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Govind Swarup and Genesis of Radio Astronomy in India

Utpal Mukhopadhyay [1]

Ex-Teacher, Satyabharati Vidyapith, Nabapally, North 24 Parganas, Kolkata 700126, West Bengal, India

Abstract: At present, India is one of the leading countries in the world in radio astronomical researches. Prof. Govind Swarup, who has left us forever in September 2020, was the driving force behind the progress of our country in this field. In the present review article, growing up of Swarup as a world class radio astronomer and his role for the birth of radio astronomy in India have been discussed with special emphasis on his contributions for the establishment of two major radio telescopes in our soil.

1 Introduction

Modernisation of radar technology just before and during World War II paved the way for the birth of radio astronomy, the second window of astronomical observation, more than 300 years after the first use of optical telescope. Naturally, when Govind Swarup (23.03.1929—07.09.2020), after obtaining M. Sc. Degree from Allahabad University in 1950, joined the National Physical Laboratory (NPL) as a research scholar of K. S. Krishnan FRS

(1898—1961), in most of the countries of the world radio astronomy was either in a nascent stage or completely unknown. Our country was also no exception from this situation. However, apart from USA, Australia also made remarkable progress in radio astronomy within a very short period. So, when Prof. Krishnan attended the 10th General Assembly of the International Union of Radio Science held at Sydney University in 1952, he was deeply moved by the advancement in radio astronomy made by Australia under the able leadership of J.L. Pawsey (1908—1962) who created a group of talented radio astronomers, viz. B.Y. Mills (1920—2011), J.P. Wild (1923—2008), W.N. Christiansen, commonly known as Chris (1913—2007), J. G. Bolton (1922—1993), R. Payne-Scott (1912—1981), R. N. Bracewell

[1] Email: utpalsbv@gmail.com

(1921—2007) etc. A number of indigenous radio telescopes were built in that country. It may be mentioned here that Pawsey and Payne-Scott made a radio observation at 11 cm. as early as March, 1944[1, 2]. Anyway, Krishnan narrated his experience in Australia in a colloquium at the NPL which attracted young scholar Govind Swarup who was then, under Krishnan's instruction, working on the development of a device for investigating electronic paramagnetic resonance at 3 cm[3]. After receiving the above mentioned information from Krishnan, reacting sharply, Swarup read as many as thirty research papers on radio astronomy (published in *Australian Journal of Physics* and *Nature*) by radio astronomers of Radio Physics (RP) division of Sydney. This made him inclined towards the new field of radio astronomy. Krishnan was also looking for starting radio astronomical research at the NPL. So, he recommended Govind Swarup's name[3]for a two-year Fellowship (under the Colombo Plan) which was accepted and in March, 1953, Swarup and R. Parthasarathy of Kodaikanal Observatory left for Australia for working under the supervision of Pawsey.

2 Formative Years

(a) Australian Chapter

After interacting with Swarup, Pawsey could realise that the former was more interested in observational astronomy rather than theoretical work. So he advised Swarup to work with different groups of radio astronomers of Australia for gaining knowledge about various techniques related to radio astronomy. Accordingly, Swarup spent first three months with W. N. Christiansen (1913—2007) and J. A. Warburton at Potts Hill field station for assisting them in the preparation of a two dimensional map of the quiet Sun at 21 cm[3]. In that work, Swarup had to Fourier transform the scans manually using only an electronic calculator.This tedious job with Christiansen had a lasting effect on Swarup and he commented – "*I learned the powerful technique of radio interferometry from Chris in 1953 and have not looked back*''[2,4]. Moreover, Swarup devised an alternative technique for preparation of a two dimensional map without using the laborious job of Fourier transformation[3, 5]. This method of Swarup is still used in medical science for X-ray imaging and tomography.

During next three months Swarup and J. A. Roberts worked at Dapto field station under the guidance of J. P. Wild for constructing a 45 MHz receiver for daily observation of Cygnas A and for determining the velocity of turbulence in ionosphere[3, 5]. In the next three months, Swarup was engaged at Pots-Hill with B. Y. Mills and Alec Little for building a phase shifter for the prototype Mills Cross antenna[3]. In the last three months of his first year stay in Australia, Swarup worked in a group with J. G. Bolton as its leader, for making a highly stable D. C. power supply of 2000 volts[5].

In 1954, when Christiansen switched over to Meudon Observatory in France for a year, Swarup and Parthasarathy, under the guidance of Pawsey, converted the Potts-Hill EW grating from 21 cm. to 60 cm. for observing the quiet Sun at 500 MHz. Their observational results[6, 7, 8, 5, 2] clearly showed limb brightening in the equatorial region of quiet Sun which supported the observation of Smerd,[9, 3, 5] but contradicted that of Stanier[10, 3, 5]. Radio emissions associated with sun spots were also studied[8]. In early 1955 Swarup, under instructions from Christiansen, built Chris Cross at Fleurs field station near Sydney which consisted of two mutually perpendicular arrangements (like a cross) of antennas for making daily solar maps at 21 cm. wavelength[11, 3, 5]. After construction of this array, the necessity for the 32 dishes in Potts-Hill was over. So Swarup approached Pawsey for donating those 32 dishes to India for radio astronomical research. Pawsey as well as E. G. Bowen, Chief of the Division of Radio-physics, agreed instantly. Krishnan was also ready to accept that gift. After making this arrangement, Swarup returned to India for starting radio astronomical research at the NPL. He was ready to initiate radio astronomy research in India. However, due to some problems, the donation of the 32 dishes didn't materialise at that time. So Govind Swarup, being invited by Donald Menzel (1901-1976), the Director of the Harvard College Observatory, left India to join Fort Davis Radio Astronomy Station of the Harvard Observatory in August 1956 [2, 5].

(b) USA Chapter

In USA, Swarup started working with Alan Maxwell (1926-2021) for studying dynamic spectra of solar bursts in the frequency range 100-600 MHz using the recently installed 8.5 metre radio telescope. During his stay there, in December, 1956, Swarup discovered a new type of solar burst known as U burst[12, 2, 3, 5]. In the meantime, in early 1957, Swarup decided to work for a Ph.D. and, being advised by Pawsey, joined Stanford University in September 1957 to work under the supervision of R. N. Bracewell[3]. As a part of his Ph. D. work, Swarup studied quiet Sun at 9.2 cm. using the newly constructed Stanford Microwave Spectroheliograph. He detected a north-south asymmetry in the emission by the quiet Sun at that particular wavelength[13, 3, 2]. In December 1960, Swarup was awarded Ph. D. by Stanford University for his thesis entitled *Studies of solar microwave emission using a highly directional antenna*. Being elated by the observations of north-south asymmetry detected by Swarup, Pawsey wrote to him on 18 April, 1861 – "*I am most interested in your ....report. I am hoping it is the essentials of a PhD thesis. I thought it was a most interesting report and I congratulate you on the outcome of your Stanford work. Your report now will be my authoritative source on the features of 10 cm observations*"[2]. Swarup joined Stanford University as an Assistant Professor on 1 January 1961.

3 Back to Motherland

In spite of being included in the Faculty of Stanford University, Swarup had always a desire for working on Indian soil. So he and three other same minded radio astronomers, viz. T. K. Menon, M. R. Kundu and T. Krishnan decided to come back to India. In September 1961, they sent a proposal to five leading scientific institutions in India for creating a radio astronomy group. At the same time the same proposal was sent to five renowned astronomers, viz. Harlow Shapley (1885—1972) of Harvard, USA, Jan Oort (1900—1992) of Leiden, Netherlands, Bart J. Bok (1906—1983) of Mt. Stomlo, Australia, J. L. Pawsey of CSIRO, Australia and J. F. Denisse (1915—2014) of Observatoire de Paris, France their for opinion. The foreign experts sent their comments to Bhava. On 6 October, 1961 Pawsey wrote – "*I have a very high opinion of the scientific talent in this group…, a group chosen from among them should have an excellent chance of building up a first class scientific institution… I regard this spontaneous movement among the young Indians who have initiated this proposal as a most encouraging sign and strongly urge you, in the interests of science in India, to try to assist them in their efforts to work out something worthwhile*"[1]. Bok's encouraging comments (23 October 1961) were – "*Here is a case of four young, but renowned, Indian Radio Astronomers, all thoroughly trained and with good research records…. hardly equalled by any group that one might assemble anywhere in the world… It seems to me that their offer to return to India as a group is a unique one and one that should by all means be accepted and acted upon promptly. An offer like the present one comes only rarely in the history of scientific development of a nation which, scientifically is obviously coming of age*"[1]. Oort commented (23 October 1961) – "*Their plans are reasonable and balanced and appear extremely suitable, starting an active centre of radio-astronomical research in your country; I should therefore like to support their proposal whole-heartedly. You are fortunate in having a group of young Indians who appear to be so well-equipped to start a research centre in a subject that is at present in the centre of interest. There is no doubt in my mind that your country …. would profit if you could succeed in realising their plans…*"[1].

Professor Mark Oliphant (1901—2000), Director of the Research School of Physical Sciences at the Australian National Laboratory and a friend of Bart Bok, was also aware of the above mentioned proceedings and he himself correspondence with Prof. Bhava during late 1961 to early 1962. In his letter to Bhava on 6 October, 1961, Oliphant remarked – "We find the presence in Australia of strong groups in radio astronomy to be most stimulating to us all and very attractive to research students. I feel sure that Indian science would be richer if some means can be found to establish radio astronomy as a vigorous branch of research and teaching. We in Australia would welcome the presence of colleagues in this field in neighbouring India and would be happy to help and collaborate in every possible way"[1]. The most inspiring reply in India came from H.J. Bhava (1909—1966). In his telegram to all the four of the Swarup's group on 20 January, 1962, Bhava wrote – "*We have decided to form a radio astronomy group. Letter follows with offer*"[14, 5]. After acceptance of the offer by Swarup on 8 February, 1962, Bhava wrote to him (3 April, 1962) – "*… If your group fulfils the expectation we have of it, this could lead to some very big equipment and work in radio astronomy in India than we foresee at present…*" So, Swarup resigned from Stanford University in March 1963 and returned to India on 31 March 1963 to join TIFR[3]. In the meantime, all the 32 dishes of Potts Hill (which couldn't be procured earlier) were received by Govt. of India. Some talented young scientists like V.K. Kapahi (1944—1999), J.D. Isloor, D.S. Bagri, M.N. Joshi, N.V.G. Sarmaand, R. P. Sinha joined TIFR nearly at the same time.

While contemplating about a suitable project, in August 1963, Swarup came across two papers – one by Cyril Hazard (born 1928) et al. and the other one by Martin Schmidt (born 1929), both published in *Nature*, describing the discovery of the first Quasi-stellar object or Quasar (termed by Schmidt) 3C 273 using lunar occultation method. On the other hand, by 1960 Martin Ryle (1918—1984) detected as many as 300 radio galaxies using Cambridge interferometer and assumed that many other weaker radio sources could be detected at large distances. On reading the above two papers, it suddenly occurred to Swarup that lunar occultation could be used for finding the exact location and angular size of numerous uncatalogued weaker radio sources also[5]. However, observations of a large number of weak radio sources with arcsecond resolutions would require a radio telescope whose collecting area should be very large, at least four times that of the Jodrell bank (76 m) or Parkes (64 m) radio telescope which was totally impracticable. So, Swarup thought of a large (500 m long and 30 m wide) parabolic cylindrical radio telescope which would enable to track the Moon each day for several hours and observe radio sources with arcsecond resolution. Swarup discussed his idea elaborately with Professor M. G. K. Menon, the Dean of the Physics Faculty of TIFR, who agreed enthusiastically. Swarup's long discussion with Bhava was also fruitful. But before construction of the abovementioned radio telescope, Swarup and his colleagues decided to build the first radio telescope of India at Kalyan.

4 Foundation of Radio Astronomical Research in India

(a) Kalyan Radio Telescope

As the leader of a group of radio astronomers, Swarup first decided to set up a grating type radio interferometer at Kalyan, Maharashtra for solar study using the 32 dishes of Potts Hill each with diameter 1.7 m. 24 of those dishes were placed along 630 m. East-West baseline while the remaining 8 were arranged along 256 m North-South direction. The construction of Kalyan radio telescope was completed in April 1965[16, 5]. During 1965-1968, this grating type interferometer was used for observing the sun in both quiet and active phase at 610 MHz. The study showed pronounced limb brightening and the temperature of the solar corona was found to be ~10^6K[16, 5].

