Detecting the disappearing frames of the Baily's beads

(4th Year Internship Program – Arthur C. Clarke Institute for Modern Technologies)

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DECLARATION

This dissertation describes the internship training and project work carried out between 21st June 2021 to 21st September 2021, as an intern at the Arthur C. Clarke Institute for Modern Technology. The work described in this thesis was carried out by me under the industrial supervision of Dr. Janaka Adassuriya and the academic supervision of Mr. C.H.Manatunga.

I declare this dissertation has not been submitted in whole or in part for any degree or diploma at this or any other university and is submitted to the Department of Physics at the University of Sri Jayewardenepura on 21st January 2022.

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ABSTRACT

Solar eclipses are interesting astronomical events to study as they are not happening every day. To study solar eclipses telescopes with special filters are used. In a solar eclipse, the moon comes in between the earth and the sun. During solar eclipses, a phenomenon called Baily's beads effect happens due to the irregularities on the edge of the Moon's disk. Hence we can study the topography of the moon and can determine the data such as solar radius using the video footages of solar eclipses using the Baily's beads. For that, the frames where the Baily's beads are appearing and disappearing have to be detected first. Then using those frames further studies can be carried out to find topographical features of the moon and other data. In this project, such a video footage of a solar eclipse which happened on 26th December 2019 was used and the exact frames where the Baily's beads were disappearing were detected using the open-source software called 'Limovie'. It is a software designed to use in tracking the objects and to get intensity variations of them with time. By using these features disappearing frames were detected successfully and there were 37 disappearing frames in the video. Also, several techniques were tried to detect these frames varying the features of 'Limovie' to get the best results.

ACKNOWLEDGMENT

I am very grateful to several people and several organizations for the opportunity given by them to engage in an internship project which was very interesting and for the huge support given by them in completing the project. The three-month period was very useful for me academic vise as well as career wise.

At first, I mention thankfully the Department of Physics of the University of Sri Jayewardenepura for granting me such an opportunity to work in a respected place like ACCIMT to complete my internship program. I wish to thank the Head of the Physics Department, Prof. A.R. Kumarasinghe, Dr. S. Jayawardhana, the Industrial Training Coordinator of Physics Department for the best guidance, and Mr. C.H. Manathunga, the Internal Supervisor of the Internship program for being the best mentor, helping throughout the internship period contacting via Zoom meetings regularly.

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Finally, I am very grateful for everyone including the above-mentioned as well as the others who were a huge support for my project to complete in success which was conducted amidst the global pandemic period.

TABLE OF CONTENTS

FIGURES

CHAPTER I

1 CHAPTER I - INTRODUCTION

1.1 Introduction of the Institute

1.1.1 Arthur C. Clarke Institute for Modern Technologies

Arthur C. Clarke Institute for Modern Technologies (ACCIMT) is a leading institute in Sri Lanka for the research and technology sector which is named after its founder patron, Sir Arthur C. Clarke, the futurist, famous British science fiction author, and inventor. The ACCIMT which is situated in Katubedda, Moratuwa was established in 1984 as the Arthur C. Clarke Centre and was renamed later. [1]

Figure 1- ACCIMT

The institution consisted of several departments and mainly focused on the research fields such as electronics, microelectronics, telecommunication, information technology, space technology and robotics. Also, it provides training for the relevant industry professionals and university undergraduates.

1.1.2 Srilankabhimanya Sir Arthur C. Clarke

Srilankabhimanya Sir Arthur Charles Clarke was an Englishman who was famous for his science fiction masterpieces, mainly **2001: A Space Odyssey**. **Loophole**, **Rescue Party** and **Against the Fall of Night** are some of his notable works which carved his reputation as an author.
Also, he was an inventor, futurist and undersea explorer. He was born in 1917 at Minehead, Somerset, England, and came to live in Sri Lanka in 1956 he lived there until he died in 2008. He was made a **Knight Bachelor** for services to the literature on 26th May 2000 and Sir Arthur C.

Clarke is well known for his ideas which contributed to establishing the geostationary satellite communication. [2]

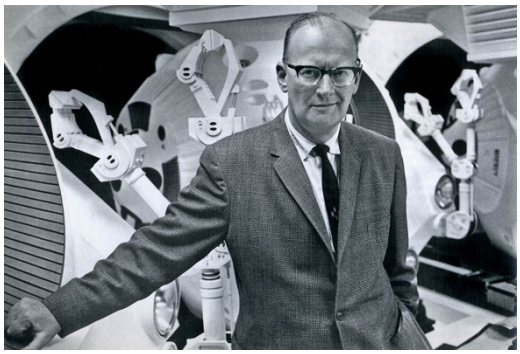

Figure 2- Sir Arthur C. Clarke

1.1.3 Research and Development Sector in ACCIMT

ACCIMT aims its researches mostly on its major divisions;

1. Communication Engineering
2. Electronic and Microelectronics
3. Industrial Services
4. Information Technology
5. Space Application
6. Astronomy

leading the Sri Lankan research field at front.

The Communication Engineering division has focused on the research and development projects involved in industrial automation, ground robotics, aerial robotics, railway systems and satellite systems. Electronic and Microelectronics division has research and development projects focusing on microcontroller-based system designing, data logging & display systems, application of sensors, analog circuit design, and power line data acquisition. Localization and vision-based automation researches are currently carried out under the Information technology division. And the Space Application division has focused on Remote Sensing and Geographic Information Systems while the Astronomy division; a majorly recognized sector in the institute carrying researches under the four major criteria;

1. Detecting Exoplanets
2. Asteroseismology
3. Cataclysmic Variables
4. Solar Radio Bursts. [3]

Having the largest telescope; **GOTO 45cm Cassegrain telescope** donated by the Japanese government, has been a huge aid for the Astronomy division to carry a vivid range of researches. This telescope facility is equipped with a spectrograph, dsphotometer, Apogee ASPEN (3056×3056 pixels), and Apogee ALTA U47 (1024×1024 pixels) CCD cameras. The spectra in the wavelength region from 4000 A to 9000 A can be obtained with this system. The photometer of the telescope has an RCA IP21 photomultiplier tube with a pulse counting system and Johnson and Morgan UBVRI filters. [4]

Figure 3- GOTO 45cm Cassegrain telescope

In the Exoplanets area, studies are carried out to discover planetary systems around stars other than the sun. These observations are mainly done using the Kepler Space telescope and TESS (Transiting Exoplanet Survey Satelite). Up to now, ACCIMT has been succeeded in detecting two new planetary systems around **Orange dwarf stars**.

