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Workshop on Astronomy for Artists held in 1989 was attended by eminent artists. Here are some artworks as the outcome of the workshop.

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Through measurements and quantitative description can wonder become knowledge and curiosity science

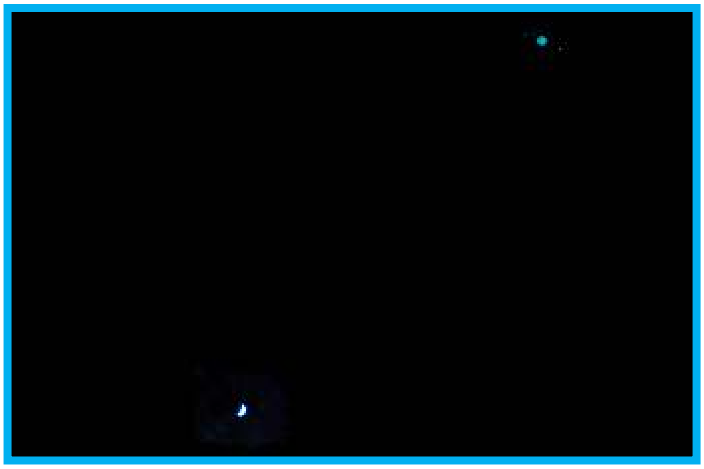
- *Pushpamala*

The Last Ten Seconds

If the history of Universe spanning some 15 billion years starting from the Big Bang is compressed to one year we arrive at the cosmic calendar. The major events in this grand chronicle read as follows:

Event	Age years (Time elapsed)	Entry in the Cosmic Calendar
Birth of the Universe	15 billion	January 0.001
Formation of solar system	5 billion	September 1
Origin of life	500 million	September 25
Dinosaurs	200 million	December 25
Man	5 million	Night of the new year eve
Recorded history	5000	Last ten seconds

- *John Devraj*



Conjunction of Jupiter and Venus on July 2, 2015 – Photo by Pramod Galgali

From Cadavers to Computers*

- C. *V. Vishveshwara*

(* *From 'Out of Focus', Bulletin of Sciences, Oct, 1991)*

THE DARK CLOUDS RUMBLE and growl. The low wind moans. Flashes of lightning splinter the night sky. In the dim light cast by masked lanterns, Dr. Frankenstein, assisted by his favourite hunchbacked research scholar Igor, toils among the unhallowed damps of the grave to extract material for his dissecting room. This macabre scene from the old classic never fails to thrill the ghoul in us. Or the scene from another chiller in which the body snatcher makes his clandestine delivery to the good Doctor's laboratory. The back door creaks in protest, while a storm rages without. The merchandise, mined out of decaying earth, is doubly precious because of the illegal and sacrilegious nature of the deed done and the act to be performed. Such spine-tingling sequences from the horror movies of the past reflect the long, fascinating, chequered history of dissection.

Leonardo da Vinci dissected cadavers in order to learn anatomy in detail, so that he could accurately depict the form and functions of the human body. Although his studies were intended to aid his art, they nevertheless secured for him an eminent place in the history of medicine. His remarkable notebooks are replete with his keen observations of human anatomy as well as zoology, comparative anatomy and physiology. And, of course, the accompanying drawings are marvels of draughtsmanship. Here is his extraordinary general introduction to the notes, which is addressed to young artists rather than to medical men:

"I wish to work miracles: it may be that I shall possess less than other men of more peaceful lives, or than those who want to grow rich in a day. I may live for a long time in great poverty, as always happens, and to all eternity will happen, to alchemists, the would-be creators of gold and silver, and to engineers who would have dead water stir itself into life and perpetual motion, and to those supreme fools, the necromancer and the enchanter. And you, who say that it would be better to watch an anatomist at work than to see these drawings, you would be right, if it were possible to observe all the things which are demonstrated in such drawings in a single figure, in which you, with all your cleverness, will not see nor obtain knowledge of more than some few veins, to obtain a true and perfect knowledge of which I have dissected more than ten human bodies, destroying all the other members, and removing the very minutest particles of the flesh by which these veins are surrounded, without causing them to bleed, excepting the insensible bleeding of capillary veins; and as one single body would not last so long, since it was necessary to proceed with several bodies by degrees, until I came to an end and had a complete knowledge; this I repeated twice, to learn the differences.

And if you should have a love for such things you might be prevented by loathing, and if that did not prevent you, you might be deterred by the fear of living in the night hours in the company of those corpses, quartered and flayed and horrible to see. And if this did not prevent you, perhaps you might not be able to draw so well as is necessary for such a demonstration; or, if you had the skill in drawing, it might not be combined with knowledge of perspective; and if it were so, you might not understand the methods of geometrical demonstration and the method of the calculation of forces and of the strength of the muscles; patience also may be wanting, so that you lack perseverance. As to whether all these things were found in me or not, the hundred and twenty books composed by me will give verdict Yes or No. In these I have been hindered neither by avarice nor negligence, but simply by want of time. Farewell."