(b) Ooty Radio Telescope

Just before the construction of Kalyan radio telescope, in January 1965, Swarup and Ramesh Sinha started searching a favourable site for a much larger radio telescope. Swarup could realise that South India, due to its proximity to the equator, would be an ideal place for setting up a radio telescope. After searching nearly 30 hills in South India, the suitable site was selected near Muthorai village situated 5 km. away from Ooty in the Nilgiri Hills at an altitude of 2100 m (11°23′00′′N, 76°39′58′′E). Taking advantage of about 11°inclination of the mountain (which is also the latitude of the place), the 530 m long and 30 m wide parabolic cylindrical antenna of Ooty Radio Telescope (ORT) was constructed on the North-South slope of the Nilgiri Hills so that the long axis of the telescope and earth's rotational axis become parallel. As a result, by rotating only the long axis of the telescope, celestial radio sources can be tracked daily for at most 9 hours 30 minutes. After visiting the location in May 1965 and again in December 1965, Bhava

Fig. 1: The Ooty Radio Telescope

approved the site. However, since the site was within the periphery of a reserve forest, Bhava had to request the Tamil Nadu Government for getting permission. After the green signal came from the government, Swarup started his work. In the meantime, a number of rising radio astronomers like S. Anathakrishnan, V. Balasubramanian, Gopal Krishna, M.N. Joshi, V.K. Kulkarni, D.K. Mohanty, A Pramesh Rao etc. joined TIFR making the radio astronomy group of that institution much stronger. The reflecting surface of the ORT was made of 1100 stainless wires. The structural and mechanical parts of the fully indigenous ORT were designed by Tata Ebasco (named afterwards as Tata Consulting Engineers) while M/s Bridge and Roof of Kolkata were given the responsibility for constructing the structural and mechanical parts. N.V.G. Sharma, M.N. Joshi, D.S. Bagri, S. Ananthakrishnan and others designed the electronic system[3, 5]. ORT started functioning on 18 February, 1970 by observing a 4C radio source and two other uncatalogued sources through lunar occultation. The telescope operates in 322-328 MHz range which is an internationally protected frequency for radio observations. By 1978, angular size of nearly 900 catalogued (3C and 4C) as well as uncatalogued radio sources were determined with resolution 0.5 – 10 arc sec which was till then the best resolution achieved in the entire world. Some of the major discoveries made with the ORT are as follows[5]:

1. In 1972, Gopal Krishna et al.[17, 5] discovered a nearly 20 pc. diameter non-thermal radio halo around the centre of the Galaxy by lunar occultation of the Galactic centre source Sagittarius A at 327 MHz.
2. Observations of the interplanetary scintillation of radio sources revealed a significant amount of emission from compact sources of angular diameter less than 0.5 arc sec[18, 19, 5].

3. The gravitational lensing of the very bright radio source 1830-211 was discovered [20, 21, 5] which was later identified as Einstein ring lens[22, 5].
4. An upper limit of HI mass in super clusters was set by Subrahmanyan and Swarup [23] through observations at 327 MHz.
5. The data obtained from ORT indirectly supported Big Bang model of the universe[24, 25, 3].

In the 1980's, Ooty Synthesis Radio Telescope (OSRT) was built for making two dimensional images of celestial radio sources by observing at 327 MHz[5]. Apart from the ORT antenna, OSRT has seven other parabolic cylindrical antennas which are placed at distances up to 4 km. During first twenty five years (1964—1989), the data collected by the Kalyan Radio Telescope, ORT and OSRT resulted in publications of 285 papers in refereed journals including 20 in *Nature*[5].

(c) Giant Metrewave Radio Telescope

On request of the TIFR Director Dr. B.V. Srikantan in May 1983, Swarup suggested in 1984 an innovative idea of constructing a radio telescope for operating at metre wavelength whose antennas would be placed over 25 km. region in a Y-shaped pattern. The site was chosen at Narayangaon (19°05′47′′N, 74°02′59′E), 80 km. from Pune in Maharashtra for placing the central array over an area of 1 square km. Swarup proposed the name of the telescope as the Giant Metrewave Radio Telescope (GMRT)[5]. He also created a cost effective design for supporting the wire-mesh panels of parabolic reflectors by using Stretched Mesh Attached to Rope (SMART). The diameter of each of the fully steerable dishes of GMRT is 45 m [26, 27, 5].

Fig. 2: The Giant Metrewave Radio Telescope

Under the supervision of Suresh Tapde and Swarup all thirty dishes were constructed by March 1996. A group of engineers of Bhava Atomic Research Centre designed the servo system while the entire antenna feeds in the frequency range 130-150, 230-235, 320-350 and 590-620 MHz. and the complex correlator system were designed by the Radio Astronomy Group of TIFR. The antenna feeds for 1000-1450 MHz. were done by Raman Research Institute, Bengaluru. GMRT started functioning in 1999. In 2001, it was opened for astronomers of India and abroad. Initially GMRT could operate at five frequency bands, viz. 130, 235, 325, 619 and 1430 MHz. with a band width of 32 MHz. Recently, installation of new antenna feeds and receivers at GMRT has enabled it to operate almost continuously from ~ 130 MHz. to ~ 1430 MHz. with much wider band width of 400 MHz. This upgradation of GMRT, renamed as uGMRT, has increased the sensitivity of the telescope by a factor of two[28, 5]. GMRT is the most powerful radiotelescope in the lower frequency range. It has been used for observing planets, exoplanets, the sun, pulsars, galaxy clusters, radio galaxies, quasars and various other sources of radio emission. On the basis of TIFR-GMRT Sky Survey conducted by the radio astronomers of NCRA-TIFR, Intema et al.[29] has published a catalogue of nearly 6 lakh radio sources[5]. GMRT has been used by astronomers of other countries also. Some of the results obtained with the GMRT can be summarised as follows[5]:

1. A double-double radio galaxy (J 1453+3304) was discovered by Saikia et al. (2006)[30].
2. Possibly the youngest supernova remnant in our Galaxy was discovered by Roy and Pal [31] at 330 MHz.
3. Saxena et al. [32] have discovered the farthest radio galaxy ($z = 5.72$).
4. Using the uGMRT, neutral hydrogen has been spotted at $z = 0.37$ (Bera et al. 2019)[33].
5. Chowdhury et al. (2020)[34] have detected HI at $z \sim 1$. It may be mentioned here that search for HI at large distances was one of the major objectives of GMRT[25, 26].

5 Concluding Remarks

It is clear from the above discussion that Prof. Govind Swarup was instrumental for initiating radio astronomical research in India and construction of three major radio telescopes in our country. In his school days, being inspired by the article *Akash Ganga* written by famous poet Mahadevi Verma, he quenched his thirst for astronomy by reading an astronomy book on this topic in his school library which was, in his own words - "…That was my first lesson in astronomy"[5]. Being a top class radio astronomer, Swarup could easily spend his life as a Faculty of world famous University or Research Institute. However, he was influenced by the idealism of M. K. Gandhi (1869—1948) and in his school days, supported the Quit India movement, joined in a procession daunting the firing of British soldier on their peaceful march. This ideology of serving his motherland prompted Swarup to resign from the lucrative professorship of Stanford University for building radio astronomy group at TIFR and initiating radio astronomical research in India. In the 1960s, when high level radio astronomical research started in only a few developed countries of the world, Swarup opened the second window of astronomy in our poverty stricken country merely eighteen years after independence in very cost effective way. For instance, under his advice thin steel wires were used for construction of the antennas of GMRT due to their light weight, small air resistance capacity, durability and lower cost than that estimated by Tata engineers[5]. For this reason, Prof. Somak Raychaudhuri, Director of IUCAA, has called Swarup as *Beacon of Frugal science*[35]. For his pioneering contributions in radio astronomy, Swarup received many awards, viz., Bhatnagar Award (1972), Padmashri (1973), INSA Vainubappu Memorial Award (1987), Harshel Medal (2005), Grote Reber Medal (2007), Homi Bhava Prize (2009) etc. He was also a Fellow of Royal Society, London. But, we should not judge the achievements of Swarup through number of prizes and accolades only. In its true sense, he was ***The Father of Indian Radio Astronomy***. Amidst the spectre of Covid-19 pandemic, Prof. Govind Swarup, has departed forever leaving behind a bright trail of his legacy.

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Cosmological Models with scale factors in $f(T)$ gravity

Ishank Chauhan[1] and Puru Gupta[2*]

Department of Mathematics, Birla Institute of Technology and Science, Hyderabad Campus, India

Abstract: In this work, we have studied the cosmological model framed in an isotropic background in the $f(T)$ theory of gravity. The field equations are derived and the dynamical parameters are studied with two different type of scale factors that favours early deceleration and late time cosmic acceleration. The model is showing an accelerating behaviour which can be confronted from the behaviour of geometrical parameters. We also analysed the violation of null energy condition and strong energy condition. To study the dynamics of the universe cosmographic parameters has been investigated.

Keywords: Torsion Scalar; Cosmographic parameter; Energy Conditions

1 Introduction

In contemporary cosmology, the study of late-time cosmic acceleration events has been a significant focus. Supernovae of type Ia give strong evidence that the Universe expands at lightning speed. Cosmography is an appropriate method for investigating the cosmic expansion history in an almost model-independent approach, based on the hypothesis that the Universe is homogeneous and isotropic on large scales. Theoretical research and cosmological measurements of the Universe show that the Universe went through an inflationary phase at the beginning and an accelerated degree after that. It is theoretically possible to accomplish this in two ways. The content of the Universe is altered in the first method by adding new fields such as phantom scalars, canonical scalars, vector fields, etc. [1,2]. Modifying the gravitational sector [3] is the second technique. Teleparallel gravity [4,5] is a gravity theory that describes gravitational effects in terms of torsion rather than curvature, using the curvature-free Weitzenböck connection [6] to define the covariant derivative instead of the conventional torsionless Levi-Civita connection of general relativity (GR). It is comparable to GR in its most basic form, but it has a distinct physical meaning [5].

The Levi-Civita connection in GR denotes curvature but no torsion, whereas the Weitzenböck connection in teleparallelism implies torsion but no curvature [6]. The dynamical objects in this framework are the four linearly independent tetrad fields that provide the orthogonal basis for the tangent space at each point of space-time. The torsion tensor is also made up of the first derivative products of tetrad. A plethora of observations during the last two decades have confirmed the

[1] Email: f20180919@hyderabad.bits-pilani.ac.in
[2] Email: f20180094@hyderabad.bits-pilani.ac.in
* Corresponding author

late-time cosmic acceleration of the Universe. These observations have developed a curiosity among the cosmologists to explain this late time dynamics. GR on its own fails to explain this expansion. Hence the idea of modifying GR has taken momentum in the last decade. Researcher are motivated to change either geometrical part of the field equation or the matter part. In $f(R)$ gravity theory, the scalar curvature R in the Einstein-Hilbert action is changed to a suitable function $f(R)$. In another modified gravity theory known as teleparallel gravity, instead of curvature, torsion represents the gravitational interaction. Further, a generalization to teleparallel gravity (similar to $f(R)$) has been developed [7,8,9,10,11,12,13,14, 15] by replacing torsion scalar T to a generic function $f(T)$. This modified gravity theory is termed as $f(T)$ gravity theory and Linder coined the name.

