
St. Xavier's College (Autonomous), Kolkata
POSTGRADUATE AND RESEARCH
DEPARTMENT OF PHYSICS
HORIZON
2019
2020
Volumes 11 & 12

CRI Limited

Premises No. 333, Mahamayatalla, Garia Main Road, Garia, Kolkata – 700084

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St. Xavier's College (Autonomous), Kolkata

HORIZON

VOLUME XI (2019)

DEPARTMENT OF PHYSICS

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Dr. Indranath Chaudhuri

FACULTY ADVISORS

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Dr. Sarbari Guha

Dr. Sudipto Roy

STUDENT EDITORIAL BOARD

Clockwise: Nilabja Ghosh, M S Dinesh, Debraj Dutta, Sagnik Ray, Mousumi Mitra, Rwitika Ghosh

Cover Page Picture: Anirban Mondal, PG2, Physics

Message from Principal

It is with great pleasure that I congratulate the Department of Physics of our college on the release of eleventh issue of their annual magazine, HORIZON.

The magazine provides the students with excellent opportunities of publishing articles in topics and subjects well beyond their curriculum, thereby motivating and empowering students to be critical thinkers and productive members of this ever-changing global society.

I hereby, extend a sincere appreciation to the Editorial Board of Horizon 2019 for this esteemed publication, and wish that the Department excels in all its endeavours and maintains its high academic standards in days to come.

May God bless one and all.

Rev. Dr. Dominic Savio, SJ

Principal

Message from Vice-Principal

I would like to congratulate the Department of Physics and its Editorial Board on the release of the eleventh edition of their departmental magazine HORIZON. The progress in academics and research in the Department is the result of the hard work and dedication of the entire team of undergraduate as well as postgraduate students under the mentorship of staff members. I appreciate the consistent efforts of the Department towards motivating research along with building the fundamentals of the subject, a glimpse of which is reflected in this magazine. The magazine serves as an excellent platform for students to express their ideas, views and thoughts.

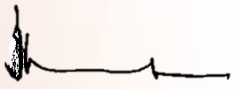
My best wishes to the Department for all its goals towards academic and research excellence.

Prof. Bertram Da Silva

Vice-Principal (Arts and Science)

Message from Dean-of-Science

The Department of Physics has published the eleventh issue of the magazine HORIZON. This magazine provides an excellent platform to publish both literary and scientific articles of the students. The creativity and the enthusiasm of the students in both academic and artistic pursuits are commendable. I wish the Department of Physics continues its journey towards excellence in the years ahead.



Dr. Tapati Dutta

Dean of Science

Editorial

We are delighted to present the eleventh edition of our annual Departmental magazine, HORIZON. Since its inception in 2009, the magazine has come a long way, establishing itself as a humble initiative allowing young minds to delve deep into world of imagination and creativity. The Department of Physics, with its rich legacy, has evolved in stages, beginning from its post-graduate teaching followed by the PhD course. The year 2019 was academically fulfilling for the Department with seminars, guest lectures and the 7th Fr. Verstraeten Memorial Lecture. The Department hit two new milestones with the introduction of weekly colloquiums helping students to think beyond the classrooms and the formation of The Xavier's Astronomical Society (XAS). We extend are deep gratitude to Fr. Principal, Vice Principal (Arts and Science) and the Dean of Science for their constant encouragement and support. I take this opportunity to thank all the faculty members and support staff of the Department for their dedication, time and hard work without which this magazine would not have been possible. I sincerely thank all the sponsors and contributors to the magazine

Dr. Indranath Chaudhuri

Head of the Department, Editor-in-Chief

FACULTY MEMBERS

SUPPORT STAFF

UG 1st Year

UG 2nd Year

UG 3rd Year

PG 1st year

PG 2nd Year

PhD Scholars

SPECTRUM 2019

Prof. Krishnendu Sengupta,
Indian Institute for Cultivation of Science

Prof. Gautam Bhattarchyaa,
Saha Institute of Nuclear Physics

Unveiling of Horizon 2018

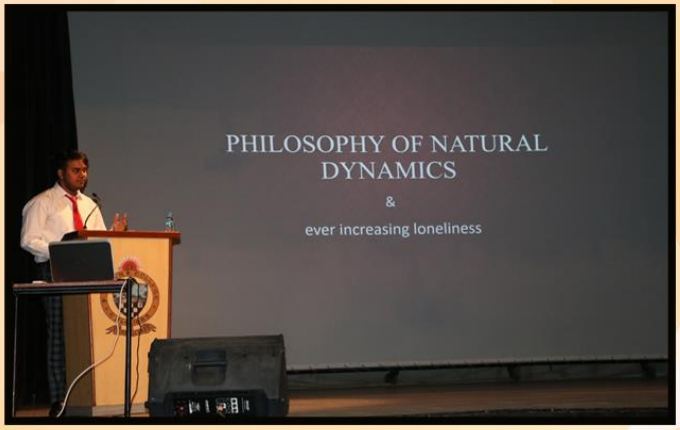
Audience

Prof. Sudipto Roy performing in cultural program

Prof. SN Roy Choudhary performing in cultural program

Dr. Sanchari Roy Choudhary performing in cultural program

Prof. Sruti Goswami performing in cultural program



Paper Presentation by student

Inaugural Song

Dance Performance

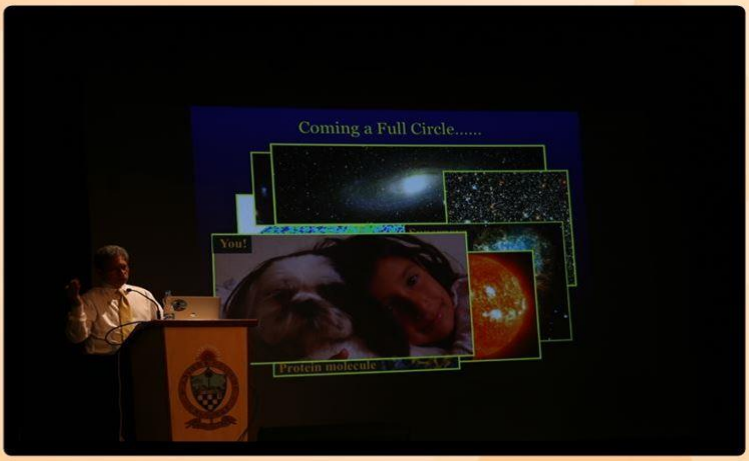
Instrumental Performance

Some other performances from cultural program

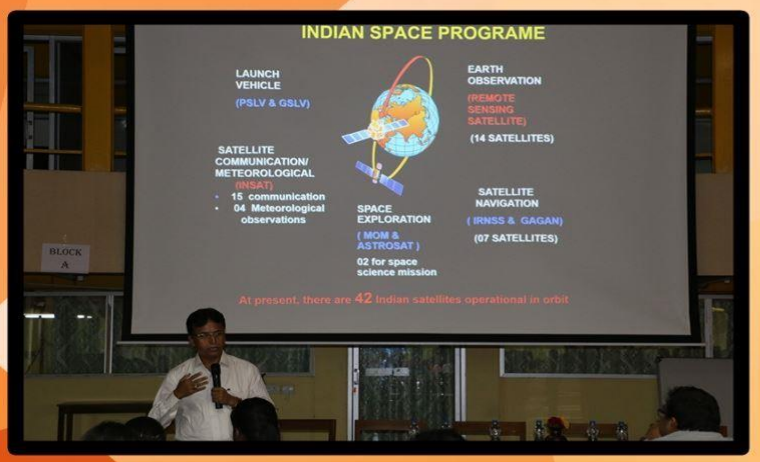
Departmental Events and Achievments

National seminar on application of Statistics in Natural Sciences.

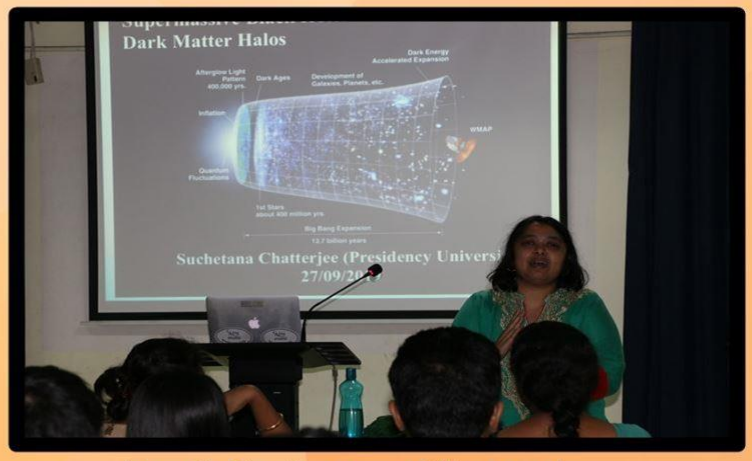
Prof. Ayanendranath Basu delivering his talk on "density power divergence measure and its uses in statistics"



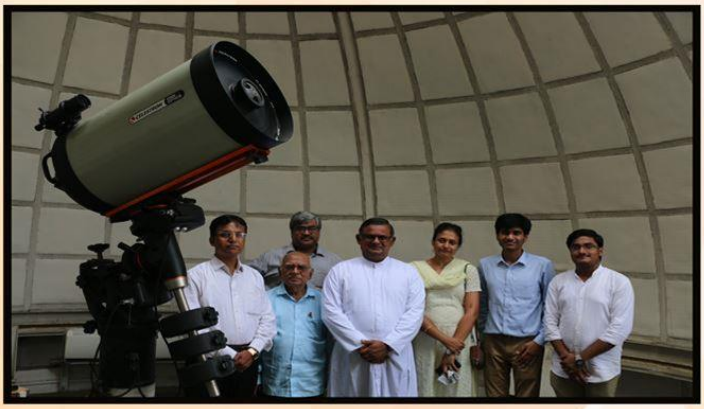
Prof. RajaguhaThakurta University of California, delivering his lecture at the 7th Fr. Verstraeten Memorial Lecture.



Dr. DebasishChakraborty giving a talk on "Indian Space Chandrayaan 2 and Bhuvan"



Prof. SuchetanaChatterjee giving a talk on "Supermassive Black Programme,holes and their Host Dark Matter Halos"



Visit to Father Eugene Lafont Observatory (FELO)

Alumni meet

Talk in one of the colloqium

Students of Bsc Ist year awarded first prize in Bigyan Mela

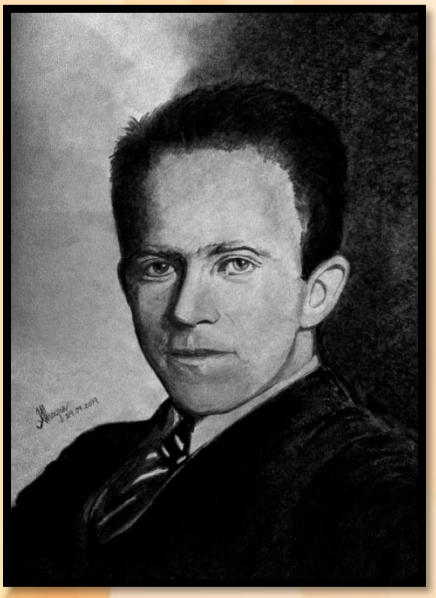
Paintings by Students

Soumyaditya Halder, UG2, Physics

Fatema Patel, UG1, Physics

Varsha Biswas, UG2, Physics

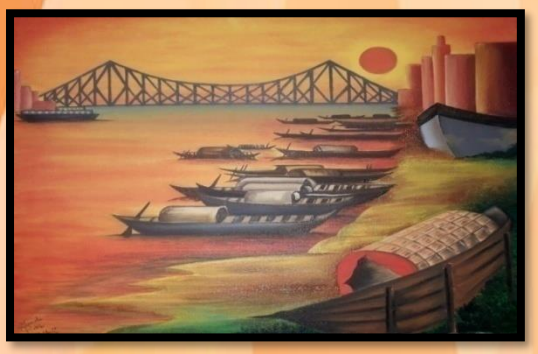
Manisha Dutta, UG2, Physics



Amisha Hazra, PG2, Physics

Ayan Sikdar, UG2, Physics

Ayan Sikdar, UG2, Physics



Manisha Dutta, UG2, Physics

Anushree Sen, PG1, Physics

I Have a Dream…

An Interview with Prof. Albert Cardinal Gomes

We met Prof. A.C Gomes in his small cabin and talked about his journey both as a Professor of Physics and a Controller of Examinations. We'd like to confess that we had a delightful talk and also got know what a beautiful person he is.

Sir, please tell us how you got interested in pursuing physics.

Right from my school days gradually I got interested in teaching of Physics. I was in a Christian Brother school, St. Mary's, Dum Dum. There the teacher who taught us physics was an Irish brother. He used to give demonstrations. Through those demonstrations I gradually moved towards physics and chemistry. Finally, I could've gone for chemistry but I chose physics. It was those experiments that were shown through them I got interested and often they set me into thinking. Like for example in those days heat engines… I had not studied heat engines as of yet. But the idea of heat engines fluffed up in my mind… the idea of heating and the explosions that the molecules created…that set me thinking. I thought about how explosions could create an engine but I hadn't read a word about it. So, from my early school days I gradually got interested.

Was it those demonstrations that got you interested in experimenting in the physics lab after college hours?

When I joined college as a teacher back in 1978, we had to teach theory as well as practical. First, I got initiated into handling practical for the students. I used to put in a

lot of effort by moving from table to table, how the students are performing, what are the problems they are facing, trying to interact with student and at the same time learning how those experiments are done. Then gradually I went into trouble shooting problems right in front of the students. There were certain problems I couldn't solve, problems I couldn't shoot so to say. But after the classes were over, when I had some free time, I used to go back to those instruments trying to find out the sources of those problems and then rectify them. Coming back to the students at the earliest opportunity telling them where lies the problem what precautions they should take. So that's how I was not only interested in trouble shooting but also got deeply involved in trouble shooting. And that kind of thing I love to do after the college hours.

I remember staying back and fixing up all the experiments for the upcoming university examinations when the students of other colleges used to come here because in those days home centre were not allowed. So, there was the reputation of the college at stake…that as in my mind. Everything should be prim and proper; all the instruments should be in working order. So, I'd stay in the laboratory till 8-8.30 in the evening. And in those days, there weren't many footfalls. Working in that huge laboratory, which is now the R.K. Hall, which you haven't seen used to be a physics laboratory. Not only that but also the joining rooms 29 and 30. Imagine working in room 29 in this flank of the building at 8.30 in the night when there is not a soul around… it was scary. I imagined hearing sounds but my eagerness, my interest kept me going.

Is our curriculum enough in terms of experiments that should be incorporated in the basic science courses?

Actually, nowadays there are lots of efforts being put; various questions are being raised by various universities across the world that whether the practical done is relevant to the theory being taught. I believe that you learn theory a lot not only while it is being taught but maybe long afterwards… maybe week afterwards… maybe months afterward when you're dealing with experiments, provided you're not doing it mechanically there is a lot of scope for learning.

I tried to develop a lot of instruments say for example taming of a galvanometer… the moving coil ballistic galvanometer which you don't use anymore. Previously lot of moving coil galvanometers were used. Professor Shounak Palit referred to moving coil galvanometer on the day we gathered in memory of Late Dr. Ranjan Ray. Now, there was one particular galvanometer which the students were using for measuring mutual conductance – that galvanometer I found to be over-sensitive. We could have gone for buying a new galvanometer. But I thought, no I'd try to tame it, make it less sensitive. So I looked up books, spent several days and weeks and then finally found a solution (he showed us through hand gestures, with a smile on his face, how he tamed it by adjusting the pieces in the galvanometer; we marveled at how he has remembered every nitty-gritty details of the instrument but we, in spite of studying it one semester back, haven't retained a single word.)

You can ask Bidyut and others what other instruments I had designed… for example

the viscosity measurement tube. In this way there are several apparatuses I had tried to develop. Nobody told me to but I felt interested. So, going back to the question you had asked previously, how is it you got interested in pursuing physics, I had actually fallen in love with the laboratory and that's what kept me going.

Looking back, what do you feel about your journey here at St. Xavier's College?

So far as I am concerned, I've been to many schools before joining St. Xavier's. Coming here, changed my life altogether. The ambience that I had, the kind of friends I made, had changed my outlook forever. This is the greenest of pastures… I've not looked for any greener pasture. Before joining the college, I was a deputy collector and magistrate of Malda. Within six months I gave up the job. I realized it was not for me, the work culture didn't suit me. Then I joined this college.

Would you please tell us that as a teacher what has been your takeaway?

I'm convinced that in order to teach students, that is teaching students is like showing kids the distant horizon. Yonder lies the horizon and you have to run towards the horizon and in order to find what lies there, that is find your motivation so that you learn yourself. It's not route learning, it is learning through experience. So, the basic thing is to help the students to learn for themselves. I can say this now after coming over here I'm no longer into direct teaching but I have read volumes of effective teaching. So now I learn, now I convince that if I'm given another chance at teaching, I would've taught them totally differently. Just now I said that helping the students to learn for themselves.

When we joined college, the culture was the teachers are sage on the stage and others are the audience. There was hardly any interaction. If you were a very effective teacher, you'd have to thrill your students with your performance on stage. But if I was given a chance today, I'd not be a sage on stage, and rather I'd want the students to rise to that platform… become sages themselves. The teachers should aim at involving the students, motivating the students so that they can come forward and take up the learning activities themselves. This is what I believe. I loved interactions in my classes… I used to ask questions and so on. And I also made myself available outside classes for the students.

What has been your experience as a Controller of Examinations?

Initially I was not happy. Why? Because away from the laboratory, away from instruments. I could never imagine that if I am spinning the college, I'd be weaned away from the lab and the class. But I wanted to send a signal to the administrators that I've been given a responsibility, I will give it a try. So here, ultimately the laboratory experience has given me an insight. Actually, at first, I found myself unable to deal with so many people. In the lab you're in the midst of instruments, whereas here you're in the midst of people. You need to get the work done through the people. So, it is not the management of instruments but of people. So, it was a new learning experience, to work as a team. Whatever this department has seen is it not because of me but because of the team. All of us have contributed to the growth of the department. I think all of us have done a pretty good job.

If not physics then what would you have chosen?

As you grow older, then your attention is drawn more and more towards human beings and their behavior. Gradually you find whatever you see around you and whatever is being sold in the name of technological development and so on and so forth is ultimately futile. The basic problem of humans is not being at rest. So there lies the work of authors who have tried to probe the human soul… those poets, writers, dramatists. And nature attracts me. This humdrum of life... I feel like running away from this maddening crowd. So, nature beckons me. And grandchildren, so long they are children their company is also very satisfying.

Do you think religion and science contradict on a fundamental level?

I don't think so. Religion tries to deal with things which as human beings we often come to know through personal experience. And we find no answer of those things in terms of science or logic. After all any human being, that's what I believe, can see only up to epsilon or delta region of their surroundings. You're at this point of time scale and can you look back into time, can you look forward into time? Yes, perhaps those who are very gifted can.

Most of us can see epsilon neighbourhood. Those who are gifted can see delta neighbourhood. So, no human being will be able to give answers to all the questions. So the science that they are creating, part of it is okay but what they are speculating, what is speculation today may materialize hundred or five hundred years or essentially later. But there will always be something beyond your capacity for answering. And religion tells us, man after all has limitations. And because of those limitations, I cannot accept the theory proposed by any person, whether it is Richard Dawkins, or Einstein. Because everyone has limitations… they cannot see the whole of eternity, therefore this universe has many secrets. Whether someday they'll be able to fathom those secrets I don't know and that's very personal.

Do you have any vision for the Department of Physics?

When I was the head, in one of my addresses to the department, I had said that I have a dream that when I'll be passing by Park Street, I'd be able to tell my friends or anybody accompanying me that there lies a department where lights are on for 24 hours. I'm talking about the physics laboratory. You can imagine what happens in the physics laboratory… research and so on and so forth, yearning for knowledge. That's the dream I had had, and still continue to have.

What is your message to the aspiring physicists from our department?

All that I can say is, be true to yourself and try to be equally strong in both theory and experiments because doing experiments and thinking of experiments go hand in hand with theory. Never neglect experimentations – that is my message. In this part of the country, in Bengal, our experience has been that for the Bengalis, it is beneath their dignity to handle instruments, *ota mistirider kaaj, intellectual-der kaaj noye* (handling instruments is not a job for the intellectuals but for the labourers.) It is peculiar to this part of the country, but perhaps it is not so elsewhere. So far as hard-core science is

concerned, they (referring to, theory and practical) are the opposite sides of coins, on goes with the other – they are inseparable. My advice to the students is pay attention.

We ended our interview here as we were running short of time. Had we had more time we would of have listened to whatever he had to say with rapt attention because that is how he is… full of wonder and delight and a lovable personality. Thank you, Sir, for your kind words and your precious time. We had an enjoyable time talking to you.

Interview taken by: Shramana Bera, Rwitika Ghosh

Compiled by: Rwitika Ghosh

DEPARTMENTAL EVENTS 2019

COLLOQUIUMS

The department of physics started conducting physics colloquiums from the academic session 2019-2020 and there has been a huge participation of students. It has been helping students to gain exposure on topics apart from the prescribed syllabus.

- On 19th July, 2019 Dr. Shibaji Banerjee, Dept. of Physics, St. Xavier's College, Kolkata delivered a talk on "Dark matter may be strange".
- On 9th August, 2019 Dr. Tapas Das, Dept. of Physics, Harish-Chandra Research Institute delivered a talk on 'Portrait of a dark face'.
- Dr. Suchetana Chatterjee, Dept. of Physics, Presidency University, Kolkata gave a talk om Supermassive Black holes and their Host Dark Matter Halos on the 27th of September,2019. The focus was on how in the paradigm of structure formation we like to address the question of relating Supermassive Black Holes with their host dark matter halos.

SPECTRUM 2019

The Department of Physics held its annual departmental fest on March 16th, 2019. The departmental magazine Horizon was inaugurated by Principal Rev. Dr. Dominic Savio, S.J. The invited speakers were Prof. Gautam Bhattarchyya, Acting Director, Theory Division Saha Institute of Nuclear Physics, Kolkata and Prof. Krishnendu Sengupta, School chair and Senior Professor, Indian Association for the Cultivation of Science, Kolkata. The title of the invited talk by Prof. Bhattacharyya was "The so-called God Particle: An incredible journey of mankind". Prof. Krishnendu Sengupta gave an interesting talk on "A journey from Science to Technology". In addition, there were paper and model presentations by students, Quiz, Coding, conundrum and many more fun events. Students from other colleges participated in the program too and the departmental students showcased their talents in the cultural program that followed. The event ended by the prize distribution ceremony where the winners were awarded for the different events by the head of the department.

7th Fr. Verstraeten Memorial Lecture

The 7th Fr. Verstraeten Memorial Lecture was delivered by Prof. Raja Guha Thakurta, Chair and Professor/Astronomer, Department of Astronomy and Astrophysics, UCO/Lick Observatory, University of California, Santa Cruz, USA on the 30th of august, 2019. His research is focused on the formation and evolution of galaxies-specifically, their accretion/ cannibalism history, dark matter content, chemical enrichment and star formation history. The title of the talk was "Galaxies: Dark matter, Cannibalism, Black Holes, Gravity Waves and the Periodic Table of Elements".

National Workshop on Density Functional Theory (DFT)

On 29th August, 2019 Department of Physics conducted national workshop on "Role of DFT in predicting electronic structures and reaction pathway" in collaboration with Department of Chemistry. Prof. Swapan K. Pati of Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR) and Dr. Anoop Ayyappan of Dept. of Chemistry, IIT Kharagpur delivered lectures in the workshop.