In India the story of dissection of cadavers dates back to the *Sushrutasamhita.* As Professor Debiprasad Chattopadhyaya tells us in his *Science and Society* in *Ancient India,* this ancient text strongly advocated direct personal observation of anatomy and comparison with accounts given in the *sastras* rather than blind acceptance of the latter. The text provides instruction in the art of selecting and preparing the corpse to be dissected. As suitable bodies may be in short supply, students are trained to sharpen their skills, not to speak of their surgical instruments, on vegetables like gourds and cucumbers as well as on dummies that is inanimate replicas of human bodies not to be confused with individuals of low intelligence. Unfortunately, this commendable objective of learning by direct observation was hampered by the orthodox view that corpses and even their mere presence meant pollution, the measure of impurity bearing inverse relationship to the caste of the corpse in question. Thus, the law-giver *Apastamba*, we are told, advocated suspension of study, especially of Holy Scriptures, when a low caste corpse was unnecessarily hanging around. No wonder that this kind of sentiment gave rise to intense aversion towards even touching cadavers, let alone carving them up for medical purposes. This difficulty continued as late as into the eighteen thirties, when the Calcutta Medical College was founded, as can be learnt from the following passage from *A Biographical Sketch of David Hare* by Peary Chand Mitra as quoted by Professor Chattopadhyaya:

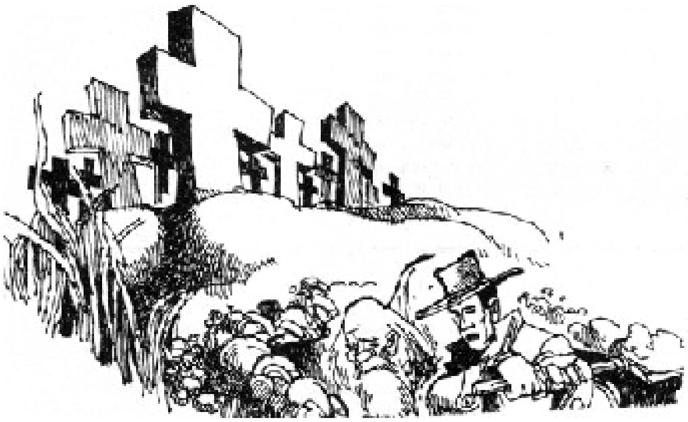
"I will state however one fact which will show how Mr Hare was anxious to see the project of the Medical College finally brought about and settled without opposition. One evening as I was sitting with him, I saw Baboo Muddosuden Gupta, the then Professor of Sanskrit Medical Science of the Sanskrit College, entering the room in all haste. Mr Hare viewing him said at once - 'Well, Muddoo what have you been doing all this time? Do you know what amount of pain and anxious thoughts you have kept me in for a week almost? I have met Radhacant, and I am hopeful from what he said to me. Now what have you to say? Have you found the text in your Shester authorising the dissection of dead bodies?' Muddoo answering in the affirmative said, 'Sir, fear no opposition from the orthodox section of the community. I and my pundit friends are prepared to meet them if they come forward, which I am sure they will not do.' Mr Hare felt himself relieved at this declaration on the part of the professor, and said he would see His Lordship tomorrow positively, meaning as far as I can recollect Lord Aukland."

As to the nature of the trump card Madhusudan Gupta had up his sleeve we are in the dark. However, "when in 1836 scalpel in hand he followed Dr Goodeve to the godown for the actual dissection of a corpse there, his courage had to be boosted by the booming guns from Fort William"!

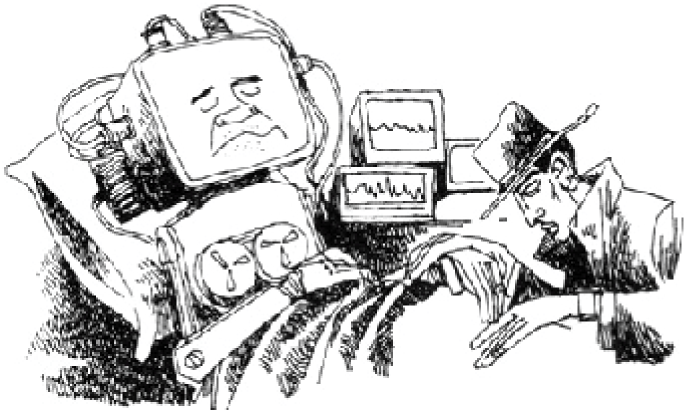
Contrast this phobia against the impurity of corpses with the tragic experience of the Hungarian doctor Ignaz Semmelweis in the middle of the last century. Semmelweis, who has been called "the saviour of mothers" for his discovery of the cause of puerperal fever, introduced antiseptic prophylaxis and thus opened a new era in medical science. He discovered that the high incidence of childbed fever and death of mothers after delivery was due to the spread of infection by students who came directly from the dissecting room to the maternity ward. He ordered the students to wash their hands in a solution of chlorinated lime before each examination, thereby drastically bringing down the rate of mortality and demonstrating dramatically the validity of his theory. But, all his life he had to face controversy, stubborn non-acceptance of an obvious fact and the frustration of witnessing senseless death when a simple measure of washing hands would have prevented tragedy. He died in 1865, a broken man committed to a mental asylum. Ironically, his illness and death were caused by the infection of a wound, apparently the result of an operation he had performed before being taken ill. He died of the same disease against which he had struggled all his life.