Determination of the internal structure of stars using their oscillations data is known as Asteroseismology. For these studies, Kepler data are used and major targets are the Delta Scuti variable stars. Here the pulsating modes are identified using the light intensity variations.

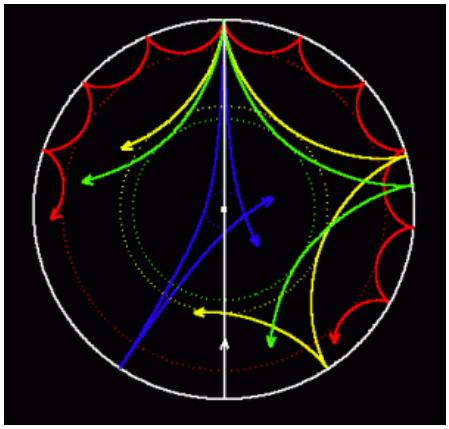

Figure 4- Sounds waves inside stars

Cataclysmic Variables are interacting binary stars comprising a white dwarf accreting matter from a companion star. Under this field, researches are carried out to understand the underlying scenarios and physics behind the period gap of orbital period distribution of Cataclysmic Variables.

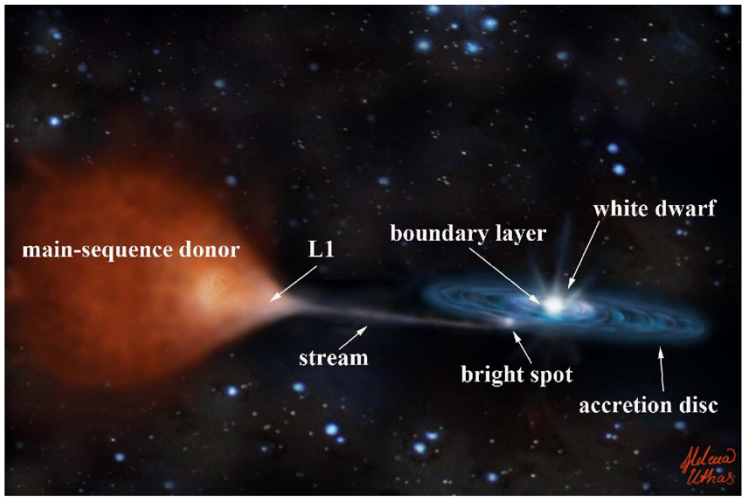

Figure 5- Cataclysmic Variables

In the Solar Radio Bursts research field, Solar observations are done using CALLISTO (Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy and Transportable Observatory) which is a programmable heterodyne receiver built in the framework of IHY2007 and ISWI (International Space Weather Initiative) by former Radio and Plasma Physics Group at ETH Zurich, Switzerland. [5]

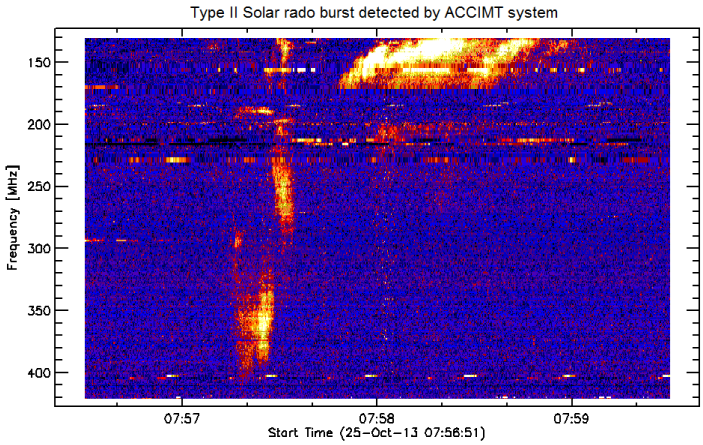

Figure 6- Type II Solar radio burst detected by ACCIMT system

1.1.4 Industrial Services and Consultancies

The institute provides test, measurement, consultancy, repair, and calibration services with well-equipped laboratory facilities. These services are provided in specific areas such as electronics, electrical and telecommunication fields.

Under the testing services tests such as radiofrequency radiation level testing, performance testing of antennas, CCTV testing, Battery testing, RCCB, MCB, RCBO testing are provided. With the Fluke 5520A multi-product calibrator and Transmille 3200A electrical tester a wide variety of electrical measuring instruments calibration services are provided. [6] Also the ACCIMT has well

experienced and highly skilled technical staff to provide consultancy in managing and servicing high-tech industrial systems, to assist in managing modern industrial systems such as microprocessor-based machinery, telecom systems, and several others.

1.1.5 Vision and Mission of ACCIMT

Vision

- To be a leading innovation center for Modern Technologies in the region.

Mission

- To develop, foster, and facilitate the domestic base of modern technological capabilities through innovation, R & D, training, industrial services, and international collaboration. [7]

1.2 Introduction of the Project-Background

1.2.1 Solar eclipses

A solar eclipse is a phenomenon where the shadow of the moon casts over the earth when the moon gets between the earth and the sun. And it is only happening when there is a new moon. But eclipses don't happen at every new moon as the moon's orbit is tilted about 5 degrees relative to earth's orbit around the sun. Hence during some new moon phases, the moon's shadow casts either above or below the earth. Solar eclipses are 4 types; total, annular, partial, and hybrid.

