



BASE line

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Contents

- 25 Years Ago -
Workshop on astronomy for artists
- News
ASTROSAT – A Space Observatory
- Why is the Darwin's theory of evolution so controversial?
– M R N Murthy
- REAPers Speak: Quantum Bit
– C M Chandrashekhar
- 147 years ago at High Grounds, Bengaluru
– B S Shylaja

25 years Ago

The awe and wonder of cosmos found ways expression on the colourful canvas of J M S Mani during the workshop held in 1989.



Birth of the new worlds – Like fertile eggs from wombs of creation, new worlds emerge from glowing gases and dancing dust clouds. - J M S Mani

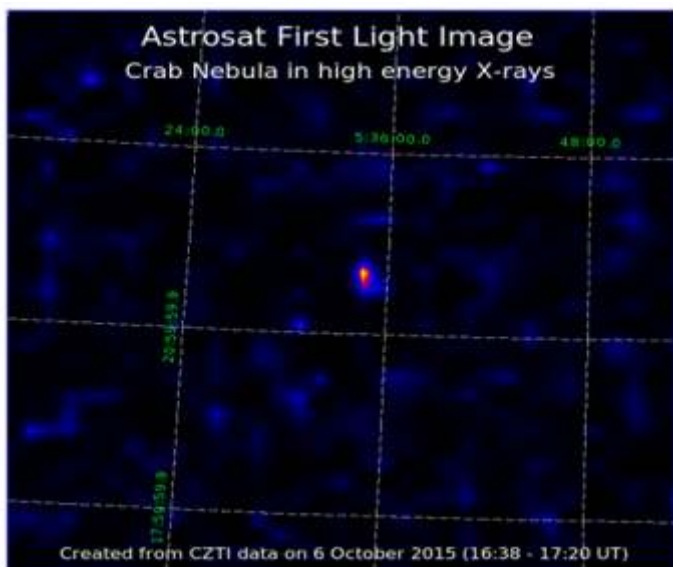


Image of Crab Nebula in hard X-rays above 25 keV. The bright spot near the centre indicates Crab. The effective imaging resolution here is about 10 arcmin. The faint patches outside are 'side-lobes' of the imaging process and they will be suppressed significantly when data from all quadrants are analysed simultaneously, which will also improve the image resolution to better than 8 arcmin. (Courtesy ISRO)

Grappling with Black Hole – To understand the complex world around us, the intellect has to wrestle with deep, abstract and difficult concepts like the black hole. – J M S Mani





ASTROSAT – A Space Observatory

ASTROSAT is India's first multiwavelength astronomy satellite. It will facilitate simultaneous observations of celestial bodies and cosmic sources in X-ray and UV spectral bands. The uniqueness of ASTROSAT lies in its wide spectral coverage extending over visible (3500-6000 Å), UV (1300-3000 Å), soft X and hard X ray regions (0.5-8 keV; 3-80 keV).

The payload of ASTROSAT includes:

1. Large-Area Xenon-filled Proportional Counters (LAXPC)
2. A Coded-mask Camera with Cadmium-Zinc-Telluride detector array (CZTI)
3. A Soft-X-ray imaging telescope with multi-foil Wolter optics and CCD detector (SXT)
4. A Scanning X-ray Sky Monitor consisting of three one-dimensional coded mask cameras (SSM)
5. Two 40-cm dia Ultraviolet Telescopes for Visible, NUV and FUV coverage (UVIT)
6. A Charged particle monitor (CPM)

Astrosat was successfully launched on September 28, 2015 using PLSV-C30 into a 644.6 X 651.5 km orbit inclined at an angle of 6° to the equator. The achieved orbit is very close to the intended one. Six foreign satellites rode piggyback on the XL variant of the launcher.

Crab Nebula was detected on Oct 9, 2015, observed by both Mission Operation Centreat Peenya, Bengaluru and Payload Operation Centre, IUCAA, Pune. During the first orbit, there was a difficulty in detecting this Crab Nebula as the satellite happened to pass through the South Atlantic Anomaly (SAA) region when Crab was in the field of view. SAA avoidance zone was deliberately kept wide to protect the instruments, and detectors were switched OFF in this interval during the initial days of Astrosat operation. When all the data were systematically analysed and data were selected based on the availability of Crab in the detector field of view, one could see the Crab emerging from Earth's shadow. The image generated by deconvolving the coded mask shadows accumulated during this interval clearly shows Crab as a bright object near the centre.