Moreover, there are two important differences between these two theories first one is the field equations in $f(T)$ gravity theory remain second order while one has fourth order equations in $f(R)$ and second theory is $f(T)$ gravity theory does not satisfy local Lorentz invariance (which is satisfied by $f(R)$ gravity) so that all 16 components of the vierbien are independent and hence it is not possible to fix six of them by a gauge choice [16]. The scalar perturbation technique is used to create the perturbed evolution equations, and the stability of the models is demonstrated in teleparallel gravity [17]. The vierbeins are parallel vector fields, which give the theory the descriptor teleparallel. The advantage is that the torsion tensor is formed solely from products of first derivatives of the tetrad. The presence of some exotic energy known as dark energy results from the change in the matter portion, and the difference in the geometric part results in extended gravity. The addition of dark energy to Einstein's equations as continuous stress has helped explain this expansion. The most exciting aspect is that, while we do not know the exact nature or origin of this energy, cosmologists agree on what it is not. Recent Planck data estimates a lion share of 68.3% in favour of dark energy. The late time cosmic dynamics and the consequent dark energy is understood through a dark energy equation of state parameter $\omega = \frac{p}{\rho}$, where p and ρ respectively denote the pressure and energy density of dark energy. According to observations, the equation of state give value =-1 at present time. More generally, the expansion of the universe is accelerating for any equation of state $\omega < \frac{-1}{3}$. Several data sources, including the Pantheon supernovae sample, Hubble constant measurements cosmic microwave shift parameter, and redshift-space distortion measurement, have been used to restrict $f(T)$ gravity [18]. Pati et al. [19] have shown the cosmological models with LR, BR and PR Scenarios in the non-metricity gravity. In Ref. [20], the impact of violating the equivalence principle in the electromagnetic domain on $f(T)$ gravity is explored.

2 $f(T)$ Teleparallel Gravity

A particular modified theory of gravity which has attracted the interests of cosmologists is so-called $f(T)$ teleparallel gravity. Inspired by the formulation of $f(R)$ gravity, in which the Lagrangian of the gravitational field equations is a function, f, of the Ricci scalar R of the underlying geometry, $f(T)$ gravity is a similar generalization. The associated dynamical fields are the four linearly independent vierbeins, and T being connected to the antisymmetric connection resulting from the nonholonomic basis.

The action of $f(T)$ gravity is

$$S_{f(T)} = \frac{1}{16\pi G}\int d^4xe\,(f(T)) + S_m, \tag{1}$$

in which $e = det(e^i_\nu) = \sqrt{-g}$

In the holonomic frame the space time has the line element

$$ds^2 = -dt^2 + a^2(t)(dx^2 + dy^2 + dz^2), \tag{2}$$

where $a = a(t)$ be the cosmological scale factor.

For this frame the torsion scalar, which depends on the signature of the metric, is

$$T = 6\left(\frac{\dot{a}}{a}\right)^2 = 6H^2, \tag{3}$$

where H is the Hubble parameter.

We take $f(T)$ as

$$f(T) = T + \alpha(-T)^n. \tag{4}$$

For this model we obtain field equations as

$$12H^2 f_T(T) + f(T) = 16\pi G\rho, \tag{5}$$
$$48H^2\dot{H}f_{TT}(T) - 4(\dot{H} + 3H^2)f_T(T) - f(T) = 16\pi Gp, \tag{6}$$

where ρ is the dark energy density and p is the pressure of the dark energy.

From Eqs. (4), (5) and (6) we obtain the pressure, energy density and the equation of state parameter ω in terms of Hubble parameter as

$$\rho = \frac{6H^2 - (2n-1)\alpha(6H^2)^n}{16G\pi}, \tag{7}$$
$$p = \frac{-4\dot{H} - 6H^2 + \alpha(2n-1)(6H^2)^{n-1}(4n\dot{H} + 6H^2)}{16G\pi}, \tag{8}$$
$$\omega = \frac{-4\dot{H} - 6H^2 + \alpha(2n-1)(6H^2)^{n-1}(4n\dot{H} + 6H^2)}{6H^2 - (2n-1)\alpha(6H^2)^n}. \tag{9}$$

3 The Cosmological Models

In order to understand the background cosmology, we need to incorporate the scale factor to obtain the solution to the field equations. We will consider two different Hubble parameters and derive their respective pressure, energy density,equation of state parameter, deceleration parameter, snap parameter and jerk parameter.

To handle Eqs. (7) and (8), which are highly non-linear, we assume the hybrid scale factor (HSF), $a(t) = t^\mu e^{\nu t}$, such that $H = \nu + \frac{\mu}{t}$, where μ and ν are the arbitrary parameters and can be constrained in the ranges $\nu > 0$ and $0 < \mu < 1$ [21, 22, 24, 23]

The Hubble parameter we consider to analyze the dynamics of the Universe are

$$H = \frac{1}{t(2\lambda - t)(4\lambda - t)}, \tag{10}$$

$$H = \nu + \frac{\mu}{t}. \tag{11}$$

We consider relation of parameters with respect to redshift parameter z to do our analysis. We are using $a(t) = \frac{1}{1+z}$ to get the desired relation.

For Eq. (10) we get t in terms of z as

$$t = 2\lambda - \frac{2\lambda(1+z)^{4\lambda^2}}{\sqrt{1+(1+z)^{8\lambda^2}}}, \tag{12}$$

and for Eq. (11) we get t in term of z as

$$t = \frac{\mu}{\nu} * ProductLog[\frac{(z+1)^{\frac{-1}{\mu}} * \nu}{\mu}]. \tag{13}$$

3.1 Scale Factor $a(t)$

We are using FLRW line element to obtain scale factor from Hubble parameter and for Eq. (10) we obtain scale factor as

$$a(t) = (t)^{\frac{1}{8\lambda^2}}(t - 4\lambda)^{\frac{1}{8\lambda^2}}(t - 2\lambda)^{\frac{-1}{4\lambda^2}}. \tag{14}$$

For Eq. (11) we obtain scale factor as

$$a(t) = t^{\mu}e^{\nu t}. \tag{15}$$

The kinematic property is universal, making it easy to explain the expansion of the cosmos, but the dynamic property is model-dependent. We will use a kinematic approach in this case. We used the FLRW space-time, which is homogeneous and isotropic, to model development of the Universe. The scale factor is used to characterize rate of expansion of the universe.

3.2 Deceleration Parameter (q)

To obtain q we use the relation $q = \frac{-1}{a}\frac{d^2a}{dt^2}H^{-2}$ which for Eq. (10) yields

$$q = -1 + 3t^2 + 8\lambda^2 - 12\lambda t, \tag{16}$$

and for Eq. (11) we obtain q as

$$q = -1 + \frac{\mu}{(\nu t + \mu)^2}. \tag{17}$$

We use Eqs. (16) and (17) to plot relation between q and redshift parameter. The values of ν and μ in Eq. (11) are taken in such a way that it shows deceleration in the initial cosmic time and then acceleration in the later cosmic time so that it overlaps with the observations made till now. Value of λ in Eq. (10) is taken as 0.5 value of ν and μ in Eq. (11) is taken as 0.585 and 0.2 respectively.

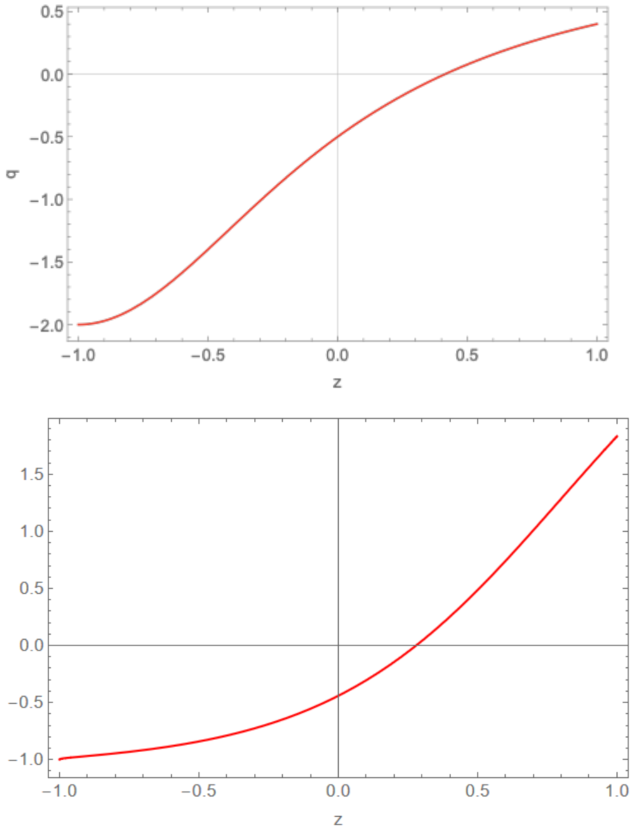

Fig. 1 Behaviour of the deceleration parameter for $H = \frac{1}{t(2\lambda - t)(4\lambda - t)}$ (Upper Panel), $H = \nu + \frac{\mu}{t}$ (Lower Panel)

3.3 Jerk Parameter (j)

To obtain j we use the relation $j = \frac{1}{a}\frac{d^3a}{dt^3}H^{-3}$. For Eq. (10) we obtain j as

$$j = 1 + 128\lambda^4 - 24\lambda^2 + 3\left(88\lambda^2 - 3\right)t^2 - 96\lambda t^3 + 12t^4 + 36\lambda\left(1 - 8\lambda^2\right)t, \quad (18)$$

and for Eq. (11) we obtain q as

$$j = \frac{2\mu + (\mu + \nu t)\left[(\mu + \nu t)^2 - 3\mu\right]}{(\mu + \nu t)^3}. \quad (19)$$

We use Eqs. (18) and (19) to plot relation between j and redshift parameter. The jerk parameter for Eq. (10) decreases slightly in the initial cosmic time and then increases in the later cosmic time (Upper Panel of Fig. 2) while for Eq. (11) it decreases in the initial cosmic time then increases slightly in the later cosmic time (Lower Panel of Fig. 2).

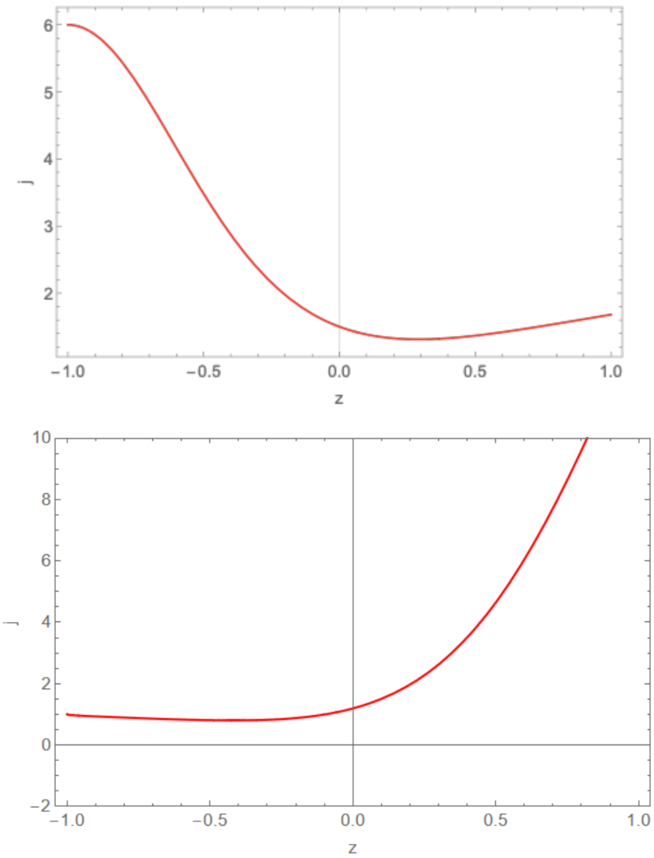

Fig. 2 Behaviour of the Jerk parameter for $H = \frac{1}{t(2\lambda-t)(4\lambda-t)}$ (Upper Panel), $H = \nu + \frac{\mu}{t}$ (Lower Panel)

3.4 Snap Parameter(s)

To obtain s we use the relation $s = \frac{1}{a}\frac{d^4a}{dt^4}H^{-4}$. For Eq. (10) we obtain s as

$$s = (-3480\lambda^2 + 75)t^4 + (-600\lambda + 8640\lambda^3)t^3 + (-11904\lambda^4 + 1632\lambda^2 - 18)t^2 \\ +(9216\lambda^5 - 1728\lambda^3 + 72\lambda)t - 3072\lambda^6 + 704\lambda^4 - 48\lambda^2 + 1 + 720\lambda t^5 - 60t^6, \tag{20}$$

and for Eq. (11) we obtain s as

$$s = \frac{(\mu-3)(\mu-2)(\mu-1)\mu + 4\nu^3\mu t^3 + 6\nu^2(\mu-1)\mu t^2 + \nu^4 t^4 + 4\nu(\mu-2)(\mu-1)\mu t}{(\mu+\nu t)^4}. \tag{21}$$

