due to Kerr effect and formation of solitons were discussed by the resource person.

Department of Physics, Pondicherry University, Puducherry.

*Title: Optical Solitons, Rogue Waves, Similaritons and their Applications*

The advanced concepts of nonlinear optics were explained in this lecture in detail. The formation of optical solitons and their propagation through optical fiber were explained. Then an excellent explanation on the formation of solitons in photonic crystal fibers was given. Afterwards, the lecture focused on the recent research topics like similaritons, and rogue waves.

14. Lecture XII: **Dr. P. Muruganandam**
School of Physics, Bharathidasan University, Tiruchirappalli.

*Title: Application of Nonlinear Physics in Bose-Einstein Condensates: Advanced Concepts*

The final lecture of the workshop was given by Dr. P. Muruganandam. In this lecture, he explained the numerical method Crank-Nicholson method to study the dynamics of solitons in Gross-Pitaevskii equations. The lecture also covered the formation of vortex solitons in dipolar condensates and their subsequent dynamics.

15. Valedictory Function

The workshop was concluded with the valedictory address by the vice-principal (Dr. C. Sebastian Rajasekaran) of our college.

The participants are asked to give their valuable feedback. Several students have registered their opinion. Indeed, we were very much happy with the feedback given by the participants and realized that the purpose of organizing the lecture workshop has been accomplished. Below we mention some of the feedbacks.

1. The students have realized that there are ample of opportunities for physics students, particularly in the theoretical physics area. In their own words; “So far we think that experimental study only has applications. But now we realize that there are several directions in theoretical research too. Also, we find it will be innovative to do theoretical studies which will ultimately lead to the development of technology”.
2. They have enjoyed the lectures. There was full attendance of the participants for all the three days. They had opportunities to discuss with leading experts in the field of nonlinear physics.
3. They have requested the coordinator to organize more such events and provide them opportunity to participate.
4. This lecture workshop has motivated many students to decide to pursue their higher studies in the field of nonlinear physics.
5. Two of the student participants from Jamal Mohamad college, Trichy, have thanked by directly sending email to me as well as Prof. Avinash Khare. The main portion of their emails are given below:
   Received by T. Kanna: "...I was inspired by the lecture about Solitons in DNA and protein. On the whole, the workshop was very useful to me to know more about the application of nonlinear physics. Thank you for arranging such a wonderful workshop. It will be very useful for us if you arrange such workshops in the future also...”.
   Received by Prof. Avinash Khare: "...I was inspired by your lecture on "Supersymmetry in quantum mechanics I & II". Actually I was not interested in quantum mechanics before attending your session. But now I am eager to know more about quantum mechanics. You are the reason behind this as you gave me motivation by your lecture...”.

Finally, Dr. T. Kanna, Co-ordinator of the lecture workshop proposed a vote of thanks. He has registered his sincere thanks to the Science Academies of our country (Indian Academy of Sciences-Bangalore, Indian National Science Academy-New Delhi and The National Academy of Sciences, India-Allahabad) for the financial support, the eminent speakers for their fruitful lectures, the enthusiastic participants of the workshop and the principal and management of the college for their various support and constant encouragement.

II Time table of the Workshop
   The workshop was conducted as per the time schedule given in the programme schedule. (Please see Annexure-I)

III Statement of Expenditure
   The complete statement of expenditure is given in the prescribed format (Please see Annexure -II).

IV Group Photographs
   Please see Annexure-III

V Number of participants who attended the workshop including the names of colleges and institutions
   Please see Annexure-IV
   (The complete list of registered participants of the lecture workshop is given)

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Science Academies’
Lecture Workshop
on
Nonlinear Physics

23 – 25 January 2014

Sponsored by
Indian Academy of Sciences, Bangalore
Indian National Science Academy, New Delhi
The National Academy of Sciences, India, Allahabad

Organised by
PG and Research Department of Physics
Bishop Heber College (Autonomous)
Nationally Reaccredited at the A" Level by NAAC
(Affiliated to Bharathidasan University)
(Recognized by UGC as “College with Potential for Excellence”)
Tiruchirappalli-620 017
Tamil Nadu, India

Schedule of the Lecture Workshop

DAY I  23/01/2014 (Thursday)  AC Seminar Hall

9.00 am–9.30 am : Registration

9.30 am–10.00 am : Inaugural function

10.00 am–10.20 am : Tea Break

10.20 am–11.35 am : Lecture 1: Introduction to Nonlinear Dynamics – I
Prof. M. Lakshmanan, F.N.A.Sc., F.A.Sc., F.N.A., FTWAS

11.35 am–11.45 am : Tea Break

11.45 am–1.00 pm : Lecture 2: Introduction to Nonlinear Dynamics – II
Prof. M. Lakshmanan, F.N.A.Sc., F.A.Sc., F.N.A., FTWAS

1.00 pm–2.15 pm : Lunch break

2.15 pm–3.30 pm : Lecture 3: Application of Nonlinear Physics in Spin Systems
Prof. M. Daniel

3.30 pm–3.45 pm : Tea Break

3.45 pm–5.00 pm : Lecture 4: Application of Nonlinear Physics in Bose-Einstein Condensates: Fundamentals
Dr. P. Muruganandam
DAY II 24/01/2014 (Friday) Conference Hall

9.45 am–11.00 am : Lecture 5: Application of Nonlinear Physics in Biological Systems
Prof. M. Daniel

11.00 am–11.15 am : Tea Break

11.15 am–12.30 pm : Lecture 6: Nonlinear Electronics – I
Dr. K. Murali

12.30 pm–1.45 pm : Lunch break

1.45 pm–3.00 pm : Lecture 7: Nonlinear Electronics – II
Dr. K. Murali

3.00 pm–3.15 pm : Tea Break

3.15 pm–4.30 pm : Lecture 8: Supersymmetry in Quantum Mechanics – I
Prof. Avinash Khare, F.A.Sc., F.N.A.,

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DAY III 25/01/2014 (Saturday) AC Seminar Hall

9.45 am–11.00 am : Lecture 9: Supersymmetry in Quantum Mechanics – II
Prof. Avinash Khare, F.A.Sc., F.N.A.,

11.00 am–11.15 am : Tea Break

11.15 am–12.30 pm : Lecture 10: Introduction to Nonlinear Optics
Prof. K. Porsezian, F.A.Sc., F.N.A.Sc.,

12.30 pm–1.45 pm : Lunch break

1.45 pm–3.00 pm : Lecture 11: Optical Solitons, Rogue Waves, Similaritons and their Applications
Prof. K. Porsezian, F.A.Sc., F.N.A.Sc.,

3.00 pm–3.15 pm : Tea Break

3.15 pm–4.30 pm : Lecture 12: Application of Nonlinear Physics in Bose-Einstein Condensates: Advanced Concepts
Dr. P. Muruganandam

4.30 pm : Valedictory function