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SYMPOSIUM ON SPACE SCIENCE &TECHNOLOGY 2020

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MESSAGE FROM THE CHAIRMAN

Professor Sisil Kumarawadu, PhD, SMIEEE

Senior Professor in Electrical Engineering
Head, Department of Electrical Engineering
University of Moratuwa, SRI LANKA
Distinguished Professor-Shanghai University of Electric Power
Chairman of the BoG-Arthur C. Clarke Institute for Modern Technologies

First and foremost, I would like to congratulate the Young Scientists and Engineers (YES) Forum, on this grand initiative, the inaugural Symposium on Space Science and Technology. Such symposiums serve as platforms for the individuals and institutions who are engaged in R&D in the specific subject domains to link up with each other, exchange ideas and findings, and to explore the common grounds for collaboration.

Space Science is much more than a hobby but has strong national relevance and importance. Arthur C Clarke Institute for Modern Technologies (ACCIMT) as a pioneering institution in the country in the area of space science and technology has a pivotal national role to play as an up-to-date knowledge hub that can readily provide solutions for the issues arising in the related areas. To that end, this initiative by YES, is very important and has the potential to steadily grow to become a major forum in the region. I take this opportunity to invite the participating individuals and organizations to take part on regular basis and make the maximum use of this symposium to network and search for opportunities for stronger collaborations. All the best!

MESSAGE FROM THE DIRECTOR GENERAL & CEO

Sanath Panawennage

It is certainly a matter of pleasure for me to issue this message on the occasion of inaugurating the 'Symposium on Space Science and Technology' organized by the ACCIMT. This event, which happens in the form of a mini-symposium under the constraints brought about by the Pandemic, will certainly have the potential of graduating into a regularly held established event in the area of space science, technology and applications, in the years to come.

Our national development dialogue has recognized the need to build an increasingly knowledge-based, innovation-driven economy; and space technology and its applications obviously constitute a key element of the bundle of advanced technologies in which we, as a nation, should build our national capabilities in propelling national development.

Symposia of this nature will certainly contribute to creating the environment for both knowledge dissemination and broader awareness towards this end.

I thank the organizing team of the symposium and wish this event be a great success.

KEYNOTE ABSTRACT - Satellite Technology

Sanath Panawennage

Director General & CEO
Arthur C. Clarke Institute for Modern Technologies

Developing Sri Lanka's National Capacity in Space Technologies: Choosing the Right Bench-Marks from Regional Experiences

Space Technologies and their Applications, once the domain of a few technologically advanced nations, have now become a domain of broader techno-economic and socio-political interest in the national development agenda of both developed and the developing nations. Today, space technologies have found applications in all conceivable facets of human activity, spanning the domains including weather forecasting and climate change mitigation, monitoring and protection of natural environmental eco systems including air, water, soil, oceans, forests and glaciers, natural resources management, surveying, urban development, surface transportation, maritime and air navigation, telecommunications, agriculture, industry and commerce, and disaster risk reduction.

Thus, space technologies, with the ubiquity of their applications across all conceivable facets of techno-economic and socio-political spheres of activity leading to an increasingly larger 'space-related' component in national economies of countries, have come to constitute a key element in the ensemble of 'core-enabling technologies', in which nations across the world are placing increasingly greater emphasis in building their national capabilities.

While Sri Lanka has already embarked upon some significant programmes toward development of its national capabilities in space technologies and applications, long term sustenance of those programmes, as well as realization of their optimal benefits through comprehensive socio-economic integration, essentially stand to benefit from effective bench-marking against carefully chosen regional experiences.

Editor's note:

The speaker Eng. Sanath Panawennage is the Director General / CEO of the Arthur C Clarke Institute for Modern Technologies; Served as the Chairman of the UNESCAP's Inter-governmental Consultative Committee of Regional Space Application Programme on four sessions including 2019/2020 session; Project Director of Raavana Nanosatellite Project; Member of the Governing Board of Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP).