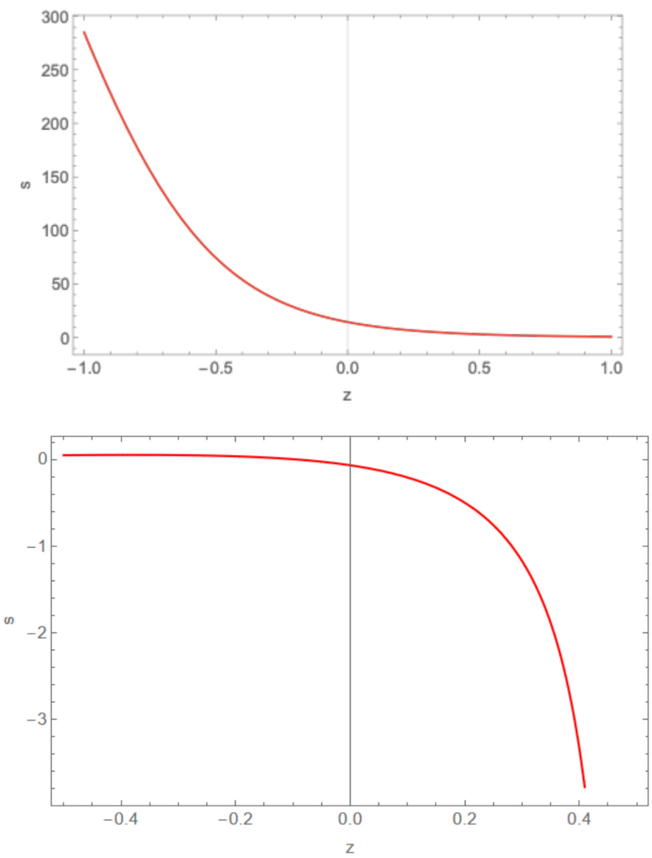

Fig. 3 Behaviour of the Snap parameter for $H = \frac{1}{t(2\lambda - t)(4\lambda - t)}$ (Upper Panel), $H = \nu + \frac{\mu}{t}$ (Lower Panel)

We use Eqs. (20) and (21) to plot relation between snap parameter and redshift.

In the literature, there are two significant geometrical diagnostic approaches. They are the $Om(z)$ diagnostics and the determination of the state finder pair (j, s) in the $j - s$ plane. These geometrical diagnostic techniques [25, 26] can help discriminate between dark energy theories. The snap parameter for Eq. (10) increases while the snap parameter for Eq. (11) decreases parabolically over the cosmic time.

3.5 Energy density (ρ)

We are using Eq. (7) to obtain ρ from the respective Hubble parameters.

For Eq. (10) we obtain ρ as

$$\rho = \frac{3}{t^2\left(8\lambda^2+t^2-6\lambda t\right)^2} - \frac{\alpha 6^n(2n-1)}{2}\left(\frac{1}{t^2\left(8\lambda^2+t^2-6\lambda t\right)^2}\right)^n. \tag{22}$$

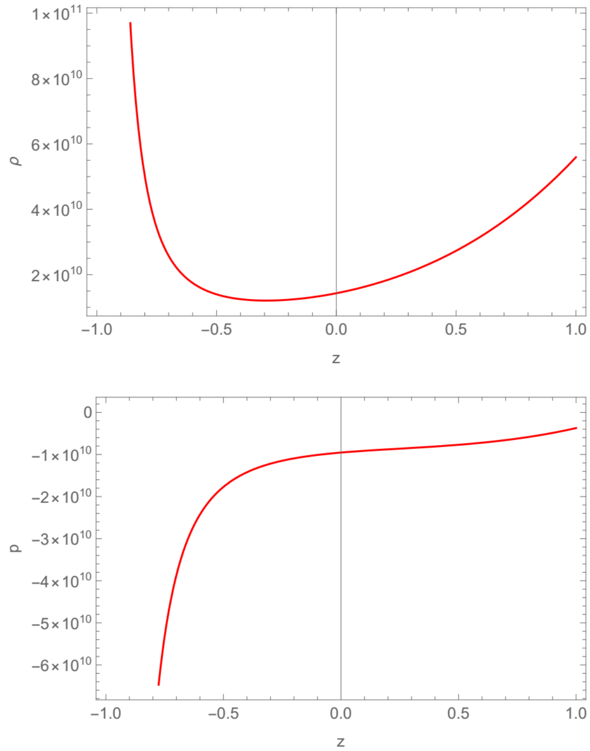

Fig. 4 Behaviour of the energy density for $H = \frac{1}{t(2\lambda-t)(4\lambda-t)}$ (Upper Panel), $H = \nu + \frac{\mu}{t}$ (Lower Panel)

For Eq. (11) we obtain ρ as

$$\rho = 3\left(\nu+\frac{\mu}{t}\right)^2 - \frac{\alpha 6^n(2n-1)}{2}\left(\nu+\frac{\mu}{t}\right)^{2n}. \tag{23}$$

We use Eqs. (22) and (23) to plot relation between energy density and redshift parameter.

The choice of n in both the Eqs. (22) and (23) have been considered in such a manner that, the energy density remains positive throughout the cosmic evolution of the Universe.

3.6 Pressure (p)

We are using Eq. (8) to obtain p from the respective Hubble parameters.

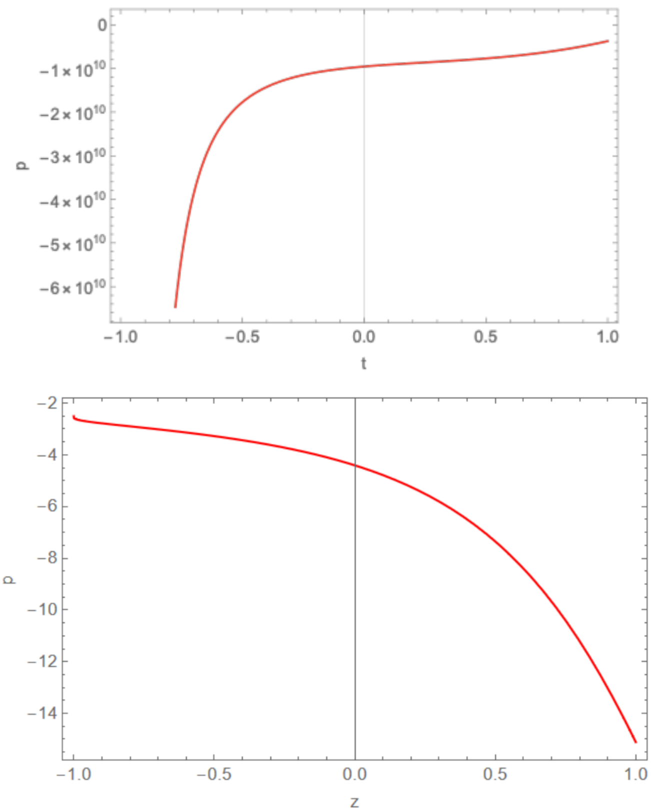

Fig. 5 Behaviour of the pressure for $H = \frac{1}{t(2\lambda - t)(4\lambda - t)}$ (Upper Panel), $H = \nu + \frac{\mu}{t}$ (Lower Panel)

For Eq. (10) we obtain p as

$$p = \frac{16\lambda^2 + 6t^2 - 24\lambda t - 3}{t^2\left(8\lambda^2 + t^2 - 6\lambda t\right)^2} - \alpha 6^{n-1}(2n-1)\left(\frac{1}{t^2\left(8\lambda^2 + t^2 - 6\lambda t\right)^2}\right)^n \left(2n\left(8\lambda^2 + 3t^2 - 12\lambda t\right) - 3\right). \tag{24}$$

For Eq. (11) we obtain p as

$$p = \frac{4\mu + \alpha 2^n 3^{n-1}(1-2n)\left(2\mu n - 3(\mu + \nu t)^2\right)\left(\nu + \frac{\mu}{t}\right)^{2(n-1)} - 6(\mu + \nu t)^2}{2t^2}. \tag{25}$$

We use Eqs. (24) and (25) to plot relation between pressure and redshift parameter. The pressure is negative in both implying the force of anti gravity which explains the accelerated expansion of Universe.

3.7 Equation of State Parameter (ω)

We are using Eq. (9) to obtain ω from the respective Hubble parameters.

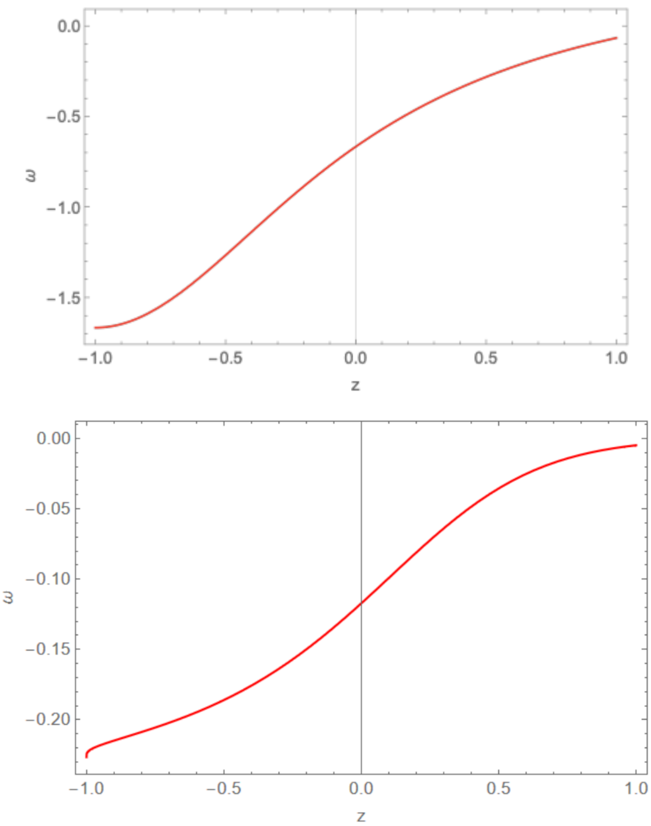

Fig. 6 Behaviour of the EOS parameter for $H = \frac{1}{t(2\lambda-t)(4\lambda-t)}$ (Upper Panel), $H = \nu + \frac{\mu}{t}$ (Lower Panel)

For Eq. (10) we obtain ω as

$$\omega = \frac{\frac{6\left(16\lambda^2+6t^2-24\lambda t-3\right)}{t^2(8\lambda^2+t^2-6\lambda t)^2} - \alpha 6^n(2n-1)\left(\frac{1}{t^2(8\lambda^2+t^2-6\lambda t)^2}\right)^n \left(2n\left(8\lambda^2+3t^2-12\lambda t\right)-3\right)}{\frac{2}{t^2(8\lambda^2+t^2-6\lambda t)^2} - \frac{\alpha 6^n(2n-1)}{3}\left(\frac{1}{t^2(8\lambda^2+t^2-6\lambda t)^2}\right)^n}. \tag{26}$$

For Eq. (11) we obtain the EOS parameter (ω) as

$$\omega = \frac{4\mu + \alpha 2^n 3^{n-1}(1-2n)\left(2\mu n - 3(\mu+\nu t)^2\right)\left(\nu+\frac{\mu}{t}\right)^{2(n-1)} - 6(\mu+\nu t)^2}{t^2\left(6\left(\nu+\frac{\mu}{t}\right)^2 - \alpha 6^n(2n-1)\left(\nu+\frac{\mu}{t}\right)^{2n}\right)}. \tag{27}$$

We use Eqs. (26) and (27) to plot relation between ω and redshift parameter. The equation of state parameter decreases from a value less than $\frac{-1}{3}$ at an initial epoch to negative values at late times in both the cases which follows in line with scientific observations. The parameters v and regulated the evolutionary behavior of the dynamical and EOS parameters. The first step was to constrain the scale factor parameters to get the geometrical parameters in the required range. Then the model parameter was constrained to produce the positive energy density (see Fig. 4 and Fig. 6).

3.8 Energy Conditions

Three energy conditions were checked to confirm the viability of both Hubble Parameters. Hence, we present here

(a) Null Energy Condition (NEC): $\rho + p \geq 0$,
(b) Weak Energy Condition (WEC): $\rho \geq 0$; $\rho + p \geq 0$,
(c) Strong Energy Condition (SEC): $\rho + 3p \geq 0$
(d) Dominant Energy Condition (DEC): $\rho - p \geq 0$.