Follow more about ASTROSAT at the Public Outreach Committee web page of the Astronomical Society of India

<http://astron-soc.in/outreach/>



Why is the Darwin's theory of evolution so controversial?

-M R N Murthy

One of the deepest interests of the human race has been the origin of the universe, life and its destiny. The ancient origin of these questions is beautifully exemplified in the *Nasadeeya Sukta* of the 10th Mandala of the *Rig Veda*, which was probably composed 5000 years before the Christian era. It starts with an assertion: "in the very beginning, there was absolutely nothing". Then it speculates: "out of this nothing arose a desire that was the seed of all creation". Then it asks the big question: "who could inform us of the origin of this universe?" It suggests a plausible answer: "he who surveys it all from the high heavens may know the secret". Finally the *Sukta* concludes with an unforgettable punch line: "may be even he does not know".

The monotheistic religions like Judaism, Christianity and Islam hold that the world is the artwork of a creator. The Book of Genesis in the Old Testament of the Bible categorically states: "In the beginning, God created the heavens and earth". The sacred book not only attributes the existence of the universe to the God, the creator, but also places Man as being moulded in the image of God: "Let us make mankind in our image, in our likeness, so that they may rule over the fish in the sea and the birds in the sky". Against this background of the supremacy of the human kind in the order of living species and theistic world view, Darwin proposed his theory of evolution which was to revolutionize every aspect of life sciences including our perception of what it is to be human. The theory not only removed "God" from his high pedestal but also equated humans to other animals, although humans are assumed to have evolved in a different direction with distinct characteristics. Because of its vast implications, many of which may not be intuitively obvious, Darwin's theory faced severe criticism soon after it was proposed and has been subjected to censorship ever since, particularly in the western world. No other theory in science has been so controversial.

For our consideration of Darwin's theory and its implications, let us imagine a very simple yet reasonably accurate model for the nature of evolutionary change. Consider an infinite plane with innumerable volcanoes, poisonous lakes, inhospitable deserts and ice lands scattered randomly throughout the plane. We deposit a



large number of bacterial cells in a safe spot far away from any of the places detrimental to life. The bacterial cells start moving in search for food and other nutrients from the point of their origin outwards in completely random directions. Simultaneously they grow and multiply by cell division giving rise to daughter cells. Each move is random and completely unpredictable as bacteria, to start with, have no faculty of knowing where food and other resources may be found. Due to some mysterious (which is not mysterious any more, as we shall see later) but random process, the cells change in their shape or acquire some property such as a feeble ability to sense the environmental condition. The change is small but completely random and the bacterial cells pass on the altered characters to the daughter cells when they divide. Bacteria that accidentally approach any of the life destroying zones in their random walk do not survive. Only those bacteria that manage to avoid, although blindly, all the death traps in their voyage will survive and keep moving in various different directions, simultaneously multiplying and passing on the incurred accidental changes to their daughter cells. Thus, after a long time, there would be different kinds of bacteria bestowed with very distinct properties in different localized regions of the plane. If one of these colonies accidentally develops the tendency to avoid the heat from volcanoes or other hazardous spots, that colony will have better chance of moving forward and their progeny will outnumber other colonies. The volcanoes and other spots that lead to cell death function as selectors or filters of bacteria that are multiplying and undergoing random alterations in their genetic characteristics.

In more technical terms, Darwin postulated three principles:

1. Individuals undergo random variations
2. Variations are genetic or inherited
3. Only some offspring survive and reproduce

Darwin's theory not only eliminated God for the creation of life but also placed human species as just one branch of a giant tree where each branch represents a species that exists on our planet. These implications of Darwin's postulates were not palatable to many religious minded people as well as to those who thought that humans are somehow special, such as only humans are endowed with a soul. Even today, Darwin's theory is not acceptable to many. Unlike Copernican revolution, which also caused a social outrage that eventually subsided, the fight against Darwinian revolution has continued. Let us look at some of the criticisms.