Modelling the Helmholtz cage for ground testing of Attitude Determination and Controlling System (ADCS) of Nanosatellites

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This research focuses on emulating the magnetic fields experienced by Nanosatellites in their orbits by means of a Helmholtz cage for ground testing of the Attitude Determination and Control System (ADCS) of Nanosatellites. The algorithms were implemented using MATLAB (2018b). The magnetic field in a certain orbit can be modeled using the World Magnetic Model (WMM) in the MATLAB Aerospace Toolbox when the orbit information is given. Using this tool, our implemented algorithm was able to acquire the orbit's magnetic field as components in three axes that can be assigned to the three sets of Helmholtz coils in the Helmholtz cage used in the study. To physically implement the required magnetic fields inside the cage, its behavior had to be analyzed. This was first done for one of one of the three coils. The selected coil was supplied with a current through an Arduino based driver which can vary the provided current according to the pulse width of a rectangular pulse. The resulting magnetic field at the center of the coil was measured by Honeywell HMR2300 magnetometer with gradually increasing pulse width. Using this data, a relationship between the pulse width and the created magnetic field was obtained. For the modelling of an orbital magnetic field inside the cage, the magnetic field experienced by a Nanosatellite in the orbit was calculated using the implemented algorithm by taking a Two-Line Element (TLE) dataset of a Nanosatellite as the input. The pulse widths related to the magnetic field in one particular axis (X - axis) throughout one period of the Nanosatellite were calculated using the derived relationship and the related current variation was applied to the relevant coil. The magnetic fields created by the coil was measured and plotted against the pulse widths. The plot of the expected magnetic field variation and the experimentally implemented magnetic field variation were found to be similar. While the theoretical variation was smooth, the experimentally acquired variation had discontinuities.

Key words - *nanosatellites, ADCS, helmholtz cage, WMM, TLE*

Simulation of deployable solar sails

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Concept of solar sailing which uses solar energy to propel a spacecraft is becoming popular as a low-cost spacecraft propulsion system, especially for high energy-consuming long-range spacecraft. To capture a sufficient amount of energy these solar sails are orders of magnitudes larger in size compared to space available in spacecraft. Moreover, these solar sails, consist of thin folded membranes supported on a backing structure made of self-deployable booms. Hence these solar sails along with deployable booms will be subjected to very high compaction to store in launch vehicle for transportation. While thin membrane panels are folded by introducing a series of fold-lines, deployable booms made of thin woven fibre composites are commonly used as a backing structure in these applications. Analogous to thin membrane panels, these booms are subjected to very high compact configurations which induce high stresses and curvatures. Hence, an optimized folding mechanism for solar sails is important to fully function during the deployment without failure. Simulation of deployment behavior of these solar sails along with booms will facilitate the identification of suitable folding mechanism and optimized designs. In this study, idealisation techniques are presented to simulate accurate solar sail deployment. First, a simulation of a selected repetitive unit cell pattern of Miura-Ori folding was performed to develop an idealization method for the intersected creases in a virtual environment. Also, the effect of membrane thickness on the deployment was studied and verified using a series of experiments. Results illustrate that the connection with rotational stiffness gives better idealisation, and the deployment force and shape have a significant influence from membrane thickness and fold-line geometry. Secondly, a simulation of woven fibre composites was performed to capture the nonlinear bending behavior which is crucial in predicting the accurate behavior of deployable booms. The numerical model developed can capture accurate moment-curvature response, as observed in experiments, including the non-linear behavior. This indicates that modelling techniques presented are capable of utilizing for simulation of a large-scale solar sail with the backing structure to develop optimised designs.

Key words *- Miura-Ori, Rotational stiffness, Woven fiber composites, Booms, Unit cells*

Shape Reconstruction of Solar Sails using Photogrammetry

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Solar sailing is a ground-breaking approach to propelling space structures through space. The larger solar sails outfitted with the spacecraft are constructed of ultra-thin, lightweight and highly reflective membranes. The solar photons strike the mirror-like surface when the sail is exposed to sun and bounce off transferring momentum to the sail, eventually giving spacecraft a small push to propel. The momentum provided by an individual photon is too minimal to drive the spacecraft. Hence, the solar sail should be sufficiently large in area to stimulate the required amount of momentum for the movement of the spacecraft. The extremely large solar sails are packed in a smaller launch vehicle and deployed to its entire area during their operation. The general arrangement of a solar sail consists of lightweight booms extend from a central hub to deploy the thin membrane quadrants. Observations of the deployment behavior of the sails are of crucial importance as the efficiency of the associated tasks is greatly influenced by the deployed state of the sail. Due to the impracticality of placing physical measuring equipment in space, a non-contact-based method needs to be employed to acquire the shape reconstruction of the target to monitor the intended deployment dynamics. There exists a wide range of optical-based methods such as Laser Scanning, Interferometry, Digital Image Correlation that have been studied. Among them, photogrammetric techniques are found to be a very powerful tool to produce accurate and reliable 3D shape reconstruction in space applications. This study is focused on developing and automating a fast and accurate stereo photogrammetry-based technique for precise shape reconstructions. The experimental validation of the proposed method performed on a scaled-down model made of paper with distinct features observed in space applications proved that the developed algorithm is capable of producing fast and credible 3D reconstructions.