The violation of the strong energy requirement has become so crucial in modified gravity theories, it is now threatened with extinction. The energy conditions NEC, WEC, SEC, and DEC for this $f(T)$ gravity model are currently as follows:

Except for the DEC, all models are expected to violate the energy conditions since they evolve in the phantom phase. Figures 7 and 8 graphically depicts the behavior of the energy conditions for the introduction of the Hubble parameters model in order. Only DEC is satisfied in the appropriate range for all three models, but WEC and SEC are violated as predicted. For Eq.(10) energy conditions are satisfied only in the later cosmic time and not during the initial epoch which does not support the observations where as for Eq. (11) all the energy conditions are satisfied during the entire cosmic time.

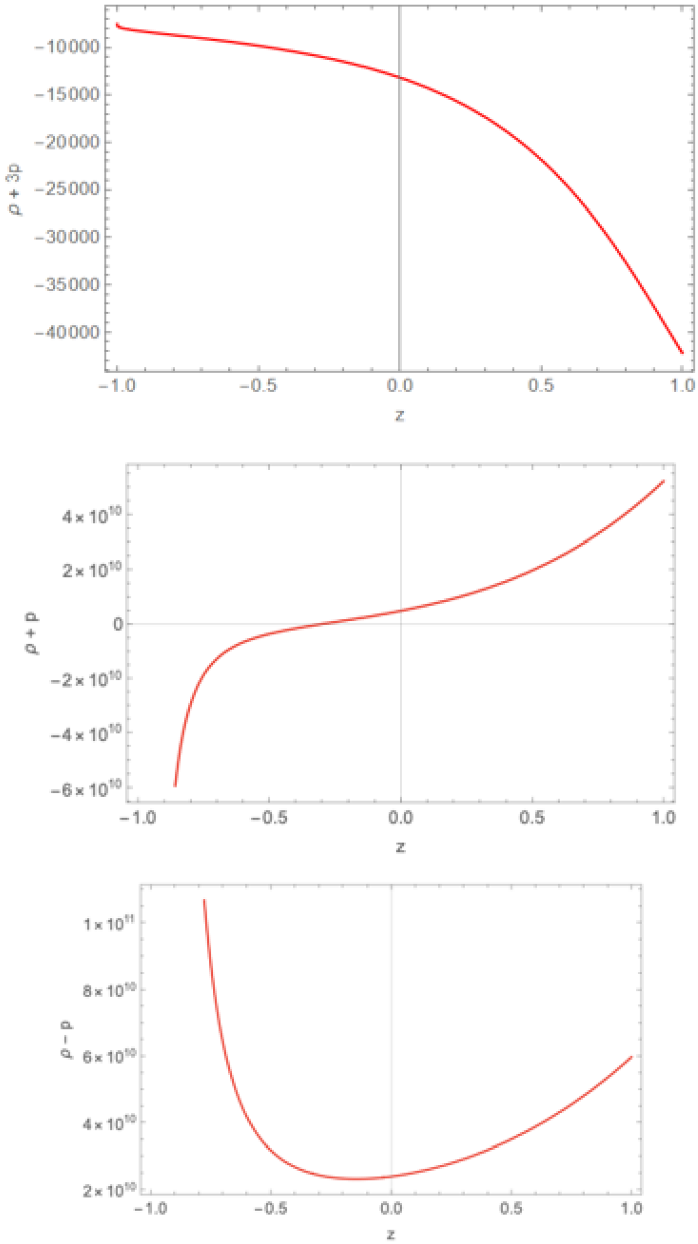

Fig. 7 Behaviour of the Energy Conditions for $H = \frac{1}{t(2\lambda - t)(4\lambda - t)}$

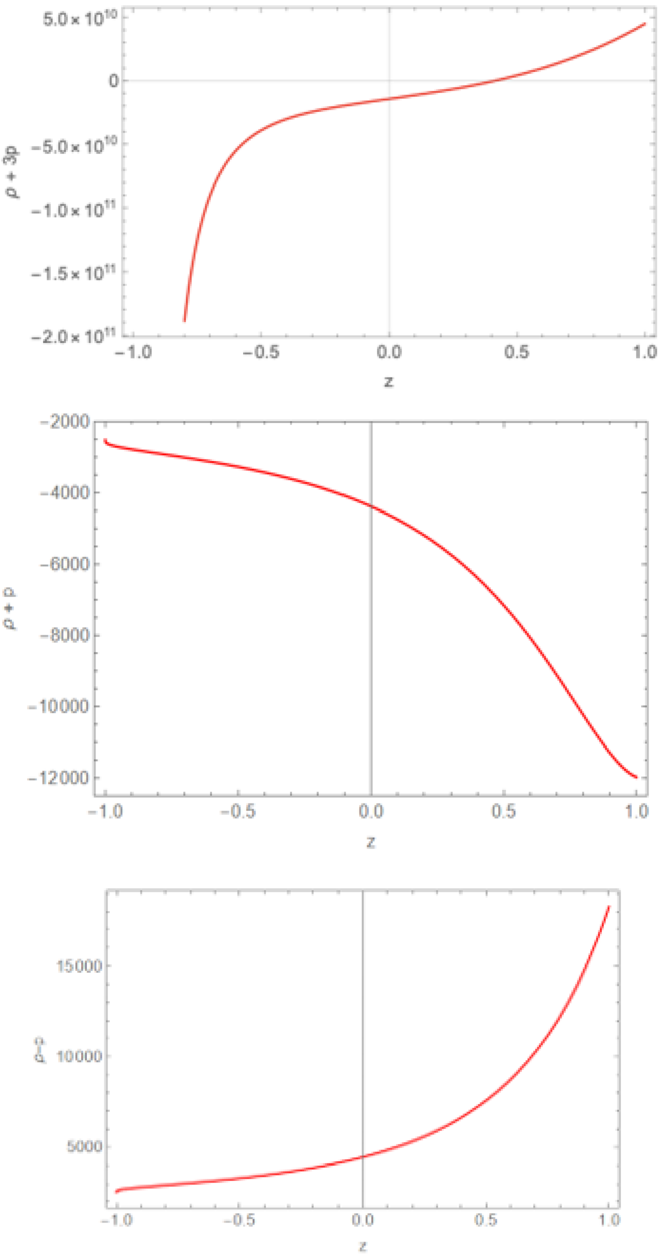

Fig. 8 Behaviour of the Energy Conditions for $H = \nu + \frac{\mu}{t}$

4 Conclusion

The physical parameters of the cosmological models are derived using the Hubble parameter $H(t) = \frac{1}{t(2\lambda-t)(4\lambda-t)}$ and $H(t) = \nu + \frac{\mu}{t}$. The equation of state parameter, from where the nature of Universe during evolution would be known, has been derived with respect to the cosmic time. The energy conditions for these two scale factors are derived along with the physical parameters such as deceleration parameter, snap parameter and jerk parameter are also derived with respect to the cosmic time. The scale factor used in this yields a deceleration parameter that is positive early and negative at late time. Relation between cosmic time t and redshift parameter z is also been derived. The graphical representation of the parameters were presented and their behaviours were analyzed. The accelerating behavior of the models under a modified theory of gravity is further validated by the violation of SEC.

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Reporting of an innovative approaches to synthesis of Martian particulate matter simulant (INDMARS) and the possibility of chemical origin of life

Tapas Kumar Bhattacharya[1*] and Mainak Ghosh[2]

Department of Ceramic Technology, Government College of Engineering & Ceramic Technology, 73 A.C. Banerjee Lane, Kolkata 700009, West Bengal, India

Abstract: The present investigation is focused on synthesizing Mars particular simulants (INDMARS-I and INDMARS-II) for the first time from India, the country of Nobel laureate Tagore. The different wet chemical route viz. combustion synthesis and aquatic salt precipitation synthesis were adopted to understand the history of the formation of matter on Mars as well as the chemical origin of life. The oxide-based composition is almost identical to the results obtained from NASA. The colour of the synthesized matter is almost identical to the image captured by the rover. The histogram of the surface topography looks exactly like the image of the rover. The specific gravity of the synthesized material is very close to that of ferrous soils. The measured values of specific gravity and tap density of INDMARS-I are 1.79 and 0.78 gm / cc and that for INDMARS-II are 1.39 and 0.56 respectively. The probability of chemical origin of life probably supports the surface topography of INDMARS-I synthesized by combustion route using urea to create high exothermicity, but the topography of INDMARS-II simulant synthesized by aquatic salt precipitation is also noteworthy.

Keywords: Mars particle stimulants; INDMARS

1 Introduction

Mars is the hotspot of astronomical studies in the upcoming time. Humanity is hopeful of colonizing Mars before the end of this century. Many space explorations are being conducted by several space agencies, both private and government, to study the geology, atmosphere and the sustainability of life on Mars. Martian regolith has been a point of interest in the eyes of many scientists. Many rovers have been sent to characterize the Martian Soil, but it could not be transported back to Earth. As a result, several institutes and agencies have devised their own Martian Soil and Dust Simulant to conduct physical, mechanical and chemical experiments and gain an insight on the processes most probable on Mars.

Razafindrambinina et al. demonstrates the method to measure the absorption spectrum of six Martian dust simulants directly with the help of photoacoustic spectroscopy. Mie theory was used with the help of absorption cross section and measured size distributions. In this way absorbing spectra was used to determine and correlate the mass percentage of iron and silica percentage in the soil [1]. Alshehhi et. al. used mask regional convolutional neural networks to detect and predict the Martian Dust Storms prevalent on the surface of Mars using satellite imagery and helps in studying the Martian meteorology which will be helpful in future human explorations. The proposed Mask R-CNN is faster and is praised for its use after training of the network. The network is able to predict 607 out 2484 dust storms on Mars [2,3,4]. Yu et al. synthesized a Martian simulant JMDS-1 from basaltic formations prevalent in Jining, southern Inner Mongolia. The synthesized simulant was then subjected to UV-NIS spectroscopy to check for absorbance and reflectance and it was also tested for thermal conductivity for potential laboratory applications [5]. Nørnberg et al. studied a fine grained magnetic iron oxide prexipitate found in Denmark for suitable simulant applications. Salten Skov 1, the simulant, showed similarity with Martian soil in terms of grain size, magnetic properties, aerosol developed a new material based standard for martian regolith simulants. The standard is developed in reference to the Rocknest, the best characterized Martian Soil till date. In accordance with this standard, MGS-1 simulants were developed, which show significant improvement over previously made simulants and is used in many studies [7,8]. Nagihara et al. used Mojave Mars Simulant (MMS) to study the varying

*Corresponding Author

[1] Email: tkb_ceramics@yahoo.co.in
[2] Email: gmainak9@gmail.com

thermal conductivity of martian regolith with different atmospheric conditions. Finite element thermal modelling was used to aid the thermal conductivity experiments that were otherwise suited for Earth regolith. It was found that with increasing atmospheric pressure, thermal conductivity increases by 20-25% [9].

Dikshit et al. showed that with the help of microbial induce calcite precipitation (MICP), it was possible to consolidate Martian regolith , that can otherwise be used to create bricks on Mars for construction purposes. The Simulant used in this experiment (Martian Simulant Soil) was procured from University of Central Florida and was used as the precursor for the development of martian bricks. *Sporosarcina pasteurii* was used to produce urease, which would facilitate the consolidation of the simulant via MICP[10].Guan et. al. developed a martian soil simulant NEU MARS-1 by grinding and mixing the basalts found in the Chahar volcanic mountains in Wulanchabu, China. The main phases present in the simulant were determined as plagioclase, augite and olivine. The simulant showed similar particle size ratio, chemical composition, phase composition, dielectric strength and thermal stability similar to the Martian soil[8, 11].The Martian Particulate simulant is devised to be chemically equivalent to the actual Martian Regolith found on Gale Crater. The chemical composition is kept identical in reference to the findings of Curiosity and all the rovers prior to that. The simulant thus formed can be used in many different chemical applications [6,11].

The present study is focused on synthesizing the Mars particle simulants, INDMARS-I and INDMARS-II by combustion synthesis and aquatic salt precipitation synthesis route to understand the idea about the history of the formation of matter on Mars as well as the chemical origin of life.