Are we about to witness a radical transformation of the art and science of dissection thanks to modern technology? Here is a recent news item, in case you missed it:

"Adam, a small but muscular fellow who wears only sunglasses and a fig leaf, may eventually revolutionise the way medicine is taught and practised. While Adam stands at the ready, the click of a computer mouse directing an interactive software programme peels off his layers, from his skin to his bone marrow. The software programme takes anatomy out of the textbook and into computers. With it, medical students can dissect without cadavers and doctors can show patients exactly what they're about to do to them. 'No one has ever illustrated anatomy in this kind of detail,' said Greg Swayne, the medical illustrator who is president of A.D.A.M. Software Inc., a medical illustration



Cartoons: Sri B G Gujjar



company in Marietta, US. 'What we'll end up with is the Gray's Anatomy of the 21st century,' he said, referring to the standard anatomy text. Educators and doctors say they are intrigued by A.D.A.M. The letters stand for Animated Dissection of Anatomy for Medicine. The design team is working its way up Adam's body. The foot and lower leg went on the market in January. The knee and hip are almost done. The thoracic region, upper extremities and head and neck will follow within two years, Swayne said."

Heaven help the patient who finds himself in the hands of a surgeon whose fingers have only punched keys, but never poked a cadaver. And, it would be a pity indeed, if generations to come have to watch on the screen Dr Frankenstein trying to breathe life into a computer that has died of viral infection.

The Worlds of Isaac Asimov: Modeling Kalgash

- Jayant Murthy

(Extracted from the Galactic Inquirer)

Asimov was born in Petrovichi, Russia with an official birthdate of Jan. 2, 1920 – although there is some confusion about the exact date. He moved to New York with his family when he was three. Asimov was a voracious reader with a phenomenal memory which he later used to good effect with books ranging from Asimov's Guide to the Bible and Asimov's Annotated Paradise Lost to Lecherous Limericks to The Black Widowers, a series of mysteries.

He first started writing science fiction with “Marooned off Vesta” which was sold to Amazing Stories in 1938 (appeared in 1939) and continued with extraordinary fecundity until about Sputnik (1957) when he almost entirely switched to writing science books which he found easier and more profitable. “Nightfall” was his 32nd story (in two years!) and was published in the September, 1941 issue of Astounding Science Fiction. It immediately made the young Asimov a big name in science fiction and is now a prime candidate for the best science fiction short story ever written and, indeed, was voted as such by the Science Fiction Writers of America in 1965.

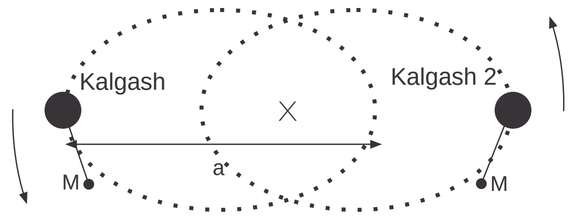
Nightfall was written only a decade after Clyde Tombaugh observed Pluto and no hint of any extrasolar planets had been seen. However, this was no bar on the imaginations of the writers of the Golden Age, as evidenced by the wide variety of worlds and life forms that they described. Nightfall was one of the first stories to focus on the social aspects of alien astronomical situations, whereby Asimov set up a planetary system which would meet his requirements. He most likely did not put much thought into whether such a system was indeed possible nor is it relevant to the story he is trying to tell.

Having been idly curious about the physical characteristics of the Nightfall system for several years, I have since collaborated with SmaranDeshmukh to at least work out the gross characteristics. I note that many multi-star systems are now being found using Kepler data including a 4 star system (Kepler-64) so perhaps the Kalgash system is not as far-fetched as it may have seemed at one time.

The novel provides many more details of the system than the short story and we have used that as the inputs for our model. Note that the names in the novel are different, for no apparent reason, than in the original and, for consistency; we have used names from the novel. We have also attempted a simulation of the entire system using a proper gravitational model but were not successful given the time available for the project. In this article, I will simply describe the major constraints placed on the system and how we converted those into a description of the system.