Green Trends of Buildings in the Urban Landscape: A Case Study from Gampaha City

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As cities become more urbanized and urban heat increases eventually. Cool roof concept is an environmental friendly construction, uses to reduce the indoor heat of a building. Cool roofs are constructed by using roofing product with high solar reflectance properties. This concept can apply for any individual infrastructure. In Sri Lanka, cool roof concept become as a new trend. The objective is to find out the green trends of roofs in urban landscape based on building ownership. The Solar Reflective Index (SRI) used to find the cool roofs. To identify the green trends using constructed year, roofs and built materials were considered in every buildings of the study area. Information was collected by direct observations, interviews and from Municipal Council (MC) and Urban Development Authority (UDA) database. Excel program was used to analyze the quantitative data and Arc Map, Arc Scene and Google Earth imageries used to create temporal variation maps and 3D Maps to find the trends in respective areas. The study reveals that 21% of private buildings have concrete roofs with SR value 59 and compare to the government buildings have 1.2% of concrete roof surfaces. Residential buildings recorded 18.6 % of asbestos sheet roofs and the SR value is 56 and 16.5% of clay roof tiles. Only 6.8% of private buildings have a grass layer or vegetated layer on top of the building. The study shows that, newly constructed private buildings have an increasing trend in cool roofs. Every individual household also pay their attention to create some green paths, green walls, roof gardening and for rain water harvesting. This increasing trend depends on due to higher land prices and small scale vertical developments but the understanding of the green concept within the community is less. Cool roofs are essential to reduce the urban indoor heat and cool roofs can be installed anywhere on every building. Therefore, higher SR value roofs are the best solution. This study is useful for the urban planners for the future constructions.

Key words *- green, sustainable, landscape*

Variation of the Reflection Properties during Leaf Expansion of *Mesua Nagassarium*

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Mesua Nagassarium (Ceylon Iron Wood) is an evergreen medium to large size tree that originated in Sri Lanka which has medicinal value, of which flowers, leaves, seeds and roots are used as herbal medicine in Asian countries. During the leaf expansion of *Mesua Nagassarium* manifested coloration which the young leaves appear pink and gradually turn to greyish-green and brown at the end of life cycle. The study evaluated reflection properties of leave samples relevant to four different maturities stages, pink, light green, dark green and brown dried leaves at visible and near-infrared ranges. Spectral signatures were collected from detached leaves using PSR 1100f Spectroradiometer with a spectral range of 320nm to 1100nm. Leaf reflection measurements were taken for $1cm^2$ area of leaf surface under laboratory condition using a leaf clip. Spectral signatures were processed and derivative analyses were performed for 400nm to 1000nm wave length regions of each leaf expansion stage. Compare to near-infrared region, reflectance of visible spectrum (400nm to 700nm) showed distract variation among different leaf expansion stages. Further reflection energy versus leaf development showed negative correlation due to higher absorption of incoming radiation at Blue and Red regions, with evidence the presence of refined leaf anatomy and high amount Photosynthetic pigments in late development stages. Red edge shift were observed at 690nm to 700nm wave length range, due to diverse of biochemical substances in different stages of leaf expansion. The young leaves showed lowest reflections at 500nm to 550nm and highest reflections at 600nm to 650nm spectral range due to higher concentration of Anthocyanin pigments in leaf tissues at early development stages, because of young foliage is in pink to flashy red colour. Pink light green and dark green leaf stages show negative correlation respective to foliage development at 600nm to 650nm spectral range. Also light green and dark green leaf stages contrast higher reflectance variation at 500nm to 550nm. The result contrast visible spectrum (400nm to 700nm) is more important for study spectral variation of *Mesua Nagassarium* respective to their leaf expansion. Two narrowband regions 500-550nm and 600-650nm are identified as important spectrum rangers for hyperspectral analysis of spectral variation in *Mesua Nagassarium* foliage.