Soon after Darwin published his book "On The Origin of Species" describing his theory of evolution, a debate on the validity of the theory was organized with Thomas Huxley, a strong supporter of Darwin's theory speaking for the theory and Wilbforce, a priest, speaking against the theory. Wilbforce tried to make fun of Darwin's theory and his opponent Huxley by asking from which side, Father's or Mother's, Huxley considers himself a descendent of apes. Huxley hotly retorted "would I rather have a miserable ape for a grandfather or a man highly endowed by nature, such as yourself, and possessing great means and influence, and yet who employs those faculties for the mere purpose of introducing ridicule into a grave scientific discussion, then I still unhesitatingly affirm my preference for the ape". The debate has never stopped.

In a nutshell, Darwin's theory implies that all species of life on our planet have evolved from a single source. All humans, no matter which continent they inhabit, are distant cousins. Chimps are our even more distant cousins. Pigs are even more distant cousins. We and reptiles had common ancestors and hence are cousins. The common ancestry of today's bacteria and humans dates back to three billion years.

In Darwin's theory, changes in the genetic characteristics are random. How these changes are brought about remained a mystery without firm basis for nearly a century. Then Watson and Crick deciphered the structure of DNA, the giant linear molecule formed by linking four kinds of nucleotides referred to by the letters A, T, G and C. The genetic information of cells is stored in the sequence of these four letters in molecules of DNA. The way this genetic information is expressed in terms of protein molecules that carry out most of the cellular functions was also worked out. The flow of genetic information in living cells is summed up in the central dogma of biology - genetic information coded by DNA is transcribed initially to RNA and expressed in terms of proteins. Nucleotide sequence of DNA molecules may undergo random changes due to errors during DNA replication or due to DNA damage caused by radiation or chemicals. The random changes in the nucleotide sequence of DNA molecules are the cause of genetic variations. In the 20th century, Darwin's original ideas were reconciled with genetics and molecular biology resulting in the development of so called "neo-Darwinian hypothesis". Extensive efforts were made to understand the body structure and living strategies of all species of life in the light of neo-Darwinian hypothesis.

BASE line

Soon after Darwin proposed his theory of evolution, some scientists were of the impression that the theory could only lead to life forms that are utterly selfish. Such ideas arose from the assumption that animals, for their survival and reproduction, have to compete for resources that are limited and hence only the fittest that are capable of suppressing or killing others will survive. It was conclusively shown in the twentieth century such an argument has no validity. It was possible to convincingly demonstrate that evolution by selection could indeed lead to cooperation as well as competition. Let us look at a simple, although trivial, illustration of the power of neo-Darwinian hypothesis in explaining "the game of life" played by different species. Let us assume that you are one of two identical twin sisters. If you give birth to a child, you would have passed on half of your genetic information to posterity. If your sister has a child, since she is your identical twin sharing the same genes, half of your own genes have been passed on to future generations, same as if you had a child. In this modern world with our innumerable commitments, let us assume that if both you and your sister get married, each of you could only have one child. However, if you decide to remain as a spinster and help your sister with all her other duties, she could have four children. You will immediately see more of your genes survive in future generations if you decide on the second choice. A similar argument applies to why honey bees are so altruistic. Neo-Darwinian hypothesis was so successful in explaining the nature of the living world that biologist Theodosius Dobzhansky made the famous remark " Nothing in Biology Makes Sense Except in the Light of Evolution ".



Charles Darwin cartoon – artist Andre Gill

Most of the objections to Darwin's theory are a result of traditional religious world view. The American philosopher had this to say regarding evolution 'by offering evolution in place of God as a cause of history, Darwin removed the theological basis of the moral code of Christendom. And the moral code that has no fear of God is very shaky'. Some of the other objections to evolution are: "Cheapening of human life" and "unwarranted elevation of animal life",

There are also some serious minded scientists who are also not entirely happy with Darwin's hypothesis. One of the most often cited objection to Darwin's theory is the so called "design" argument. A living cell, let alone a human body is so complex in its structure, organization and function that a modern air craft manufacturing factory is trivially simple in comparison. Such intricate design of a living cell or organ surely needs a designer just as a wrist watch implies a watch maker. That watch maker, as far as life is concerned, has to be intelligent beyond human comprehension and could be no other being than God.