XAVERIAN ASTRONOMICAL SOCIETY

This year marked the inception of the Xaverian Astronomical Society on the 3rd September, 2019. It was indeed a moment of pride and joy for the Department of Physics who had long dreamed of such a society of like-minded enthusiasts about space and beyond. Initially conceived by Shashwatt Sharaff and Ankit Kumar Gupta of the Physics department of the college and later joined by some other passionate astronomy lovers and with the able guidance and supervision of Father Principal Dominic Savio, Vice-Principal Prof. Bertram da Silva, Dean of Science Dr. Tapati Dutta and professors Dr. Shibaji Banerjee, who is also president of the society and Dr. Suparna Roychowdhury of the department of Physics, the inaugural program was carried out.

AIMS AND OBJECTIVES

- The Xaverian Astronomical society is not restricted to astronomical discussions and observations by enthusiastic physics students but also aimed at promoting scientific temper among people of all backgrounds and making science fun and curious by reach out programmes with underprivileged children who have limited access to sophisticated infrastructure. Special camps and visits to the observatory or planetarium would be arranged.
- To annually conduct the Fr. Eugene Lafont Memorial Lecture.
- To imaginatively utilize our one-of-a-kind observatory to enable the College to keep up and improve its rich inheritance of research and quality teaching as a leading institution of the nation.
- To publish astronomical facts, latest findings and received enquiries on a bulletin board. Conducting workshops, seminars, quizzes and other such events is one of the top priorities of the society to strengthen the position of our observatory.
- To expose students to different international and national project programmes, research areas in the field of astrophysics and astronomy, and related career opportunities.

XAS began with the idea that we are not alone in the universe and there's much more to the universe which needs to be explored. So XAS always will aim at promoting this idea through its activities and try being instrumental in igniting a spark towards astronomy in individuals from various backgrounds. XAS will work towards producing men and women of a spiritual scientific temper who may flower into leading scientists and value equity, social justice and scientific pursuit.

Collaboration of XAS with NSS

After the inception of the Xaverian Astronomical Society, its collaboration with NSS has been one of the most notable events of XAS. The academics team of XAS along with the Secretary and Vice-Secretary coordinated a visit to the Jhajhra high school along with NSS. It was a one-hour session with 10th Standard students. This was an attempt in reaching out to

the underprivileged children who don't have much exposure to such information. They were given an introduction by the NSS after which the students were explained the aims of the society and how helpful it would be for them. The academics team had prepared a questionnaire which was distributed among the students. The students showcased a great deal of enthusiasm all throughout the session, even with the questionnaire. The answers were discussed later. It proved to be a fruitful visit along with NSS. This was a preliminary activity where the response of the students was observed and they were made aware of the topic. The members of XAS wish to conduct a main event in the college in the near future, where the same set of students would be called and attend a programme. The main attraction of the event would be a visit to the Fr. Eugene Lafont Observatory where there would a demonstration. XAS aims at organizing more such events and making astronomy a favorable field.

Seminar on "Application of Statistics in Natural Sciences"

In 16th and 17th December, 2019 Department of Physics along with Department of Statistics in collaboration with Inter-University Centre for Astronomy and Astrophysics (IUCAA) organized a two-day national seminar on "Application of Statistics in Natural Sciences".
The invited speakers who delivered talk in the seminar were Prof. Mihir Arjunwadkar of Pune University, Prof. Saurabh Ghosh of ISI Kolkata, Prof. Supratik Pal of ISI Kolkata, Prof. Rajesh Kumble Naik of IISER Kolkata and Prof. Ayanendranath Basu of ISI Kolkata.

International Workshop on Course Geometry

On 16th August, 2019 a one-day international workshop (partially funded by DBT Star College) on Coarse Geometry was held in collaboration with department of Mathematics, St. Xavier's College, Kolkata. Dr. Atish J. Mitra, Department of Mathematics, Montana Tech, USA, delivered a talk on 'A Gentle Introduction to Coarse geometry'.

Coarse geometry is a way of exploring large-scale geometric structures of a space, while ignoring small-scale behaviour. For example, there are concepts of coarse dimensions that (while being dual concepts of topological dimension) predict large-scale properties of spaces. Similarly, coarse extension theory attempts to understand the coarse geometry of spaces through extensions of certain classes of functions between them. Moreover, coarse geometric concepts can be efficiently encoded into algebra– by considering certain C* algebras which predict the coarse geometry of the corresponding spaces. In this introductory exposition, some of these concepts were discussed. Also, some applications of these ideas to physics were touched upon and some recent applications to very practical areas of topological data analysis were demonstrated.

Student's Activities

The students of the Department of Physics took part in various co-curricular activities and extracurricular activities. The students received scholarships, participated in various workshops, completed some projects at other institutes, participated and secured positions in various Science camps and Science fairs.

Many students received the prestigious INSPIRE Scholarship, provided by the Government of India.

1. Rupa Basu, a PhD student was awarded as "BEST ORAL PRESENTATION " at "3rd SERB School in non-linear dynamics " held at IIT Patna on 3rd-31st December 2019.

2. Shashwatt Saraff, a third year B.sc student has completed a project on nuke physics and cryogenics at Tata Institute of Fundamental Research, Mumbai. He also did a project on nanotechnology at Saha Institute of Nuclear Physics, Kolkata.

3. Ayaskanta Ghosh, a third year BSc student completed a project on Compton imaging at Tata Institute of Fundamental Research, Mumbai.

4. MD Sariful Islam, qualified in the National Graduate Physics Exam conducted in January 2019 during his 1st year.

5. MD Sariful Islam attended the National Initiative on Undergraduate Science Physics Camp 16.1 on topics of Quantum Mechanics, Theoretical and Experimental Physics. It was organized by Homi Bhabha Centre for Science Education, TIFR, Mumbai from 10th to 22nd June, 2019.

6. MD Sariful Islam qualified for National Initiative on Undergraduate Science Physics Camp 16.2, held in December 2019 by Homi Bhabha Centre for Science Education, TIFR, Mumbai, where he did a project on Quantum Machine Learning.

7. Students of BSc 1st and 2nd year participated in college model category at the Bigyan Mela and secured the first position.

8. Ayantika Saha, a third year BSc attended a winter school on radio astronomy conducted by NCRA-TIFR.

9. Ayantika Saha and Aryaa Dattamunsi presented a paper on 'Pattern Formation in 2D Electrodeposition of Lead Tin using Solder Electrodes' at the 33rd Annual IAPT Convention, Ranchi.

10. Ayshi Mukherjee and Aritra Paul presented a paper on 'Pattern Formation in 2D Electrodeposition of Copper in Presence of Magnetic Field' at the 33rd Annual IAPT Convention, Ranchi.

11. Avishuman Ray and Tamoghna Ray also presented a paper on 'Analysis of Mercury Droplet Flow on an Inclined Plane' at the 33rd Annual IAPT Convention, Ranchi.

FACULTY ACTIVITIES

Prof. D.N. Bose delivered a talk at the International Workshop on Physics of Semiconductor Devices (IWPSD) 2019 on ` Growth of Compound Semiconductors - Characterization & Applications' on 18th December 2019.

Dr. Sarbari Guha presented a lecture on "*Gravitational Collapse*" in the colloquium of the Department of Physics, Presidency University, Kolkata, on 13th February 2019.

Dr. Sarbari Guha delivered a lecture on "*Status of the Generalized Second Law of Thermodynamics in Chaplygin gas models*" in the One-day seminar on Recent Trends in Relativity & Cosmology, Department of Physics, Jadavpur University, on 15th March 2019.

Dr. Sarbari Guha was an Invited speaker and Member of the International Scientific committee at the International Symposium on "*Nonlinear Dynamics*" organized by the Mathematical Institute of the Serbian Academy of Sciences and Arts, in Belgrade during September 2019**.**

Dr. Sarbari Guha gave a lecture on *"*Some Aspects of General Relativity and Cosmology*"*, at the Mathematical Institute of Serbian Academy of Sciences and Arts, Belgrade, on September 09, 2019 and also scientifically interacted with the faculty members, students and postdoctoral fellows at the Serbian Academy of Sciences and Arts, Belgrade, Serbia, during 9th and 10th September, 2019.

Dr. Suparna Roychowdhury gave a seminar at Presidency University, Physics Department on 3rd April, 2019.

Dr. Suparna Roychowdhury gave a talk and presided over sessions at Uniexplore, 2-day seminar at Vivekananda College, Kolkata on 7th November, 2019.

Dr. Suparna Roychowdhury Acted as the Joint Convenor in the Two-Day National Seminar on Applications of Statistics to Natural Sciences in collaboration with ICARD, IUCAA Resource Centre, Ballygunge Science College, Kolkata on 16th and 17th December, 2019.

Dr. Aditi Ghosh attended the C. K. Majumdar Memorial Workshop in Physics 2019 from 28th May – 7th June 2019.

Dr. Shibaji Banerjee did a presentation on the astronomical facilities in St. Xavier's College, Kolkata at the S.N. Bose National Centre for Basic Sciences.

Dr. Shibaji Banerjee served as the Secretary of the Xaverian Astronomical Society (XAS) of St. Xavier's College, Kolkata during the inauguration of the society on 3rd September, 2019.

Dr. Shibaji Banerjee gave a lecture on "Dark Matter may be strange" on the first colloquium organized by our department on 19th July, 2019.

Publication in journals by faculty members

1. Thermodynamics of FRW universe with Chaplygin gas models; Samarjit Chakraborty and Sarbari Guha, General Relativity and Gravitation**,** Vol. 51, issue 11 (2019) pp. 158.

2. Mathematical Model of ingested glucose in Glucose-Insulin Regulation; Sourav Chowdhury, Sourabh Kumar Manna, Suparna Roychowdhury and Indranath Chaudhuri, Accepted for publication in Journal of Applied and Computational Mathematics.

3. Time Evolution of the Matter Content of the Expanding Universe in the Framework of Brans-Dicke Gravity; Sudipto Roy, journal of Research in Astronomy and Astrophysics, Vol. 19 No. 4, 61 (14pp), March 2019, DOI: 10.1088/1674-4527/19/4/61.

4. Evaporation of a Droplet: From physics to applications; Duyang Zang, Sujata Tarafdar, Yuri Yu. Tarasevich, Moutushi Dutta Choudhury, Tapati Dutta, Physics Reports (2019),doi.org/10.1016/j.physrep.2019.01.008.; IF:20.033.

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6. γ-Rays from Dark Matter Annihilation in Milky Way Satellite Galaxies: An analysis with Particle Dark Matter Models for 45 Dwarf Spheroidals; Ashadul Halder, Shibaji Banerjee, Madhurima Pandey, Debasish Majumdar
(https://arxiv.org/abs/1910.02322)

7. Intensification of Gravitational Waves Near Compact Star; Ashadul Halder, Shibaji Banerjee, Debasish Majumdar (https://arxiv.org/abs/1902.06903)

8. Mass and life time of heavy dark matter decaying into IceCube PeV neutrinos; Ashadul Halder, Shibaji Banerjee, Madhurima Pandey, Debasish Majumdar
(https://arxiv.org/abs/1905.08662v1)

ALUMNI'S CORNER

Foreword:

As the Founder Editor of the magazine 'HORIZON' of the Department of Physics, St. Xavier's College, Kolkata, it is a matter of great pride and immense pleasure for me to introduce to our community this new section named "Alumni's Corner" in this eleventh edition of HORIZON. Our department boasts of highly illustrious alumni, who have made us proud, through their achievements and contributions to the society at large. Although the idea of this new section came to us very late this year, we are extremely thankful to Professor Dr. Gour Prasad Das, who by virtue of his committed nature and amicable personality accepted our request to contribute an article within a very short time. I am confident that his article will arouse the interest of all readers.

Dr. Sarbari Guha, Associate Professor

Prof. Dr. Gour Prasad Das:

Prof. Gour Prasad Das is a condensed matter physicist and a materials scientist working as a Visiting Professor in the Indian Institute of Technology Kharagpur. He is an alumnus of St. Xavier's College from the 1970-73 batch of Physics. His professional career spans over four decades, serving as a Senior Scientist in Bhabha Atomic Research Centre and subsequently as a Senior Professor in the Indian Association for the Cultivation of Science in Kolkata. He has published over 150 original research papers in international journals and book chapters in diverse areas such as alloys, intermetallics, nanostructures, renewable energy materials, semiconductor devices, spintronics materials etc. He has delivered invited talk in more than 100 international conferences all over the world, and occupied visiting positions in several institutes abroad, such as Max Planck Institute Stuttgart (Germany), Virginia Commonwealth University, Richmond (USA), Institute of Materials Research, Sendai (Japan) and University of New South Wales, Sydney (Australia). Prof. Das has spearheaded a number of national and international research programs, and is well known for his passion in delivering lectures for students and researchers at various levels.

Renewable Energy and Hydrogen Economy

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Why Renewable Energy?

Energy is the most vital requirement for the progress of our civilization. Ironically it is this progress that puts maximum concern on the way our natural resources viz. fossil fuels such as coal and natural gas are getting depleted must faster than the millions of years it took to create these fuels. Our current global energy need is about 15Tera Watt, and 85% of it is being provided by fossil fuels [1,2], which is the most natural choice for domestic, commercial, automobile, aviation and other sectors. Apart from the fact that these highdensity energy sources are not renewable, it also is associated with emission of Carbon and greenhouse gases that has irreversible effect on environment. Even if we had an unlimited supply of fossil fuels, burning them sends greenhouse gases into the atmosphere, trapping the suns heat and contributing to global warming. Climate scientists generally agree that the earth's average temperature has risen in the past century. If this trend continues, sea levels will rise, and scientists predict that floods, heat waves, droughts, and other extreme weather conditions could occur more often [3]. Other pollutants are released into the air, soil, and water when fossil fuels are burned. These pollutants take a dramatic toll on the environment and on humans. Air pollution contributes to diseases like asthma. Acid rain from sulfur dioxide and nitrogen oxides harms plants and fish. Nitrogen oxides also contribute to smog.

The world's energy need is expected to grow by 33% during the next 10 years. The only way to tackle this situation is to use renewable energy sources that are continually replenished by nature, e.g. sun, wind, water, tidal wave, geothermal, and plants. Renewable energy technologies turn these fuels into usable forms of energy, most often electricity, but also heat, chemicals, or mechanical power [4]. We often call renewable energy technologies clean or green, because they produce few, if any, pollutants. *We need new energy sources that are abundant,*

secure, renewable, clean and cost effective. Fortunately, renewable energy is plentiful, and the technologies are improving all the time. Most of us already use renewable energy in our daily lives. Let us first have a look at the

different sources of renewable energies.

The various renewable energy sources are as follows [4].

(a) Hydropower:

Hydropower is our most mature and largest source of renewable power, producing about 10 percent of the nation's electricity. Hydro-power plants convert the energy in flowing water into electricity. The most common form of hydropower uses a dam on a river to retain a large reservoir of water. Water is released through turbines to generate power. Run of the river systems, however, divert water from the river and direct it through a pipeline to a turbine.

(b) Bio-Energy

Bio-energy is the energy derived from biomass (organic matter), such as plants. But we don't get all of our biomass resources directly from trees or other plants. Many industries, such as those involved in construction or the processing of agricultural products, can create large quantities of unused or residual biomass, which can serve as a bio-energy source. After hydropower, biomass is another leading resource of renewable energy.

(c) Geothermal Energy

The Earth's core, 4,000 miles below the surface, can reach temperatures of 9000F. This heat geothermal energy flows outward from the core, heating the surrounding area, which can form underground reservoirs of hot water and steam. These reservoirs can be tapped for a variety of uses, such as to generate electricity. The geothermal energy potential in the uppermost 6 miles of the Earth's crust amounts to 50,000 times the energy of all oil and gas resources in the world.

(d) Solar Energy

Solar technologies tap directly into the infinite power of the sun and use that energy to produce heat, light, and power. People have used the sun to heat and light their homes for centuries. Passive solar design combined with energy efficiency will go even further. Energy-efficient features such as energy saving windows and appliances, along with good insulation and weather-stripping, can make a huge difference in energy and cost savings.

(e) Wind Energy

For hundreds of years, people have used windmills to harness the winds energy. Today's wind turbines, which operate differently from windmills, are a much more efficient technology. Wind turbine technology may look simple: the wind spins turbine blades around a central hub; the hub is connected to a shaft, which powers a generator to make electricity. However, turbines are highly sophisticated

power systems that capture the winds energy by means of new blade designs or airfoils. Modern, mechanical drive systems, combined with advanced generators, convert that energy into electricity.

(f) Ocean Energy

The ocean can produce two types of energy: thermal energy from the suns heat, and mechanical energy from the tides and waves. Ocean thermal energy can be used for many applications, including electricity generation. On the other hand, wave energy uses mechanical power to directly activate a generator, or to transfer to a working fluid, water, or air, which then drives a turbine / generator. Most of the research and development in ocean energy is happening in Europe.

(g) Hydrogen Energy

Hydrogen is the most abundant element in the universe, and has high energy content. A hydrogen atom consists of only one proton and one electron. An optimistic view is that hydrogen is the clean fuel of the future! It burns with oxygen to make only water vapor - no soot, no nitrous oxides, and no carbon dioxide with its potential greenhouse warming. So, is Hydrogen based economy [5,6,7] our ultimate destination? Despite its abundance and simplicity, Hydrogen gas does not occur naturally in Earth's atmosphere. Researchers are developing highly efficient, advanced reformers to produce hydrogen from natural gas for what is called Proton Exchange Membrane fuel cells. We can think of fuel cells as batteries that never lose their charge. Today, hydrogen fuel cells offer tremendous potential to produce electrical power for distributed energy systems and vehicles. In near future, hydrogen could join electricity as an important energy carrier: storing, moving, and delivering energy in a usable form to consumers. Renewable energy sources, like the sun, cannot produce energy all the time. But hydrogen can store the renewable energy produced until it is needed. Eventually, researchers would like to directly produce hydrogen from water using solar, wind, and biomass and biological technologies.

Hydrogen Production:

Enormous efforts are on to produce the hydrogen cleanly and in a cost-effective fashion. The possible routes are (a) Fossil Fuel reforming (b) Solar photovoltaic and photocatalysis, (c) nuclear (d) solar thermal and (e) bio-inspired routes [8,9].Thermo-chemical cycles and electrolysis have the greatest possibility of successful massive hydrogen production from water. Specially, the Sulfur-Iodine (SI) cycle is known to be a suitable thermo-chemical water-splitting method for mass production of hydrogen. During this process, the sulfuric acid thermal decomposition is the highest endothermic step in the SI cycle. The sulfuric acid decomposition reaction takes place in two steps, first decomposition of the acid to form gaseous SO_3 and H_2O at temperatures above 350°C, followed by decomposition of the SO_3 to SO_2. The decomposition of SO_3 requires very high temperature (between 750 and 900 °C) and

does not take place without a catalyst. Thus, catalytic decomposition of sulfur trioxide is one of the most important and challenging steps in the SI cycle [10].

Hydrogen Storage:

We now discuss the various ways for efficient storage of molecular hydrogen in solid state [11], for which a fundamental understanding of how hydrogen interacts with materials is of utmost importance [12]. High storage capacity, satisfactory kinetics, optimal thermodynamics are some of the essential criteria for a potential hydrogen storage material. Most of the metals in the periodic table, their alloys or inter-metallic compounds react with hydrogen to form metal hydrides. The bonding between hydrogen and the metal can range from very covalent to very ionic as well as multi-centered bonds and metallic bonding. In fact, some metal hydrides can store hydrogen in a density higher than that of liquid hydrogen. It is exciting as well as challenging to probe the possibility of storing hydrogen in a more compact and safer way compared to pressurized gas and cryogenic liquid[13]A classic textbook example is Palladium hydride (PdH_x) that can retain a substantial quantity of hydrogen within its crystal lattice. At room temperature and atmospheric pressure, palladium can adsorb up to 900 times its own volume of hydrogen in a reversible process. However, Pd is a heavy metal and hence does not yield good gravimetric efficiency, apart from the fact that it is quite costly.

So, several groups all over the world are concentrating on complex hydrides formed by a combination of metals or metalloids, where hydrogen atoms are bonded covalently to a metal or metalloid atom to form an anion. This anion is then bonded ionically to a metal cation present, to form a complex metal hydride [14] In general, complex metal hydrides have the formula $A_xM_yH_z$, where ”A" is an alkali metal or alkaline earth metal cation or cation-complex, and “M" is a metal or metalloid. Well-known examples feature anions of hydrogenated group 3 elements, in particular Boron and Aluminum. Compounds such as $LiBH_4$ (lithium borohydride), and $NaAlH_4$ (sodium alanate) are among the most widely studied. The variety in complex metal hydrides is very large. The possibility of forming complex metal hydrides using lightweight elements opens a promising route to achieve very high hydrogen content by weight, e.g., $LiBH_4$ contains 18 wt% hydrogen. Accordingly, there is an increasing interest to explore complex metal hydride systems and their subsequent optimization for practical use. Combining several complex hydrides into one storage system might improve the storage characteristics, but the complexity of reaction mechanisms requires further fundamental research on such materials. While complex hydrides involving light metals show impressive gravimetric efficiencies, the desorption temperature of H_2 is rather high. Lithium imides, for example, constitute one such promising material showing reversible hydrogenation when reacted with LiH [15]. We have made attempts to bring down the desorption temperature close to room temperature by suitable alloying with Ca or Mg [16] which essentially weakens the effective bonding between the Metal M^+cation and the complex $(NH_2)^-$ anion [14]. Alanates, Borates, Amidoboranes are

the other families of complex hydrides that are being extensively studied both experimentally and theoretically. For a comprehensive overview of the materials aspects of these complex hydrides as hydrogen storage materials, the reader may refer to review articles by Shin-ichiOrimo [14] and Bhattacharya and Das [17].

Nano-structured Materials:

Apart from complex hydrides, there are other kinds of novel materials that have been investigated, e.g. carbon based materials activated with nano-catalysts, clathrate hydrates, metal-organic complexes, and more recently nanostructured cages viz. fullerenes and nanotubes decorated with simple or transition metals that serve to attract hydrogen in molecular form [18]Nanostructure materials built from lightweight elements, such as Boron, Carbon and Nitrogen, have several attractive features, such as large surface area, low density, high structural stability etc. that can be exploited for efficient hydrogen storage of hydrogen. The storage takes place as hydrogen molecules are adsorbed on the surface of the solids [13]. The possibility of storing hydrogen in molecular form is advantageous over chemical storage in atomic form, which requires dissociation of the hydrogen bond and the formation of a hydride. For a comprehensive overview of the nanostructured materials for hydrogen storage, the readers may refer to a recent review article on simulation, modeling and design of Hydrogen storage materials[19]

In conclusion, I would like to say that no matter how long our fossil fuel reserve is going to last, it is a forgone conclusion that we do need to switch over to renewable energy sources, such as solar, wind, hydroelectric and bioenergy and thereby reduce our dependence on fossil fuels. However, it is easier said than done, because of the simple reason that it is easier to simply dig out coal or petroleum that Mother Nature has taken millions of years to regenerate. There are other issues that have got to do with global politics rather than science and technology. I would like to add here that while the developing countries in Asia are sincerely trying to achieve some breakthrough in hydrogen economy; in the western world, particularly in the United States, the euphoria on hydrogen seems be on low ebb. This may be because of several reasons such as the finding of huge gas reserves and other political reasons. However, the Asian initiative on hydrogen storage is looking forward to an optimistic goal in the foreseeable future.

Acknowledgment: The author would like to thank all his students and collaborators in India and abroad for successful collaborations in the field of hydrogen storage.