Keywords *- Mesua Nagassarium, ceylon iron wood, spectral signatures, spectroradiometer, hyperspectral remote sensing*

Upgrading biodiversity conservation in around Batadombalena foot trail and cave area using GPS tracking

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Batadombalena is located at an elevation of 380 - 410 m above sea level in Kuruwita, Sri Lanka where isolated wild tropical rainforest along with high biodiversity. The GPS coordinates on the location are 6.7765° N, 80.3959° E. Moreover, this cave is the pioneer of the South Asian archeology. Hence, the first time excavation was in 1928, by Mr. P.E.P Deraniyagala and it was found as primitive man's cave. After recovered, they indicated the modern human's place was 39 000 years old. Therefore, Batadombalena area is the most important to all of us which represent cultural, social as well as economic values. Fundamentally, there was no accurate map with precise coordinates for certain ecological studies. Accordingly, conservation and management of biodiversity-rich area has been becoming somewhat difficult. Because this, forest patch is been destroying gradually due to human activities. On the other hand, there should have surveyed in the last decade properly then conservation and management are established adequately. This study aims to produce a qualitative assessment of GPS for wildlife mapping applications for use in applied ecological research for the future. This map arrangement is including of Garmin 30 satellite based navigation system and Basecamp GPS. We have noted GPS waypoints and observe and collect data of environmental parameters such as air temperature, light intensity and physical parameter such as snails count every 100 m in along the foot trail to Batadombalena cave premises during both dry and wet periods. Ultimately, data of environmental parameters and GPS waypoints were combined and keep the record for future ecological researches. The environmental change and forecast about certain conditions are to be collaborating with upgrading digital GPS maps according to current investigations. Because of that modern mapping system's accuracy and consistency will be precisely higher than the past one. Thus, this study suggested that all the above GPS data and parameters should be utilized for environmental management and conservation programs in the Batadombalena eco-system.

Keywords *- GPS, mapping, eco-system, physical parameter, environmental parameters*

The Use of Hyperspectral Remote Sensing for Rare Earth Mineral Exploration

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Rare earth elements (REEs) are vital for the development of modern high-tech and renewable energy sectors, thus non-invasive and fast exploration approaches are necessary to compensate the increasing REE demand. Hyperspectral remote sensing is such an approach that can acquire information related to the chemical composition of REE compounds in a remote target and their spatial distribution by the combination of imaging and spectroscopy. Hyperspectral analysis can detect the characteristic narrow absorption features produced by REE compounds in the visible and near infrared (VNIR) and shortwave infrared (SWIR) regions of the electromagnetic spectrum. However, only a few hyperspectral REE exploration studies are reported, mostly on the carbonatites (e.g. Iron Hill, Colorado; Sarfartoq, southern west Greenland; Lofdel, Namibia). In this context, hyperspectral remote sensing could be an innovative and effective approach to explore the potential REE resources in Sri Lanka, such as Eppawala carbonatite, Pulmoddai and other beach placers and pegmatite. According to the proposed methodology, the area of interests initially identified using multispectral satellite data and then hyperspectral data is used to further characterize REE-enriched zones. The validation for the outcomes is performed by field investigations and laboratory geochemical and spectral analyses. However, the use of hyperspectral remote sensing for rare earth mineral exploration has been limited by the lack of high-quality hyperspectral data. Therefore, more high quality hyperspectral data must be made available for the research communities as well as exploration companies.

Key words *- REEs, RE mineral exploration, Hyperspectral remote sensing, Sri Lanka*

KEYNOTE ABSTRACT - Astronomy and Astrophysics

S. S. Gunasekara

Principal Research Scientist
Acting Director (Space Technology & Application Division)
Arthur C. Clarke Institute for Modern Technologies

Glimpse of Astronomy Research at the Arthur C Clarke Institute for Modern Technologies (ACCIMT)

Astronomy is one of the oldest sciences in the world. Unlike many other branches of science, astronomy evokes a sense of wonder among mankind through dazzling celestial displays and can spontaneously create interest in the public. Such interest, if properly focused on educational and research activities, can result in knowledge enhancement, cultural and social benefits to the society. Though our neighboring countries have recognized the importance of being involved in astronomy, not much progress has been made in the development of astronomy in Sri Lanka. However, as an outcome of the Basic Science Workshop held in Bangalore, India in 1991 UN recommended and supported the establishment of an astronomical observatory in Sri Lanka.