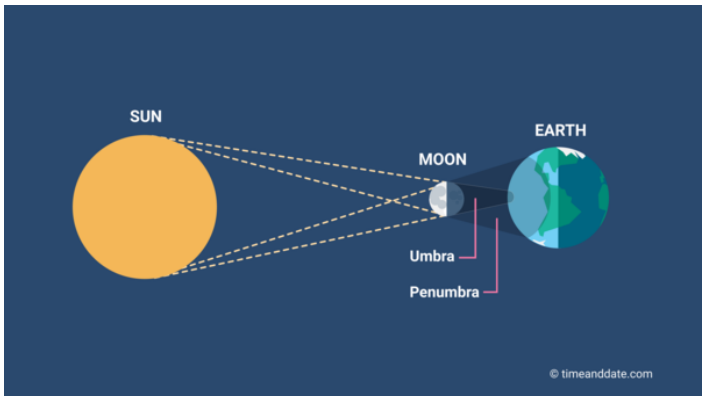

Figure 7- Solar eclipse

Total solar eclipses-
Sun has a diameter that is 400 times greater than the diameter of the moon. But the moon is closer to earth almost 400 times than the sun. Because of this accidental phenomenon when the orbital planes intersect and the distances align accordingly the new moon can completely block the sun to the earth and hence a total solar eclipse occurs. This happens somewhere on the earth about every 18 months. The umbra part; where all the sunlight is blocked out and which is a dark slender

cone and the penumbra; which surrounds the umbra with a lighter funnel shape are the two types of shadows of a total solar eclipse.

Partial solar eclipses-
When the penumbra passes over the earth a partial solar eclipse occurs remaining a part of the sun always in view. Areas that are far away from the path of total solar eclipse observe a partial eclipse.

Annular solar eclipses-
Having a maximum duration of 12 minutes and 30 seconds, an annular eclipse happens when the configuration is same as a total eclipse but the distance between the moon and the earth is slightly greater than the distance between the earth and moon when a total eclipse is occurring. Here the tip of the umbra doesn't reach the earth and the antumbra reaches the earth and a ring can be seen around the moon at the regions situated within the antumbra.

Figure 8- Types of solar eclipses

Hybrid solar eclipses-
Here the distance between the moon and earth is near to the limit for the umbra to reach earth and in most cases, these solar eclipses are started as annular and then become total and again become annular towards the end of the path. Also known as annular-total (A-T) eclipses. [8]

1.2.2 Baily's beads

The arc of bright spots seen during total and annular solar eclipses are known as Baily's beads which are named after the **Francis Baily**, an English astronomer who called the attention to them. These spots are formed by breaking the sunlight in several places where the irregularities on the edge of the moon's disk are situated. The irregularities are the valleys and mountains of the moon's disk.

Figure 9- Baily's beads

Hence using the Baily's beads, the topographical features of the moon can be studied and the solar radius can be determined using the beads. So video footages are taken during total and annular solar eclipses using back screen on cameras with proper solar filters. Baily's beads could be observed in a short period between the time that the diamond ring forms along the leading edge and when the totality occurs. These beads are called as disappearing beads as they can be seen when the light of the sun is diminishing. Then the beads reappear on the opposite side as the moon moves away from the totality and these beads are known as reappearing beads.

The Diamond ring can be seen when the beads are seen as a diamond set in a bright ring. This phenomenon and the following Baily's beads effect can be seen without filters as less than 0.001% of the photosphere of the sun is visible at that time. After disappearing beads a thin reddish edge is visible known as the **chromosphere**. [9] Using the video footages of eclipses, the frames where the beads are appearing and reappearing could be determined to use in further analysis.

1.2.3 Limovie Software

To detect the frames of disappearing and appearing Baily's beads a software known as '**Limovie**' (Light Measurement tool for Occultation observation used Video recorder) can be used effectively. It is an open-source application that can be run using Windows or Linux operating systems developed in 2005. Basically, it measures the light intensity of each video frame. So user can records intensity variation data of a target point and a plot can be generated using the software too. As the target point moves with the time in such recorded footages it is hard to analyze without these types of software. And most recently this application has been upgraded to do double star analysis in which two targets can be analyzed at the same time.

This application can be used for the following astronomical analysis.

1. Analyzing accurate event time on Lunar and Asteroid occultation
2. The relation between exposure of video camera and inserter's timestamp
3. The position and magnitude of double star components
4. Discovery of a new component of double star
5. Investigation of the shapes and sizes of Lunar and Asteroids
6. Detection of the small drop of brightness on asteroid occultations
7. Planet occults of its satellite and mutual event of Jupiter's satellite [10]

The light intensity variation data can be obtained as a file of '**Comma Separated Value'** (CSV) file read by spreadsheet like Excel. Also, there are a few drawbacks when using this application such as;

1. DV Codec is necessary to read the captured video file
2. Maximum file sizes that can be read are up to 1GB for DV files and 2GB for non-compressed files [11]

So the video footages should be converted using the suitable applications to match the desired video properties.