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ARTICLES

A Journey to the World of Dark Matter

Anindita Sarkar, 3rd Year, BSc Physics

The identity of dark matter has been one of the most interesting unsolved problems in theoretical physics and cosmology. The name 'dark matter' sounds somewhat mysterious. Indeed, there remains a lot to unravel the puzzle which dark matter presents to us.

'Dark matter' can be thought of anything which does not interact with electromagnetic radiation (hence, the name) and whose presence can only be detected via gravitational effects. They can be both baryonic or non- baryonic, although the term predominantly refers to the non-baryonic dark matter. 'CDM' refers to the **c**old **d**ark **m**atter- composed of particles which are supposed to move at non-relativistic speeds.

'Baryonic' matter refers to matter made of baryons-composite subatomic particles having odd number of valence quarks. Familiar examples include protons and neutrons.

The name 'dark matter' was coined by the Swiss astronomer Fritz Zwicky. He studied the coma cluster in 1933 and estimated the gravitational mass of the cluster using the velocity dispersion of galaxies (standard deviation from the average value of radial velocity) in virial theorem, an equation which relates the average kinetic energy of a system to its total potential energy. He found that the estimated mass was far greater than that inferred from luminous matter, with the latter being insufficient to support the observed velocity dispersion of galaxies. He then concluded that velocity dispersion of the galaxies needed far more mass to keep them gravitationally bound than that could be accounted for by luminous galaxies themselves. This extra mass, he attributed to the mysterious 'dark matter' (dunkle materie in German).

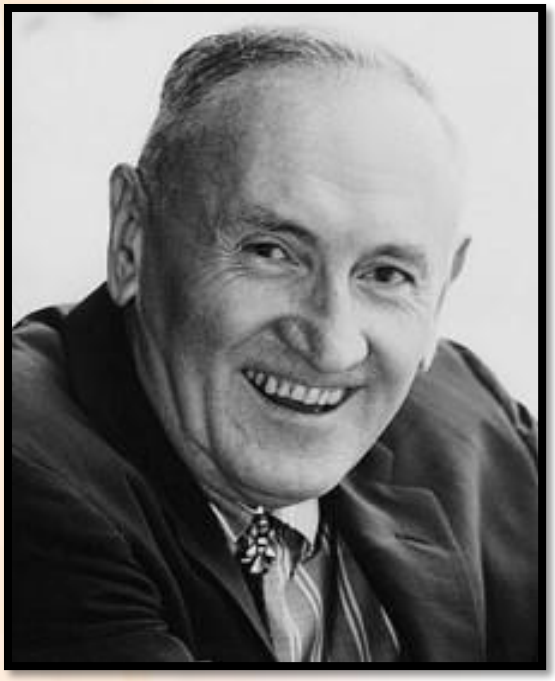

Figure 1 : Fritz Zwicky

Pioneering work was also carried out by the Dutch astronomer Jan Oort in 1932, when he studied the velocities of stars in the neighborhood of the Sun and found them as too large to be contributed by luminous matter alone, in the galaxy.

Although dark matter has not yet been directly detected, indirect evidence has

been obtained from a variety of astronomical and cosmological phenomena.

Existence of dark matter in galactic systems can be inferred from the study of galactic rotation curves. A rotation curve is a plot of the variation in the (circular) orbital velocity $v(r)$ of a suitable test particle at different radial distances r from the centre of a galaxy. The velocities can be obtained from radio measurements of 21 cm line of neutral hydrogen. Since neutral hydrogen clouds are present even at large distances from the galactic centre, they can act as tracers of the mass distribution at large distances from the visible extent of a galaxy.

Considering a sphere of radius r which encloses the orbit and has a mass M, we can write, using Newtonian limit of General Relativity:

$$\boxed{v = \sqrt{\frac{GM}{r}}} \quad \ldots ①$$

$$M = 4\pi \int_0^r \rho(s) s^2 ds$$

$\rho(s)$ being the mass density of the sphere, contributed by stars, galactic gases etc.

From ①, we expect $v(r)$ to fall off with increasing r, as $v \, \alpha \, \frac{1}{\sqrt{r}}$. However, in sharp contrast to the predicted model, spiral galaxies tend to have rotation curves that are either flat or slowly rising. This anomaly can be resolved by assuming the presence of a non-baryonic CDM whose mass increases linearly with r.

Particularly important in this context is a dwarf irregular gas rich galaxy DDO 154. Gaseous hydrogen has been detected in this galaxy in upto an extent of 8kpc, with visible extent of the galaxy being about 2 kpc. The rotation curve is almost flat upto this extent (8 kpc). At $r \sim 8\, kpc$, mass to luminosity ratio is greater than 75. This implies that a large amount of mass (almost 90%) is provided by dark matter

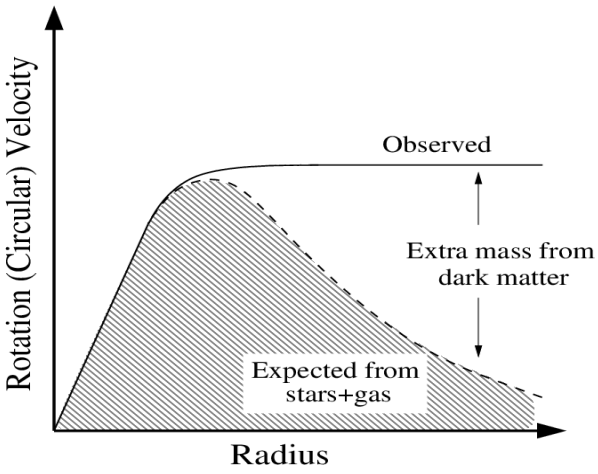

Figure 2 : Predicted vs. observed rotation curve

halo.

$$1\ kiloparsec(kpc) = 3.086 \times 10^{19}\ metre$$

Independent evidence of CDM comes from the galactic clusters. A galaxy cluster consists of a large number of galaxies (typically hundreds to thousands) bound together by gravity. The self-gravity of the galaxy cluster and that of galaxies is not sufficient to hold the hot, x-ray emitting gases present at the center of cluster. The gases would have diffused out in a very short time(less than the Hubble time) but for CDM which essentially acts as a potential 'well' thus preventing the gases to escape. We can obtain an estimate of CDM contribution to the total mass of the cluster by studying its trapping effect on the gas.

Hubble time is the reciprocal of Hubble constant which is a unit that describes how

fast the universe is expanding at different distances from a given point in space.

Gravitational lensing also provides important insights about dark matter. Gravitational lensing is the phenomena whereby path of light bends due to curvature produced by gravity of massive objects when light is passing by such objects. Hence the image of a distant light source gets distorted by a massive object. Mass distribution of a galactic system(say, a cluster) can be estimated by studying the distortion produced in the image(s), which can then be compared to the amount of visible matter present in the system to get an idea of the probable amount of dark matter which might be present in the system.

The observed matter density in the universe is found to be about 0.3. The estimated baryon density is around 0.04 ± 0.02. Thus, it can be concluded that ordinary (baryonic) matter is not enough to account for the matter present in our universe.

But what is dark matter composed of, exactly? We don't yet have a suitable candidate from the standard model of particle physics. There have been quite a number of candidates, based on the supersymmetric and various other extensions of the standard model. With the recent progress, more and more particles have been suggested as probable constituent of dark matter. Notable ones include **WIMP**s (**W**eakly **I**nteracting **M**assive **P**articles), axions, cosmions, light gravitinos, sterile neutrinos etc.

WIMPs are non-baryonic, electrically neutral particles, with mass in the range of $(1 - 10^5)\frac{GeV}{c^2}$and interaction cross section $(10^{-41} - 10^{-51})cm^2$. They arise from many supersymmetric theories and remain prime target particles for experimental detection.

[The interaction cross section for a nucleus incident on the target nucleus is defined as the total cross section of all processes associated with proton and/or neutron removal from the incident nucleus.]

Axions arise in the study of quantum chromodynamics, to resolve the strong CP problem. Their mass ranges from around $(10^{-12} - 1)\frac{eV}{c^2}$. Axions can couple to protons, neutrons and electrons. In particular, they can decay into two photons, with a lifetime,

$$\Gamma \cong 6 \times 10^{24} q^{-2} \left(\frac{m_a}{1\ eV}\right)^{-5} sec.$$

m_a is the mass of axion and q usually ranges between 0.05 to 0.7.

The cosmion is a hypothetical particle, with a mass in the range of $(4 - 10)\ \frac{GeV}{c^2}$. It was originally predicted as a solution to the solar neutrino problem.

It may be the case that there is no CDM but it arises purely due to failure of general relativity. However, till date there has not been a theory of gravity which can work without the concept of CDM yet matches with the observations made across vast scale, from solar system to galactic clusters. Moreover, developments in particle physics predict various CDM candidates, independent of astronomical evidences, which make it quite difficult to reject the need for CDM.

Several experiments are being designed to test for detection of dark matter:

- Production of CDM particles with the help of particle accelerators (ex: Large Hadron Collider in CERN).
- Cryogenic Dark Matter Search experiment aims for direct detection of WIMPs by searching for elastic scattering of WIMPs with nucleons.
- Axion Dark Matter experiment for detection of axions. It uses a resonant microwave cavity with a superconducting magnet.

With no hard experimental evidences in hand till now, the existence of dark matter is not beyond doubt. It however provides a compelling, useful paradigm which is helpful to resolve many discrepancies that arise in astronomical and cosmological phenomena.

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IS OUR UNIVERSE UNIQUE?

Sreeja Roy Chowdhury, 1st Year, BA English

From science fiction to science fact, there is a concept that suggests that there could be other universes besides our own, where all the choices you made in this life played out in alternate realities. The concept is known as a "**parallel universe**," and is a facet of the astronomical theory of the multiverse. Physicists talk about parallel universes, but what they mean, is not always clear. Do they mean alternate histories of our own universe, like those often shown in science fiction, or whole other universes with no real connection to ours?

The idea of parallel universes is pervasive in comic books, video games, television and movies. *The Chronicles of Narnia(1950-56),* a C.S. Lewis book series, features several children who move between our world and the world of Narnia through a wardrobe in their house. Another famous example is the Netflix original science fiction television series *Stranger Things* that begins with the investigation of a young boy's disappearance in a small town, including discussion of an alternate dimension called the Upside Down.

The idea of a physical multiverse came later to physics than it did to religion and philosophy. The Hindu religion has ancient concepts that are similar. The term itself was, apparently, first applied by a psychologist, rather than a physicist, named **William James** in 1895, "Visible nature is all plasticity and indifference, a multiverse, as one might call it, and not a universe."

There is actually quite a bit of evidence out there for a multiverse. Around 13.7 billion years ago, simply speaking, everything we know of in the cosmos was an infinitesimal singularity. Then, according to the **Big Bang Theory**, some unknown trigger caused it to expand and inflate in three-dimensional space. As the immense energy of this initial expansion cooled, light began to shine through. Eventually, the small particles began to form into the larger pieces of matter we know today, such as galaxies, stars and planets. One big question with this theory is: are we the only universe out there? With our current technology, we are limited to observations within this universe because the universe is curved and we are inside the fishbowl, unable to see the outside of it.

Famously, physicist **Stephen Hawking**'s last paper before his death, published in May 2018, also suggests that our universe may be one of many similar to our own, resolving a cosmic paradox of the late physicist's own making. He told Cambridge University, "We are not down to a single, unique universe, but our findings imply a significant reduction of the multiverse to a much smaller range of possible universes." In the 1980's, the Cambridge scientist, along with US physicist **James Hartle**, had developed a new idea about the beginning of the universe, one that solves Einstein's theory. The Hartle-Hawking idea used a different theory called quantum mechanics and as it emerged it carried with it the implication

that the Big Bang would create not just one universe – but an endless supply.

We don't know what the shape of space-time is exactly. One prominent theory is that it is flat and goes on forever, hence, the number of possible particle configurations in multiple universes would be limited to $10^{10^{\wedge 122}}$ distinct possibilities, to be exact. So, with an infinite number of cosmic patches, the particle arrangements within them must repeat – infinitely many times over. This ultimately means there are infinitely many "parallel universes": cosmic patches exactly the same as ours, as well as patches that differ by just one particles' positions, and so on down to patches that are totally different from ours.

According to MIT cosmologist **Max Tegmark**, there are four levels of parallel universes; the first level, an infinite universe that, by the laws of probability, must contain another copy of Earth somewhere; the second level consisting of other distant regions of space with different physical parameters, but the same basic laws; level three consisting of those universes where each possibility that can exist does exist, as described by the **Many-Worlds Interpretation** (MWI) of quantum physics and lastly, the fourth level with entirely distinct universes that may not even be connected to ours in any meaningful way and very likely have entirely different fundamental physical laws. This approach is one of the few attempts to comprehensively categorize the concepts of parallel universes in a scientific context.

The Many-Worlds theory and the Copenhagen interpretation aren't the only competitors trying to explain the basic level of the universe. The **String theory**, among other theories, that can be closely linked with parallelism, is a theoretical framework in which the point-like particle physics are replaced by one-dimensional objects called strings. It describes how these strings propagate through space and interact with each other. It was originated by the Japanese-American physicist, **MichioKaku**, who said that essential building blocks of all matter exists on a subquantum level. Thus, it is a theory of **quantum gravity** and the multiverse theory forms a major part of it. In some theories, there are copies of you sitting right here, right now, reading this in other universes and other copies of you, engaged in different activities in several other universes.

Like the Many-Worlds theory, string theory demonstrates that parallel universes exist. According to the theory, our own universe is like a bubble that exists alongside similar parallel universes. Unlike the Many-Worlds theory, string theory supposes that these universes can come into contact with one another, that gravity can flow between these parallel universes. When these universes interact, a Big Bang like the one that created our universe occurs. While physicists have managed to create machines that can detect quantum matter, the subquantum strings are yet to be observed, which makes them – and the theory on which they're built – entirely theoretical. It has been discredited by some, although others believe it is correct.

Not everyone agrees with the parallel universe theory, however. Physicists use the phrase "parallel universes" to discuss diverse concepts, and it can sometimes get a little confusing. For example, some

physicists believe strongly in the idea of a multiverse for cosmological purposes, but don't actually believe in the Many-Worlds Interpretation. Others believe the quantum physics adage that if it's possible, it's bound to happen somewhere and sometime, meaning it may be inevitable that quantum effects allow contact between parallel universes.

A 2015 article by astrophysicist **Ethan Siegal** agreed that space-time could go on forever in theory, but said that there are some limitations with that idea. The key problem is the universe is just under 14 billion years old. So, our universe's age itself is obviously not infinite, but a finite amount. This would limit the number of possibilities for particles to rearrange themselves, and sadly make it less possible that your alternate self-did get on that flight after all to see America. But rather than seeing this lack of other universes as a limitation, Siegal instead takes the philosophy that it shows how important it is to celebrate being unique.

So, do parallel universes really exist? According to the Many-Worlds theory, we can't truly be certain, since we cannot be aware of them. The string theory has already been tested at least once – with negative results. Dr. Kaku still believes parallel dimensions do exist, however. Einstein didn't live long enough to see his quest for the **Theory of Everything** taken up by others. Then again, if Many-Worlds is correct, Einstein's still alive in a parallel universe. Perhaps in that universe, physicists have already found the Theory of Everything.

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India: A "Thriving" Democracy

Kobid Deb Roy, 2nd Year, BSc Physics

(The article is the opinion of the author alone and does not necessarily reflect the opinions of the department or of the college.)

"Politics is more difficult than Physics"

Yes. These were the words spoken by one of the greatest physicists the world has ever seen, Dr. Albert Einstein, when he was offered the post of the Prime Minister of the newly formed Jewish State of Israel in 1948 when they gained Independence from the British.

It is politics that forms the backbone of any nation and lays the foundation for the future of a state. It helps the state to fight against any insurgency, and enables the state to overcome any calamity in the future.

However, in recent times, money, muscle power and insurgency have played a predominant role in this "Rajneeti" or the ideals of kings or politics. The declining standards and principles of democracy have now reached an abysmal low. There have been several instances where two political figures having the same goal but espousing varying ideologies indulged in acrimonious public criticism of one another. This bitter infighting among different political parties with vested interests becomes a convenient tool for external rulers in their violent and brutal quest to conquer the "divided" land. We may take the instance of a very prominent leader of one of the foremost leading political organizations of India who remained undeterred and unfazed in making the following comment about his compatriot, none other than Subhas Chandra Bose -

"In 1924, the terrorist member of the Swarajya Party supported the candidature of Mr. Subhas Bose as Chief Executive Officer of the Calcutta Municipal Corporation and it is noteworthy that after his appointment to that post many jobs in the Corporation were given to terrorists."

(*Ami Subhas Bolchhi(Bengali)-Sailesh De-Part 1)

This is the situation prevalent in India where the different political ideologies do not deter the so- called "leaders" from branding their fellow men "terrorists". Those brave men who sacrificed their lives and their families for the sake of their motherland certainly deserved recognition as heroes which they were denied.

This alone explains how a small island country like the United Kingdom was able to conquer, dominate and rule a country like India which is the seventh largest country in the world. It is this division between the Indians which the British took advantage of to consolidate an Empire about 5000 miles from their country.

Over the years, we have seen many instances where Indians joined hands with the British only to achieve their ends, depriving the motherland and her people the right to freedom. But even after Independence, have India and her people attained freedom? Have people yet obtained the right to raise their voice against what is wrong? Have the people been bestowed with their "democratic rights", their right to free speech? Well, time will say.

As the world's largest democracy, the process of voting is an integral part of India and a large majority of the people take pride in the right to vote for "it is my right to choose whom I like". But, is the matter really so simple?

It has been found that nearly 37% of the voting process in the nation is controlled by money and muscle power, rigging and insurgency. So, the only way a person can express his view is also being controlled by "Criminalized Politicians". About 54% percent of the MLAs (Member of the Legislative Assembly) have criminal charges pending against them. Nearly 31% of the MLAs are illiterate. Illicit funding of the electoral process is another major feature. Is this what we call a "developing" nation?

*(Money and Muscle Power In Indian Politics-Milan Vaishnav)

The Constitution of India, incorporated on 26th November, 1949, says that India is a "Sovereign, Socialist, Secular, Democratic, Republic".

Let us see what it actually means

Word	Literal Meaning	Actual Scenario
1)Sovereign	India is free from any type of External control	Though India was interested in a fair justification of the Kashmir crisis, the decisions of the US and UK for a fair plebiscite led to the scenario under which the country is reeling even today. (*The most Dangerous Place-Srinath Raghavan)
2)Socialist	Socialist Government aims to end poverty, ignorance, disease and inequality of opportunity	22% of India fall below poverty line,35% illiterate, almost 9% unemployed, and 33% mortality Rate(*National Portal of India)
3)Secular	The state has no official religion. People of all religious faiths are equal in India	The Gujarat Riots of 2002 saw mass killings due to religion. Even the partition of India and Pakistan was due to Communal unrest and violence.
4)Democratic	A system of government by the whole population or all the eligible members of a state, typically, through elected Representatives	Polls are rigged, there is mass loss of lives owing to violence, destruction of properties, affecting the polling condition. People are not even allowed to cast their vote.
5)Republic	The country is a public matter, ruled by the interests of the common people and not by private people or their interests	Though The country does not have any monarchial form of government now, it is totally driven by the interests of the "bourgeois" class and the rich and affluent businessmen which is very prominent from the recent surge of privatization

This is the country for which numerous, young lives were sacrificed for the sake of the motherland. They tried to protect the inherent wealth of Mother India, which was plundered not only by foreign invaders but also by the citizens of the nation who call themselves "leaders".

What happened to those 47 tons of gold that were mysteriously airlifted in secrecy in 1991 for the economic crisis to liquefy, though nothing happened and changes were brought about by a later Government a few days later? No traces of that gold have been found till date.

(*To the Brink and Back-Jairam Ramesh)

How did a silver-trader from Gujarat become the largest industrialist India has ever had in just 26 years of establishing his company and gained so much power as to control the contest of Indian Prime Minister Rajiv Gandhi from Bombay?

(*The Polyester Prince-Hamish McDonald)

Is this the country for whom countless number of young, free-spirited lives gave up their lives to the cruel and brutal torture of the foreign rulers? Is remembering then only through a bust at a crowded area where no one even gives a look at it and naming a few roads and bridges by their name their only designation after the independence for which they sacrificed themselves ?

How can a national leader like Netaji go up in the air just like that with no information about him? Was the only reason why he was avoided only because he went against the policies of the prevalent government? Why is it that for joining hands with Germany and Japan for the fight for India's liberation he was designated as a "Quisling"-one who joins hands with the enemy for occupying the country ? Why did the prevalent "leaders" of India join hands with the British who after hanging to death a revolutionary commented-

"He played like a fawn

And at the Dawn

Was slain at the lawn"

*(Ami Subhas Bolchhi-Sailesh De)

Numerous lives were lost during the phase of building this country. Shahid Khudiram Bose, Surya Sen, Gopinath Saha, Jatin Mukherjee, Satya Bakshi, Chittaranjan Das, Bal Gangadhar Tilak, Bhagat Singh, Chandrasekhar Azad, Rajguru-the list goes on and on without an end to it. Even today, our brave Army, Navy and Air force are always protecting our country-numerous lives have already been lost

owing to different wars. But, did all of their contributions just go in vain that still masses of people are residing on footpaths and with half-filled stomach, while upper class owns 3-5 luxury cars? People with the true knowledge and efficiency being left behind while the "powerful" people are always the one deciding what will happen? Is thus what they wanted? I rather think that they would have been really pained if they survived today and witnessed these misfortunes of India.

It is time that we, as Indians became aware of the situation prevailing in the country. It is our duty to be part of the period of genesis of the land of sages, the land of harmony, the land of the Bhagawad Gita, the land of the oldest religious philosophies of the world, the land where people have rushed many a time to seek inner peace. We should join hands to protect this beautiful land. Let not there be another Kashmir, another Assam, or another Gujarat of 2002. Let there be peace. The period of experimenting with different political ideologies - Communism, Socialism, Far Right, etc.- is over. Let us unite and sing together along with the Bard -

"Where the mind is without fear, and the head be held high,

Where knowledge is free; Where the world has not

Been broken up into fragments by narrow domestic walls;

Where words come out from the depth of truth

Where tireless striving stretches its arms towards perfection

Where the clear storm of reason has not lost its way

Into the dreary desert of sand of dead habit

Where the mind is led forward by thee into ever widening thoughts and action, -

Into that heaven of freedom, My Father

Let my country awake."

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The Observer-Machine

Sagnik Ray, 2nd Year, BSc Physics

The following discussion is basically an analysis of a thought experiment. The experiment is quite simple, involving a number of observers and a moving particle. The purpose of this experiment is to understand the role of observers in physics, and finally in realising the origin of Coriolis force.

Understanding the 'observer-machine':

Consider the following statement: "An inertial observer is observing a particle, and concludes that it is moving with constant velocity". An inertial observer is, say a man with undiminished eyesight who is not accelerating. Now if the particle is either approaching head on or moving away (along his line of sight) from the observer, then there is nothing more to the aforesaid statement. But if the observer's line of sight is perpendicular to the particle's trajectory then a little more brainstorming reveals that a single observer *cannot* serve as an inertial observer. Human eyes can cover a certain region beyond which it cannot see. So, a single observer will be able to observe the particle as long as the particle is within this field of view, as soon as that particle moves out of this field, the observer must *turn* his head in order to see it. But if the observer turns his head then he is no longer an *inertial* observer, since rotation is not uniform motion (even if the observer turns his head with constant angular velocity, his line-of-sight changes direction at every instant). We must then reformulate our notion of inertial observer in the present scenario.