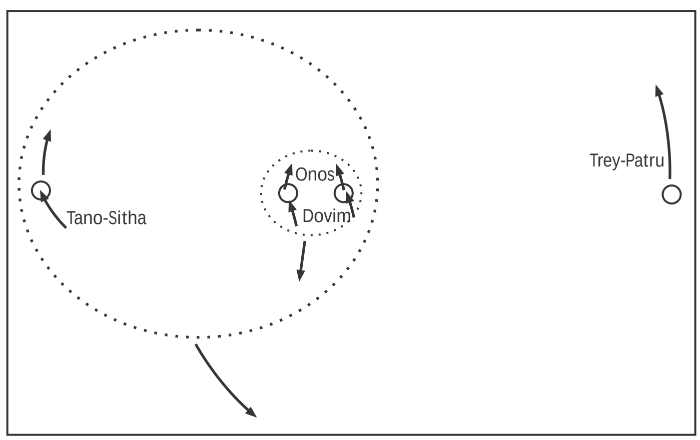
Because Asimov was most interested in the social aspects of a world without darkness, there are relatively few clues about the kind of system and, as I mentioned earlier, these were largely to give an alien feel to the story. The distance scale was set by the 10 light minute (1.2 AU) distance of Kalgash from its main sun (Onos) and the maximum distance of 110 light minutes (13.4 AU) for the system's farthest star from Kalgash. For perspective, this puts Kalgash at just outside the orbit of the Earth and the farthest star at just inside the orbit of Saturn. Four of the 6 stars are in two pairs of binary stars and are all white stars. Very little was known about stellar evolution at the time and it is likely that Asimov just assumed they were normal A type stars, if he thought about it at all. Remember that the story was written two years before the standard Morgan-Keenan stellar classification system was derived. However, main sequence A stars are much too bright for the parameters in the story and would make life impossible on Kalgash, and so we have assumed that all four stars are white dwarfs with brightnesses at the planet of 50 to 100 times that of the full Moon at the Earth. In our own work, we focused on the critical actors in the story: the red star Dovim and the moon Kalgash 2.

Darkness occurs once in 2049 years when Dovim is the only sun in the sky and Kalgash 2 passes in front of it. The star itself is dim and red and therefore must be a red dwarf which we have assumed to be an M0 main sequence star. We know that the star is bright enough that the stars of a nearby cluster are drowned out. Extrapolating from our own Earth, the apparent magnitude of the Sun is -26.74 with the faintest object visible in the daytime being about -4th magnitude, a difference of about 22.5 magnitudes. If we take the brightness of the stars in the cluster to be 0th magnitude, this puts Dovim at a distance of 44 light minutes from Onos (the parent star of Kalgash) which in turn gives it an angular diameter at the planet of 3 – 5 arcminutes. By comparison, the angular diameters of the Sun and Moon at the Earth are both 30 arcminutes.



Kalgash and its moon in an eliptical Keplerian Orbit

We know from the story that the angular diameter of Kalgash 2 is 7 times that of Dovim (21 – 35 arcminutes) and that an eclipse must last a minimum of 9 hours, compared to less than 8 minutes on the Earth. The reason for such a long eclipse is that civilization must collapse over the entire planet and thus must last over much of the planetary day which is implied to be similar to an Earth day. We also know that the mass of Kalgash 2 is about the same as that of Kalgash and that the eclipse occurs when the moon is closest to the planet. From Kepler's Laws, the moon moves fastest when it is closest to the planet which is, of course, when it is its largest in the sky. Again using Kepler's Laws, we derived a relationship between the actual size of Kalgash 2 and the length of the eclipse (see the paper for details). It is only possible to have an eclipse that long if the size and density of the moon is similar to that of the giant planets; i.e., a density close to that of water. We ignore here how such a system might have formed taking recourse in the unlimited imaginations of the science fiction writer and the Universe.

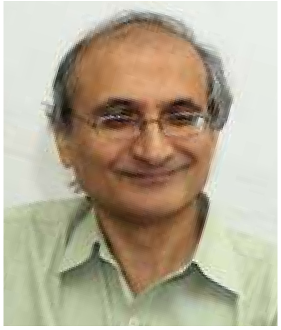


Trey-Patru orbiting Tano-Sitha-Onos-Dovim.

We have made a first stab at modeling the stellar system of Isaac Asimov's Nightfall and have come up with a defensible configuration, shown here. However, we have only focused on Kalgash 2 and Dovim. We now have to move on to the more difficult task of the details. Is it possible to match the actual motions of the suns described by Asimov — the configuration that would lead to one eclipse every 2049 years — and would such a system even be stable? Whatever the truth, I would like to thank the Good Doctor for providing me with a lifetime of thought-provoking reading and for leading me into science.

• The short story is at
https://www.uni.edu/morgans/astro/course/nightfall.pdf.
http://galacticinquirer.net/article/the-worlds-of-isaac-asimov/
• Our model is at http://arxiv.org/abs/1407.4895

See
http://www.taralaya.org/taralaya-videos.php
for the lecture delivered on 10th May 2015



Jayant Murthy is a Senior Professor at the Indian Institute of Astrophysics. He works on interstellar matter, diffuse radiation fields and space missions. He is very passionate about teaching and nurturing the interest in research among the youth. He is very actively involved in REAP.