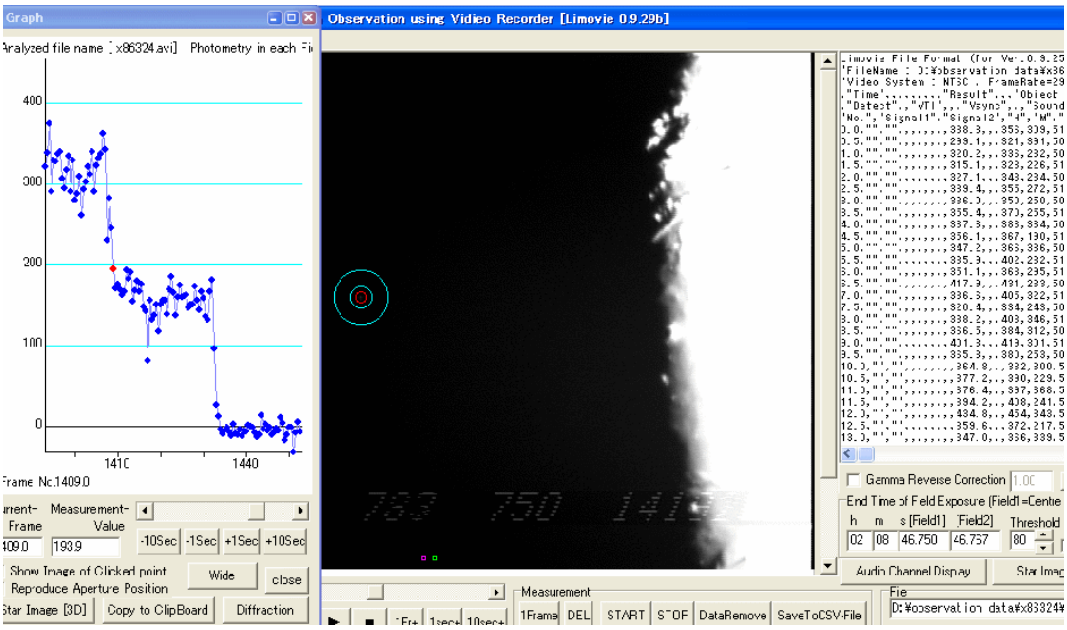

Figure 10- Limovie software

1.3 Introduction of the Project-Task

The main project work is to determine the frames of disappearing Baily's beads on the given video footage using the Limovie software. But initially, some literary knowledge had been obtained to get familiar with the software and to know about video codecs which were essential when converting the video footage to a supportable format for Limovie. Hence the main tasks could be mentioned as follows;

1. Literature reference.
2. Installing the necessary applications.
3. Converting the video file.
4. Getting familiar with the Limovie application.
5. Determining the disappearing beads and obtaining the light curves.
6. Analyzing the light curves to determine the disappearing frames

CHAPTER II

2 CHAPTER II - LITERATURE REVIEW

2.1 Importance of the solar eclipses

Since the ancient era, solar eclipses are such mischievous phenomena that may concern as some supernatural events but latterly recognized as major astronomical events occurring two to five times per annum. The moon is gradually moving away from the earth approximately about 4 cm per year and in the present era, the moon is at the perfect distance to the earth to appear as the same size as the sun. So when the moon comes in between the earth and the sun, the sun is covered by the moon.

By observing solar eclipses several physics theories have been proved and various literature related to astronomy have been studied as during this phenomenon a rare opportunity to observe the corona is provided. Normally corona is not visible due to the brightness of the photosphere. Such a remarkable incident was happened in 1919. The total solar eclipse which happened that year helped to confirm the Einstein's theory of general relativity.

2.2 Contribution of Baily's beads to the Astronomy

By observing the Baily's beads the details of the lunar profile can be determined as it provides a direct view of the irregularities of the lunar disk. Not only that but also it supports to determine many other data related to astronomy. By observing Baily's beads from several locations the information about relative positions and shapes of the sun and moon can be determined to about $\pm 0''.02$. [12]

Also by analyzing this effect the following criteria can be studied.

1. Checking the accuracy of the eclipse predictions near the path edge.
2. Measuring the solar radius to detect the short-term variations or systematic change over a period of years.
3. Deriving a calibration of visual observations to photographic methods.
4. Extending the accurate limb profile measurements beyond the polar regions of the moon as refined by grazing occultation observations of stars. [13]

2.3 Video Codecs

Video Codec is a compression technology that is used by content distributors to compress videos into a shareable size. Latterly the video is decompressed for viewing. Not only for video but codecs are also used in audios as well. AVC (Advanced Video Coding) or H.264 is the most common video Codec while AAC (Advanced Audio Coding) is the most common audio Codec. In here Video Encoding is coming forth before the codecs, which is the process of converting a raw video into a digital format compatible with many devices. So each Codec has its own encoder.

After encoding the video file is stored in a video container format which includes the video Codec, audio Codec and metadata such as subtitles and preview images. Common containers are .mp4, .mov, .ts and .wmv. Containers can store several Codecs which is useful when streaming the same video in different playback platforms such as QuickTime on Apple operating system and Windows Media Player on windows operating systems. [14]

To use videos in Limovie the DV Codec should be there in the container as it reads the image from the AVI file using the API of "Video for Windows". So the DV Codec has to install or the video has to convert using a software that encodes DV Codec.

2.4 Detecting the disappearing Baily's beads with "Limovie"

In the Limovie there are several features to successfully do intensity variation analysis; specially to detect the beads and to execute the project works as follows;

- Can import both CSV files and AVI files to detect intensity variation.
- Can capture videos directly using the application itself.
  For that there are 3 methods;
  1. Using miniDV camcorder**:** Can connect directly via IEEE1394 (firewire) cable.
  2. Using DV encoder converter: Video signal is converted to DV signal for .avi file in the capture equipment and IEEE1394 port is necessary on user's computer in this way.
  3. Capturing device with software encoder: DV conversion is made by the software in the computer. Can connect via USB 2.0 port. [15]
- Video player
  Has many functions to analyze objects in the video more accurately. There are options to play, pause, forward by seconds/ frames.

Figure 11- Video player

- Can do the Gamma reverse correction.
- Can track the position of the target.

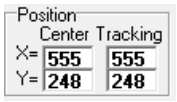

Figure 12- Position tracker

- Can measure the video file details such as frame rate, total number of frames in the video.
- Intensity measurement tool.
  There are options to delete the recorded data or to save the recorded data as a CSV file.

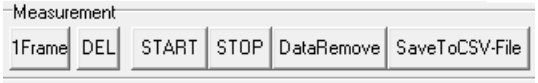

Figure 13- Intensity measurement tool

- Can do two methods of intensity measurements; Aperture photometry and PSF photometry.
  PSF photometry is effective for the analysis where the noise is higher such as stellar eclipses by asteroids, observing and detecting star eclipses by the moon. Aperture photometry is best for the star eclipses caused by the moon with less noise.

- Can set the tracking radius and the background radius to compare the signal to noise ratio.
- Can change the tracking shape.
  There are 3 settings; Standard, Avoid Sunlit Face, and Meteor/Lunar Limb. Standard mode is used when the background is uniform. If the background is uneven and has some light the outer radius should be decreased to cut the noise. Avoid Sunlit Face mode is used to avoid light from surrounding stars if there are any. Meteor/Lunar Limb mode has several applications and it is mostly used when the stars overlap with the lunar edge.
- Can get the 3D view of the tracking point using the feature, Star Image [3D].
  Hence the inner and outer radii can be adjusted properly.