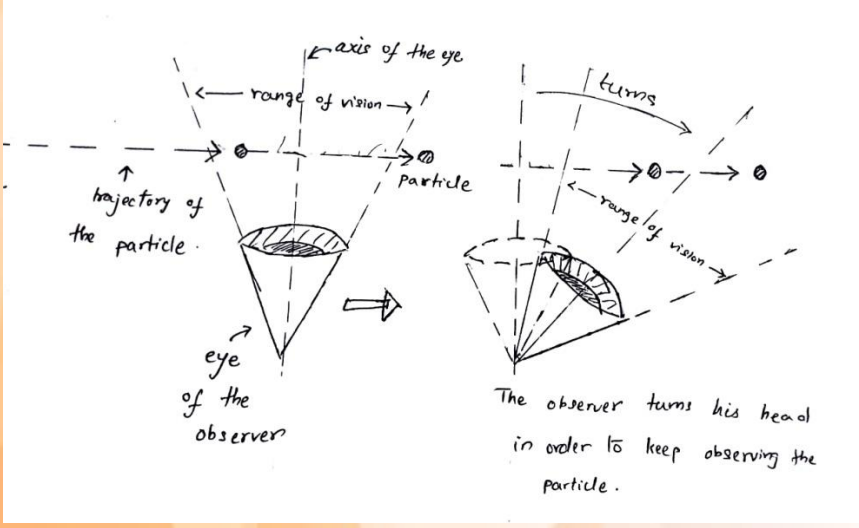

Figure 1

Let us consider an *array* of observers in the following manner. They are all of same height with equally strong eyesight. All of them stand in a straight line facing the line of motion of the particle, with equal spacing say x_0 in between them (see figure 2 below).

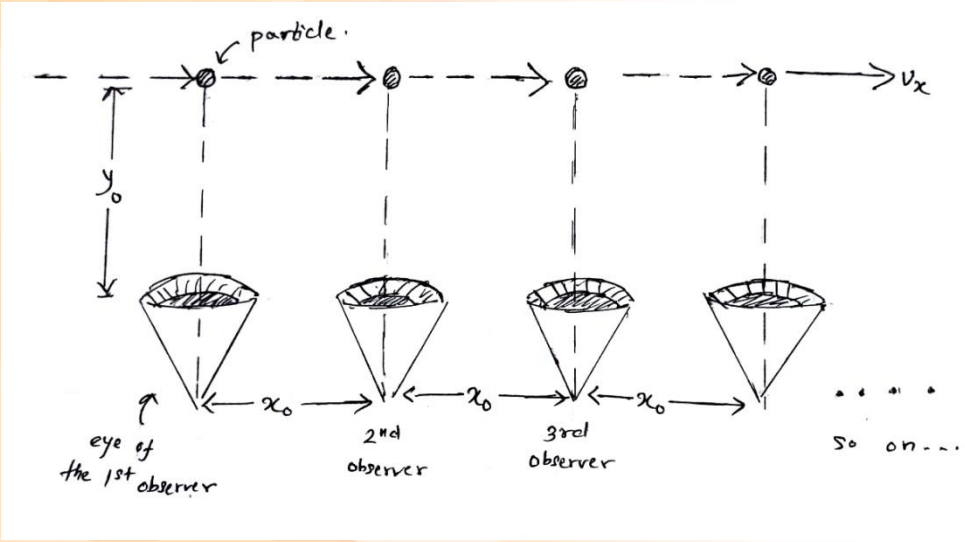

Figure 2

The first observer finds the particle at a distance of y_0 directly in front of him (the particle is at the same height as his eyes from the ground). He looks at his wrist watch and finds the time to be say, t_0. Now, before we proceed further, let's talk about the wrist watches. It is assumed here that every observer has with him an identical wrist watch and that they all tick together, i.e. they are all *synchronized.* In other words, when the wrist watch of the first observer read t_0, so did the watches of each and every other observer. (A point to note: the arguments are completely non-relativistic in nature.)

The next observer finds the particle to be in front of him at the same distance y_0 at an instant $2t_0$. The third observer finds the particle directly in front of him at the distance y_0 at an instant $3t_0$ and so on. These data so collected by the observers are now sent to a single person who analyses the data. *This* person, the collector and analyser of data is the inertial observer. Let's take a moment to understand this. It's clear that a single observer cannot be an inertial observer because of the reason mentioned above. But a *linear collection* of observers, now that's different. In this case, a single observer observes the position and the time and leaves it at that. Since there are a number of such observers, each one has a set of data, and no one needs to turn his head to follow the particle. We can keep track of the particle for as long as we want by increasing the number of such observers.

Let's call the collector and analyser of data the Observer (with a capitalized 'o'; it's kind of dramatic, that' why). He knows that the separation between each observer was x_0, and the data provided to him reveals that the particle had covered equal distances (x_0) in equal intervals of time (t_0), so the speed of the particle was constant. Moreover, since every observer had found the particle to be at a constant distance (y_0) in front of them, it implies that the particle's trajectory was a straight line parallel to the linear collection of the observers. Thus, it turns out that $v_x = \frac{x_0}{t_0}$, and$v_y = 0$ (x, y form the coordinate frame with x parallel to the linear collection of

observers and y perpendicular to x). Our Observer then concludes that the particle's velocity was constant; however, he is not wholly satisfied. It is so because in between two successive observers, there was no one to keep track of the particle. One can say that the particle became invisible while moving from one observer to the next. How can one be sure that it had not changed course in that region? After all the data provided to the Observer are only discrete positions of the particle, not its continuous trajectory. Some error is bound to come into play. So, the Observer decides to decrease the separation between individual observers and increase their number. The error is somewhat reduced. In theory he can continue to do so until he gets an almost continuous array of such observers with infinitesimally small separation in between them. In reality though, if all the observers are of same width, then if they are made to stand shoulder to shoulder, the smallest separation and thus the measure of error is their body width. The error cannot be reduced further.

The arrangement thus mentioned above is what I prefer to call an 'observer-machine'. Each individual observer works independently and the data collected is sent to the Observer, it's analysed and the behaviour of the system or particle under observation is deduced. The observer-machine can be arranged in a number of ways, the simplest one being the linear format as discussed above and the only arrangement that serves as an inertial one. Any other arrangement would be non-inertial. Here's an example to clarify my point.

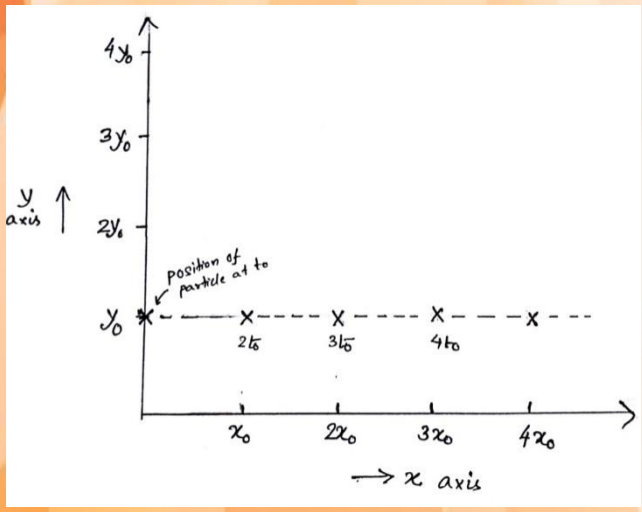

Figure 3 : Plot of the position of the particle

Consider the same linear arrangement as before, but with one observer shifted *towards* the line of trajectory of the moving particle. If every other observer had found the particle to be at a distance ofy_0 in front of him, then let's say this one would find the particle at a distance of $\frac{y_0}{2}$ in front of him. Thus, while analysing the data, the Observer would be under an impression that a sudden force had acted on the particle at that point, displacing it momentarily. But there was no real force present and the existence of a force to the Observer is only due to the arrangement of the observers, making the observer-machine a non-inertial one.

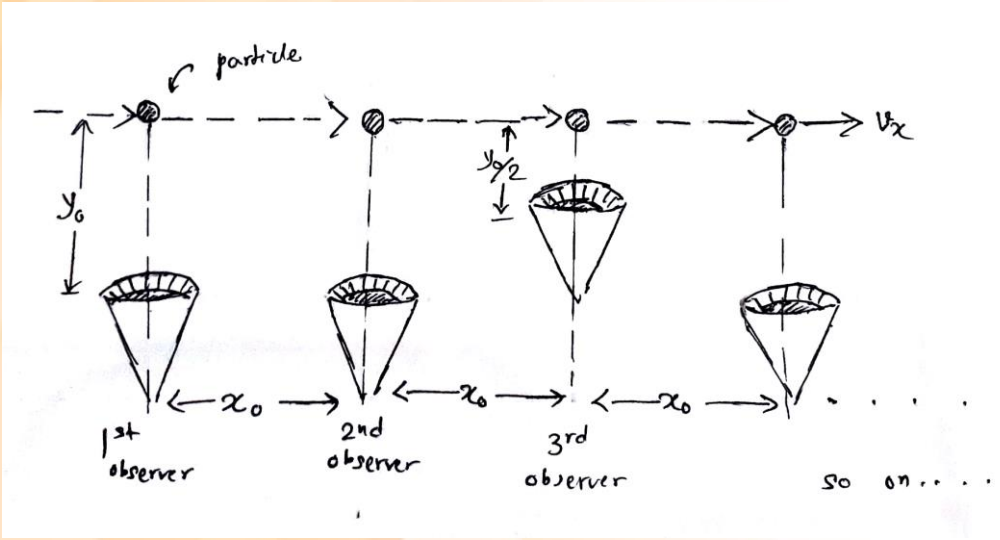

Figure 4

The observer-machine as a rotating frame:

We now wish to arrange the observer-machine in such a way that it represents a rotating frame. Let's consider the following arrangement

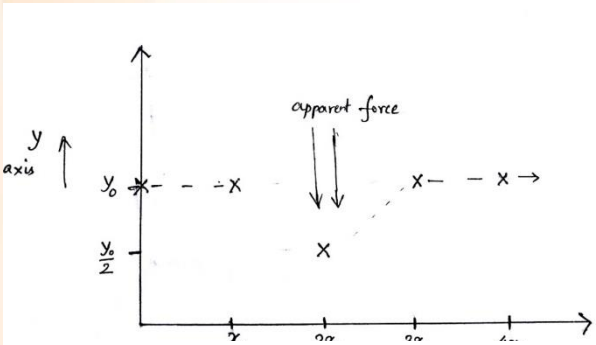

Figure 5: Plot of the position of the particle

The observers are arranged in a single file as was done previously with a separation of $x_0$between them. But here the second observer's head is tilted at an angle φ with respect to the head of the first observer who's looking straight ahead. The third observer's head is tilted at an angle of 2φ with respect to the first observer and so on (see the figure below).

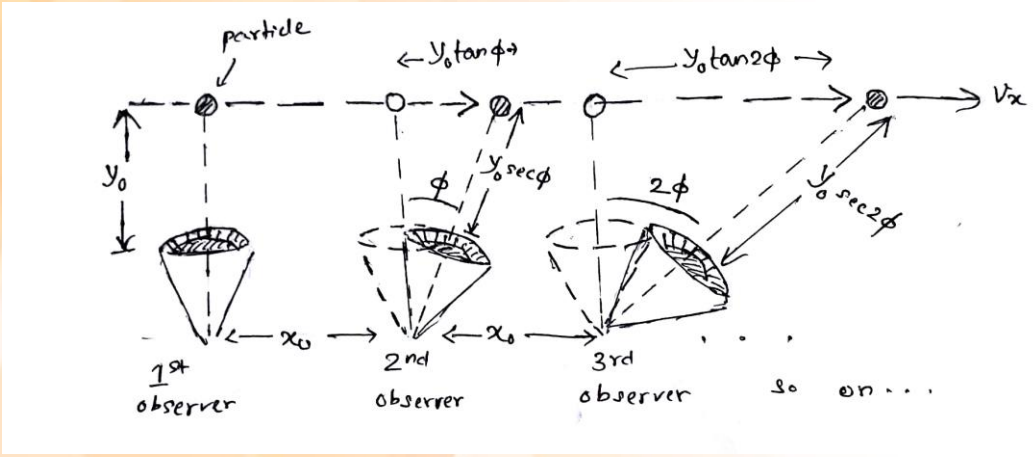

Figure 6: The height 'h' of the eye is considered negligible

It's interesting to see what happens next. The first observer finds the particle at a distance y_0 in front of him at an instant t_0 just like the arrangement of the inertial observer-machine. But the next observer *doesn't* find the particle at the same distance in front of him. Since his head is tilted, he finds the particle at a distance of $y_0 sec\varphi$ in front of him, which is obviously greater than y_0. Also, the instant at which the second observer sees the particle is *not* $2t_0$but something greater than that, precisely it is$t_0\left(2+\frac{y_0}{x_0}tan\varphi\right)$. To understand how this comes about, one must realise that the particle has travelled a distance of $x_0 + y_0 tan\varphi$ before it is seen by the second observer. Since the actual speed of the particle (i.e. with respect to the inertial observer-machine) is$\frac{x_0}{t_0}$ so the time taken by the particle to reach from the first to the second observer is$t_0\left(1+\frac{y_0}{x_0}tan\varphi\right)$. Since the first observer's watch had read t_0 when he had seen the particle so the next observer's watch must read$t_0 + t_0\left(1+\frac{y_0}{x_0}tan\varphi\right) =$ $t_0\left(2+\frac{y_0}{x_0}tan\varphi\right)$.Similarly, the third observer finds the particle at a distance $y_0 sec2\varphi$ in front of him at an instant$t_0\left(3+\frac{y_0}{x_0}tan2\varphi\right)$ and so on; all these data so collected is then delivered to the Observer.

Our Observer makes the following deductions: since the particle was found at a distance of y_0 in front of the first observer but at a distance greater than y_0 in front of the second observer so he readily concludes that $v_y \neq 0$, in other words the trajectory of the particle is in no way parallel to the linear collection of the observers. When the particle was in front of the second observer, the value of $v_y = \frac{y_0 sec\varphi - y_0}{t_0\left(1+\frac{y_0}{x_0}tan\varphi\right)}$.

But when the particle was observed by the third observer, $v_y = \frac{y_0(sec2\varphi - sec\varphi)}{t_0\left(1+\frac{y_0}{x_0}(tan2\varphi - tan\varphi)\right)}$, a close inspection reveals that the value of v_y had actually *increased* as the particle had moved from the second to the third observer. A force must have then acted on the particle along the line of sight of the observer. Further calculations reveal that the value of v_y increases continuously as the particle moves; however, v_x remains constant. From the perspective of the

Observer, the only explanation amounts to the existence of a force field that acts on the particle along the line of sight of the observers. This force field is known as the *Coriolis force field* and it depends on the velocity of the particle as measured by the observer-machine and the angular velocity of the frame (i.e. the angular velocity that our observer-machine mimics). This is given by the well-known relation,

$$\vec{F} = -2m\vec{\omega} \times \vec{V}_{rot}$$

Where m is the mass of the particle, $\vec{\omega}$ is the angular velocity and $\vec{V}_{rot}$ is the velocity of the particle as measured in the rotating frame. $V_{rot} = \sqrt{{v_x}^2 + {v_y}^2}$, since v_y changes so does V_{rot} and as Coriolis force depends on V_{rot} so the force on the particle also changes. Thus, the Coriolis force field is a time dependent variable field. *Also,* the Coriolis force changes due to the change in the angular velocity of the frame, which is the case in this scenario. Generally, ω is considered constant. But with the given arrangement of the observer-machine, ω is indeed variable. We must realise that as such there is *no* angular velocity involved with our arrangement, the observers don't turn their heads continuously, their heads are only tilted at certain angles and they are static. *But,* as the particle moves from the first to the second observer, the angle of tilt increases from 0 to φ, and the time in which this happens is the time the particle takes to be seen by the second observer, i.e.$t_0\left(1 + \frac{y_0}{x_0}tan\varphi\right)$. Therefore, $\omega = \frac{\varphi}{t_0\left(1+\frac{y_0}{x_0}tan\varphi\right)}$. But this value changes when the particle is seen by the third observer, because the time taken by the particle to move from the second to the third observer is$t_0\left(1 + \frac{y_0}{x_0}(tan2\varphi - tan\varphi)\right)$ but the numerator of ω is still equal to $2\varphi - \varphi = \varphi$.

From the vector relation of Coriolis force, one can easily find the direction of the Coriolis force on the particle using the right-handed rule of vector product ($\vec{\omega}$ is taken to be directed into the plane of the paper since its sense is clockwise) and the reader must verify that the direction so obtained tallies with the direction of force inferred from our experiment. However, a total match of the result obtained from this experiment with the vector relation is difficult because of the fact that the observer-machine can only provide and deal with discrete data, not continuous ones. In other words, the velocity of the particle is actually an average velocity, but the vector equation requires it to be instantaneous. Thus, this experiment involving the observer-machine aims at understanding Coriolis force qualitatively, rather than quantitatively. The Coriolis force wouldn't have existed had the Observer known that the observers' heads were tilted. But this piece of information was withheld from him and the only way he could have reasoned out the observations was to introduce the existence of a force (although *we* write the expressions of time and position as functions ofφ, the Observer is not *aware* that they are functions of φ, to him they are just numerical data supplied by the observers).

There is another point worth mentioning. It is the following: the observer-machine can observe the particle as long as the tilts of

the observers' heads are less than 90°. As soon as $n\varphi \geq 90^{\circ}$ (for some $n+1^{th}$ observer), that observer's line of sight becomes parallel to the actual trajectory of the particle, thus he can no longer see it; to the Observer, it appears as if the particle has accelerated to infinity.

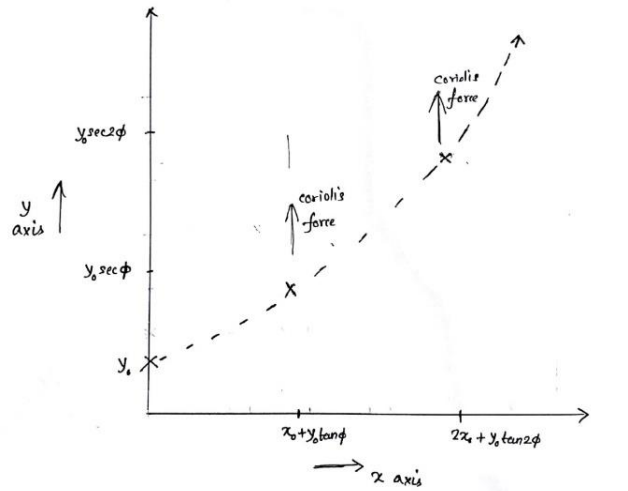

Figure 7 : Plot of the position of the particle

Acknowledgements:

I would like to thank Debraj Dutta of my class, for when I had first discussed the idea with him, he had helped me gain more insight. Also, I am grateful to my mechanics course professor, Dr. Subhankar Ghosh for developing in me this curiosity that had ultimately fueled me in writing this article. I hope the reader finds it interesting to read and ponder over.

Reference:

An introduction to Mechanics, by Kleppner and Kolenkow, pg: 359 (the vector relation of Coriolis force)

Vedanta and Quantum Physics: An Astounding Connection

Soumyaditya Halder, 2nd Year, BSc Physics

"Learn how to see. Realize that everything connects to everything else"

-Leonardo Da Vinci.

So is the saying and some of the salts of the earth have been able to discover the obscure connections among physical or the metaphysical elements around us. And the links between the spirituality of religions and rationalism of science have been sought out. Keeping any partialness aside, it can be strongly concluded that among all the religions, Hinduism proves itself to be the most scientific and philosophically approved one. The Vedas treasure innumerable truths and facts that have later astounded various great philosophers, scientists and many great men all over the world.

One of those world-famous persons, who could decipher the essence of the Vedas as a trove of science mingled with philosophy, is Erwin Schrodinger. Being a strong approver of the Vedas, he totally declined to consider the other religions (even his own) as rational. The Vedas had conquered his mind, captured his heart and blossomed in his scientific creativity and theories and it is perhaps the Vedas that had nurtured him to be a connoisseur of Quantum Mechanics.

Classical physics became outdated at the atomic and subatomic levels. To understand and explain the happenings in realm of the sub-atomic world, quantum physics was born. Subatomic particles behave in unpredictable ways, sometimes a particle is a 'WAVE' and at some other times it is a 'PARTICLE'. This discovery marked the starting point of quantum physics. In many ways this is similar to Vedanta. Vedanta teaches us that the mind is made of waves or 'vrittis' and these MIND WAVES BECOME THE OBJECTS("manomatramjagata", "manahkalpitamjagata"), which we see around us in the physical universe.

Schrodinger's wave function is the heart of quantum physics. Schrodinger's equation represents a physical system and this physical system always consists of an observing system ("Drashta" in Vedas) and observed system ("Drishya" in Vedanta).

The observed system is a wave function and this wave function is the wave component of the wave -matter duality as postulated by De Broglie. Wave function only collapses in the presence of an observing system and becomes a particle, if there is no observer the particle remains as wave. Similarly, Vedanta also says that it is the "Drashta" (observing system in Quantum physics) that makes this "Sristi/Drishya" (observed system in quantum physics) to appear or exist.

In an autobiographical essay Erwin Schrödinger explains that his discovery of Quantum mechanics was an attempt to

give form to the central idea of the Vedanta. He was a believer of Monism or the monist philosophy which advocates the oneness or singleness of philosophical and cosmological stance which posits ultimate unity of all things despite the apparent differences and distinctions. He considered the notion of the plurality to be result of deception (Maya)-"the same illusion produced by a gallery of mirrors, and in the same way Gaurishankar and Mt. Everest turned out to be the same peak seen from different valleys."

"The multiplicity is only apparent. This is the doctrine of the Upanishads. And not of the Upanishads only, the mystical experience of the union with God regularly leads to this view, unless strong prejudices stand in the way."

-Erwin Schrodinger.

Even there are other great scientists who have found the lyrics of the Vedas captured in the note of science and tuned under rationalism.

"I go into the Upanishads to ask questions."

-Neils Bohr.

"After the conversations about Indian philosophy, some of the ideas of Quantum physics that had seemed so crazy suddenly made much more sense"

-W. Heisenberg

References:

To look for more details one can search in the following books

The Tao of Physics –by Fritj of Capra

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HAPPINESS IS…

Sanjana Mullick, 3rd Year, BTech Biotechnology

We often tend to ignore the most important our life ~ HAPPINESS. The term happiness though is a bit abstract in the present-day world can be achieved easily just by being ourselves without any pretence or façade. A happy soul can laugh endlessly without caring about the stares from strangers, can look into the positives of life and try to weave the embroidery for its "DREAMS OF YORE". It can lower stress levels, promote optimism and develop a sound mental health with positive psychology.

Here, are some of common yet unknown facts about happiness. Check out how many you can practice in your life and elevate your mood!