As a result of this initiative, in 1996 Japanese Government bestowed the 45cm Cassegrain Optical telescope to Sri Lanka. Considering the heavy expenditure involved in the development of the infrastructure, it was decided to install the telescope at the Arthur C. Clarke Center for Modern Technologies.

At the time of the donation of this telescope facility, it has been equipped with a photometer and a spectrograph for the acquisition of scientific data. Over the years ACCIMT telescope facility has been upgraded with state of art CCD cameras, echelle spectrograph, optical filters, etc enabling researchers to engage in new research and broaden their horizons in diverse fields of astronomy such as emission line stars, variable stars, solar astronomy, etc. ACCIMT has also submitted a proposal to the government to set up a National Astronomical Observatory for the country.

Since the inception of this telescope facility the space applications division of the institute has been engaged in basic astronomy research in collaboration with local universities. Offering astronomy research projects to final year undergraduates, introducing astronomy modules to the university curriculum of some universities have brought promising results for the future of astronomy in the country. Research exposure on this telescope facility paved the path for a few of the undergraduates to contribute internationally significant experiments in physics in

the century such as detection of the gravitational waves in LIGO (Laser Interferometer Gravitational-wave Observatory) experiment in 2015.

Over the past few years, researchers at ACCIMT have uplifted their research to the international caliber and have made significant discoveries such as finding new exoplanets. It is high time to collaborate with ACCIMT at a time they are celebrating the 25th anniversary of the largest telescope facility in the country.

Editor's note:

The speaker Mr. Saraj Gunasekara is a Principle Research Scientist and also serves as Acting Director, Space Technology & Applications at the Arthur C Clarke Institute for Modern Technologies. He was awarded a Master of Technology (M.Tech.) in Space & Atmospheric science from University of Andra, India in 2013 and a B.Sc. Special Degree in Physics (1st Class) from University of Colombo, Sri Lanka in 1994.

Comparative Systematic Analysis of Milankovitch Cycles for Identify Variations of Glaciers & Interglacial Periods in Late Pleistocene, South Asia

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Variations of earth precession phenomenon have led to changes in the earth's orbit; due to these variations, the earth's climate found to be strongly impacted. These climate changes observed were connected with the behavior of the global ice sheets, including the spreading and retreating movements recorded. Earth's climate depends essentially on the cycle of glaciers growth and retreat. These alternating glacial movements, as well as the interglacial periods, coincide with the variations in earth's orbit called Milankovitch cycles, which affect the insolation, and the sunlight exposure of different regions in the world and thus the behavior of ice formation. This paper aims to document the variations of the earth's axis orientation; as well as to discuss how these changes have affected the surface temperature of the South Asia Region, around 12,000 YBP(Years before present). Experiment methodology consists on compelling a standardized dataset of the sea-level index (Data SET 01-Radio Carbon Journal, Katupotha.J, Data SET 02- SEAMIS database and selected 35 number of carbon dating values in South Asian Region) and then compare it with the data of Milankovitch Cycles. The resulting shows that the sea-level variations dominantly happened between 12,500 YBP to 11,000 YBP, indicated $25_m \pm 5_m$ recorded to be the lower sea level documented than the current sea level found around the South Asia region. This incident is representing a quick glacier transition from the interglacial period in the Late Pleistocene.

Key Words *- Milankovitch cycles, Sri Lanka, Sea Level, Carbon dating, Late Pleistocene*

Determine the Properties of Recorded Type III Solar Radio Bursts on 7th May 2019 at 10.28 a.m. and 9th May 2019 at 12.59 p.m.