In the twentieth century, neo-Darwinists have taken great pains to argue how a watch could indeed appear without a watch maker. The key requirement is the time scale. Evolution has taken place over three billion years. This is a time span we could not possibly imagine. What appears incredible and improbable could become very probable if we take into consideration evolutionary time scale. As an illustration, let us consider an ant weighing 1 mg and an elephant weighing 1000 kg. Let us assume that an ant colony perishes after producing a progeny colony once every ten years. In each generation the average weight of ants increases by 1 in 1000 parts, which is not noticeable at all. How long will it take for the ants to weigh as much as an elephant? A simple calculation shows that it takes less than 21,000 years, which is a negligible fraction of the time over which life has been evolving on our planet.

If a theory is right, as science progresses, evidence in support of the theory gets accumulated. Contrary evidences obtained in subsequent investigations prove the theory as false. In the later part of 20th century, the information encoded in the genomes in several organisms has been obtained. A great deal has been learnt on the three-dimensional structure of proteins and other giant molecules that function in cells of all living species. The structure and function of these molecules are amazingly similar in all organisms, pointing to their common origin. Thus, although bacteria look very different from us, many of the molecular processes and molecular machines in

humans and bacteria are very similar. In other words, although we are externally very different, there is great deal of biochemical similarity among us. We could construct an evolutionary tree, a picture that depicts how different species have evolved over time, using molecular data. The results provide surprisingly powerful support for evolution as proposed by Darwin.

More recently, there have been objections to the Darwinian and neo-Darwinian ideas on the nature of evolutionary change. Under the Darwinian hypothesis, evolution consists of an unimaginably large number of small random steps, selection acting at each step as the driving force of evolutionary change and emergence of new species. Darwin himself had stated: "If it could be demonstrated that any complex organ existed which could not possibly have been formed by numerous, successive, slight modifications, my theory would absolutely breakdown". Some biologists think that evolutionary changes could be abrupt and catastrophic. Mitochondria is a subcellular organelle in all animal cells. Lynn Margulis suggested that mitochondria is a remnant of a bacteria that was engulfed by a larger cell and the two decided to live happily ever after adhering to a phenomenon known as "symbiosis". More recently another noted biologist Shapiro has revisited evolution in his book :evolution, perspectives from the 21st century", where again he proposes other processes like gene transfer between existing species and gene rearrangements within an organism as major sources of evolutionary change. In the neo-Darwinian hypothesis, DNA in the nucleus of cells remains constant except for accidental mutational changes and genetic information flows from this nearly unchanging DNA to proteins. However, Shapiro points out innumerable illustrations of recent work where it is shown that the nuclear DNA is dynamic and reprogrammed by the proteins of the cell so as to evolve strategies of survival. According to Shapiro, DNA is a read/write device instead of what neo Darwinists regarded as a read only device. This attribute of DNA expands the scope of evolution although it does not implicate a designer.

The period called "pre biotic evolution", that covers the span of time between our lifeless planet and appearance of the first independently dividing cells still is steeped in great mystery. Thus, evolution remains a fascinating and continuing pre-occupation in the new millennium as well,

Finally we may briefly consider why there has been no strong religious opposition to Darwin's theory of evolution

in our country. One of the main reasons is certainly the lack of deep understanding of the implications of Darwinian Theory. When I give a talk on Darwinian evolution to +2 students, one of the often repeated questions is this: "Darwin's theory tells us that humans have come from monkeys. Is it possible that at a future date monkeys will evolve from humans?" This question reflects a twofold misunderstanding of Darwinian theory. We have not evolved from monkeys. Darwin's theory states that today's man and an old world monkey such as chimp have had a common ancestor. Also, Darwinian Theory does not have any predictive power on future evolution as evolution is a random process.