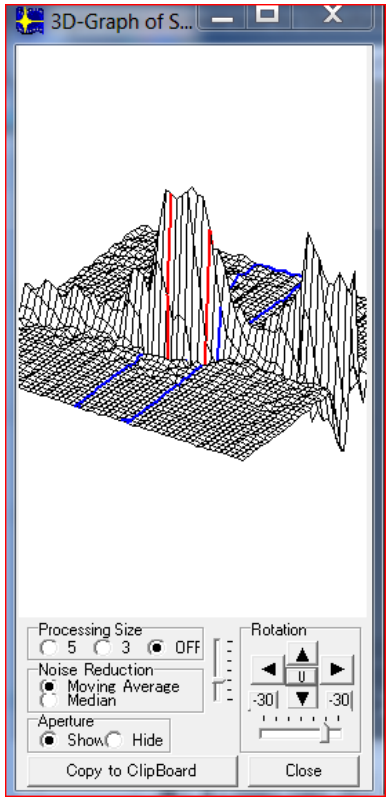

Figure 14- Star Image [3D] feature

- Can get the intensity variation plot.
  There are several settings of the plots that can be adjusted such as the scales and radius of the selection point. The disappearing frame of the beads can be detected using the plots as the intensity of the target point becomes uniform after the disappearance. And the plots can be saved as images.

Figure 15- Limovie application

2.5 Converting video files to AVI format with VirtualDub

VirtualDub is a video capturing/processing application for 32-bit and 64-bit Windows platforms. As some video files couldn't import to Limovie directly due to the unsupported Codec formats, third-party applications like **VirtualDub** could be used to convert the file into a supported AVI format.

But when using VirtualDub the operating system should have the necessary plugins to deal with some file formats. Hence the plugins should be installed inside the VirtualDub folder first.

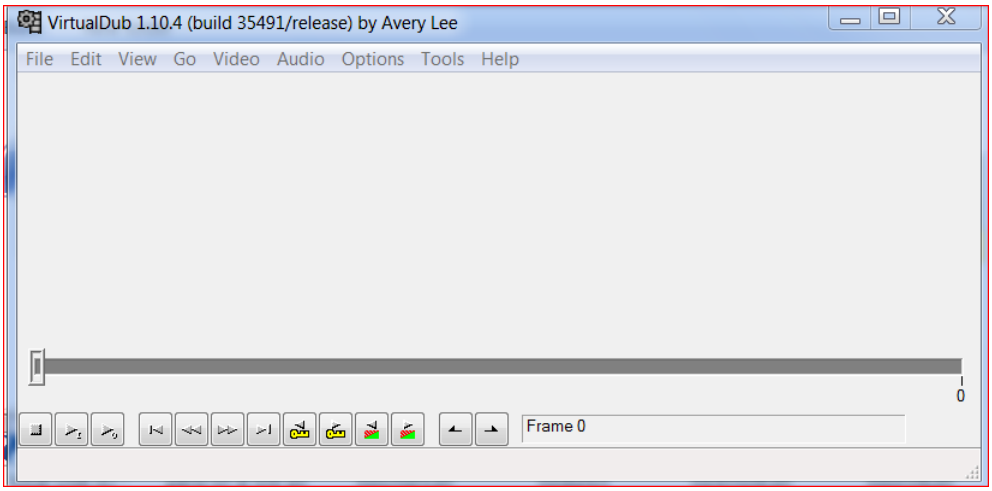

Figure 16- VirtualDub application

CHAPTER III

3 CHAPTER III - OBJECTIVES AND METHODOLOGY

3.1 Objectives

3.1.1 Main objectives

- Getting familiar with the Limovie software.
- Detecting the disappearing beads
- Tracking the objects and getting the light intensity curves
- Detecting the frames where the beads are disappearing

3.1.2 Secondary Objectives

- Studying about the solar eclipses
- Studying about the video Codecs
- Getting familiar with the VirtualDub software
- Studying about the astronomical importance of Baily's beads

3.1.3 Academic Outcomes

- Gaining knowledge to use Limovie for getting intensity variation curves of targets
- Gaining knowledge to handle various video formats to use in various applications

3.2 Methodology

3.2.1 Installation of the Limovie software

The main software that used in this project was Limovie which is an open-source application deals with intensity tracking of targets. The installation was done using the Limovie homepage; http://astro-limovie.info/limovie/limovie_en.html.

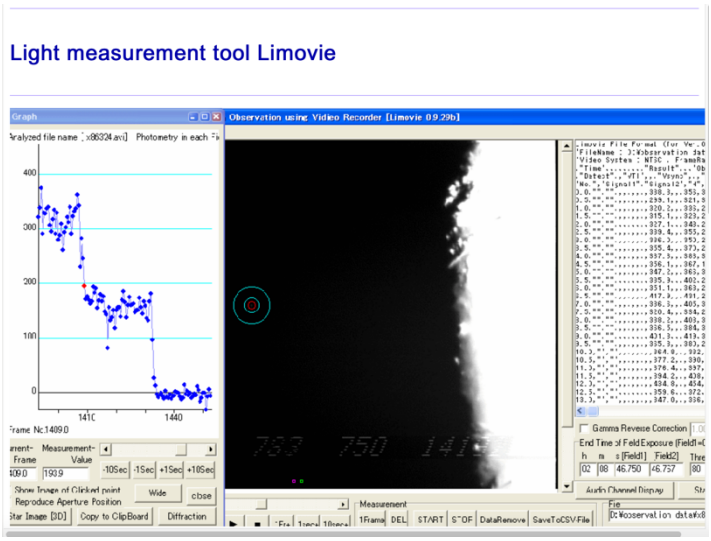

Figure 17- Limovie homepage

The software was downloaded first using the link on the homepage and then it was installed on the computer.

3.2.2 Getting familiar with the Limovie features

Limovie is an application that could handle easily as it is user-friendly. But getting to use the features was necessary. To understand the features and how to work with them, the manual was downloaded using the homepage but it was in Japanese. So alternate site was used to get an English-translated version of the manual using the following URL; https://astro-limovie.info/occultation_observation/limovie_en.html.