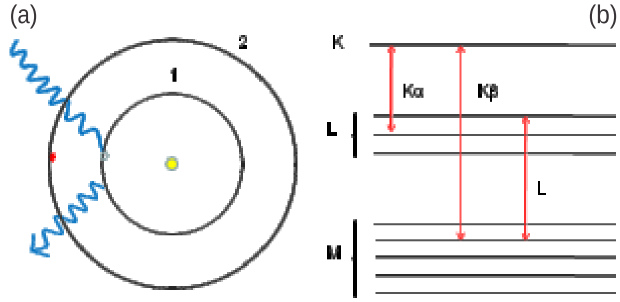
Space Exploration in X-rays

- Shyama Narendranath

Strange are the ways of nature that to un-decipher its numerous puzzles, we depend heavily on what we observe. Whereas astronomy from ground is restricted to the visible and a limited window in the Infra-red, space astronomy offers a plethora of opportunities to see the universe in myriad ways. Even the planets and small bodies in our solar system which have been observed since the advent of humanity first by the naked eye and later on with optical telescopes are today seen in an entirely new light when observed from Space.

The X-ray region of the electromagnetic spectrum do not penetrate Earth's thick atmosphere and hence X-ray observations must be done on satellite platforms. The strongest source of X-rays in the solar system is the Sun. The outer atmosphere of the Sun called 'corona' consists of plasma which reaches over a million degree Kelvin emitting X-rays. Apart from the Sun, all other objects in the solar system also show X-ray emission. What processes emit X-rays? What does it tell us about the source? Why does the emission vary with time or in space? There are such numerous questions fundamental to our understanding of planetary systems that can be addressed with X-ray observations.

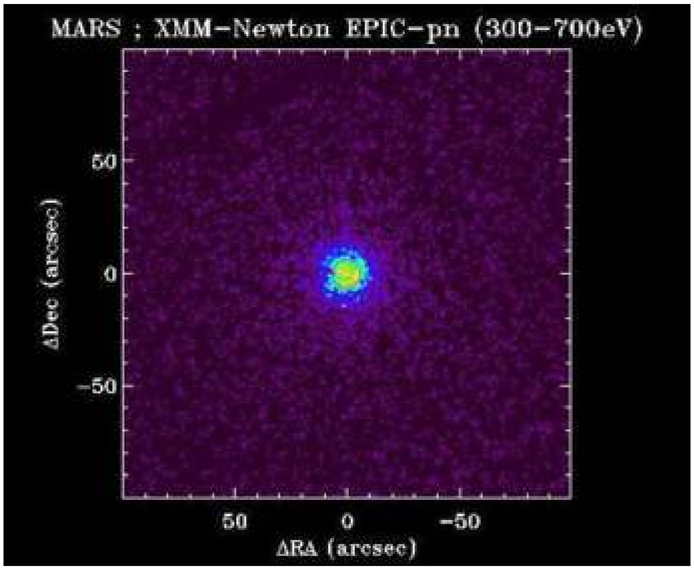
X-ray fluorescence is perhaps the most popular technique used in space as well as in laboratories to analyse the chemical composition of a material. On airless bodies in the Solar System, this technique can be used to map the surface chemistry. Missions to the Moon, Mercury and Asteroids have carried X-ray spectrometers to measure the surface elemental abundances. The Chandrayaan-1 X-ray Spectrometer (C1XS) was flown with precisely this objective in mind. From an altitude of 100 km above the Moon's surface, C1XS measured X-rays emitted by the Moon triggered by Solar X-rays. The principle is rather simple. X-ray photons from the Sun interact with atoms on the surface of the Moon via photo-electric effect and leave a vacancy behind. The excited atom returns to the ground state when an electron in a higher energy shell fills this vacancy. In the process, an X-ray fluorescent photon is emitted. Now, the difference between energy levels in atom is unique and hence if we measure the energy of the emitted photon, we know exactly which atom emitted it! If we can also count the number of photons, we will also know how many atoms are there or in other words the abundance.



(a) X-ray fluorescence: vacancy filled by higher shell electron (b) Energy level diagram

C1XS measured the abundance of a number of elements like Mg, Al, Si, Ca and Fe which are what the rocks of terrestrial planets are made of. But a precise quantitative measurement of these elements was new. An unexpected finding was that Na which is considered moderately volatile was found to be in the order of 2-3 % as opposed to < 1% in some samples returned by Apollo missions. Does this mean Moon wasn't heated up as much as we thought it did? Or is this sodium coming from meteorites? Inspired by the findings, these investigations would be continued using a similar experiment (but bigger) on the second lunar Mission Chandrayaan-2. Would this reveal new compositions on the Moon that will re-write its evolutionary history? Only time will tell!