Most religious practices in India are based on Folk lore. Every small village has its own deity and a tale associated with the prowess of the deity. Thus, there is no Universal God head. Jains, who have been in the main stream of Indian civilization do not worship any god at all. In Jain temples we only see idols of *Tirthankaras*, who are mere humans like us except for their high moral standing Thus, Jainism could be considered as an atheistic religion. Even Buddha had little to say regarding God; his main goal was to find the path which brings peace to the life of common people, His wheel represents eight fold virtues which are believed to deliver us from our sorrows. In the Upanishads, we come across a monotheistic God resembling Judaic God. In contrast, Shankara's *adhvaita* Vedanta preachers a brand of the so called "pantheism" which equates God with the whole universe. Unlike the scientific universe, Shankara's universe is filled with divinity and everything that ever existed or will exist in the universe is an expression of the divine. This diversity of looking at the meaning of life delivers us from prejudices and perhaps accounts for why theory of evolution does not shake us to the roots.

M.R.N. Murthy, Professor at Molecular Biophysics Unit, IISc has been closely associated with all the educational activities of the Planetarium. His contribution to the fields of crystallography and protein synthesis are very well known; as are his passions to teach and convey the joy of research to the younger generation. He has written many popular articles in English as well as Kannada.



Reapers Speak:

QUANTUM BIT

- Chandrashekhar C M

Every form of information processing: computing, communicating, storing and securing using today's digital technology is carried out by expressing the information in binary number system. That is, each number, alphabet or part of the image in a digital system are typically stored and processed in the form of 0's and 1's. Straightforward implementation of binary operations using logic gates in electronic circuitry gave an inherent place for the binary system in all modern computers and computer-based devices. Each digit in the device in the form equivalent to 0 or 1 and are referred to as a bit making it a basis element of computers. Without going into the details, I will leave it to the reader to imagine the immense contributions of physicists, mathematicians and engineers since the development of digital technology that began in mid twentieth century to the current form where we are reaping the rewards in almost every aspects of our current day activities.

The advancement in computers has also significantly contributed to simulate, simplify the calculations, comprehend the results (data) and predict the future events to a very good approximation in various systems researchers consider for their study. Most of these systems are macroscopic in nature where classical laws of physics (nature) describe the system. One of the important question Richard Feynman posed in one of his key note speech with a titled "Simulating Physics using Computers" in 1981 was the limit of these computers based on binary system in simulating (imitate) the quantum systems including the real physical world. Quantum mechanics validated by numerous experiments for over a century says that (a) the world is probabilistic which involves complex number called amplitude rather than just probabilities with real number between 0 and 1, (b) the physical objects will be in all possible states (configuration) with certain complex amplitudes which is known as superposition state and only upon measurement we can observe them in some definite configuration. For a simple two level quantum system, a superposition state can be represented by,

$$|\Psi\rangle = a|0\rangle + b|1\rangle.$$

Here a and b are the complex amplitude and upon measurement the system will collapse to state $|0\rangle$ or state $|1\rangle$ with probability $|a|^2$ and $|b|^2$, respectively.

To simulate a single quantum particle we need two bits. With increase in number of particle and the interaction between them, we need one bit to represent each configuration of the many quantum particle system. To simulate 20 quantum particle system we need around 1 Million bit. In Figure. 1, we illustrate the number of bits required to simulate interacting quantum particles. For a quantum system with few thousand particles, the number of bit we need is of astronomical scale pushing our current computers capabilities to its limit. Therefore, for effective simulation of quantum systems, binary bit architecture of the current day computers can be replaced by the basic element which is quantum mechanical in nature, that is, a quantum bit (qubit) which can simulate two level quantum system. In Figure. 2, illustration of the bit, a scalar quantity is shown along with the qubit which is a vector quantity that can be represented on a sphere (Bloch Sphere) with each point on the sphere corresponding to the possible superposition state of a single quantum particle (qubit).