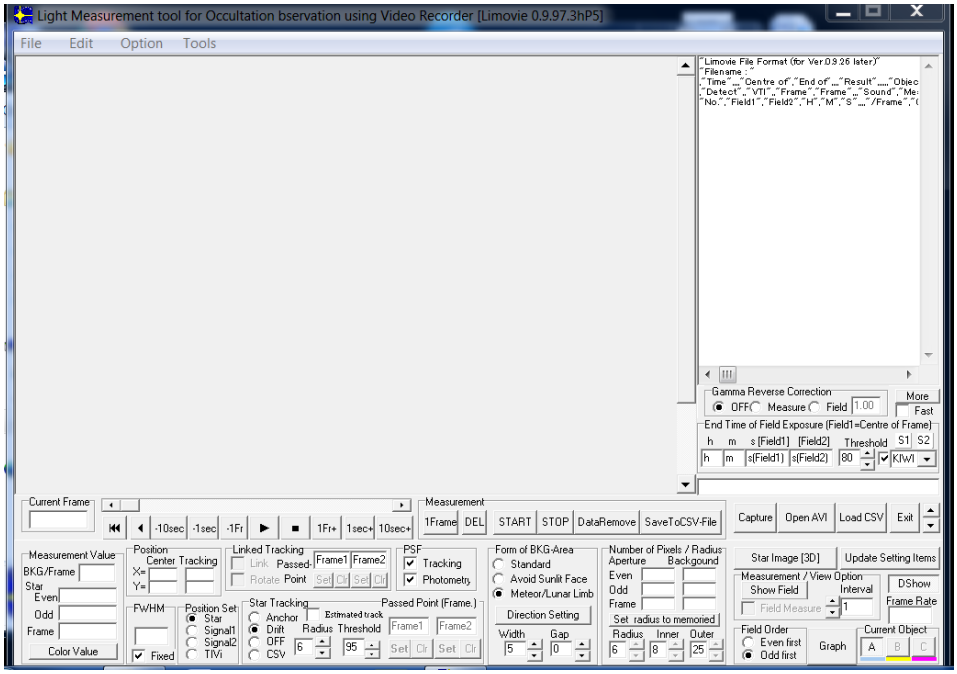

Figure 18- Limovie interface

After getting familiar with the features to set radii, track targets, get light curves, and to save data the video was imported to the software. But the original video Codec was not supported in Limovie.

3.2.3 Studying about the video Codecs and installing the VirtualDub software

As the Limovie didn't compatible with the Codec of the original video it was necessary to understand the Codecs and to determine how to convert the video into a supportable format. After studying the Codecs, a software called **VirtualDub** was found to be one of the best applications to convert the original video to the supported Codec. It was downloaded and installed using the homepage URL; https://www.virtualdub.org.

Figure 19- VirtualDub homepage

Then the video was imported to the VirtualDub but again some errors obstructed the course. Again after some studies about the application, video Codecs and plugins the error was found and necessary actions were taken. There the error was with the plugins and suitable plugins were installed inside the VirtualDub folder to overcome the error. The following link was used to download and install the plugins; https://codecpack.co/download/VirtualDub-Filter-Pack.html.

Then the video was successfully imported to VirtualDub and converted into the supported AVI Codec using the Export feature in the File option.

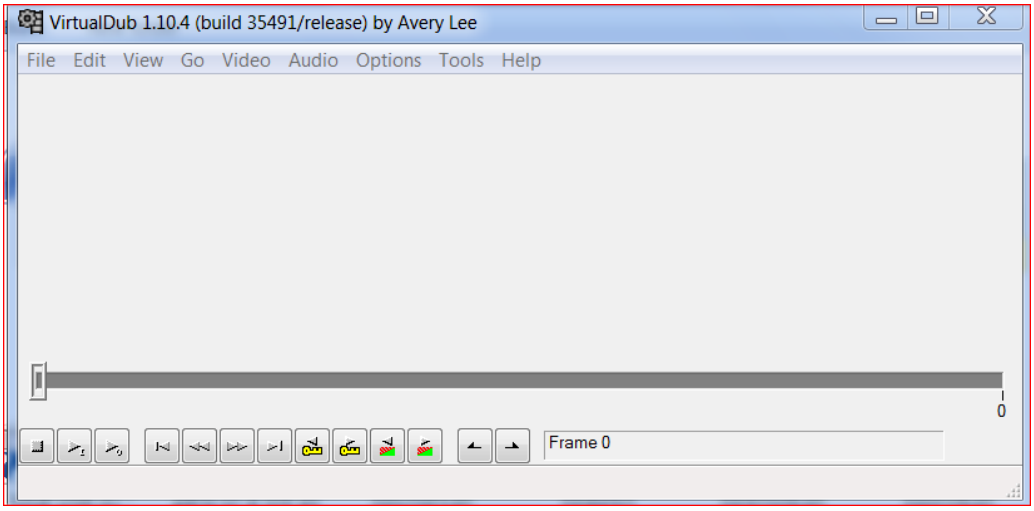

Figure 20- VirtualDub interface

3.2.4 Importing the video into the Limovie and target tracking

Converted video was imported to Limovie using the File menu and the features of the software were tested with the video. Then the beads were identified and the time range for each bead to track were determined.