- Nostalgia can help you look into the brighter side of life! Being nostalgic involves cognitive process of remembering which often has memories and emotions blended with it. Retrospection can enable you to look forward to future. Any change whether good or bad always affects or human mind. Reflecting on those memories can develop self-worth and promote optimism to face the future with courage. Also, nostalgia helps you to feel less lonely. Hopefully you found an excuse to flip through your childhood photographs!
- Even food makes you happy! Happy food such as milk, spinach, and chicken help to promote the production of excitatory neurotransmitters like serotonin which arouses the sensation of calmness whereas inhibitory neurotransmitters GABA's building block, an amino acid, I-Glumatine is found I pork and beef. GABA has tranquilizing effects on the body. And of course, the thought or sight of your favourite food makes you feel good instantly! So, stop dieting and grab a pizza now!
- Pets are friends with benefit! When we pet or play with our furry friends, oxytocin is instantly released from the posterior pituitary which instantaneously lowers stress level and lowers our blood pressure. Planning to tame a cat or a dog?
- Exercise elevates the mood! When the sun rises, so does our mood. Researchers analyzed 2.4 million tweets across the globe which showed positive messages being at the peak at the start of the day and grew more negative as days passed by. In case you're having a bad day, run out a few miles. Research has shown that just 20 minutes of exercise can release serotonin (which increases the appetite and lifts the mood) and dopamine (which signals reward and pleasure to the ventral tegmental area of the brain). Early to bed and early to rise, to be happy exercise!
- Music too makes you happy! Upbeat music=upbeat mindset. If you're an ardent listener of rousing music then congrats, you are better able to put yourself in a positive mood. Music can improve blood flow and lower levels of cortisol and ease pain. At

the same time, listening to old music can induce a stressful response and bolster negative emotions like anger and aggression. Why? The beats and rhythm of the songs you select modulate the heart beats and activity of brain thus next time you tune to a song, be careful. Depressed? Play your favourite songs in a loop!

- The weather can influence happy feelings! Milder summers, springs and winter can boost our mood whereas harsher climate has a negative effect. On a bright sunny day while you are at your workplace you focus more of enjoyment and socializing while on rainy days you are generally blue. Why so? Rainy days mostly force you to stay indoors without much interaction and feel miserable, whereas on sunny days, you can plan outing, go for short trips and feel happy. There have been cases reported of Seasonal Affective Disorder (SAD) which was successfully treated with light. We are not entirely devoid of photoperiodic responsiveness. Open the windows and let the sunlight have a positive effect in your mind at the beginning of the day!
- Happiness and fragrance! Like some perfumes can elevate the olfactory nerve to stimulate the limbic part of the brain for positive impact whereas some aroma associated with cultural occasions (scent of night jasmine or parijat associated with Durga Puja) evokes happy memories and lifts our mood and make people more altruistic. Researchers at University of Florida found that flowers' smell positively influences your emotions. Take time to stop and smell a rose to be cheerful!
- Joy is contagious. Charity or small acts of kindness and altruism increase your longevity. Friends are often exposed to same environment, including environment, risk, and pressure. Researches propose that if one of your close friends is happy, it increases the likelihood that you'll be happier by 15%.

What we dream of is what we seek and we definitely seek happiness in life. So, chase the dreams, flu high like a kite, smile in the roughest of the situations. Laugh until you forget the reasons to cry and stay happy with the simple life hacks!

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POETRY AND PROSE

Ball Dance

Gaurav Somani, 1st Year, BSc Physics

Throw your hands up in the air,
And look into the sky.
The Universe keeps calling you,
Since the day you started crying.
Show me the highs and all the lows,
Show me that perfect picture pose,
I am sitting naked by the lake,
But honey, nothing turns me on.

So I ball dance, with the Universe and
Let all my thoughts go down.
There was a fine line, between you and I,
But honey, it's all blurred out.
I unlocked my door,
Let you swim in my sea,
So many starry eyes in the pool,
But honey you looked through me.
My lips were bit bitter,
But when you taste them, it feels sweet,
You drew all the curtains,
And we went back to sleep.

So we ball dance, with the Universe and,
Let all my fears die.
There was a fine line, between you and I,
But honey, now it's all gone.

Amour Perdu

Rajeshwari Guha, 1st Year, BA English

The strumming of a guitar and a low mellifluous voice: that's the first thing I hear when I find myself standing in a dark hallway. The voice puts me in a slight trance and I can't help but follow it. Down the hallway, there lay a cozy room and at one corner, I find a girl sitting on a chair with her back facing me.

Unsure of whether I should enter the room, I raise my voice and ask the girl, "Hello? Can you tell me where I am?" Strangely, I get no response- not a flinch, not a movement on her part. Sighing, I enter the room in hope of getting to know my location. I walk towards her chair and stand beside her. But she doesn't stop singing: she keeps on weaving subtle webs of notes and staccatos with such felicity that it renders me speechless. I try to move my mouth and ask her again, or maybe tap on her shoulder to get her attention, but I don't do either.

Instead, I find myself sitting on the sofa facing her. I start to observe her appearance, and as I do so, I can feel my heart racing. Her waist-long raven hair gracefully covers her back and her dainty fingers moves skillfully on the guitar. She's in deep concentration with her eyes closed, her long lashes falling beautifully on her pale smooth cheeks. The hem of her baby blue dress dances with the wind and I realise that she has a short petite frame, with a small waist, and a convenient height for forehead kisses.

I check myself as I think about this; I shouldn't be crossing the line. I don't know who she is; but I do know, by now, that she cannot perceive me. I don't exist in the world in which she lives: I'm merely a hoax, a gap in the passage of time. It reminds me of The Story of Genji in which Lady Murasaki quite freakishly writes on the travels of souls into different worlds and time parallels: is that what's happening to me?

This girl is unlike everyone I've ever seen. She has this eerie calmness about her and an aura I can't quite put into words. I've never seen someone so calm and at peace: even the most level-headed individuals are inwardly agitated by the trials and tribulations of mortal life, and no matter how much they pretend, I always find a hint of anxiety in the curve of their lips, in the angle of their eyebrows, or the quick movement of their eyes. But I don't find such things in her; it's almost as if she's deceased.

I don't know what came over me, but I really want to embrace her; to caress her cheeks, to kiss her hands. I stand up and walk towards her. I'm nervous and my head is reeling, but nonetheless, I extend my hand to touch the top of her head. But I can't. I'm not being able to touch her; my hand is passing through her and I have no mass. Truth to be told, I'm furious and sad. I want her, I tell myself, but I don't know why. I've never felt like this before. I can't put a name on this feeling but love seems too farfetched. How can I fall in love with someone whom I don't know? Whom I've never talked to? Who doesn't even exist in my world and neither do I in theirs?

I've been pondering on these questions when, quite abruptly, I see her stand up. She's goes to her bookshelf and slowly caresses the spines of her books. I smile because I can feel how much she loves them; and I think of how we might collect books together. I see her inserting her hand

in between two books and take out an envelope which seem to be important. Is it perhaps a love letter from a lover who has long departed to some other place? Or is it a letter she intends to give to someone?

She carefully keeps the letter on her study table and stares at it. I wonder why she is behaving so peculiarly. Her eyes have the quality of a pitless void and her face is of someone who's deeply speculating on something. She leaves the letter on the table, obviously wanting it to be seen, after it's days of being hidden amidst heavy books.

The girl starts wending the way to her balcony door, and stands by the railing, deep in thought. I follow her and discern that we're on the highest floor of a very tall building. The view raises both awe and fear in me as the gusts of wind, the chirps of crickets and the voiceless night have a sinister undertone which might have been an appropriate atmosphere for Mr. Hyde to dwell in. But all this doesn't seem to perturb her: she's completely sangfroid and peaceful. Finally, I register that I should be afraid of this calm; and that the thing that was disconcerting me was its similarity to the lull before a storm.

Her hair flows with wind like a strange halo and she looks at once, both powerful and fragile. I notice the slight frown on her face. I'd tell you that I understand that something is awry, that something was about to happen, but I think that you can already perceive that. There's a sharp pang in my chest and I want to embosom her from behind and whisper into her ear that everything was going to be alright. She'd fit in my arms like a missing puzzle piece; and I feel like I've known her all my life. For the first time, I don't want to know where I am, or who she is, as long as I get to see her. I want to tell her "honey, can you tell me how I might exist with you? I'd leave my world for all it's worth!", but I know it'll be of no avail.

She climbs the railing and steps on the flat surface. Her pale petite body gleams in the moonlight. My breathing becomes ragged, my heart clenches and my eyes water. This cannot be happening. Under all that calm lay a humungous whirlpool of sorrow, and I can't do anything. She's a few centimeters away, but it feels like an eternity.

I can't take this anymore. I scream with all my strength: "No, don't do this! Look at me, I'm here! I love you. Please listen to me, sweet, please look at me for once", and as I'm repeating my apparent futile words, I hear her gasp. She turns around and looks at me: her eyes widen. Our eyes meet and I feel the barrier slowly crumbling down- the world stops around us and her face breaks into the most stunning smile I've ever seen. "I was waiting for you, my love. I thought you'd never come", and with that she tries to get off the railing; but Fate conspires treacherously with Destiny, and so she makes the wrong move. She slips, and with her, my heart slips too.

I wake up from my sleep, with my pillow drenched in tears, and my body shaking. I clutch my chest and sob uncontrollably: I never got to be with the person I was meant to be.

Student Life: The Spring of Life

Soumyaditya Halder, 2nd Year, BSc Physics

Behold! It's the correct time,
the spring of life-
to mold yourself and
to bring forth the person,
beneath the apparentness,
perhaps latent in a deep slumber
waiting for an ignition,

- A provocative spark.

But, be cautious, there are:
challenges to confront;
innumerable heads to compete with
and, unnumbered difficulties;
all these in a span –
comparable to a blink?
Yes! unknowingly it's a rat race
one has been into-
to forget oneself and,
be indulged in a show!
No! don't come out –
as it is the only way:
to thrive, to accomplish,
to establish and to get:
those, once aspired.
There will be flaws,
but don't succumb to those;
or else: a nip in the bud.
Hear the obligatory call-
the call of optimism;
to disclose as the petals of flower,
keeping the woods of mind –
evergreen.
Because it's only the spring
-and miles to go:
before the frosty snow.

The Lady with the Oily Rag

Pranjali Shome, 1ST Year, Department of Education

The very first sun-rays fell on her face through the broken thatched roof. The roof was screaming help to get a repair. Though they were gentle, the rays brought the sad news. News about broken roof, leaking taps, shattered windows, colourless walls, near empty food jars and most importantly- another day of unimaginable struggle for existence.

Waking up wearing one of the three saris she owned, she caressed her two children covered in tattered clothes and faced the sun and thanked God for keeping her alive yet another day. The sari was unsightly with distorted colour and mismatched stitches here and there.

Completing her daily chores, she set her foot to the outside world, carrying her oily rag. Broad daylight made the world see her better. She was stooping as though heaven and hell had jointly thrown away all the universal deeds upon her shoulders. Her wrinkles bore the history of cries flowing through the crevices made up of poverty. Her degrading bones were witness to hunger, piercing out as salty water through her cloudy lenses. Those white lashes bore thousands of unspoken tales, which with time had vanished in polluted air. Her sore feet, screaming with pain, had tampered on millions of stone chips and forever engrossed the struggle with bloody sweat. Her downcast gurgling stomach bore the harsh truth how money equated to food. Slow walking brought the image of the buoyant eyes and ravenous stomach of her children, thus making her move fast. Her broken feelings compelled her to ponder why some human beings on Earth are rich and some are poor like her. She brushed aside her thoughts when her eyes caught something worth putting inside her oily rag.

Rag picking made her smile when she visualized food and her children enjoying the food.

The Nature

Ishaan Poddar (ex-student), St. Xavier's College (Batch 2019)

The lovely bright smiling sun tells me "Hi" and to shine like it when I wake up.

The lovely blue sky tells me to soar high when I wake up.

The noisy city traffic greets me but tells me to be soft.

The sea tells me to be big and deep from my heart.

The trees tell me to stick to roots,

But to touch the Moon.

The Almighty tells me through its Lovely "Nature" to be good and beautiful in my Nature.

In all GOD created nature with deep, beautiful and thoughtful colours in His own unknown canvas.

To teach, to Love and spread kindness in all.

The Strange Seed

Chandrarka Sahu, 2nd Year, BSc Physics

One day up at the attic, I saw a mysterious box with a seed in it. Instantly I went and planted it in the garden. The very next day, when I woke up, I saw a miracle. The size of the seed had increased and its upper surface was bulging out of the soil! I came near it and was amazed. As soon as I touched it, I heard a strange sound. It was coming from inside the seed. The next day, I saw the colour of the seed had changed. Previously, it was white, now it was red. I told my friend Anirban about it. He was also surprised to hear about it and wanted to see it. I told him to come to my house that evening. The seed was then green and its size had further increased. Both of us couldn't understand what was happening. Anirban said," I don't think this is a seed. To reveal its mystery, I think we should dismantle and see what's inside it." I agreed with him.

The next evening Anirban came to my house with some tools. I had observed that the seed changes its colour at an interval of four hours. That means it changes its colour six times per day. Anirban took a screw-driver and a hammer and I took a spade. We both went to the garden with the aim of dismantling the giant seed. As soon as we came near it, we heard a strange noise. But this sound was somewhat different from the one I had heard before. This noise was louder. I told Anirban not to hit it. I dug and removed some amount of soil from its sides. Anirban and I then lifted it and put it on the soft grass. It was very heavy. The seed was creating the same sound while we were lifting it. I brought my magnifying glass and observed it. There were many marks and curves on it.

"What is it?", I whispered to myself. Suddenly, I heard a mechanical voice- "Did you ask me?" Anirban was also startled. The voice came from the seed.

"What are you?", I asked.

"I am a pro-techliocyte"

"What does it mean?"

"It means bio-organic cellular robot."

"What?! A robot cannot be bio-organic! Then you are a living entity!"

"No. I don't have life, but I have brain."

"From where you came?", I asked in disgrace.

"Up."

"You mean from outside the earth?"

"Yes."

I could not believe my ears. "I see, you are a part of the extra-terrestrial world."

"Right. The name of my planet is Tetrocylonil. My creator had sent me to your planet to collect information about it."

"But how did you come in my attic?"

"I was transported there from my world, eleven days ago."

"How did you grow such big in one day?"

"The more I collect information, the more I grow. In the box, I couldn't grow as I didn't receive any information in there. Here, out and exposed to earth I had collected many data and facts. Thank you."

"And what about your colour change?"

"The colour change was a signal which I was giving to my creators, so that they can track me and take me back to my planet. They have received the signal and will import me from here at any moment."

Anirban and I were spellbound. A complete silence prevailed for a moment. Sometime later the pro-techliocyte began to speak again.

"You humans are of diverse characters. You know many things and you will know more in course of time. Our world is more advanced than yours, but yours is more progressive. I am sure that you will reach our stage of civilization within the next two hundred years. Without your help, I wouldn't have been able to know these. I am thankful to you and for that I am giving you a gift from my world."

After telling these words the pro-techliocyte began to glow and it slowly vanished in front of our eyes.

After a few seconds I noticed that there was something shining in the grass above which the techliocyte lay. It was a silver coloured pen.

A few days later while I was using the pen, I noticed that its colour changed according to my wish!! If I wanted to write in red, the ink turned red or if I wanted to write in blue, the ink turned blue!! Maybe it was also a techliocyte!!

Water, Water Everywhere;

Not a Drop to Drink

Pranjali Shome, 1st Year, Department of Education

Elegance never had a better description
than the movement of infinity
3-atom bound molecule- together, hand-in-hand.
Congregated yet liberated.
Starting as immortal;
with the credence of never ending.
Phlegmatic yet cataclysmic.
Breaking all stumbling blocks with the mindset of
moving forward-
it fills the buckets of aqua bodies, dampening
the terrain-
bringing life to unborn-
renewing the life of near-dead
donating with open hands.
Twinkling rainfalls adding precious drops,
filling up every brim.

But when takers become killers, doomsday slowly
and harmoniously sweeps in.
White candy flosses of sky take every drop back-
banks and beds start to show their bare self, hideous face-
cracked, rough, beastly;
chuckling with bare teeth at the dry throats.
Buckets, jars, bottles- stand alone-
lonely, desolate, jobless.

Revenge never felt better for life givers.
Dancing with exaltation, watching the lives
yearning desperately for a drop.
Not so far away- when salty tears will turn edible for needs.

C/o কোলকাতা

Utsab Sarkar,2nd Year, MSc Physics

নীহারিকা,

আমি এখন দার্জিলিংয়ে, হয়তো সপ্তাহ খানেক থাকব। সপরিবারে হাওয়া বদল বলতে পারো। ভয় পেওনা, তোমার সাথে দেখা হবে না আমি জানি। দূরবীনে চোখ রাখলেই যেমন আকাশের নীহারিকা দেখা যায়না, তেমনই দার্জিলিংয়ে আসলেই নীহারিকা সেনগুপ্তের দেখা পাব, এই আশা রাখিনা। এখানের পাহাড়ি আঁকাবাঁকা পথ দেখেই নাহয় খান্ত হবো।

সেই এক যুগ আগে যখন তোমার মা চাকরির বদলি নিয়ে চলে এসেছিলে এই দার্জিলিংয়ে, সেই তবে থেকে আমার সাথে আর দেখা করোনি। যোগাযোগটাও রাখোনি, বা রাখতে দেওয়া হয়নি। বিশ্বাস করো তোমার মায়ের নাম্বার, নতুন ঠিকানা, সব খুঁজেছিলাম, অতিন কাকার বাড়িও গেছিলাম। কেউ দেয়নি, হয়তো বারণ ছিল অথবা কোনো কারণ ছিল।...

অবশেষে মাঝিদের মতন সন্ধের আগে পারে ফিরতে বাধ্য হলাম।....থাক সেসব কথা।

তারপর বলো কেমন আছো? সময় মতন খাও তো? এই পাহাড়ি আবহাওয়ার সাথে রঙ মিলিয়ে নিয়েছনা খুব তাড়াতাড়ি? নিউজলপাইগুড়ি থেকে হোটেলে আসতে পথে যেটুকু পাহাড় দেখেছি তা কলকাতার রুদ্ধশ্বাস দুপুর আর সন্ধের এক চিলতে চিলেকোঠার গল্প ভোলাতে যথেষ্ট।

শুনেছি কাছ দিয়ে নাকি তিস্তা বয়ে গেছে ! দেখা হয়েছে তা কখনও? কলকাতায় থাকতে তো আমার মতো তোমারও অভ্যাস হয়েছিল প্রায়শই বিকালে গঙ্গার ঘাটে বসে আকাশ আর জোয়ার ভাটা দেখার। সে বদভ্যাস কি এখন আছে? নাকি পড়ন্ত বিকেলে কারও কাঁধে মাথা রেখে নিশ্চিন্তে দুদণ্ড নিরিবিলি সময় কাটানোর মুহূর্তগুলো জীবন থেকে একেবারে অতীত হয়ে গেছে!! কোন উত্তরটা বেছে নেবে তুমি?...

আমি তো বিকেলে ছুটি থাকলেই যাই। সেই একই ঘাট, একই লাল সিঁড়ি, একই জেটি আর লঞ্চের ভোঁভোঁ শব্দে যাত্রীদের বাড়ি ফেরার তাড়া। সবই এক, খালি আকাশটা পাল্টে যায় রোজ রোজ। আরও কয়েকটা বদল হয়েছে এই কয়েক বছরে। এই যেমন সেদিন দেখলাম ভাঙা পারের ছোট্ট খাঁজে দুটো কাঁকড়ায় বাসা বেঁধেছে। ঘাটের বাঁদিকের গাছটাও শুকিয়ে একেবারে ন্যাড়া হয়ে গেছে, এখন খালি ডানদিকের বটগাছটা পাতা ফল ফেলে ঘাট ঢেকে দেয় তবে তা ছায়াদেয় এখনও। অনেক ছায়া...।

ঘাটে গেলেই মনে হয় যেন প্রতিচ্ছবি দেখছি জীবনের। খালি চরিত্রগুলো বদলে গেছে, আর আমার অংশীদারি কমে আসছে ধীরেধীরে। অলিগলিগুলো এখন যেন স্মৃতি গিলতে আসে, তাই ফেরার পথে বড় রাস্তা ধরি। তবু সে আমার শহর... একাকিত্বের।

পাহাড় হয়তো দূরত্ব বাড়িয়ে একা দাঁড়াতে শেখায় কিন্তু চরম ব্যস্ততার মাঝেও ভালবাসতে সেখায় কি, শহরের মতো?

কেমন আছি জানতে চেয়োনা কখনও।

ইতি

নাগরিক জীবনের কীট

B-জ্ঞান

Arghyamalya Biswas, 3rd Year, BSc Statistics

অনু পরমাণু মিলেমিশেজগৎ
পৃথিবী বাতাস এখনদূষণময়
ধূলিকণা,কার্বনেধুঁকছে বাতাস
সময় ,তাকে কি ফেরানোযায়?

চাকা থেকে দুনিয়াঘুরতে শেখা
নক্ষত্র দেখেছে গ্যালিলিওদূরবীন
সময়ের সাথে বিজ্ঞানএগোয়;
পরিবেশকেন নয় বিশুদ্ধ, দূষণহীন।
সংখ্যার খেলায়গতিময়মুঠোফোন-
সত্যি কি সবার আধুনিকবিজ্ঞানী মন!?
অনু পরমাণু মিলেমিশেজগৎ-
বিজ্ঞান এগোয় ,মানুষহয়তো না...

আলোকলতা

Utsab Sarkar,2nd Year, MSc Physics

আলোকলতা, তোমারজন্য
ছাইভস্মলেখা....
আলোকলতা! তুমিআমায়
ভাবছোবসেএকা..?
আলোকলতাবিস্ময়কর
চোখদুখানিটানা....
দেখেছিলামরোদবিকেলে
রাস্তাঅজানা..।
আলোকলতারোজদুপুরে
বারান্দাতেআসে
সঙ্গেসখী, আলোকলতা
গল্পভালবাসে।
আলোকলতাআলোকলতা
বড্ডসাবধানী,

আলোকলতাঅল্পকথা
ভীষণঅভিমানী..।
আলোকলতাহলদেপাতা
মিথ্যেআব্দারি,
মেলারথেকেবেলুনকিনে
ভাবে; আহামরি....
আলোকলতাঅনেকদূরে
আলাপেসংশয়-
আলোকলতাআমারমনে
ছড়িয়েঘরময়...

অবৈধ

Ayan Sikdar, 2nd Year, BSc Physics

এত হিংস্র এই শীত ...
এহাতে চাদর ঢেকে এই তীর্থ মেজাজে মেশাই
মন্ত্রণাহীন; যেন কানে লাগে সাধকের ওঁ
শরীরে অহংকার ! সে নেবে তোমাকে প্রথম ...
এই ঘরে যত শূন্য , এই আলো আঁধারের কাছে
সব মৃত্যু , শব–জন্ম — এই হিসেব পাঁজরের ‘পর
যত বিষাদ ; এনে আমাকে ঢেলে দিও...
এই রক্তদাগ, সে ব্যথা এখনও শীতল
তালাবন্ধ ঘর , অথচ দুয়ার খোলা মানে ঋণ

প্রসবের চিৎকার, কেন ঋদ্ধ এই বা আঁচল
এভাবে পারিনি বলেই দূরে যাওয়া অভিশাপ
ভেঙেছে , ভেঙেছে আর কেড়েছে আমার সংসার
সেই থেকে আমি যাযাবর ; ভুলেছি স্মৃতিকে মহৎ
তোমার স্বামীকে বলো — সে আজও এই পুত্রহীন

আমাদের যে রাত ছিল ! তাই আজ অসমাপ্ত দিন ...

St. Xavier's College (Autonomous), Kolkata

HORIZON

VOLUME XII (2020)

DEPARTMENT OF PHYSICS

EDITOR-IN-CHIEF

Dr. Indranath Chaudhuri

FACULTY ADVISORS

(L-R): Prof. Gayatri Banerjee, Dr. Sarbari Guha, Dr. Sudipto Roy

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Clockwise from top: Mousumi Mitra, M S Dinesh, Rwitika Ghosh, Abhinandita Sinha, Biswasaran Panda, Gaurav Somani, Aparajito Bhattacharya

Editorial

The Covid-19 pandemic that swept across the world last year (and still hasn't quite left) showed all of us that our preconceived notions of stability and normalcy are fragile. But it also showed us that we-- as a collective whole, even when forced to stay physically separate within our own homes can come together and overcome any obstacle, however daunting that might be. And that is exactly what the twelfth edition of our annual Departmental magazine, HORIZON stands to prove.