Number of particles in quantum system	Superposition of quantum states	Number of bits needed to simulate quantum system
1	$ 0\rangle, 1\rangle$	$2^1 = 2$
2	$ 00\rangle, 01\rangle, 10\rangle, 11\rangle$	$2^2 = 4$
3	$ 000\rangle, 001\rangle, \dots, 111\rangle$	$2^3 = 8$
4	$ 0000\rangle, 0001\rangle, \dots, 1111\rangle$	$2^4 = 16$
10	$ 0000000000\rangle, \dots, \dots$	$2^{10} = 1024$
30	$ 0000000000\dots\rangle, \dots, \dots$	$2^{30} = 10737 \times 10^5$ 1G
50	$ 0000000000\dots\rangle, \dots, \dots$	$2^{50} = 11259 \times 10^{11}$ 1P

Figure 1. Number of bits required to simulate quantum system of n particles

Therefore, n qubit which can be in superposition of all possible configuration can effectively simulate quantum system with n particles. Along with reducing the number bits required to simulate quantum mechanical system, quantum computers will be able to exploit other quantum properties like entanglement to engineer systems with unprecedented power and capabilities. Most importantly the ability to model quantum systems will have a very huge impact in strengthening our understating of physical principle where quantum mechanics dominates. This will also led way to understand many phenomena which has remained unclear for decades now like black hole and quantum gravity from principles of quantum information.

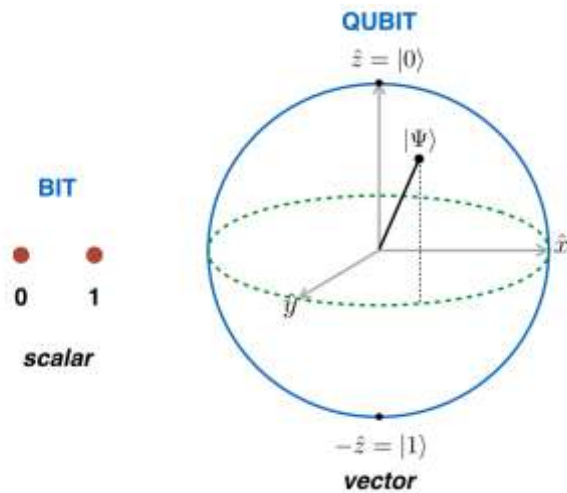


Figure 2. Classical bit (BIT) and a Quantum bit (QUBIT)

Over last two decades, a significant development in the area of quantum information and quantum computation has been reported indicating the quantum revolution the world will embrace in near future.

Chandrashekar is currently a faculty in theoretical physics at the Institute of Mathematical Sciences (IMSc), Chennai. After finishing his B.Sc in National college Jayanagar, he studied at the University of Oxford, UK on Rhodes Scholarship and subsequently at the Perimeter Institute for Theoretical Physics and Institute for Quantum Computing, Canada. After his Ph.D he worked as a postdoctoral fellow in Ireland and in Japan (Okinawa Institute for Science and Technology, Okinawa). He has also been awarded Ramanujan Fellowship this year by the DST, Government of India. Chandrashekar's research interests are mainly in the area of quantum information theory.

home page <http://www.imsc.res.in/~chandru/>.

During his pre-university and B.Sc days, he was part of the weekend lecture programs at BASE (which later turned into formal REAP). He believes, the years spent at BASE laid the foundation for his career in research in basic science.



147 YEARS AGO AT HIGH GROUNDS, BENGALURU

- B S Shylaja

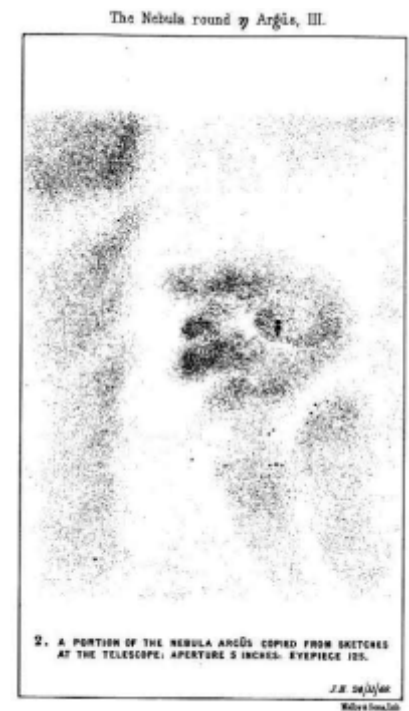
The dawn of 23th November, 1868. The exact location is Bangalore Base South End. There stood a young British Colonel with a small 4" telescope, the first ever to land at 13N and 77.5E (High Grounds, Bengaluru, where the Planetarium stands today). He wrote

"...I...had a look at the Nebula round Eta Argus..... unusually bright objectthe altitude at times was about 15 degrees, ...the air was clear enough to have stars of the third magnitude within a degree of horizon roughly speaking...."