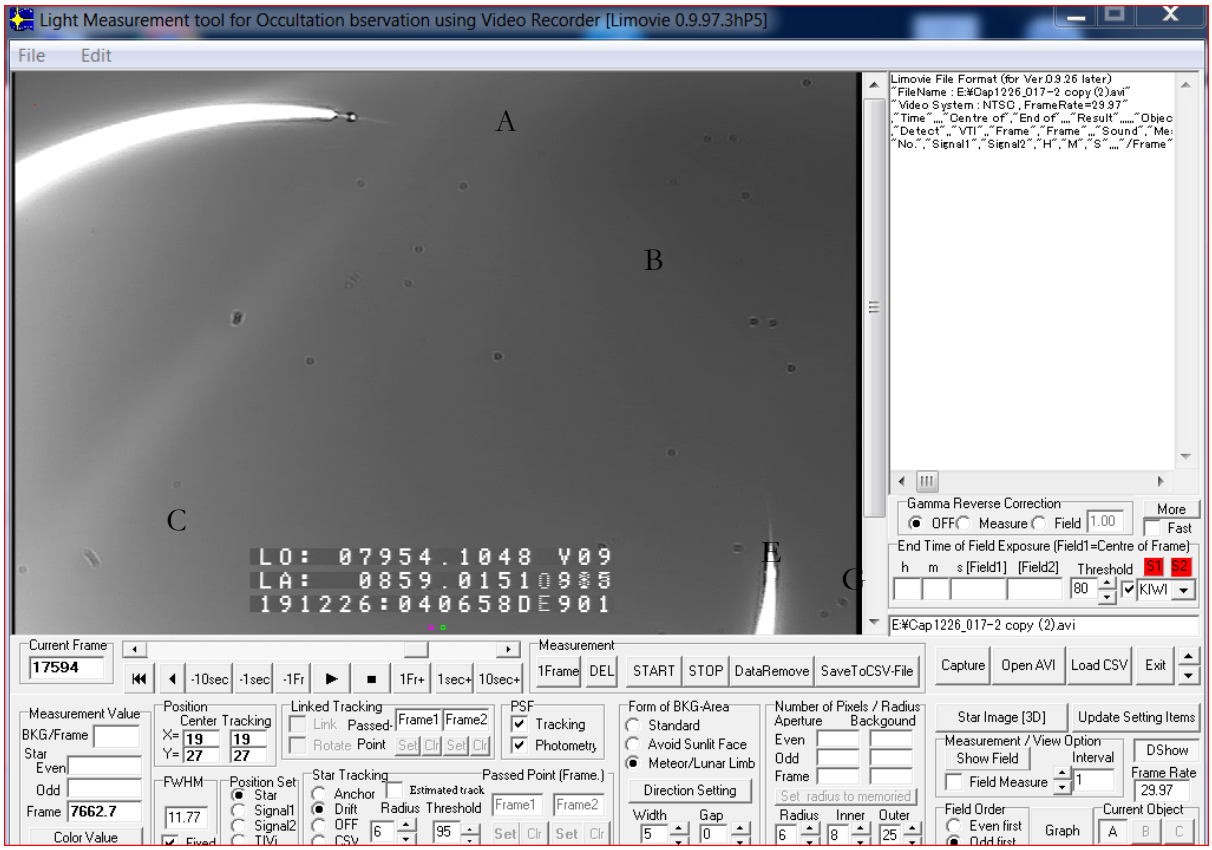

Figure 21- Tracking targets with Limovie features

In the above figure 21;

- **A** is a bead.
- **B** is the video player area where the video can be seen.
- **C** is the toolbox where the video playback tools are available. Using this the video can stop, pause, forward as the user wishes. So it is helpful to determine the necessary period where the intensity tracking should be done for each bead.
- **D** is the current frame number display board. So the user can track the time period as framewise.

After that, each bead was selected as a target and intensity tracking was started. Initially, the shape of the tracker was selected from the options shown in the **E** box. There the Standard option was selected for the targets where no nearby beads were presented and Meteor/Lunar Limb option was used when there were nearby beads that obstructed the tracking.

The inner and outer radii were set as appropriate focusing on the size of each bead and the background. For that, the options available in the **E** box were adjusted by observing the target using the option Star Image [3D] shown in the above figure as **F.**

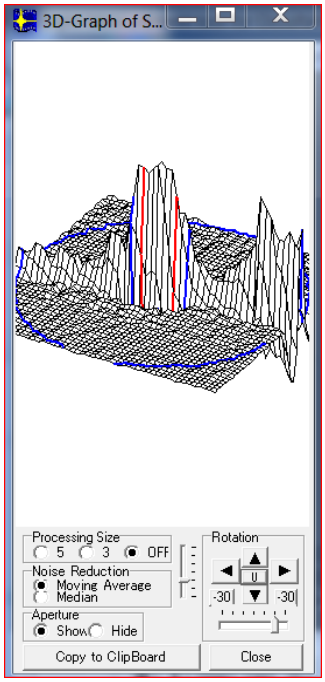

Figure 22- Setting radii

The red circle denotes the inner radius which should be just around the target area and the outer radius is shown in Blue where the background of the target is set. Using the options in Star Image [3D] the target could be rotated 360 degrees to set the radii very accurately.

3.2.5 Getting intensity curves and detecting disappearing frames

Then the intensity data tracking was started at the beginning of the determined starting frame of each bead and stopped at the final frame of the period using the START and STOP options in the measurement toolbox shown as **G** in the above figure. If some error happened during the measurement process, the data set can be deleted using the DataRemove option and data can be saved using the SaveToCSV-File option.

Before saving the data the intensity variation plot can be observed using the **H**; the Graph option. If the intensity measurements are taken correctly the intensity value should be decreased and should have a constant range.

If the plot was correct it was saved as a PNG file using the Save Image option in the Graph window. Also, the scales of the axes were adjusted if necessary using the Scale, Y Axis Min, Y Axis Max options in the same window.