HORIZON has always been a place where the young minds of the Physics Department pour in their creativity and scientific curiosity and this time it is no different. Although like the rest of the world, Physics Department too fell into a stupor at the height of the pandemic, the Department was quick to get up on its feet and nurture the spirit of scientific enquiry with events such as online webinars and paper presentation organized by the Department and the Xaverian Astronomical Society (XAS), and the colloquium lectures thereafter. We thank Fr. Principal, Vice Principals (Arts and Science) and the Dean of Science for their help and constant motivation. We are grateful to our faculty and support staff, not to mention the students who showed utmost dedication and made this edition possible, and last but not the least the contributors and sponsors to the magazine.

Indranath Chaudhuri,

Dr. Indranath Chaudhuri

Head of the Department, Editor in Chief

HORIZON 2020 – A Prologue

The year 2020 began under the shadow of Covid-19. From the month of January itself, scary news of the epidemic raging in Wuhan and other affected areas in China, were percolating through the social media and news channels. But in spite of all that we never believed that this virus would actually bring our lives to a standstill. The last thing we thought of, not even in our wildest dreams, was the sudden cancellation of the annual seminar of our department, "SPECTRUM 2020" scheduled for 21st March 2020, owing to the suspension of all classes and other activities in the campus, except for the bare necessities of the college. With that was cancelled the publication of the 2019 edition of our departmental magazine, HORIZON, since the inaugural session of SPECTRUM 2020 included the release of this magazine by our Father Principal.

Thus, began our arduous journey in search of a new way to continue our day-to-day activities, which also included our profession — searching for a way to complete the unfinished courses of the January to April semester of 2020. So far as our department is concerned, we are glad that the teachers and students came together to find a way out. That is another story, to be told elsewhere. But we must admit that during all these times we were hoping against hope for the resumption of normal classes in the campus. However, that was not to happen, and till today, we have to remain contented with online classes, both theories as well as labs.

As the online semesters began in August 2020, all of us (the teachers) got completely occupied in the preparation for online mode of teaching. Slowly we realized that it will not be possible to organize an actual physical program in the near future for the release of the departmental magazine, HORIZON. The only way out was to release an e-copy. By that time, we had already lost one of our dear colleagues — Professor Dwarka Nath Bose, on 9th August 2020. As the editorial board met to discuss about the possible release of HORIZON in the online mode, we felt that we should include an obituary for Professor Bose. But that could only be incorporated in the 2020 volume. This meant that we have to publish the 2019 volume along with the 2020 volume, which could only happen at the end of 2020. The decision was in favour of a combined volume.

However, troubled times were far from being over, and more losses were in store for us. By November 2020, we learnt that one of our brave boys, Neelangshu Saha, was in an advanced stage of his disease. We were still hoping for a miracle. From December 2020 to January 2021, the students were busy appearing in the pending exams which were conducted online, and the teachers were busy too. The news of Neelangshu's failing health was pouring in day by day, and finally he left us on 15th February, 2021. A bright young fellow, positive minded, dutiful, enthusiastic, and full of energy, was snatched away by the whims of nature.

Our annual seminar SPECTRUM was still pending, along with the online release of HORIZON. The challenge was now on us. We must keep the positive vibes of Neelangshu continued through our activities, and we must pay our tribute NOW. In an unprecedented move, it was decided that the 2020 version of HORIZON needs to be extended to February 2021, so that we can express our emotions for Neelangshu at this time, in our departmental magazine, the release date being 20th March 2021, the day of our online program SPECTRUM 2021 on Microsoft Teams, where we will pay our tribute to Neelangshu in a special way.

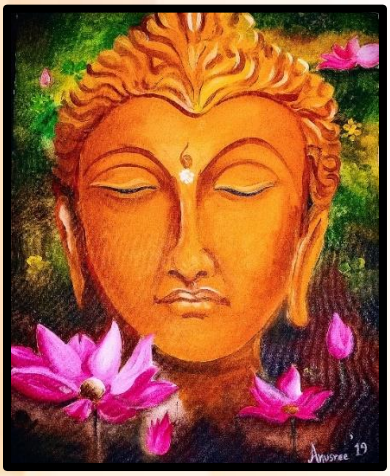
---- Sarbari Guha

Due to the lockdown the new batches that joined our department did not have the opportunity of having their group photos clicked. So, we came up with a new idea of including them in our magazine.

UG1 STUDENTS

PG1 STUDENTS

Paintings and Photographs



Anusree Sen, PG2, Physics

Debayudh Debnath, PG2, Physics

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ISO - 200
Location - Kumortuli

Debayudh Debnath, PG2, Physics

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ISO - 200
Location – Bakkhali

Debayudh Debnath, PG2, Physics

Model - Nikon D3300
Aperture - f/11
ISO - 400
Location – Maidan

Debayudh Debnath, PG2, Physics

Model - Nikon D3300
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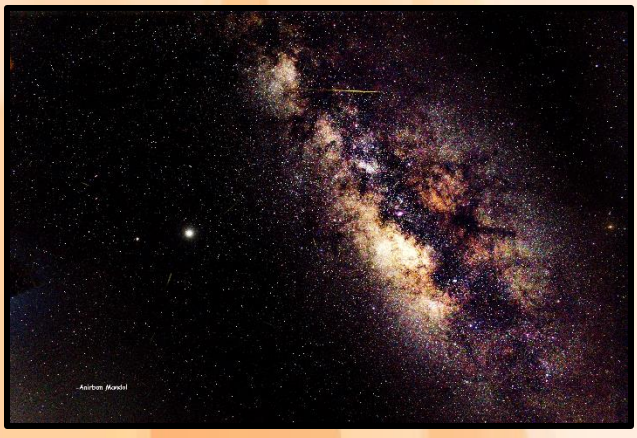
Location – Beleghata



Anirban Mondal, PG2, Physics

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Location – Panskura

Anirban Mandal, PG2, Physics

Model - Nikon D3500
Aperture - f/4.5
ISO - 1600
Location – Panskura

Anirban Mandal, PG2, Physics

Model - Nikon D3500
Aperture - f/6.3
ISO - 1600
Location – Panskura

OBITUARY

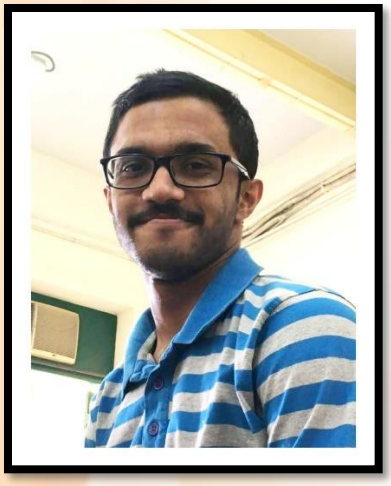
Prof Dwarka Nath Bose (25/07/1938 – 09/08/2020)

Prof Dwarka Nath Bose was born on 25th June 1938 to Mrs Lalita Bose and Dr Sunil Chandra Bose, the first Indian cardiologist and brother of Netaji Subhash Chandra Bose.

Dr Bose, fondly referred to as DNB sir, did his schooling from St Paul's school, Darjeeling, graduated from St Xavier's College, Kolkata with Physics Honours, did his MSc (Tech) in Radiophysics and Electronics from Calcutta University and completed his PhD from Reading University, UK, in 1965.

He joined as a research associate at the Materials Research Laboratory Pennsylvania State University, in 1966-1970. He taught in the prestigious Indian Institute of Science, Bangalore, India, from 1970-1977 and was a professor of Materials Science Centre at Indian Institute de Microtechnique University de Neuchatel (Switzerland), 1982 and Virginia Polytechnic Institute & State University USA 1985-1986. He was the Dean Faculty and Planning, Indian Institute of Technology, 1989-1991.

As the honorary visiting Professor of Physics Department at the St. Xavier's College from 2012, he had been a mentor to the Solid State Electronics specialization apart from being a guiding light to the post graduate students of the department. He instituted the Father Verstraeten Memorial Lecture where stalwarts from different branches of Physics were invited for talks. Prof. Bose was an ardent sports lover and had wide interests in arts and music. He breathed his last on 9th August, 2020 and till the last day of his life he was dedicated to Physics and the students.



NEELANGSHU SAHA

(2nd August, 1999 – 15th February, 2021)

Neelangshu Saha, a bona-fide student of the Department of Physics, was a joyous person with a kind soul, who could cheer up everyone around him and also, put in a lot of effort in making any kind of activity a success. In his 11th grade, when his life had been pretty much similar to anyone else's, he was diagnosed with Alveolar Rhabdomyosarcoma. His life seemed like hour-glass, slipping away from his grasp and he was taken to the Tata Memorial Hospital, Mumbai for his treatment and within a month he started with his elaborate and tedious procedures.

He was in a lot of pain from the condition, treatment and its side-effects. Mental weakness was an added exhaustion. He had been advised to stay home for almost a year and also to restrict any visitors to avoid the chances of any sort of an infection. His family and friends never left an opportunity to cheer him up and supported him in this tough phase. People normally start treating cancer patients differently, but his mother always believed in treating him as normal as anyone else. She cooked all kinds of his favourite dishes and the family used to spend quality time doing lots of things.

Neelangshu couldn't appear for his board exams in 2017, alongside his friends with whom he had studied for more than 10 years. For 1 year he fought bravely and in December 2017, he was told that he had won.

Finally, he took his board exams next year with the junior batch. However just after his Physics paper, there was the first sign of a relapse. The doctors had told that it wasn't advisable to write an examination immediately after his chemotherapy. However, he wasn't ready to give up. He had gone through 33 cycles of chemotherapy and 51 rounds of radiation during the first spell of his illness. So, he underwent chemotherapy at a hospital in Kolkata. His school (Adamas International School) supported him too in this to a great extent. He scored an aggregate of 86.75% in his 12th boards. With the marks he scored, he got admission into the Department of

Physics, St Xavier's College, Kolkata. The way Neelangshu fought his illness and managed to give his board exams is truly inspiring.

His treatment continued after joining college too. The professors of the department and the Dean of Science supported him and helped him in every way possible. In the span of 4 years, he had 2 relapses, but he fought it gracefully and was always active in everything he did. He worked so hard for our departmental fest Spectrum. He used to carry out work for our fest while being admitted in the hospital and that was his determination is doing things. The pain he used to go though was never visible in his face. He bore all the hardships with a smile in his face.

During the last 6 months his condition started worsening. He used to go for chemotherapy sessions but it showed no effect on his illness. When we took our pending Semester 4 exams in December 2020, he was going through a lot of pain, yet wrote the exams and submitted within the stipulated time. Many of us had even advised him to talk to the professors for removing the time factor or take extra time. However, he never went for those. It was in January 2021 when his condition started worsening beyond recovery. He couldn't sit for his semester 5 exams and was completely bed ridden. It was on 15th February, 2021 when he succumbed to his illness.

He set an ideal infront of us that we all have our own demons to fight against but we shall never forget to open the heaven of love and selflessness unto all. He left us with a dream of Spectrum to be realized. But to us he never left, rather he could never. He is still there within each of us, our Neelangshu.

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- Article in The Telegraph: https://www.telegraphindia.com/west-bengal/high-performer-in-marks-and-spirit/cid/1416888
- Interview taken by Humans Of SXC: https://m.facebook.com/story.php?story_fbid=1569327209891289&id=487556094735078

-Compiled by BSc Physics 3rd year Students

Neelangshu – Our clear sighted boy

As I sit down to write about Neelangshu, my words are failing me. All my memories are coming in a gush. Neelangshu was such a remarkable kid — yes, for me he 'is' a kid — younger than my son. But in wisdom, he appeared to be elder than all of us. A sheet of paper is just not enough space to capture all aspects of his personality.

I met him during his third semester, when I was teaching Mathematical Physics to his class. At times he used to be absent in my class and I thought that he was not serious. But very soon I came to know about the actual reason for his absence. Ever since I held him in awe, and I am sure that not only me, but all his teachers did the same. His sheer grit and determination to hold on to life, in spite of being on the wrong side of luck, is something to revere.

Neelangshu was doing his undergraduate project under my supervision. In November 2020 he informed me that the doctors have given up. I could not believe my ears, but I struck a bold face and advised him not to give up and to remain positive, although I myself did not believe in my advice. Ironically, I am the mentor of his class and my duty was to give him the best possible advice to keep him going.

How much pain did he bear just to complete his fourth semester examination in December 2020, is not possible for us to fathom. In January 2021 he lamented that he was unable to write the fifth semester exams owing to his illness. During this time, I tried to share heart-warming videos and songs on YouTube, which were of short duration, so that he could bear the strain of viewing them. But suddenly, around 16th January, his daily response came to a halt. Soon I learnt from his mother that he was admitted to hospital due to some emergency. Although he recovered to some extent but the disease had already advanced too far. He hid not respond to my short WhatsApp messages after 31st January. I found that he was not reading the messages. Hence, I stopped sending him any message after 2nd February, leaving him in the hands of nature.

On 15th February 2021, online classes began for the new semester. He left us on the same day in the evening. As if he was waiting to be remembered by us during the running semester. He left us just the night before Saraswati puja. On the morning of Saraswati puja I felt that our best tribute to him would be to take a pledge to continue our academic journey against all odds.

I remember Friday, 13th March 2020, the last day I met him in the college. During lunch time he came to the staff room along with his friends to discuss about the arrangements for Spectrum 2020, scheduled on 21st March, which was never held. I enquired whether Spectrum was being called off due to the pandemic. He replied: "No ma'am"! Next day was my preparation day, so I was not in the college. And I never met him in person after that, except through online interactions.

-Sarbari Guha

Neelangshu, we all will meet you one day…

Kobid Deb Roy, BSc. Physics, Third year

It was back on 23rd February, 2020 when we all assembled at Dharramtallah at 9am in the morning on a bright Sunday morning, ready to go to the picnic together. As I came out of the car, Neelangshu, standing there among the crowd, suddenly rushed to me, embraced me and said*," Kobid!! Finally picnic ta hochhe*" (Kobid, finally we are having the picnic!). It is that memory, that hug which I really cherish now.

Neelangshu was an indomitable spirit, whose physical absence among us will never be able to tarnish the impact he had left on us. The incomparable physical pains which tormented him for so very long time were never able to take away the smile from his face. Every time someone met him, the constant factor in him was the smile on his face, not reflecting any of the hardships that he had been enduring.

It was God's good grace that I had come to know Neelangshu from the very first day of college. Till the last day before the college shut down due to the Corona Lockdown, we used to sit together every day and had discussions of all sorts and every kind. I still remember the large bites I used to take from Neelangshu's sandwich and he, in turn, liked my homemade chowmein. Though how much I try and wish for, those days will never come back. I still feel tears in my eyes as I remember those days.

After death, a person lives through all the good deeds that he has done in his life. Neelangshu's greatest deed- he used to spread a positivity and a zeal of life into everyone around him. A sad or depressed person could not have remained so for much long if Neelangshu was around him. His mere presence used to cheer up the people around him. I remember many a times when he would cheer me up if I was sad –his beaming smile has etched his face in my heart.

I remember how tirelessly and selflessly he had worked for the Spectrum 2020 to make it a grand success. It deeply pains me to see that today he is not among us to witness Spectrum, whatever be the mode of occurrence. The innumerable "meetings" which we had in the canteen, our visits to the stores in College Street searching for sponsorships (though in vain and then finally ending up in the Coffee House sipping cups of coffee), visits to the narrow memento's shops ordering for mementoes for Spectrum-the list goes on. I remember in 2018, when we went out during the Pujas, he was beaming with unmeasurable joy, saying "Thank you, *toder jonno ei prothom pujote berote parlam bondhuder sathe*" (Thanks to you people that I am finally able to be out during the Pujas with friends). Before that, he could not go out pertaining to his long, arduous chemotherapy sessions. I still remember those words of how happy a person can be to be able to go out with his friends for the first time in his life-sadly, that was his first and last outing with friends during the Pujas. In 2019, he was in Mumbai for chemotherapy and in 2020, there was the pandemic.

I would like to sum up saying Neelangshu was an indomitable spirit, a person capable of growing flowers in hardy rocks when everyone has given up. The pain that he has suffered in his life- may no one ever face that. In his short span of life, he has given us all a very important message-to be optimistic and keep fighting your backlashes without ever thinking of giving up.

He was and will always remain among us. Like the bright moon in the dark night sky, he is like a ray of hope among all that is dark around us. He will never be missed, for he will always remain among us.

DEPARTMENTAL EVENTS 2020

Neutrinos: From Impossible Dreams to Unreachable Stars
A Webinar by Dr. Srubabati Goswami

On the 30th of September, 2020, the students of St. Xavier's College (Autonomous), Kolkata, as well as students from various colleges from all over India were fortunate enough to attend a webinar named **Neutrinos: From Impossible Dreams to Unreachable Stars by Dr. Srubabati Goswami**, organized by the **Post-Graduate and Research Department of Physics, St. Xavier's College (Autonomous), Kolkata.**

Srubabati Goswami is an Indian scientist specializing in High Energy Physics, Astroparticle Physics and Neutrino Physics. She is the first Indian woman to earn a Ph.D. in neutrino oscillations from Science College, University of Calcutta. She is Senior Professor in Theoretical High Energy Physics in the Physical Research Laboratory. She is a fellow of Indian Academy of sciences, National Academy of Sciences (India) and Indian National Science Academy.

Being from the astrophysics background, Dr. Goswami gave an informative insight into the very famous Supernova Explosion: Death of Stars which was probably the highlight of the evening. She also showed us sneak-peek into her work which revolved around solutions to solar neutrino problems.

A Slice of the Heavens: A Webinar by Dr. Sayan Basu

On the 14th of August 2020, not only the students of St Xavier's College (Autonomous), Kolkata, but also the students all over India got the opportunity of being a part of the webinar named **A Slice of the Heavens** by **Dr. Sayan Basu**, organized by the **Post-Graduate and Research Department of Physics, St. Xavier's College (Autonomous), Kolkata** in collaboration with **The Xaverian Astronomical Society.**

To speak of Dr. Sayan Basu, he is a radio astronomer at the University of Pretoria. He is also affiliated to the Hartebeesthoek Radio Astronomy Observatory (HartRAO), a research facility under the South African Radio Astronomy Observatory (SARAO). He has worked on a project related to the Southern African Large Telescope (SALT), the largest optical telescope in the Southern Hemisphere.

Dr. Sayan Basu gave a very interesting talk on **Extragalactic Radio Sources for Navigation,** where he primarily spoke about quasars, a subclass of active galactic nuclei (AGN), which are the primary reference points in intergalactic space. Radio Telescopes are the main instruments to observe radio sources and their preference depends on the angular resolution. Space navigation was another highlight of the evening. An interesting out-take from the talk was the little details he provided about Chandrayan-3 (ISRO's third mission to moon's south pole)

Departmental colloquium : Black Holes with Hair

A Webinar by Dr. Betti Hartmann

On the 26th of February, 2021, the **Post-Graduate and Research Department of Physics, St. Xavier's College (Autonomous), Kolkata** organized its Departmental colloquium online. A talk was given by **Dr Betti Hartmann** on '**Black Holes with Hair'.** Students of St. Xavier's College (Autonomous), Kolkata, as well as students from various colleges all over India participated in it.

Dr. Hartmann's lecture consisted of four parts, namely - what are black holes, simplicity of black holes: no hair theorem, violation of no hair conjecture, and summary on the concept of black holes. She spoke about time dilation in relation to one of the predictions of General Relativity. We got to know about the Schwarzschild radius which is what makes a mass a black hole.

One of the greatest attractions of the talk was when she showed the night sky of south-east Kolkata of 27th of February 2021, and pointed out how the Sagittarius constellation looked more like a teapot than an archer. She gave us two examples of black holes possessing hair. One was black holes inside solitons, and another was black holes in anti-de sitter. Her talk was really interesting and aligned just perfectly for both undergraduate students and postgraduate students

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ARTICLES

COVID-19 Pandemic & New Normal

Ahona Majumdar, 2nd Year, MSc. Physics

A man without mask is your enemy, turn away from him. Shops, malls, markets etc. without provisions for sanitizing individuals are no less than dungeons, not worth visiting. Marriage ceremonies, birthday parties or for that matter any social get-togethers are history today. Friendly meetings are supposed to be done over video conferencing apps as most of the friends are reluctant to meet in public. Always watch out whether you are maintaining social distancing norms laid down by ICMR, if at all you are meeting any of your acquaintance one to one. No need to visit schools or colleges, classes are getting conducted online. Work from home, no need to go to office unless there is a pressing need and get paid less. If you wish to buy laptop go for online shopping and avoid visiting any electronic shop. Order food online, use Swiggy, Zomato and avoid food joints or restaurants. Preference is still there to buy vegetables, fruits and other perishables from the local market. But before using them, sanitize them properly or pour hot water over them or store them away for at least 9 hours. If you need to visit overseas countries ensure that RT-PCR test is done 48 hours before you board the flight and you have a COVID-19 negative test report in hand. Otherwise, you won't be allowed to board the flight. If you are stuck in foreign country, then in many cases, the only option you have is to register in India's Bande Bharat Mission scheme and wait for your turn. If you manage to get on board, you cannot meet your family upon arrival. You'll be quarantined for a fortnight and shall be allowed to meet your family thereafter, provided you do not develop any symptoms.

Yes, this is the new normal! This is the way the Wuhan virus has changed all our lives. All of a sudden, COVID-19 has completely transformed our ways of life. The pandemic condition that we are living in today set in almost like a bolt from the blue in Dec'2019 and is still far from over. Vaccines are in the market but are they fool proof! I doubt. The virus has devastated our lives. It has caused deaths of millions and it is still there. The so called developed countries in the world like US, UK, France and others, also feel defenseless today. Death toll is on the rise even now in many countries. Who is going to have the last laugh, China or US, the virus or the mankind? These are the questions that remain unanswered.

Survival 2020

Abhinandita Sinha, 2nd Year, BSc. Physics

"It is not the strongest species that survive, nor the most intelligent, but the one most responsive to change."

-Charles Darwin.

Humanity or the human race has faced the stormy sea of times starting from the discovery of fire to the invention of supercomputers, but they have emerged victorious in all their battles to become the most mentally equipped species of this planet. If we take into account the existence of extraterrestrial beings. We have and still are venturing in the abyss of not only God particles, cellular entities but also the black holes of which even the fastest of the fastest, i.e., LIGHT, is afraid of.

But, all of a sudden, we, WE! The CONQUEROR of CONQUERORS,

have been injured by our own weapons. This has shown that guns and swords are nothing but parasites, because they derive their existence from us and at the same time damage our UNITY.

Truly speaking, after the world was hit by the deadly bioweapon,

Sars-Cov2, many of us have realized what true battle is and who are the true warriors .Under the combined trauma of lockdown, online lifestyle and threat to extinction,

where we the common people are desperately searching for a tinge of our 'fundamental rights', from my perspective and personal experience ,it has been a suffocation for most of us ,both mentally and physically. Although some might argue that we are the so called 'e-GENERATION' but ultimately at the end of the day we are also made up of flesh and blood with OXYGEN being the main life force.

In the first 2-3 months of the pandemic, it seemed really comforting for the middle and upper middle-class people to stay at home. But as the days passed by, the poison started seeping into the tissues and the cells, into every organelle withering the very will to live. We have been suffering bouts of depression, mental agony while we still put on HAPPY FILTERS on our profiles. While some took up their pens, paint brushes, the others picked up music while rest started on with their DSLRs trying to capture their bit of freedom. As the saying goes, art comes only to the people in pain, thus we have witnessed outstanding pieces of talent blooming in this period.