He was one of the first to observe the sudden brightening of Eta Carina (which was called Eta Argus in those days). He reports that it reached naked eye visibility and has sketched the appearance of the nebula surrounding it. The report in the Monthly Notices (where he is referred to as Leut. Herschel) is followed by the report of his father (who is cited usually as Sir John Herschel), who has identified all the stars and the subsequent development of the nebula.

"...Had I known I could see it so early I should have tried sooner. It is now on the meridian (and therefore at an altitude of 20 degrees.) at sunrise". Subsequent observations on 22nd and 23rd were done with Royal Society's 5" refractor; his hand drawn sketches appear in the Memoirs of the RAS.

That was the first record of telescopic observations from Bengaluru; the Colonel was John Herschel (1837–1921, grandson of William Herschel); he carried out independent observations and left behind important observational records.



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Sketch made by John Herschel - reproduced from the Memoirs of RAS)



Continuing the tradition of astronomical observations the younger John did extensive observations of southern nebulae apart from the solar prominences. His observations of the nebulae other than Eta Carina are not available completely. Only the second list is available suggesting that the first list also existed.

Born in South Africa where his father Sir John Herschel was engaged in observations of the southern celestial hemisphere, the younger John grew up playing with the telescopes.

He joined the Great Trigonometric Survey of India and his interest in the skies continued. Obliging to the demands of the duties he undertook the task of measuring the latitudes of most of the towns in South India along the 78 degree meridian. He moved to other parts of India and was in charge of the "Bombay Party" till November 1869, after which Lieut. Rogers took over the charge from him.

He seems to have kept a watch on the beautiful skies all along and carried out independent observations. He spent the period from 1864 – 1872 in different parts of South India. His work is very well documented and received appreciation from seniors - "Lieutenant John Herschel, whose scientific acquirements and business habits prove him worthy of the honored name he bears, has continued his investigations, and matured the mechanical applications of formulae required for the reduction of all geodetical figures....."

The other important observation of John Herschel is that of the total solar eclipse, from Jamakandi about 500km north of Bangalore along with Campbell. Although the Madras Observatory reports it with a single sentence as "the beginning of the event was clouded out.....", John has meticulously recorded ⁶ the spectrum and identified the spectral lines. He writes, "The totality commenced unseen...I went to the finder removed the dark glass and waited....Soon the cloud hurried over revealing the scintillating corona.....Instantly I marked a prominence near the needle-point, an object so conspicuous... It was a long finger like projection Three vivid lines, red, orange,

blue and no trace of continuous spectrum.....".

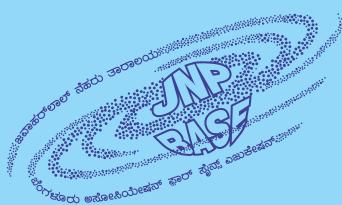
He cautions about the appearance of "ghost" images seen through the telescope. "....which when first remarked was mistaken for a companionso exact is the resemblance that it was only by accident that the true explanation presented itself. ...the red companion which was to the right (i.e. North) at first was also on the right (i.e. South) after reversal proving that the cause lay in the telescope and not in the sky...."

One of his interesting observations concerns the migrations of locusts; their huge number disturbed his observations in 1870. "An unusual phenomenon was noticed by Lieut. Herschel, Oct. 17 and 18, 1870, while observing the Sun at Bangalore, India." - says the report. "dark shadows crossing the sun....." – he wrote. This phenomenon attracted world-wide attention and the unusual increase of pests in that year has been cited globally.

John Herschel was the first to record astronomical observations of stars nebulae and of the sun from Bangalore. His task began even before unpacking and installing the tools of the surveyors, which included a telescope, on 24th and 25th November 1869. He was, therefore, the first to initiate such professional observations from Bangalore, which now hosts prestigious institutions actively engaged in astronomy and astrophysics.



Eta Carina as seen today (Courtest ESA)



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