2 Methodology

The INDMARS-I and INDMARS-II simulants were synthesized by combustion route and aquatic precipitation pathways respectively, using a variety of pure salt graded chemicals as precursors with precise stoichiometry recorded by rovers [12]. The synthesized materials are properly dried and screen in different fraction. Topographic images of the surface of the INDMARS-I and INDMARS-II simulants were taken to compare with the image of the rover. The simulant was primarily characterised by specific gravity and tap density. The specific gravity of the simulant was measured by the standard specific gravity bottle using the principle of Archimedes. The tap density or loose density was measured by tapping the powder sample in a 10 ml cylinder with 25 stocks as per standard practice. The soft computation technique in MATLAB was adopted to draw the histogram of surface textureINDMARS-I and INDMARS-II and both are compared with image captured by rovers.

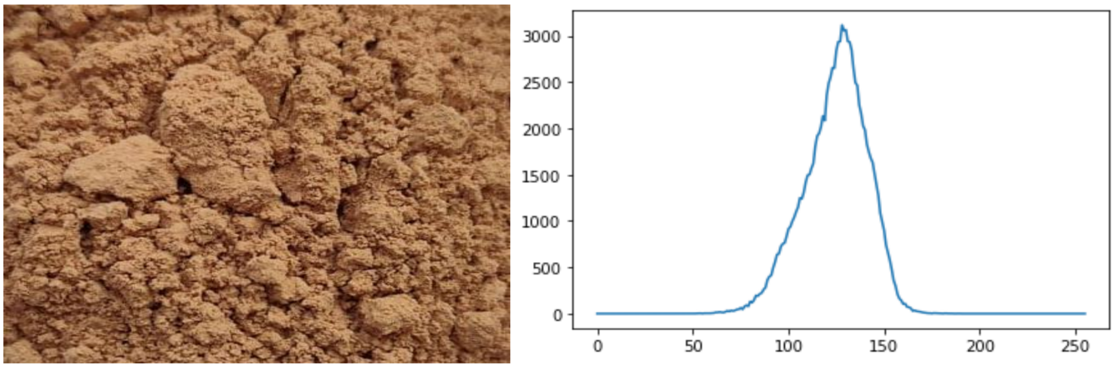
3 Results and Discussion

The chemical composition of two synthesized particulates matter INDMARS-I and INDMARS-II simulant is almost identical with the results obtained from Mars rovers by mass spectrometry [1-3]. The composition is listed in Table-1. It is composed mainly with some ceramic materials like silica and ferric oxide together with alumina, calcia and sulphur trioxides. The surface texture of INDMARS-I and INDMARS-II is totally different due to differences of synthesized routes.

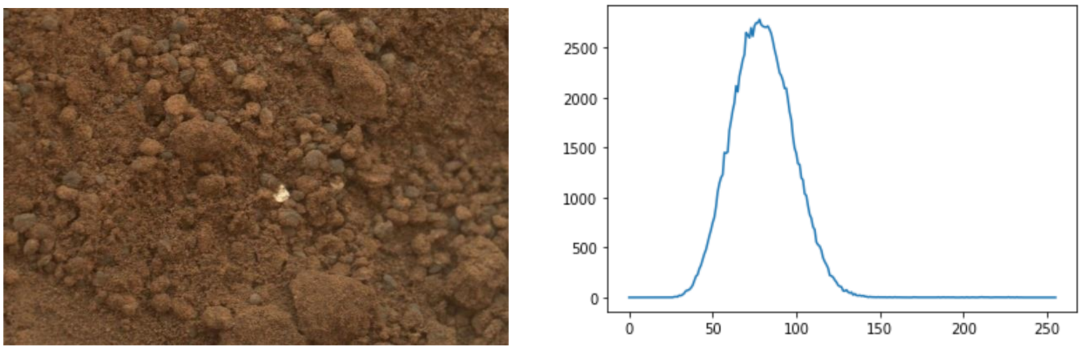
Table I: Composition of Martian soil

SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	Cl
45	0.89	9.56	16.90	8.25	6.61	2.90	0.49	0.91	7.61	0.88

The colour of the simulant is reddish in nature, identical with the surface topographic colour reported by rovers. The images of INDMARS-I, INDMARS-II simulant with rovers image and their respective histogram are shown in Figs. 1 and 2.



(a)



(b)

Fig. 1: Surface topography of Martian's particulate matter (a) Synthesized (Finer fraction) of INDMARS-I, with its histogram, (b) Rover's Image with its histogram

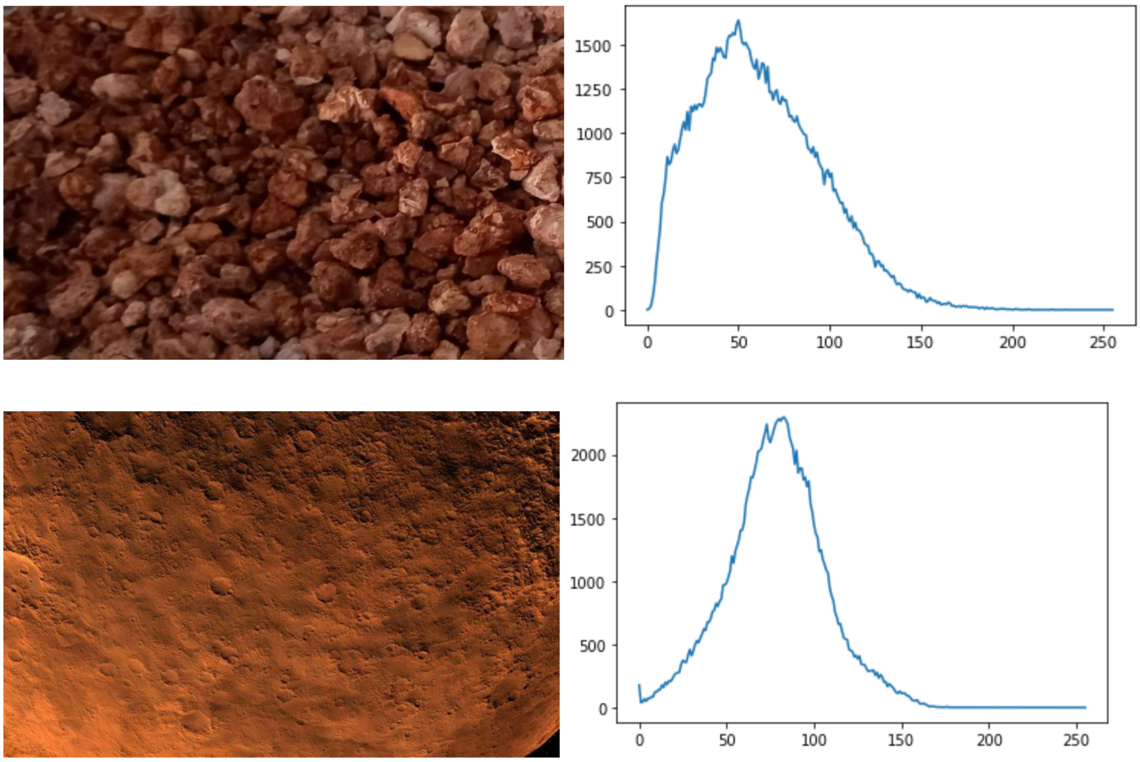


Fig. 2: Surface topography of Martian's particulate matter (a) Synthesized (Coarse fraction) with its histogram, (b) Rover's image with its histogram

The simulant synthesized by combustion route in Fig. 1, shows identical histogram as obtained from rover'simage. This indicates that combustion-type reactions may occur during the formation of matter particles on Mars. In combustion synthesis, urea was used for creation of high exothermicity. Urea is very essentially related with living cell and plays an important role in metabolism of nitrogenous compounds by animals. The body releases nitrogen using urea in many processes, converting more toxic ammonia into urea by the combination of carbon dioxide in the liver through the urea cycle[13].Plants absorb urea and are widely used as one of the sources of NPK nitrogen and widely used as fertilizer. Scientist Friedrich Ohler first discovered urea in 1828 from an inorganic substance ammonium cyanate [$NH_4CNO = CO(NH_2)_2$] without the use of biological aid, which was an important conceptual milestone in chemistry. The matter of Mars is composed of inorganic matter which should be related to the chemical origin of life. The molecular structure of water plays a significant role in supporting of life. The surface texture of the INDMARS-II and its histogram are identical to another image captured by the rovers shown in figure. The INDMARS-II was the result of salt precipitation from very dilute aqueous solution. The channels and the banks found in the Valles Marineris and the soil profiling suggest the presence of flowing water many times ago. The soil image captured by rover broadly resembles that of the surface topography as shown by INDMARS-II, which further strengthen the possibility. The mind of the scientist always cries out for the parallel behaviour of the presence of water on Mars.

4 Conclusion

This investigation concluded that the synthesis of INDMARS-I and INDMARS-II simulant was successfully achieved and reported first time from India. The chemical composition is almost identical to the NASA report. The colour of both stimulants are reddish and their respective histogram showed the close resemblance with the images capture by rovers. The Urea added simulant can be correlated with the chemical origin of life.

Acknowledgement

The authors would like to thank Prof. (Dr.) Krisnendu Chakraberty, Principal, Government college of Engineering and Ceramic Technology, Kolkata for his kind permission as well as valuable suggestions to publish this research paper. Authors also indebted to Prof. Partha Haldar, Department of Mechanical Engineering, Government college of Engineering and Ceramic Technology for his kind co-operations and great help in MATLAB operation without which it would not be possible to publish.

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Making of a cryptographic mechanism to enhance security in message transmission

Sayantan Chakrabarti[1*] and Rahul Binani[2]

Department of Information Technology, B P Poddar Institute of Management and Technology, Kolkata 700052, West Bengal, India

Abstract: Cryptography is a familiar technique to safely send a message or data where privacy and secrecy needs to be maintained from the source to the destination. This transferring of confidential information has been considered under a threat now-a-days due to the intermediate attackers. The idea of making this machine started off with a hybrid security approach consisting of different algorithms, viz., Substitution and RSA, including some secret bit adding. Further transferring the encoded message over a network. When a certain encoded message is sent, each of its character gets shifted by a certain position, and then it is converted into bytes. RSA is applied over these bytes for several timesand finally some extra bits are added to these to end up with the encrypted text. Then this encrypted text is transferred over the network. At the receivers' end the same process chronologically opposite manner is applied to find the actual plaintext.

Keywords: Encryption; Decryption; RSA; Substitution; Bit padding

1 Introduction

A mechanism which deals with privacy of the message or information from attackers, i.e., keeps the message safe and secure by changing its actual form is known as Cryptography. This is generally segmented into two types: named as Symmetric Key Cryptography and Asymmetric Key Cryptography. Symmetric key cryptography has classical cryptographic mechanism such as Transposition Cipher and Substitution Cipher. On the other hand, Asymmetric cryptography has modern approaches like Stream Cipher and Block Cipher. However, we would be focusingupon both the kind of cryptographic techniques and will be building an asymmetric cryptographic machine. When a single key is introduced by both the sender of the data and the receiver of the data to encrypt and decrypt the data respectively is called Symmetric Key cryptography. However, if there are different multiple keys for this approach with the sender and the receiver, it is named as Asymmetric Key Cryptography. The keys that are required amongst the sender and receiver are shared through secretmeans.

This project aims at securing the confidentiality on the exchange of information between the sender and receiver using a mixture of existing algorithms making it much stronger. Many algorithms in the society have already been cracked by the unethical attackers, and now it's high time to introduce something new approach which successfully helps in maintaining privacy and confidentiality of data among the users.

2 LiteratureReview

Paper [1] states that Cryptography has a vital role in data security purpose. It ensures that the contents of a message are securely transmitted and would not be changed. Network security plays most vital role in information security as it is attached withall hardware and software function, characteristics, workings processes.

Paper [2] gives an idea that Nowadays security is very much needed to protect our sensitive data in computer or over the internet medium such as in online banking, online shopping, stock market and bill payments etc by proposing a new cryptographic algorithm AEDS (Advanced Encryption and Decryption Standard) which is designed by adding features of DES and AES algorithms and compared all the algorithms and it is discussed that AEDS is more robust for securing ofdata.