Described above were spectroscopic techniques whereas imaging also has immense science prospects. Visible light can be focused using a mirror or a lens to yield an image. But unfortunately X-rays just get absorbed unless the photons are incident at grazing angles. X-ray telescopes with grazing incidence reflecting elements have been flown on many highly successful observatories such as the Chandra X-ray Observatory, XMM-Newton and Suzaku. The Soft X-ray telescope on ASTROSAT (to be launched in September 2015) would be the first such Indian X-ray telescope. Another method that has attracted attention recently is the use of multilayer coatings of a high atomic number and a low atomic number element (alternately) on a substrate. X-rays undergo Bragg diffraction at every interface and add up in phase and can be focused. Such a telescope would make the X-ray telescope more compact and would be ideal for planetary missions.



X-ray image of the Martian disk (courtesy: ESA)

A picture is worth a thousand words! Imaging helps to see a structure in the source. For example, the image of Mars in X-rays shows us how extended and structured the X-ray emission is. Another reason to focus X-rays is when the signal is very weak as in the case of solar wind charge exchange emission (SWCX). Solar wind ions meet neutral cold gas and exchange their charge resulting in X-ray emission. Measuring these help us understand how solar wind erodes the very outer parts of planetary atmospheres. This is a relatively new field in astronomy and dedicated observations of SWCX are yet to happen.

We have only talked of the pebbles on the shore. As we explore the Universe, numerous possibilities open up which enrich us. Space exploration is rewarding in every sense: new technologies, new challenges, new revelations and above all it inculcates a feeling of humans as of one kind occupying this tiny sphere in a small corner of the Universe. It makes us humble!

Shyama Narendranath, is with the Space Astronomy Group, ISRO Satellite Centre. Her research interests are chemistry in the solar system and related space instrumentation. She has been a co-investigator on the C1XS experiment on Chandrayaan-1. She is the Co-PI of the Chandrayaan-2 Large Area Soft X-ray Spectrometer currently. She is also involved in the development of soft X-ray multilayer mirrors and on coronal composition of the Sun.

What is a gene?*

- Vidyanand Nanjundiah

150 years ago a Moravian monk, Gregor Mendel, discovered the basic laws of genetics. Working by himself in the monastery's garden, he designed and carried out systematic observations of the transmission of characters or traits (e.g. tallness or shortness) from one generation to the next. He found regularities in the manner in which certain traits of the adult pea plant were passed down from parents to offspring. In the process, he discovered something remarkable. There seemed to be hidden factors within the plants that were associated with a trait. In fact a pair of factors were associated with each trait. One member of each pair came from the male parent and one from the female parent, and there was a probability of 50% that either factor would be transmitted to an offspring. The factors themselves were invisible, but their presence could be easily inferred from the effect that they had on a particular trait. Because there were only two factors associated with a trait, the relative proportions in which they could combine were mathematically easy to calculate. For example, suppose a pair of factors was denoted by the symbols A and a. If one of the two parents had both A factors and the other parent had both a factors, all their offspring would have one A and one a. Symbolically, this can be written as AA x aa=Aa (100%). However if both parents had one A and one a factor, that is, if both were of type Aa, it is easy to see that the offspring types would be AA, Aa or aa with different probabilities. It would be AA with a probability of 25% (because the probability of getting an A from each parent is 50%, and 50%x50%=25%), Aa with a probability of 50% (A from the father and a from the mother or vice-versa) and aa with a probability of 25%. Symbolically, one writes Aa x Aa = AA(25%)+Aa(50%)+aa(25%). The proportions are 1(AA):2(Aa):1(aa). Once Mendel had a hunch that the proportions were as simple as these, and and after it was clear what the combinations AA, Aa and aa led to, the predictions could be easily verified by counting.

Mendel's "factors" A and a are what we call genes. Genes are large polymers, and form parts of chromosomes. Each polymer string is a molecule known as DNA (some genes are made of a related molecule known as RNA, but for our purposes the difference is unimportant.) The monomeric unit of a DNA molecule is a molecule of the type known as a nucleotide. Each nucleotide consists of one of four nitrogenous bases combined with a molecule of sugar and a molecule of phosphoric acid (the sugar and phosphoric acid are the same in all nucleotides; the bases can be different). Our bodies are made of proteins and other molecules that are made by the action of proteins on the food we eat and the air we breathe. So are the bodies of all plants, animals and microbes. What we call characters or traits result from the properties of proteins, and the genes in our cells specify what proteins a cell can make. Genes also have a role in specifying how much of a protein is made and when it is made. The nature of the link between genes and proteins is not difficult to explain. But the detailed relationship between proteins and traits, and therefore between genes and traits, is extremely complex. As a result, today the word 'gene' is used in more than one sense. To begin to understand them, it helps to look at genes as sentences in a language.