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This research was partially analyzed the most dominant Solar Radio Burst (SRB), the observable Type III. SRB is a structure of a frequency space that varies with time; typically start in the corona at frequencies of order 100 MHz; an essential diagnostic tool in the understanding of solar accelerated electron beams; a signature of propagating beams of non-thermal electrons in the solar atmosphere and the solar system. Solar radio frequency range from 70 MHz to 2.2 GHz, and most radio bursts are detected in the low-frequency range, and that is below 200 MHz. The series drift rate of Type III Solar Radio Bursts is approximately -10 MHz s^{-1}, -1.13 MHz s^{-1} and the recorded SRBs' mean plasma frequency is 299.4133 MHz and 100.2541MHz as recorded on 7th May 2019 at 10.28 a.m. by the KRIM solar observatory and 9th May 2019 at 12.59 p.m. by the Greenland solar observatory that engaged in investigating the characteristics of Type III solar radio burst. Our selected series of the SRB Type III was associated with the C1.12 Solar Flare and C6.79. According to real data, experimental data was higher, and it was 1198.66 Km s^{-1} and 3796.28 Km s^{-1}.

Key words *- solar radio burst, Type III, Solar flare.*

Determination of the Depth of Solar Chromosphere using the Time Difference between Umbral Contact Points through the Simultaneous H Alpha and White Light Observations during an Annular Solar Eclipse

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Solar chromosphere is a main layer in the solar atmosphere which is located between the photosphere and the solar corona. The spectrum of the photosphere is dominated by absorption lines at certain wavelengths while the chromosphere has emission line spectrum at same wavelengths with strongest at Hα (656.3 nm). Therefore, the chromosphere can only be observed through a narrowband Hα telescope or during a solar eclipse. The study was carried out to determine the depth of the solar chromosphere using the data taken during the annular solar eclipse of 26th December 2019 (Saros =132) at Jaffna Fort (GPS; Lat. =09^{0}39.64318' N; Lon. = 80^{0}00.54175' E, ~14 km liner distance to the central line of the eclipse) using a White light filter mounted Newtonian reflector (Aperture=130 mm, f/5) equipped with a prime-focus CMOS camera (Pixel size = 2.8 µm, Array= 1280x960) and a Hα telescope (Aperture=40 mm, f/10, Pass band <1.0 Å) equipped with a CMOS camera (Pixel size = 3.6 µm, Array= 1280x1024). GPS data was recorded using the Ublox Neo 6M GPS module. Two camera feeds and GPS data were fused in real-time into one video before recording for synchronization. 2nd and 3rd umbral contact points were identified by analyzing Baily's beads and compared with the simulations of Eclipse Calculator 2.0 software. Time difference between the occurrence of each contact point detected through white light and Hα was measured. Angular velocities of the Earth and the moon at the time were calculated using the data taken from four planetary orbital ephemerides databases including NASA Horizon SDO DE430. The small-angular equation was used to calculate the depth of the chromosphere. Results for the depth of solar chromosphere obtained from the study for two umbral contact points were $(8.756 \pm 4.164) \times 10^3$ km and $(7.505 \pm 4.164) \times 10^3$ km. Past studies have reported the depth of Chromosphere in between 3000 km and 5000 km.

Key words *- Solar Chromosphere, Solar Eclipse, H-alpha,*

Study of Orbital and Super Orbital X-ray Flux Variability of the LS I +61 303 Object from 2009 to 2018 using Swift XRT

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LS I +61 303 is a binary system located 2 kpc away from the Earth that consists of a giant Be-star (spectral type B0Ve) and a compact object. The nature of the compact object remained unknown, and the two possibilities are a neutron star or a black hole. The variable nature of LS I +61 303 in radio wavelengths was discovered in 1978. The variable nature of the radio flux suggests a non-uniform magnetic field, along the Be-stars orbit. Thus one could also expect variability in X-ray flux. This study reports a detailed analysis of the X-ray in the energy range between 0.3 - 10 keV coming from the direction of the LS I +61 303 objects. Here, the archive data was obtained from the UK Swift Science Data Center and Data Acquisition Instrument is the X-Ray Telescope on the NASA-lead Swift Satellite (Swift XRT). Observations spanning from October 2009 to December 2018 allows studying the X-ray flux variability as a function of the orbital and super orbital phase. Preliminary results show variability in X-ray flux. However, there is no statistically significant evidence for a correlation between the variability and orbital or super orbital phases. Lack of correlation challenges the-state-of-the-art understanding of the source. Details of the X-ray observations and its consequences to the-state-of-the-art understanding will be presented.

Key words - *binary system, neutron star, black hole, flux, variability*