But what is most striking are the army of ‘WHITE APRON’-ed warriors. They have come up with all their force equipped with Empathy and Love towards their fellow human beings. Many have lost their lives in this process, but this has only made their teammates braver. My mother is a health officer so I have had the opportunity to observe her very closely. The undaunted spirit with which they are working day and night is enough to pointed right into our conscience, that warfare leads us nowhere. It is brotherhood and empathy which can help us progress.

Although we still can neither detect the future nor is time travel possible till now, thus with the present only in our control, it would be best for us to “LIVE AND LET LIVE”.

Let us π!

Debraj Dutta, 3rd Year, B.Sc. Physics

Posing the problem

Pi or π is the ratio of a circle's circumference to its diameter. Because it is an irrational number it cannot be written as a fraction. Instead, it is an infinitely long, non-repeating number. Well, this is how most of us or at least I used to know pi, just like any other boring mathematical constant. But, just recently I came across a phenomenon relating to pi on the internet that absolutely blew my mind. Originally discussed in the paper "Playing pool with Pi" by mathematician G. Galperin, it goes like this:

Consider two sliding blocks and a wall as shown in figure 1. Initially block A (say of mass m_A) is stationary while the other block B (say of mass m_B) is moving with some velocity 'v' towards block A. Let's assume that there is no friction, and that any occurring collision between blocks or a collision between a block and the wall is purely elastic. Now, our goal is to calculate the number of collisions that would take place, before the process ends. Well guess what, if the mass of block B is 100^k (k being a whole number) times the mass of block A, then the total number of collisions 'n' equals (k+1) significant digits of pi!

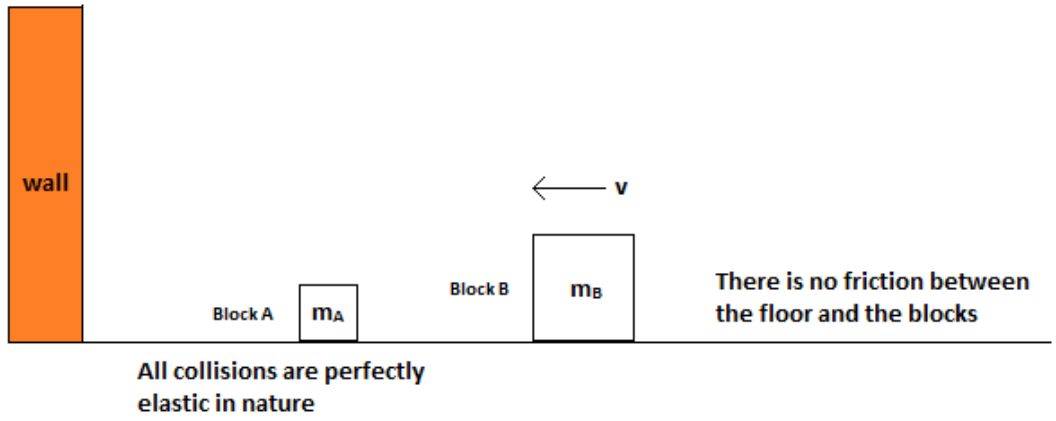


Figure 1

Suppose, when both the blocks have equal masses, k is 0 and the number of collisions result in 3, the first significant figure in the number pi. Similarly, when mass of B is 100 times the mass of A, k is 1 we have 31 collisions, when B is 10,000 times heavier than A, k is 2 and the number of collisions is 314 and so on. The process simply acts as a digit calculating machine, which successively produces the significant digits of the number

π=3.14159265358979323846264338327950288419716939937510582097494459230781……

But the question is how in the world has this anything to do with an irrational

number describing the ratio of the circumference of a circle to its diameter! How can the number of collisions by the blocks result in pi! Well, we now have two options, we can either accept the fact to be true without questioning any further, or we can be that one stubborn person who just cannot accept things unless they make sense to him. And, for this instance let's just choose the second option, clearly because it sounds less boring. Before proceeding into trying to get some sense out of it, we can first try to find out if the number of collisions actually count to pi or not.

Calculating number of collisions

Before we can calculate the number of collisions, we need to have some basic understanding about the mechanics of collision, and in particular elastic collisions since that is what we are concerned with in our problem.

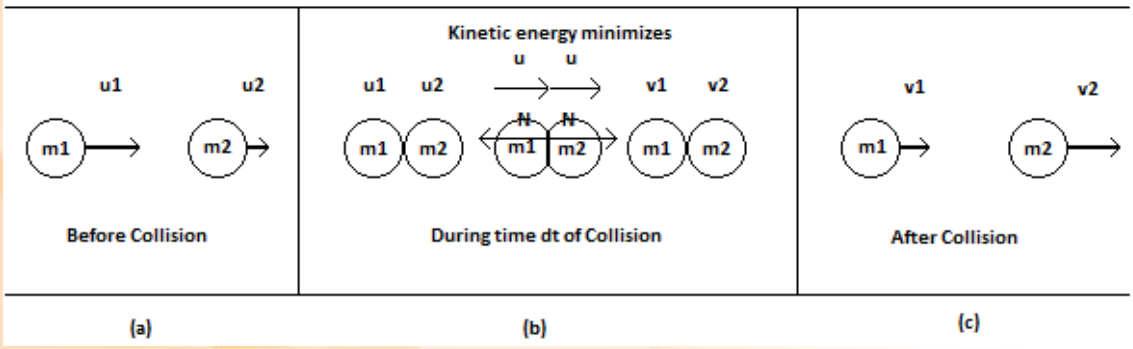


Figure 2

Essentially, collision is a process of momentum transfer by internal forces of a system. Consider the simplest case of two bodies of masses m_1 and m_2, moving in same direction along the same line with velocities u_1 and u_2 (figure 2(a)) such that $u_1>u_2$. Upon collision normal forces 'N' act on the bodies in opposite direction. During the small time interval dt of collision, deformation takes place and the velocity u_1 decreases while the velocity u_2 increases to a point when $u_1=u_2=u$. The kinetic energy minimizes while the deformation and hence the stored potential energy maximizes (figure 2(b)). The elastic potential energy is then released, kinetic energy of the system increases, u_1 decreases and u_2 increases further till the point when $u_1=v_1$ and $u_2=v_2$(figure 2(c)) such that $v_2>v_1$. Note that during the process, no external force acts on the system. Thus, the momentum of the system remains conserved.

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2 \qquad (1.1)$$

In elastic collision, besides momentum the energy of the system also remains conserved. Elastic materials deform on the application of force and regains original shape upon removal of the force i.e., the kinetic energy changes to potential energy during deformation and upon regaining original shape potential energy is completely released as kinetic energy. Thus, the initial kinetic energy equals the final kinetic energy

$$KE_{initial} = KE_{final} \qquad (1.2)$$

$$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 \qquad (1.3)$$

Since in our problem, we are dealing with collision along a line, collision is head on because of the fact that the line of motion of the bodies before and after collision remains same.

Thus in one dimension eliminating, m_1 and m_2 from the equations (1.1) and (1.3), we have

$$u_1 - u_2 = v_2 - v_1 \qquad (1.4)$$

Replacing v_2 in eqn. (1.4) from eqn. (1.1), we get,

$$v_1 = \frac{(m_1 - m_2)}{m_1 + m_2} u_1 + \frac{2m_2 u_2}{m_1 + m_2} \qquad (1.5)$$

Similarly, for v_2 we have,

$$v_2 = \frac{(m_2 - m_1)}{m_1 + m_2} u_2 + \frac{2m_1 u_1}{m_1 + m_2} \qquad (1.6)$$

Also consider the case when a block collides with a rigid wall, then upon collision the velocity of the block simply changes sign. Returning to our original problem of finding out the number of collisions in the process, knowing the initial velocities of the two blocks, we can calculate the velocities of the blocks after each collision until the process ends. With this knowledge, I simulated the process in python with the following code:

```
from __future__ import division
n=0
M=input("Enter M : ")
U=0
U=-10
while U<u or u<0:
        print "u = ",u,"U = ",U
        if U<u:
                u1=((1-
M)*u+2*M*U)/(1+M)
                U1=((M-1)*U+2*u)/(1+M)
        else:
                u1=-u
        n=n+1
        u=u1
        U=U1
print "\n",n
```

Refer to figure 1 and note the following facts about the source code

a) Velocity u_1 is the velocity of block A, and velocity u_2 is the velocity of block B
b) M is the ratio of the mass of block B to block A
c) Velocity towards right is considered positive, and towards left negative
d) The calculation ends when block B starts moving towards right with a velocity greater than that of A
e) n is the no of collisions that has occurred
f) u_1 is 0 initially and u_2 is arbitrarily chosen to be -10 (-ve sign indicating velocity towards left)

Now, setting M=1, we obtain n=3 as shown.

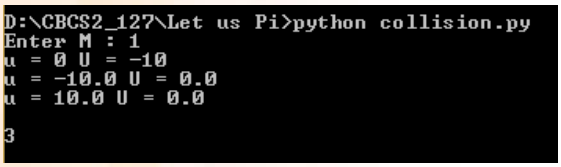


Figure 3

Similarly, setting M=100, n comes out to be 31.

```
D:\CBCS2_127\Let us Pi>python collision.py
Enter M : 100
u = 0 U = -10
u = -19.801980198 U = -9.80198019802
u = 19.801980198 U = -9.80198019802
u = -38.8197235565 U = -9.21576316047
u = 38.8197235565 U = -9.21576316047
u = -56.3000521207 U = -8.2645654037
u = 56.3000521207 U = -8.2645654037
u = -71.5506756504 U = -6.98605812599
u = 71.5506756504 U = -6.98605812599
u = -83.9676090553 U = -5.43087527893
u = 83.9676090553 U = -5.43087527893
u = -93.0590925967 U = -3.66060826241
u = 93.0590925967 U = -3.66060826241
u = -98.4650675203 U = -1.74536666125
u = 98.4650675203 U = -1.74536666125
u = -99.9714358095 U = 0.238998372053
u = 99.9714358095 U = 0.238998372053
u = -97.5185393142 U = 2.21389812329
u = 97.5185393142 U = 2.21389812329
u = -91.2035224499 U = 4.10111874093
u = 91.2035224499 U = 4.10111874093
u = -81.2764848946 U = 5.82591881438
u = 81.2764848946 U = 5.82591881438
u = -68.1305766504 U = 7.31998942983
u = 68.1305766504 U = 7.31998942983
u = -52.2864277468 U = 8.5241594738
u = 52.2864277468 U = 8.5241594738
u = -34.3715292294 U = 9.39073904356
u = 34.3715292294 U = 9.39073904356
u = -15.0953820297 U = 9.88540815615
u = 15.0953820297 U = 9.88540815615

31
```

Figure 4

And for M=10,000, n calculates to 314 and so on and so forth. Thus, the posed problem seems to hold true. The collisions indeed count to the significant digits of pi. In fact by taking different values of M, we can plot for n vs M, as shown below.

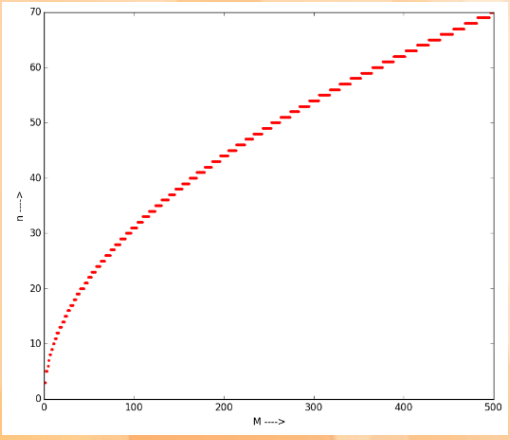


Figure 5

Note from the graph that a single value of n corresponds to a range of values of M. Also, the range keeps getting larger for higher values of M.

Now that we know that the process truly functions like a digit counting machine for pi, we can start trying to explore what is actually is happening in here.

An attempt to explain the process

Let's begin by plotting for the velocities of the blocks A and B vs the collision number for particular value of M (mass ratio m_B/m_A). Suppose M=100, then the plot is shown as below.

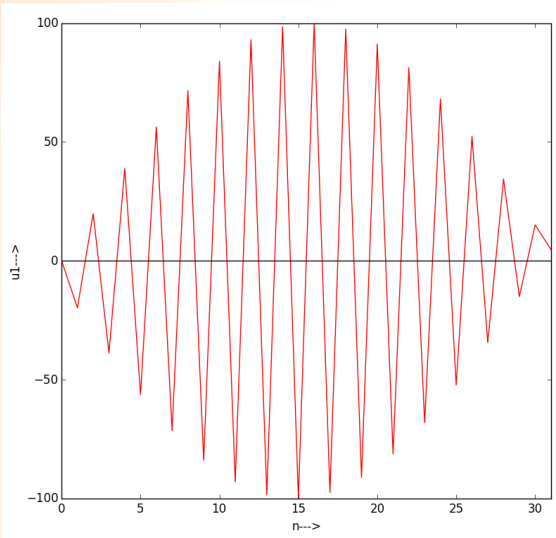


Figure 6(a)

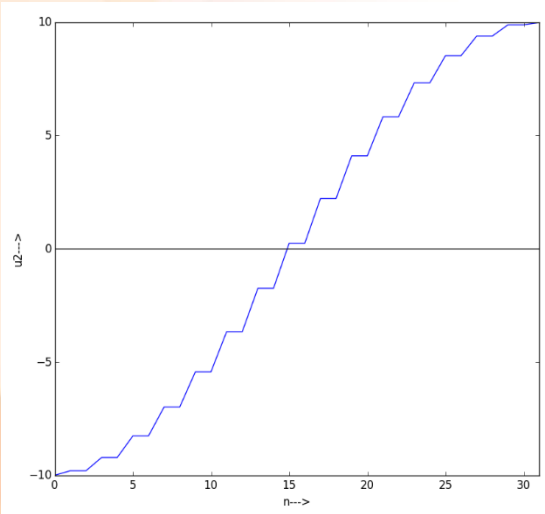


Figure 6(b)

Refer to figure 6 (a & b) above. The red curve plots the velocity of block A against n, while the blue curve plots the velocity of block B against n. Note the following things about the red curve:

a) Obviously, a jump from one pointed end to the next represents individual collision by block A, since upon collision, velocity of block A changes direction. In fact it oscillates between the wall and the heavier block B.
b) A jump from –ve to +ve velocity by the block A is due to a collision with the wall, as the velocity changes only in sign and not in magnitude.
c) A jump from +ve to –ve velocity represents a collision between the two blocks, as the velocity of block A changes both in magnitude as well as direction.
d) The process will always end with a positive value of velocity of block A.
e) The velocity maximizes toward the centre of the plot.
f) **The outline of the plot for even values of n looks like a sinusoid. Similarly, the outline of the plot for odd values of n looks like a –ve sinusoid.**

Refer to the blue plot and note that:

a) Parts of the curve when the velocity remains constant corresponds to a collision of block A with the wall, since block B remains unaffected.
b) The velocity towards left decreases, becomes zero, then increases towards the right.
c) The plot somewhat looks like a –ve cosine curve.

We see that both these curves show sinusoidal behaviour. Well, this is interesting, since pi may have something to do with these curves. But before getting into that we need to understand the reason, why these curves look like these.

Refer to eqn. (1.3),

$$\frac{1}{2}m_A u_1^2 + \frac{1}{2}m_B u_2^2 = \frac{1}{2}m_A v_1^2 + \frac{1}{2}m_B v_2^2$$

$$\frac{1}{2}m_A u_1^2 + \frac{1}{2}m_B u_2^2 = constant = k(say)$$

$$u_1^2 + \frac{m_B}{m_A}u_2^2 = 2k$$

$$u_1^2 + Mu_2^2 = 2k \qquad (1.7)$$

Initially, if $u_1=0$ and $u_2=-u_o$, then

$$k = \frac{Mu_o^2}{2}$$

Substituting k in eqn. (1.7),

$$u_1^2 + Mu_2^2 = Mu_o^2 \qquad (1.8)$$

$$\frac{u_1^2}{Mu_o^2} + \frac{u_2^2}{u_o^2} = 1 \qquad (1.9)$$

Eqn. (1.9) represents an ellipse with major axis Mu_o^2 and minor axis u_o^2, however for large values of M, the major axis becomes very large as compared to the minor axis. To avoid this, we can scale the axes in a way that the ellipse becomes a circle. Instead of plotting u_1 vs u_2, we can plot u_1 vs U_2 ($=\sqrt{M}\,u_2$). So that the eqn. (1.8) now becomes,

$$u_1^2 + U_2^2 = Mu_o^2 \qquad (1.10)$$

which is the equation of a circle with radius $\sqrt{M}\,u_o$, as plotted below, taking M=45.

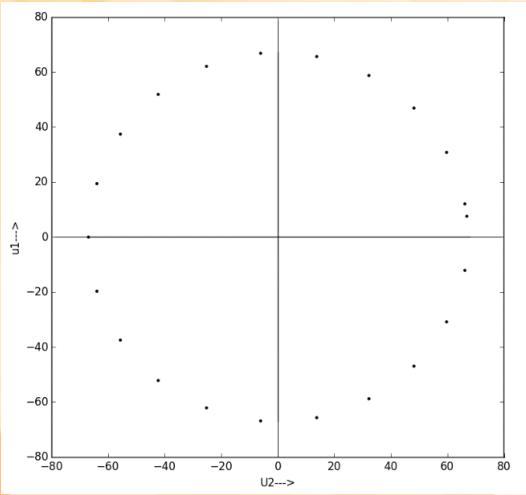


Figure 7

Thus, we can see that the plotted points describe the boundary of a circle. However, more of the information can be extracted from the last plot, if we join the successive points as shown in the next plot.

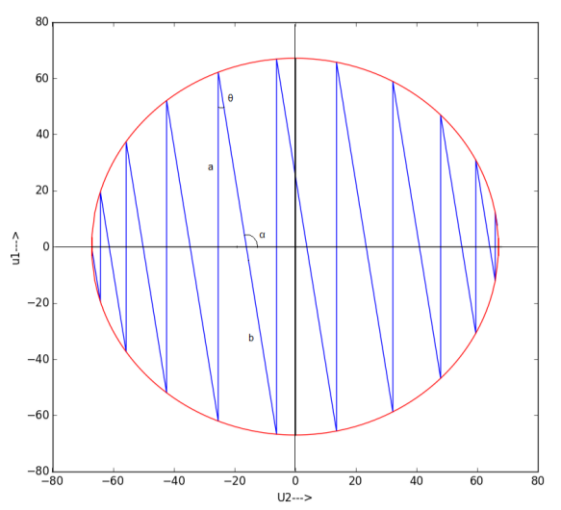


Figure 8

A transition from one pointed end to the next represents a collision by block A. These transitions can be of two types (transition a and b) as shown in the plot above. From eqn. 1.1,

$$m_A u_1 + m_B u_2 = m_A v_1 + m_B v_2$$

$$m_A u_1 + m_B u_2 = constant = k(say)$$

Initially, let u_1=0 and u_2=u,

$$k = m_B u$$

Substituting k in the previous equation,

$$m_A u_1 + m_B u_2 = m_B u$$

$$u_1 = Mu - Mu_2 \qquad (1.11)$$

$$u_1 = Mu - \sqrt{M}\, U_2 \qquad (1.12)$$

Eqn. (1.11) is the equation of straight line with slope –M, and y intercept Mu. Essentially, this line should represent the relation between the two velocities before and after collision between the two blocks, since momentum remains conserved before and after collision. In the above plot this line is given by the eqn. (1.12). Note that for a given value of M, slope $-\sqrt{M}$ remains constant for every collision between the two blocks. It represents the transitions 'b' in the plot. Note that all the transitions from a positive to a negative velocity of the block A, obey eqn. (1.12). Only the intercept changes every time the initial velocity of block B changes. Since, the velocity of block B increases from $-u_o$ (velocity of block B at the very beginning) becomes zero, then positive, the intercept Mu also changes accordingly, describing the different slanted lines in the plot. Similarly, the transitions 'a' in the plot represent collision between block A and wall, since transitions 'a' represent a change in the velocity direction only and not in its magnitude. These are the vertical lines of the plot. Also, from the plot, the angle α is given as,

$$\tan(\alpha) = -\sqrt{M} \qquad (1.13)$$

And, since the lines 'a' are perpendicular to the x-axis, we have from geometry,

$$\alpha = \theta + \frac{\pi}{2}$$

Substituting value of α in eqn. (1.13),

$$\tan\left(\theta + \frac{\pi}{2}\right) = -\sqrt{M}$$

$$\cot(\theta) = \sqrt{M}$$

$$\theta = tan^{-1}\frac{1}{\sqrt{M}} \qquad (1.14)$$

Now, consider the following figure 9,

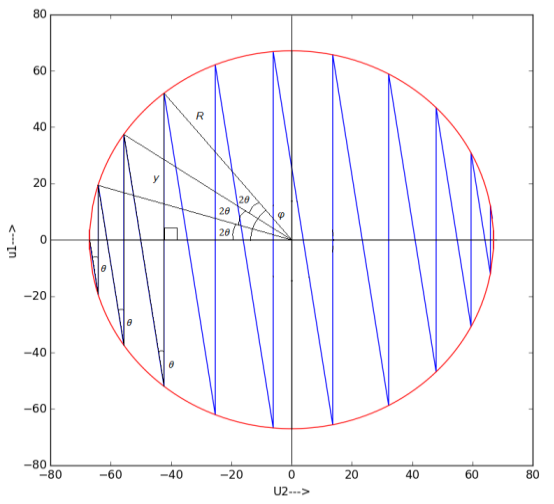


Figure 9

Using the property that the angle subtended by an arc at the centre of a circle is double the angle subtended by the same arc at the circumference of the circle, we can show that the angle subtended by any such pointed end of the plot at the centre of the circle is 2θ. Also, using trigonometry we can have,

$$y = R\,sin(\varphi)$$

$$u_1 = \sqrt{M}\,u_o\,sin(\varphi) \qquad (1.15)$$

However, it will be more convenient if we can bring in the collision number 'n' into the relation, since that is what we should be concerned with. Let's mark the collision number on the plot, and try to find some relation using it.