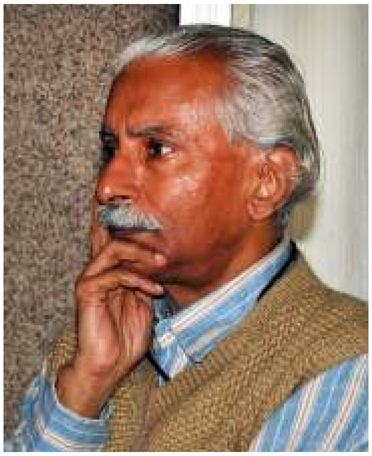
The analogy is between genes and a language in which meanings are conveyed using combinations of symbols called alphabets, say English. Written English consists of strings of letters that are organised into words. Some words have just one letter and other have many. But to keep things simple, we will restrict ourselves to cases in which every word has exactly four letters. A gene can be compared to a sentence that, if read correctly, conveys a message. The message could be "Dogs walk fast". However, the message may be embedded within a written text that contains other messages. The longer text could be "That crow went home. Dogs walk fast. Some girl drew cats." To make it more difficult, other combinations of letters may be found within and between words, and there may be no spaces. So the actual text could be "mnjhthatxprtcrowweypsrtnthomeuhgfmdtbnmnjhdogsypsrtwalypstkxprtfaypsrtstuhgfmsqwlkmnjhsomeypsrgirldrewcatsuhgfm". How can we make sense of this? We can do so by using the following rules: "(1) When the letters mnjh come together, it means a new sentence is about to begin (this is highlighted in yellow). (2) When the letters uhgfm occur, it means that a sentence has ended (highlighted in green). (3) The letters xprt, or ypsrt, or ypst, or ypsr, or dtbn, or sqwlk do not mean anything (all in red). When they occur, they should be removed. (4) After doing all that, the text should be read in units of four letters at a time. Once we follow the rules, we get three understandable sentences, namely "That crow went home. Dogs walk fast. Some girl drew cats." Notice that some combinations of letters in the original message could be interpreted to mean something; they were symbols that stood for something. They were words that could be found in an English dictionary. For instance, "Dogs" stands for "four-legged domesticated mammals that bark". Other combinations of letters were not English words. They were not symbolic. Among them, some marked the beginning or end of a sentence (e.g. "uhgfm"). Other combinations did not indicate anything and had to be ignored (e.g. "dtbn" or "ypsrt").

Now let us look at the corresponding picture in the case of DNA. A gene too consists of a string of 'letters', but here a 'letter' is a compound molecule known as a nucleotide. Sets of three nucleotides make up a word. In this language, each word is an amino acid. Corresponding to the three sentences mentioned in the previous paragraph, there are three genes. Each gene consists of a string of nucleotides. But the sense of 'gene' can vary from case to case. We will refer to the various senses as Gene A, Gene B, and so on. (1) Gene A is a sequence of DNA, all of which codes for a protein. Because three nucleotides in succession code for an amino acid, a string of nucleotides can be 'read' in units of three. The result is a string of amino acids, which is a protein. Gene A can be compared to a sentence whose meaning is immediately obvious, for example "Dogswalkfast". Since each word has exactly four letters (in our illustration), we know where one word ends and the next begins. A change in any of the letters in Gene A has the potential to change the meaning of the sentence or to make it meaningless. Gene A is a special case of Gene B, which comes next. (2) Gene B is also a continuous sequence of nucleotides, but only some of it codes for a protein. Before, after and within the coding portions, there are other strings of nucleotides that do not code for anything. An analogy to Gene B would be the statement "mnjhdogsypsrtwalypstkxprtfaypsrtstuhgfm". Here, in order to see what the message is, we need more instructions. In the case of real genes, the instructions have nothing to do with symbolic meanings like the ones that interpret nucleotide triplets in terms of amino acids. Instead, the instructions are automatically implemented, because they follow from chemical reactions. After the instructions are implemented, one gets back Gene A ("Dogswalkfast" in the analogy). (3) There is a third type of gene, Gene C. Gene C consists of a sequence of DNA that does not code for a protein itself, but regulates the working of Gene A or Gene B. In our example, the letters mnjh and uhgfm would be examples of Gene C. Other examples of the Gene C type are strings of DNA that encode a protein (like a Gene B), but the main role of that protein is to influence other genes to make, or not make, proteins.

Mendel's genius was to identify pairs of genes that (as we know) led to the appearance of different versions of the same trait. What was the nature of the genes that Mendel discovered? The answer is interesting. In some cases the difference was similar to that between the sentences "Many cats" and "Many bats", in which a change from the letter c to b indicates a change in the type of mammal that is specified. In other cases the difference was similar to that between "Many cats" and "Many casqwlkts" – a piece of DNA had got transposed within the gene. The nature of the genes varied too. Some were genes that specified a protein with enzyme activity (a Gene B type); one was a Gene C type; it helped the message of another gene to be read.