*Corresponding Author

[1]Email: 92sayantan@gmail.com
[2]Email: binanirahul1808@gmail.com

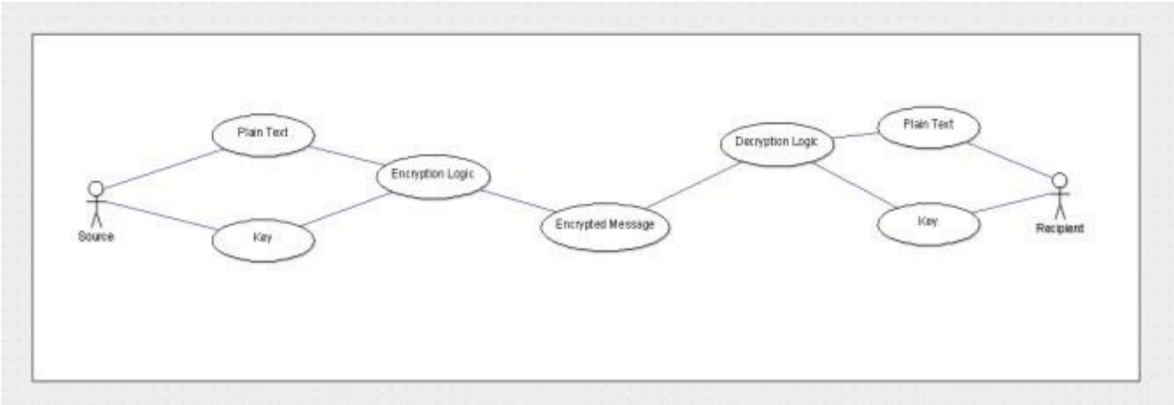


Fig. 1: Secure message passing mechanism

Paper [2] gives an idea that Nowadays security is very much needed to protect our sensitive data in computer or over the internet medium such as in online banking, online shopping, stock market and bill payments etc by proposing a new cryptographic algorithm AEDS (Advanced Encryption and Decryption Standard) which is designed by adding features of DES and AES algorithms and compared all the algorithms and it is discussed that AEDS is more robust for securing of data.

Paper [3] tells that The algorithm required for enhancing security should fulfil the requirements of authentication, confidentiality, integrity and non-repudiation. In this paper, the brief introduction of AES, DES, RSA, Diffie-Hellman, RC4, Blow Fish, El-Gamal, MD5 and Miller-Rabin gives an idea of different security approaches.

Paper [4] describes about the availability of multiple data security methods at market. They may vary by speed, strength and resource consumption that is use of CPU, Power, Storage device. Among them popular and interesting algorithms are described.

Paper [5] discussed a new cryptographic algorithmic method to secure the data for inducing Data Security that can be used to secure the various applications on cloud computing.

Paper [6] signifies the necessity of data security in modern days. It also signifies the utility of different data security algorithm like AES, DES and give some idea about data compression.

Paper [7] focuses on various types of cryptography algorithms that are already exists like AES, DES, TDES, DSA, RSA, ECC, EEE and CR4...etc. It also focuses on the different challenges in securedata transmission over different medium.

3 Proposedworks

Enhancement of security in data communication is the ultimate motive ofthis project. Here we have introduced a hybrid algorithm which has its base upon the RSA (Rivest, Shamir, Adleman) Algorithm, substitution and bit padding. Before moving to the task, some points about the individual algorithms. Starting off with the most important part of this algorithm, i.e., RSA Algorithm. Having its base set upon asymmetric cryptography the keys are generated using very large prime numbers. After the key formation, encryption starts. The formula for encryption reads $c = m^e *$ (mod n) where c is cipher text. The decryption formula reads $c^d = m *$ (mod n). The encryption and decryption can be done by anyone but what plays an important role in security is the formation of keys using unbreakable primenumbers.

Secondly, the substitution algorithm is a cryptographic technique where the plain text is replaced with other characters following a set of sequence and shifting rules. Here we have used monoalphabetic substitution.

Lastly, we have implemented bit padding i.e., adding random bits to the end of the cipher text. These bits are added for the purpose of fooling the man in the middle who gets an incorrect idea about the exact length of the message. Moreover, if the attacker decrypts the whole message, it would not get the exact message.

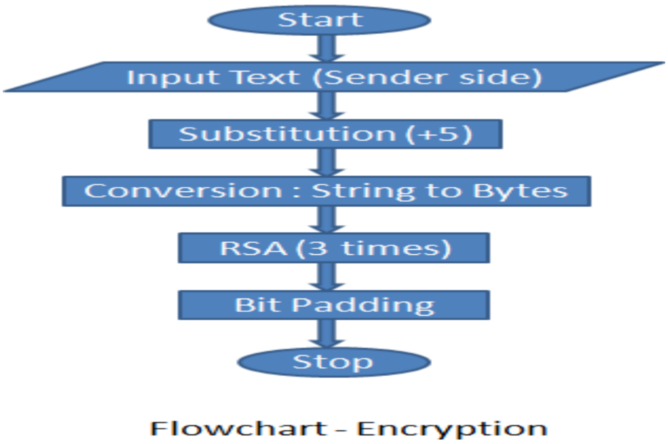


Fig. 2: Encryption Mechanism

At the beginning, 2 keys are generated, i.e., public and private at the server side and receiver side each.

When the sender generates a message and sends it to its receiver, firstly the message is substituted by its 5 successive characters. Then the resultant string is converted into bytes and this set of bytes undergoes RSA encryption for 3 times i.e., the output of each RSA acts as the input of the next. Finally, the output of the third RSA is added up with some random bits as a concept of bit padding. Ultimately this whole sequence is transferred over thenetwork.

As it is in the more secure form, the attacker even if attacks won't succeed easily in decrypting this cipher text into plain text. As this message reaches the receiver side the decryption process starts. The message leaving aside the padded bits is extracted. Reverse RSA is applied (decryption of RSA) for 3 times and finally this is shifted with 5 predecessor characters. Ultimately the plain text reaches the receiver.

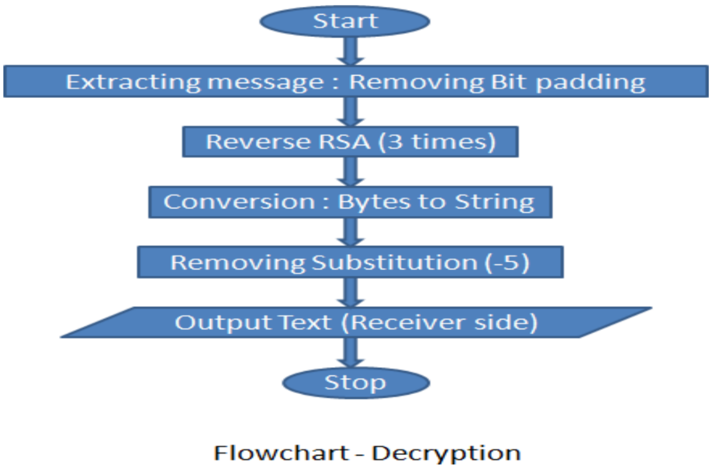
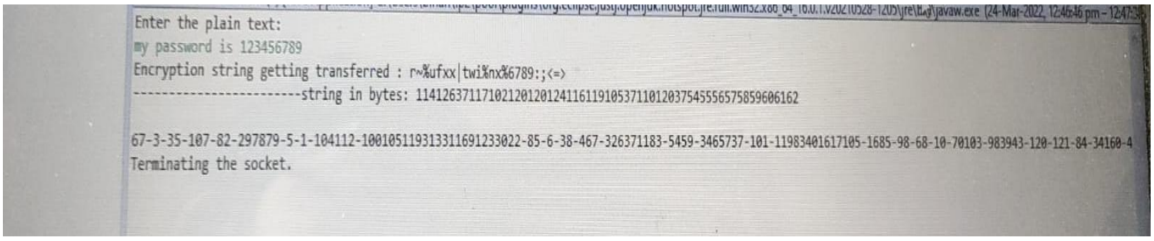


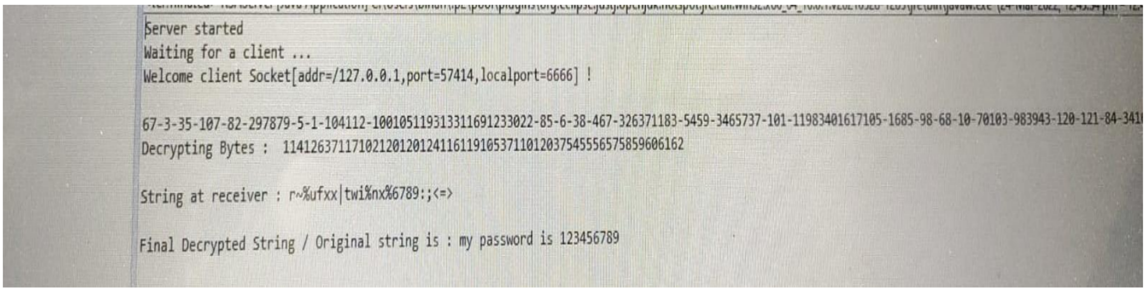
Fig. 3: Decryption Mechanism

4 Results

The plaintext generated by the sender when converted into cipher text is of the type Big Integer. This Big Integer variable is transferred over the network to the receiver side. Upon decryption it returns back the plain text. As we see the cipher text is long enough but is transferred easily over the network to the receiver. It also ensures security which is our main concern; however, time taken is also minimal.



Sender side



Receiver side

5 Conclusion

A build in technique which ensures safety, security and privacy of information through mathematical concepts and codes is generally referred to cryptography. With the help of different concepts, we have successfully formed a hybrid algorithm of asymmetric cryptography. We have reduced the chances of attacks over the messages flowing over a network. In today's world of new technology when we from all sides are surrounded by OTPs and Passwords, we sometime or the other find the need to exchange the same over the communication network itself with someone. A fear arises at this time that what if someone steals our confidential password or OTP over the transmission network. This feeling worsens if the credentials are of some Bank Account details. To release such stress this algorithm would play a vital role. Common people would be more assured about the security of their message.

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BOOK REVIEW

Suman Beri: A fearless woman scientist

**Suman Beri-Higgs Boson, Top Quark and Single Top Quark:
The story of Punjabi woman scientist**

Duren, Shaker Verlag, 2022. ISBN978-3-8440-8469-6ISSN 2198-8552.

xxii+160p. Price: 23.90 Euro

Anjana Chattopadhyay[1]

Former Director, National Med. Lib. (MOH & FW)

The author of the book Rajinder Singh is a prolific explicator, he is credited with 140 articles and 38 books. He is a lauded biographer of pioneering Indian physicists. Recently he focused his attention towards Indian women physicists who deserve to be remembered for their contributions. The present book is an addition to this series, where he revealed illuminating details of Suman Beri's life and work.

[1] Email: anjanachattopadhyay@gmail.com

Suman Bala Paruthi (nee Beri) was born on 6 August 1949 to Daulat Ram Paruthi and Morni Devi. They had two sons and two daughters. Suman was the youngest in the family. Her brother Ish Kumar died in 1974 due to heart attack. Her second brother Suresh Chandra is retired Professor of Medicine from the Government Medical College, Patiala. Her elder sister Saroj Bala is a retired Post Graduate teacher.

Suman started her school education at the Convent of Jesus and Merry School, Shimla. She didher Higher Secondary from the Punjab University in 1965. Completed her B.Sc. (Honours) in 1969 and M.Sc. (Honours) in 1970 from the same university. In 1972, she qualified ETT Course (Russian) withdistinction. She did her Ph.D. under the supervisor Virinder Singh Bhatia in 1976. Her Ph.D. thesis was on "*A comparative study of the fluxes of low energy helium and Z >10 nuclei in primary cosmic rays over Fort Churchil in 1963, 1964 and 1967*."

In fact Suman wanted to be an engineer, but after pre-engineering she realized that she wasthe only one female student in the engineering college. Suman's instinct led her to study and face the challenges of studying physics, a male dominated subject. While going through the process of admission some faculty members wanted to dissuade her. But the Head of the Department, Bal Mukand Anand came forward to confirm her admission to the Physics Department, Punjab University (PU).