From figure 10,

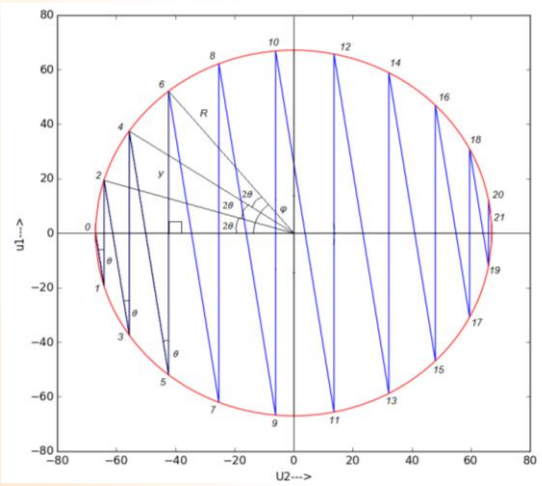


Figure 10

$$\varphi = 3 \cdot 2\theta$$

Thus, in general,

$$\varphi = h\theta \qquad (where\ h\ is\ even) \qquad (1.16)$$

For even number of collisions, we can have,

$$\varphi = n\theta$$

And hence,

$$u_1 = \sqrt{M}\,u_o\,sin(n\theta) \qquad (1.17)$$

Similarly, for odd number of collisions,

$$\varphi = -(n+1)\theta$$

$$u_1 = -\sqrt{M}\,u_o\,sin\{(n+1)\theta\} \qquad (1.18)$$

We, can now plot for u_1 vs n, for even and odd values of 'n' separately which should result in sinusoids with shifted phase as shown in figure 11(a),

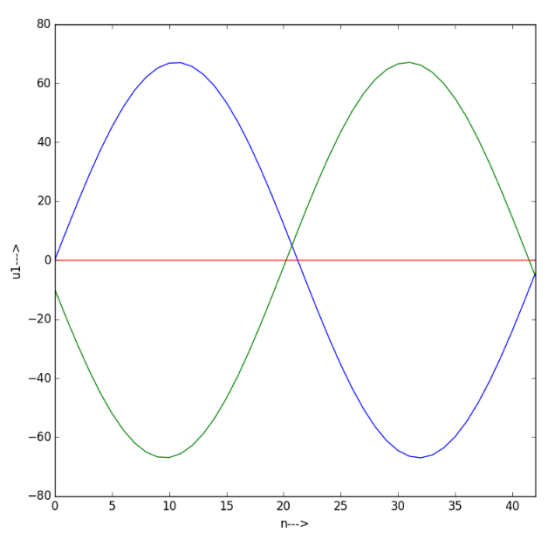


Figure 11(a)

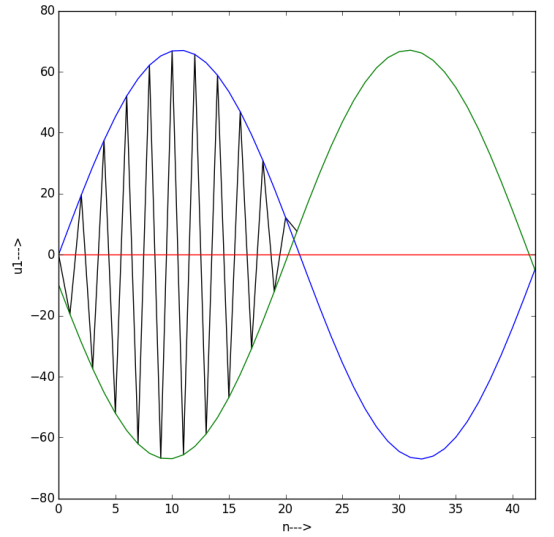


Figure 11(b)

Figure 11(b) combines plots from figure 6(a) and figure11(a). It clearly shows that the velocities after even number of collisions all lie on the sinusoid described by eqn. (1.17) whereas the velocities after odd number of collisions all lie on the sinusoid described by eqn. (1.18) that we did predict initially. The velocity of block A jumps between the two sinusoids alternately. The process finally stops after the velocity lands on one of the two curves, and the blocks simply move towards the right infinitely without any further interaction. For instance, in the above case, the process ends in odd number of collision and hence on the –ve sine curve. From now on, I shall refer to the –ve sine curve as the odd curve and the positive sine curve as the even curve. Also, instead of plotting for u_1 vs n, we will now plot for $U_1 = (u1/\sqrt{M}\,u_o)$. This fixes the amplitude of the odd and even curves to unity, no matter what the value of M is as shown in figure 12(a).

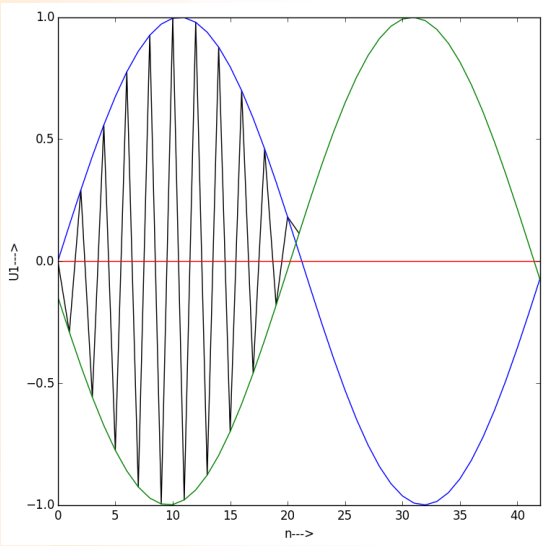


Figure 12(a)

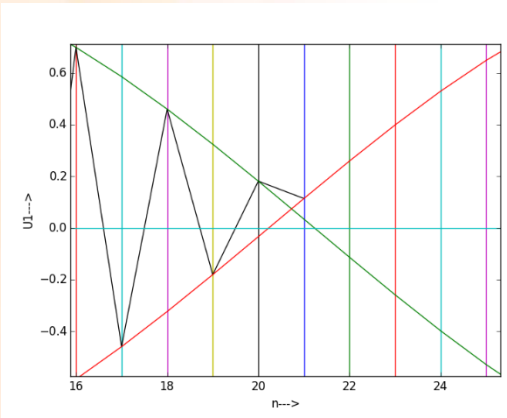


Figure 12(b)

Now, let us have a look at the same plot for a range of values of M from say M=93 to M=108. For convenience the portion where the oscillation ends is magnified for each such plot as shown below in figure 13.

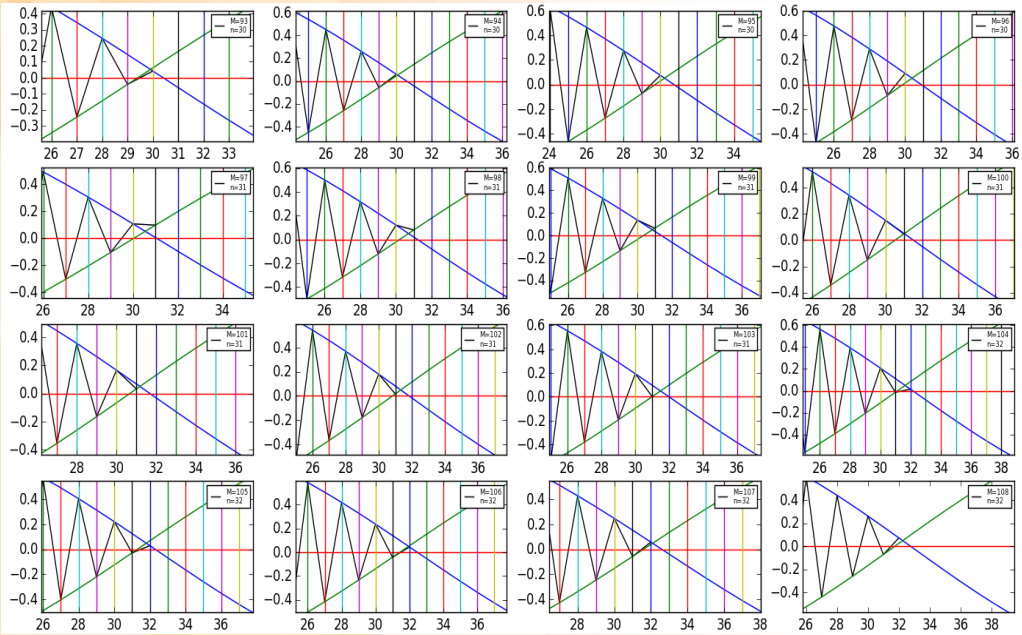


Figure 13

For M=93 to M=96, process ends at 30 collisions and hence on the even curve, for M=97 to M=103, we have a total collision of 31 and process ends on the odd curve, and for M=104 to M=108 n is 32 and ends on the even curve again. The collision process can end only when both the blocks are moving towards right with block A moving faster than block B, as indicated by each of the above plots i.e. the velocity of block A is positive at the end irrespective of the fact that the total collisions incurred is even or odd. In fact, there is a nice way to explain the end of the collision process. Recall, that a collision of block A with block B can only decrease the velocity of block A (although the velocity can increase in magnitude towards the left, but then it becomes more negative), whereas a collision of block A with the wall increases the velocity (changes the sign of velocity from –ve to +ve). Thus we can never have a collision between the two blocks that increases the velocity of block A. Nor can we have a collision between block A and the wall that will make the make the velocity of block A more negative. For example, consider plot in figure 12(b). The collision ends on the odd curve. Now, there is no way that the block can suffer another collision, since that would mean a jump from the odd curve to the even curve with a decrease of velocity. Similarly, consider the plot in figure 13 for M=95. The collision ends on the even curve. For the block A to suffer another collision, velocity must jump from the odd curve to the even curve with decrease in magnitude which is impossible, as seen from the plot. For better understanding, we can combine all the plots in figure 13 into a single plot.

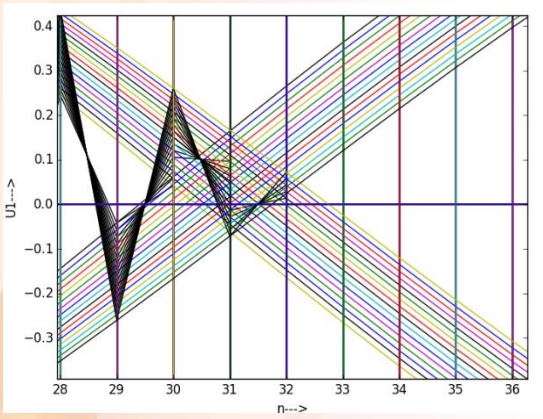


Figure 14

Refer to the above figure 14. Note that the moment, it becomes possible to lower the velocity of block A by collision with block B, the velocity jumps from the even curve to the odd curve. We explain this by saying that, no matter how small the relative velocity $u_1 - u_2$ is towards the right, block A reaches block B, and collides with it. In the same way, the moment, velocity of block A turns negative, there is no way we can stop it from colliding with the wall. This is natural, since the process cannot end in a negative value of u_1. No matter how much small it is, the velocity jumps from the odd curve to the even curve.

Now, there is another way to explain the same thing. We understand that, no collision can take place once the velocity of block B becomes greater than or equal to block A towards right. Therefore, in the plot for u_1 vs u_2, we can mark this threshold by drawing the straight line $u_2 = u_1$, having slope equal to 1. However, if we are scale the ellipse into a circle, as in figure 9, we are to divide the slope by $\sqrt{M}$, since we are plotting for u_1 vs $\sqrt{M}u_2$.

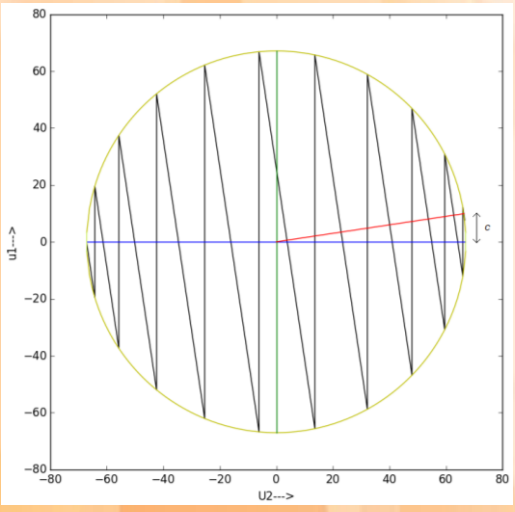


Figure 9

Figure 15 shows the line $u_2 = u_1$ marked in red. Now, consider the arc defined by this line and the x-axis. The interesting part is no matter what the value of M is, the collision process will always end with a velocity lying on this arc 'c'. This is because, for any point on the arc, would mean a greater velocity of block B than that of the block A towards the right, since at the point where the line meets the circle is the point where both the blocks are moving with same velocity towards right. Also, the fact that the final velocity of block A should be positive, marks the x-axis as the lower boundary for the arc. Now the line $u_2 = u_1$ subtends an angle $tan^{-1}\frac{1}{\sqrt{M}}$ on the x-axis. So, if ϕ' is the angle subtended by any radius w.r.t to the negative x-axis then for the line $u_2 = u_1$,

$$\varphi' = \pi - tan^{-1}\frac{1}{\sqrt{M}} \qquad (1.19)$$

i.e., final velocity of block B should lie on the circle at a point subtending an angle lying between π and φ'. This φ' now corresponds to an n' (non-integral n) given by,

$$n' = \frac{\varphi'}{tan^{-1}\frac{1}{\sqrt{M}}}$$

$$n' = \frac{\pi}{tan^{-1}\frac{1}{\sqrt{M}}} - 1 \qquad (1.20)$$

Correspondingly, the final velocity should end on a value of 'n' that lies between $\frac{\pi}{\theta} = \frac{\pi}{tan^{-1}\frac{1}{\sqrt{M}}}$ (the point where the even curve crosses the x-axis, as $u_1 = \sqrt{M}\, u_o \sin\left(\frac{\pi}{\theta} \times \theta\right) = 0$). and n'. Since $\frac{\pi}{tan^{-1}\frac{1}{\sqrt{M}}}$ and n' differ by 1, and also the odd curve leads the even

curve by an ‘n’ value of 1, we should expect block A to have its final velocity between the points where the odd and the even curves cross the x-axis as shown in the figure 16.

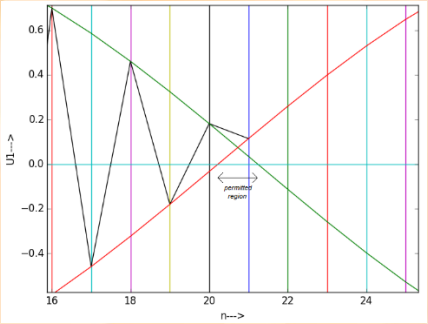


Figure 10

Now we are more or less familiar with the way the process is taking place. But let’s just go back to the original question i.e. if the mass of block B is 100^k times the mass of block A, then the total number of collisions ‘n’ should give (k+1) significant digits of pi. We, shall solve the problem for two cases, both even as well as odd total number of collisions.

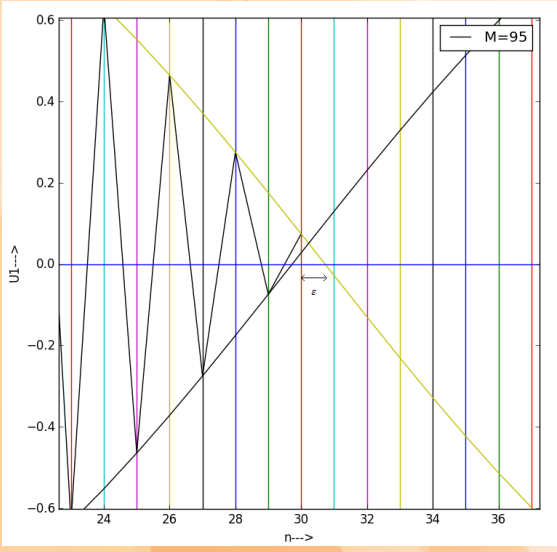


Figure 11(a)

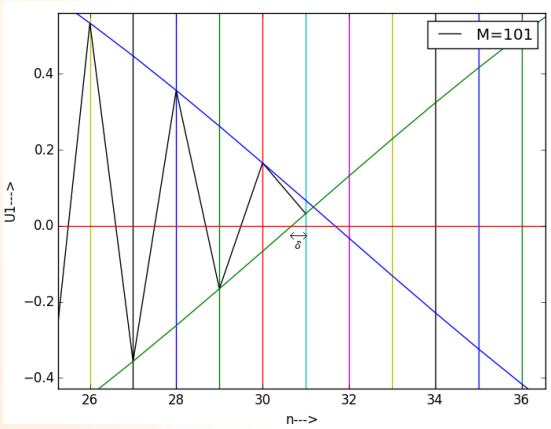


Figure 17(b)

Consider a case (figure 17(a)) in which the process ends in even number of collisions, on the even curve. Now, using eqn. (1.17), we have, for even ‘n’,

$$u_1 = \sqrt{M}\, u_o\, sin\{(n+\varepsilon)\theta\} = \sqrt{M}\, u_o \sin(\pi) = 0 \qquad (1.21)$$

where ε is fractional i.e., $0 < \varepsilon < 1$, as the permitted range is 1 less than the point where the even curve crosses the x-axis. Also, since $\varepsilon = 0$, corresponds to the case, when the block A comes to rest at the last collision, such a collision with the wall would not be possible. Hence ε is greater than 0 in this case. Also, since we are taking the final velocity to land on the even curve $\varepsilon = 1$ would not be possible for that would mean the process concludes on the odd curve. This can be verified for every case in which the process ends with even number of collisions.

Thus, we have from eqn. (1.21),

$$(n+\varepsilon)\theta = \pi \qquad (1.22)$$

Similarly, in a case when ‘n’ is odd (figure 17(b)), using equation we can write,

$$u_1 = -\sqrt{M}\, u_o\, sin\{(n+1-\delta)\theta\}$$

$$= -\sqrt{M}\, u_o \sin(\pi) = 0 \qquad (1.23)$$

where, $0 \leq \delta < 1$,

Again, this is verified for every case in which the process ends with odd number of collisions. Thus, using eqn. (1.23), we have.

$$(n+1-\delta)\theta = \pi \qquad (1.24)$$

But, since δ is fractional, $1-\delta = \varepsilon$ is also fractional, such that, $0 < \varepsilon \leq 1$ holds. Thus, we can write eqn. (1.24) as,

$$(n+\varepsilon)\theta = \pi \qquad (1.25)$$

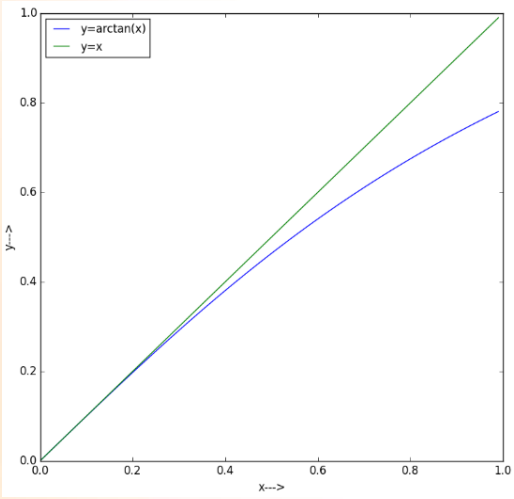
We can see that eqn. (1.22) and eqn. (1.25) are practically the same, hence the eqn. should hold for both even as well as the odd values of 'n', with $0 < \varepsilon \leq 1$. From the question, we can have M in the form of 100^k. So, let us calculate M, θ and hence $\frac{\pi}{\theta}$ for different values of k.

k	M	$1/\sqrt{M}$	θ	π/θ
0	100^0	1	0.7853981633 97	4.0
1	100^1	0.1	0.0996686524 91	31.5203684917
2	100^2	0.01	0.0099996666 86	314.169737055
3	100^3	0.001	0.0009999996 66	3141.59370079
4	100^4	0.0001	9.99999996667e-05	31415.9266406
5	100^5	0.00001	9.99999999967e-06	314159.265369

We find, from the above table that for small values of $\frac{1}{\sqrt{M}}$, $\theta = \tan^{-1}\frac{1}{\sqrt{M}}$ is almost same as $\frac{1}{\sqrt{M}}$. In fact, if we expand $\tan^{-1} x$ into its taylor series expansion, then $x - (\tan^{-1} x)$ is given by,

$$x - (\tan^{-1} x) = x - (x - \frac{x^3}{3} + \frac{x^5}{5} - \frac{x^7}{7} + \frac{x^9}{9} + \cdots)$$

$$= \frac{x^3}{3} - \frac{x^5}{5} + \frac{x^7}{7} - \frac{x^9}{9} + \cdots$$



Thus, the deviation of $\tan^{-1} x$ from x is of the order of x^3. The above plot (figure 18) shows the deviation of $\tan^{-1} x$ from x. Only for the case when $\frac{1}{\sqrt{M}}$ is 1, that the deviation is appreciable for the selected values of k, as calculated in the table above.

For the case k=0, block A actually stops after its final collision, hence ε is 1, as a result 'n' is 3. However, for all the other cases (k>0 and k being integral) $\tan^{-1}\frac{1}{\sqrt{M}}$ is sufficiently close to $\frac{1}{\sqrt{M}}$. Thus, we can have,

$$\theta = \tan^{-1}\frac{1}{\sqrt{M}} \approx \frac{1}{\sqrt{M}} = 10^{-k} \qquad (1.26)$$

As a result, $\frac{\pi}{\theta} \approx 10^k\pi$. Thus, increasing k by 1 shifts the decimal place in the number pi by 1 towards the right. And with the case k=0 eliminated, ε is now fractional i.e., $0 < \varepsilon < 1$. Since we know that $10^k\pi$ can have non integral values only for pi being an irrational number, 'n' simply results in the integral part of $10^k\pi$.

For, example for k=1, M is 100, and from the table we have $\theta = 0.09966865249 \approx 0.1$ and π/θ is $31.520368491 \approx 31.415926535\ldots$

But since ε is fractional, and n integral, n has to be 31.

Similarly, for k=2, M=10000. Using table $\theta = 0.009999666686 \approx 0.01$ and π/θ is $314.169737055 \approx 314.15926535\ldots$

But with ε fractional and n integral, n has to be 314.

Now, let us have a look at the plot in figure 5,

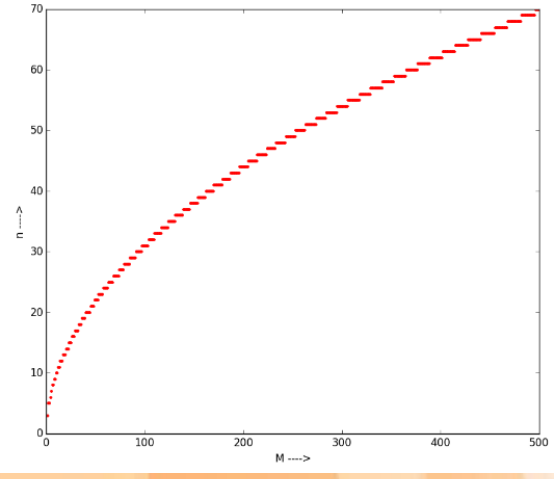


Figure 5

We already found that a range of values of M corresponds to a single value of 'n' especially for larger values of M. This can now be easily explained using the eqn. (1.25),

$$n + \varepsilon = \frac{\pi}{\theta}$$

$$n + \varepsilon = \frac{\pi}{\tan^{-1}\frac{1}{\sqrt{M}}}$$

And we have already proved the fact that,

$$n = integer\ part\ of \left(\frac{\pi}{\tan^{-1}\frac{1}{\sqrt{M}}}\right)$$

For large values of M, the change in the term $\tan^{-1}\frac{1}{\sqrt{M}}$ will be small. In fact, larger the value of M, smaller will be the change in the term. Thus, the change in the value of $\frac{\pi}{\tan^{-1}\frac{1}{\sqrt{M}}}$ will also be small for large M. And if the change is so small that it is only the fractional part that changes, then the integral parts remain same, then 'n' remains same. As a result, more than one value of M corresponds to a single value of 'n'. Also, as M gets larger, the range of M-values corresponding to a single 'n' gets larger. This is exactly what we get to see in the above plot. For example, n is 31 for M=97 to M=103 (figure 13) and so on.

Sometimes mathematics and physics conspire in ways that feels too good to be true. And what can be a better example than this problem itself. Obviously, pi is an absolutely unexpected answer to this simple question of counting collisions. But then, this is what makes it beautiful. This is what leaves you thinking that what in the world has this anything to do with pi. And you just

cannot think of anything else till you get it right.

P.S. : You need to be stubborn.

Acknowledgement:

This paper would not have been possible without the exceptional support of Rishita Sengupta (B.Sc. Computer Science), Mousumi Mitra and Sagnik Ray (of my class). Their enthusiasm, knowledge and exacting attention to details have been an inspiration and kept my work on track from my first encounter with the problem. Also, I am grateful to my mathematical physics course professors Dr. Sarbari Guha and Dr. Suparna Roychowdhury for developing in me this curiosity that ultimately helped me write this paper.

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