(see http://biotechlearn.org.nz/themes/mendel_and_inheritance/identifying_mendel_s_pea_genes).

*Talk given at the Jawaharlal Nehru Planetarium, Bengaluru, on 12 July 2015 (see http://www.taralaya.org/taralaya-videos.php)



Vidyanand Nanjundiah has been associated with the educational activities of the Planetarium for over two decades. After completing his Ph D in physics from the University of Chicago, he switched over to biology. His scientific interests range over developmental biology and the evolution of social behaviour. Currently he is at the Centre for Human Genetics, Bengaluru 560 100. (vidya@ces.iisc.ernet.in)

REAPers Speak:

The Sun as a Rosetta Stone in Astrophysics

- Smitha H N

The solar atmosphere with its unique density and temperature variations allows us to study rare physical phenomena which cannot be observed in terrestrial laboratories. One such phenomenon is the quantum interferences between the atomic states. These interferences imprint their signatures in the linearly polarized spectrum of the Sun. This spectrum, also known as the Second Solar Spectrum, is as rich as the intensity spectrum and arises due to coherent scattering of radiation in the solar atmosphere.

We often encounter spectral lines arising due to fine structure splitting of the atomic levels - for example, the Na I D_1 & D_2, Ca II H & K, Ba II D_1 & D_2. The polarization profiles of these lines observed on the Sun show features which can only be explained by considering quantum interferences between the fine structure (J) states. This is known as J-state interference. In case of atoms with non-zero nuclear spin, the J-states split into hyperfine structure (F) states. The F-state interferences also leave their signatures in the Second Solar Spectrum. My research interests are in developing the scattering theory for atom-radiation interaction in such systems, adapted to the solar atmospheric conditions. It is then used to model the profiles observed on the Sun. The theory of J-state interference was tested by modeling the profiles of the Cr I triplet between 5204-5208 A (angstroms). These results are presented in Figure 1.

Spectral line modeling, in addition to sophisticated theories, requires also highly accurate spectro-polarimetric observations. The observations shown in Figure 1 were procured with a state of the art instrument, ZIMPOL (Zurich Imaging Polarimeter) at Istituto Ricerche Solari Locarno (IRSOL) in Switzerland. The J-state interference theory was later extended to the case of F-state interference and tested by modeling the Ba II D_2 line at 4554 A . In the presence of weak magnetic fields, the partially split magnetic substates (m) undergo interferences giving rise to the Hanle effect. This effect was also later included in the J and F-state interference theories.

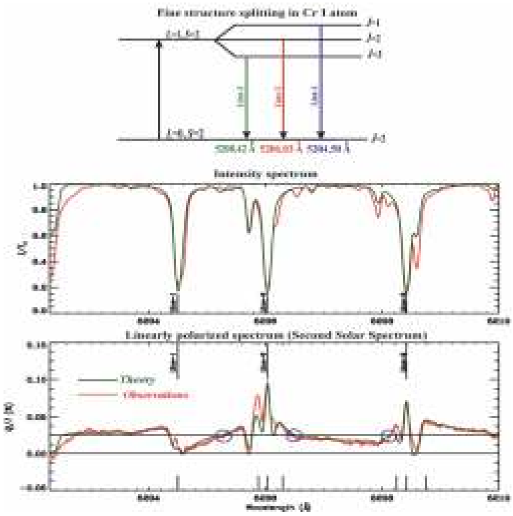


Figure: cr-fit.jpeg

Figure caption: *A comparison between the observed and the theoretically computed intensity and linearly polarized spectra of the Cr I triplet. L,S,J represent the orbital, spin and total angular momentum quantum numbers respectively. The blue circles indicate the signatures of J-state interferences observed on the Sun but not in terrestrial laboratories. Our theory reproduced these features and also the intensity and polarization profiles.*

I am currently studying the effects of solar atmosphere on the polarization profiles. This includes working with the two-dimensional and three-dimensional radiation magneto-hydrodynamic simulations of the solar atmosphere. These atmospheres are used to model the polarization profiles and extract the magnetic field information. Such a study conducted at different layers in the atmosphere gives us the height variation, and thus the spatial and temporal evolution of the magnetic field.

Smitha completed her PhD at the Indian Institute of Astrophysics and is currently a post-doctoral researcher at the Max Planck Institute for Solar System Research, Goettingen, Germany. She took-up REAP for three years alongside her graduation, a programme which laid the foundations in Physics and Mathematics. She is grateful to her teachers: Dr. Shylaja, Prof. Lokanathan, Prof. Bala Iyer and Mr. Madhusudhan. She feels that every lecture and the discussions that followed have been inspirational and insightful. She believes that the knowledge and the research education gained during this programme has played an important role in shaping up her research endeavours.

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Ph: 080-22379725, 22266084
E-mail: info@taralaya.org Website: www.taralaya.org