In 1974, she was appointed as Teaching Assistant. She was promoted to the post of Lecturer in1981. During this period she conducted two projects under DAE Scheme (1973--1974) and one projectunder TIFR (1981--1984). She was upgraded to the position of Reader in February 1987 under the UGC Merit Promotion Scheme. In 1996, she was raised to the post of the first woman Professor in Physics. She retired from the Department of Physics, PU, Chandigarh in August 2009. After her retirement, she continued in the Department as Professor until 2014. She became CSIR Emeritus Scientists in 2012. From 2015-17, she served as UGC Emeritus Fellow. She also worked as adjunct Professor in Sholini University, Solan. She served as the President, Physics Association for about ten years till her retirement in 2009. She was the founder Vice-President of the Society for the Promotion of Science and Technology in India from 2008--2015. Unfortunately she is not a fellow of three Indian Science Academies.

The document traced the history of the foundation of cosmic ray research in India. Initially it started at the Forman Christian College, Lahore in 1920s. When the American scientist Arthur HCompton visited in 1926 and started a research project in India with the support of the PunjabUniversity, Lahore. As the Punjab University did not have its own suitable laboratory, the researchrelated to the project was conducted at the Government College and the Forman Christian College, Lahore. A H Compton (USA) and C T R Wilson (UK) shared Nobel Prize in physics in 1927. This project implanted interest in the field of cosmic ray research among the scientists of the PU. In 1946, Hari Ram Saran and O P Sharma recorded valuable observation on measurement of directional total intensity ofcosmic rays in Lahore. Piare Singh Gill, a student of the same college also made valuable researchfindings on cosmic rays. In 1945, the Bombay Chronicle reported the progress of the cosmic rays research done in the Forman Christian College.

Due to the development of the particle accelerator, scientists found more than 100 subatomicparticles, classified as Quarks (6 types) and Leptons. Proton and neutrons are made up of still smaller particles called quarks. Quarks and Leptons are the building blocks of matter. C T R Wilson first took the photograph of ionized particles through his newly invented Cloud Chamber method, for which hereceived the Nobel Prize in Physics. The cloud chamber method was further improved by D M Bose (Kolkata), who laid the foundation of High Energy particle physics in India. In 1940, D M Bose and Bibha Chowdhuri showed the advantage of photographic plate method over the cloud chamber method forthe detection of cosmic particles. This method was further studied by C F Powell (UK), who won the Nobel Prize in physics for his work in 1950. Later he wrote a book on the subject and duly acknowledged the work of D M Bose and Bibha Chowdhuri.

B M Anand from Punjab University did his Ph.D. under C F Powell and he introduced theemulsion technology in the Department of Physics, PU. The Compact Muon Solenoid (CMS) is one ofthe two large particle detectors constructed on Large Hadron Collider (LHC) at CERN. The CMS is built to study particles like Higgs boson and dark matter. In the construction and experimenting of CMS, 206 institutions from 47 countries (including India) were involved. As per CERN Library's record, many scientists from India participated in CERN projects. Suman made valuable research contributions inparticle physics in Hadron-Nucleus Collisions in nuclear emulsions. She was a member of India-CMS collaboration and served as a co-investigator in CMS project.

She visited Fermi Lab, USA in 1993 and 1996 to collaborate with Manbir Kaur (Ph.D. scholar), Dimtri Bandurin (Virginia) and Ashis Kumar (New York) in D Zero (D0) experiments. Their research findings were published on the front page of *"Fermilab Today"* along with the photograph of fourscientists. Fermilab is the United States' premier national laboratory for particle physics research. The *'Fermilab Today"* is one of the most reputed journals in high energy particle physics.

She worked in the top quark group and the group successfully discovered top quark. In 2009the landmark discovery of single top quark was observed. The experiment involved 501 discoverers from 80 institutions across the world. She made notable contributions in these projects. Review of modern day Cosmic ray research remains incomplete without the inclusion of Suman Beri's contribution in the field. I feel there is an utmost need to revise the write up entitled with "The pioneers of cosmic ray research in India" by Hardev Singh Virk and Rajinder Singh [*J. Space Sci. and Tech.* **5** (2016) 17--23].

A separate chapter has been devoted to high light the publication of Suman Beri's achievements through press. It has provided copies of many press clippings mainly from Punjab dailies. Her publications are frequently reported in Indian print and electronic media, whenever they became international news. However date and source of their reference are missing in many of the clippings documented. She has published 1615 articles (under single or joint authorship) in literary journals with high impact factor. She edited one book on high energy and nuclear physics. The Department of Science and Technology, Government of India published "*International Comparative Performance of India's Research Base (2009-14): A bibliographic analysis*." According to this the publication Suman Beri and Vipin Bhatnagar of PU (both of them related to the CERN and Fermi Lab projects) are the two teachers, who are in the list of top 10 scientists in the country in terms of publications. She was honoured by the Rotary Club, Chandigarh for the discovery of the top quark. She received the Best Faculty Award from the Ministry of Human Resources and Development.

Suman's life journey to a scientific career was not easy. She had to struggle through various personal tragic events. She was married in 1977 to Hainder Krishan Beri, who was in Agriculture Research Services in the Central Institute of Fisheries Technology. Unfortunately he expired in 1992 due to cardiac arrest. She learnt lesson from the compelling events and reaffirmed herself to never give up. Fortunately she received support from her parents, in-laws, friends and colleagues. During the time of difficulties she got the support of scientific meditation techniques at home by joining Yogoda Satsanga Society of India, headed by Sri Paramahansa Yogananda. She always respected good teaching of all religions and believed that "Spiritualism starts where religion ends."

She is very fond of gardening, cooking and public relations. She always accommodated herselfin any situation. She is a perfect balance between a traditional and modern Indian woman. Difficulties and challenges could never deter her from achieving her target. From the enrolment of students under her guidance, it appears that she lifted feminism in the field of science. It is notable that 12 out of 17 Ph.D. scholars completed under her supervision were female.

It is a brilliantly written biography which re-emphasized that science has no gender or ethnicity. Only the merit of research matters. I am sure the document will inspire younger generation to pursue their dream of scientific exploration and discovery.

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Report

THE SKY WATCHING CAMP

Swagatam Biswas [1] and Ankita Saha [2]

Department of Computer Science & Engineering, Government College of Engineering &Ceramic Technology, Kolkata 700010, West Bengal, India

Sky watching is basically observing the sky to spend leisure time or out of interest for the enrichment of our knowledge on space and cosmos. To generate interest in celestial observation among the students and the teachers, a Sky Watching Camp was organized on the rooftop of the hostel of our college, Government College of Engineering and Ceramic Technology from 3pm to 9pm on 9th April under the guidance of our professors of physics Dr. Nilesh Majumder, Dr. Prasenjit Paul and Dr. Saibal Ray. Our professors set up a 6 inches Galilean telescope for watching the celestial objects. In this report our experience has been shared below.

Figs. 1&2: Pictures of the telescope

[1] Email: swagatambiswas204@gmail.com

[2] Email: ankitasaha269@gmail.com

- **OBSERVATIONS**:

❖ **<u>PHASE I (*In the day light*)</u>**

A screen was hold parallelly in front of the eyepiece and the image of the sun could be seen. To see the sun through the telescope directly we can fit a solar filter. Keeping the screen at a certain distance the image was prominent and very light sunspot was seen. It was hard to capture with the camera.

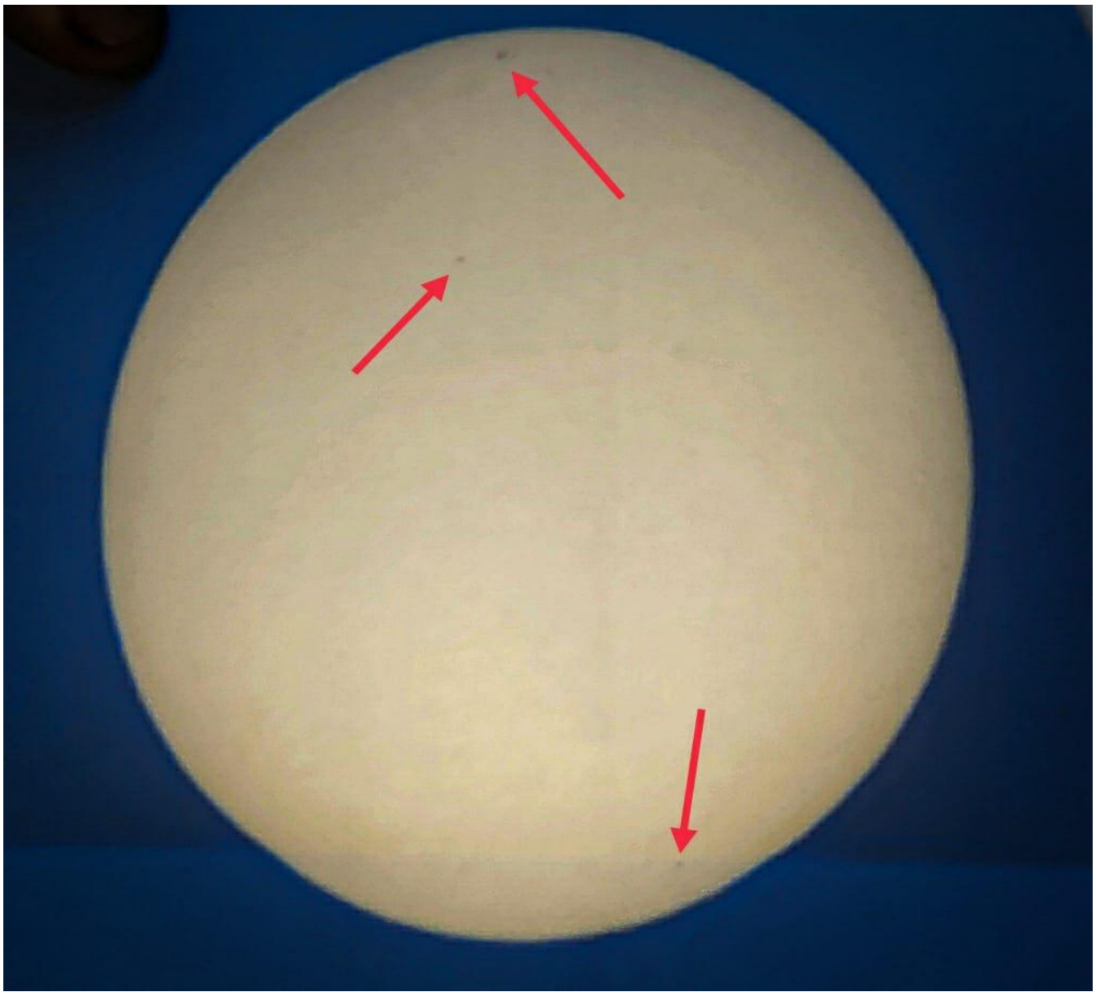

Fig. 3: The Sunspots

Three sunspots are formed on the screen. We had an option to watch Mercury but we also couldn't see that. It was visible in northern hemisphere.

❖ **<u>PHASE II (*After Sun set*)</u>**

As the sun sets slowly and we have seen the moon. We take our telescope to a place from which the moon could be seen. Fixing all the nobs and focusing the lens a beautiful, clear moon was seen by us. The craters on moon were clearly visible there. A Barlow lens was used to see the moon more clearly. *<u>Barlow lens</u>* create magnified image by increasing the effective focal length of the telescope. The Orion were also seen in the sky that day.

Fig. 4: Picture of the Moon captured

- **LIMITATIONS:**

For the bright rays of sun two solar filters got cracked. Holding the screen parallelly in front of the lens steadily for a long time was a problem. While observing the moons many times the clouds were covering it, that was also a problem. The moon was moving with time so we had to adjust the telescope accordingly many times. It was our first sky watching camp so it wasn't well organized.

- **FUTURE AIMS:**

Planets like Jupitar, Mars can only be seen from June onwards up to December. So we are like to organize our next sky-watching camp on October preferably. It will be better time to avoid the cloudy sky and also we are planning next sky watching camp on a place with less pollution. We can make our own data sheet time to time to understand the changes with time, more prominently. Some lectures or discussion can be held on this topic to grow our interest and knowledge.

Even though it was the first sky watching camp and we faced many difficulties, still the whole experience was very much interesting. We hope to explore more things of the sky next time.

Fig. 5: Fixing the telescope