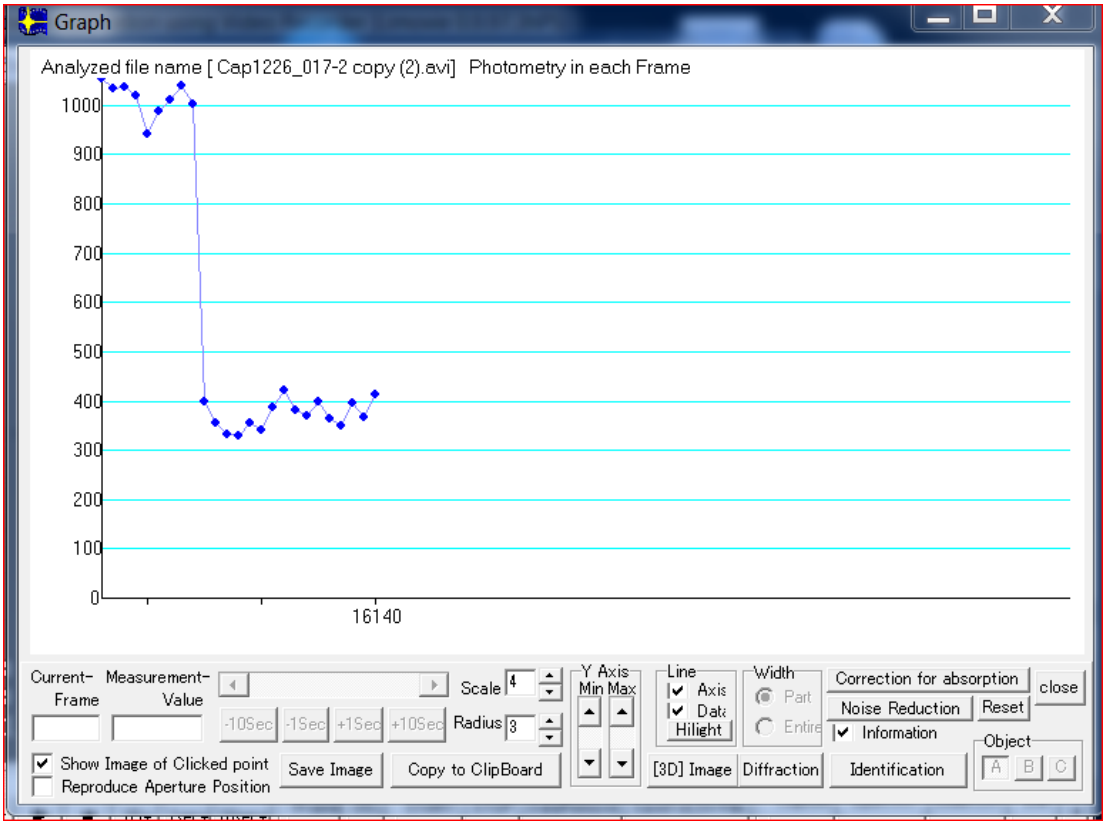

Figure 23- Graph window

After getting the intensity data sets for all the determined beads, the data sets were observed carefully to find the frames where the intensity becomes approximately constant for each bead.

Finally, the data set, plot and disappearing frame for each bead were submitted to Dr. Adassuriya on the due date.

CHAPTER IV

4 CHAPTER IV - GANTT CHART

	21ST June- 15th July				19th July- 12th August				16th August- 21st September					
Task	1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week	9th week	10th week	11th week	12th week	13th week	14th week
T_1														
T_2														
T_3														
T_4														
T_5														
T_6														
T_7														
T_8														

Table 1- Gannt Chart

T_1	Literature study
T_2	Installation of Limovie software and getting familiar with the interface
T_3	Installation of VirtualDub and converting the video file
T_4	Getting familiar with the Limovie features
T_5	Detecting the beads and time periods of tracking for each bead
T_6	Tracking the intensity variations of beads
T_7	Getting plots and determining the disappearing frames
T_8	Finalizing and submitting the documents

Table 2- Gannt Chart tasks

CHAPTER V

5 CHAPTER V - RESULTS AND OBSERVATIONS

In this project, 37 disappearing beads were identified and the intensity plots are as follows.

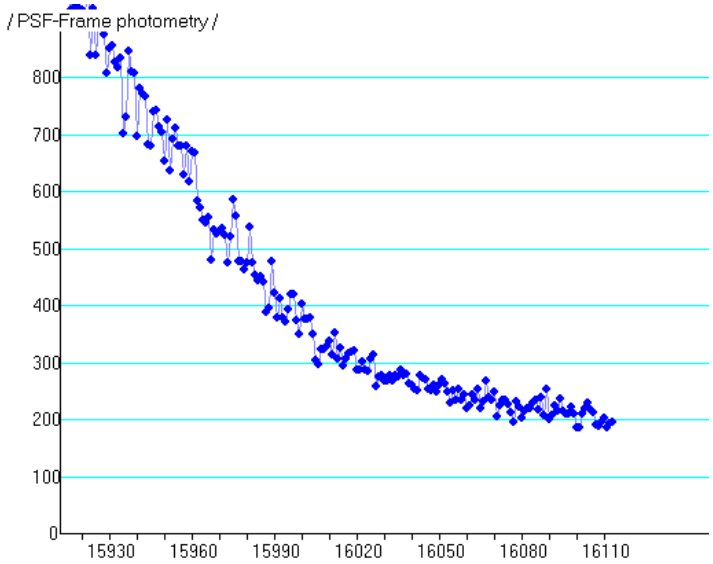

Figure 24- Bead1

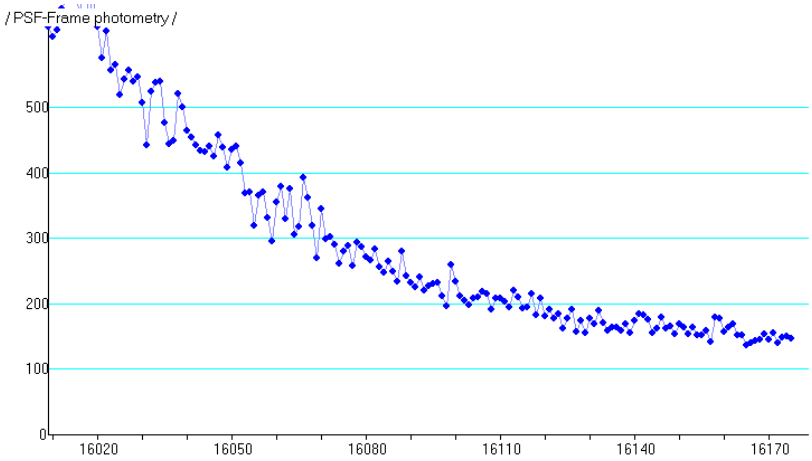

Figure 25- Bead 2

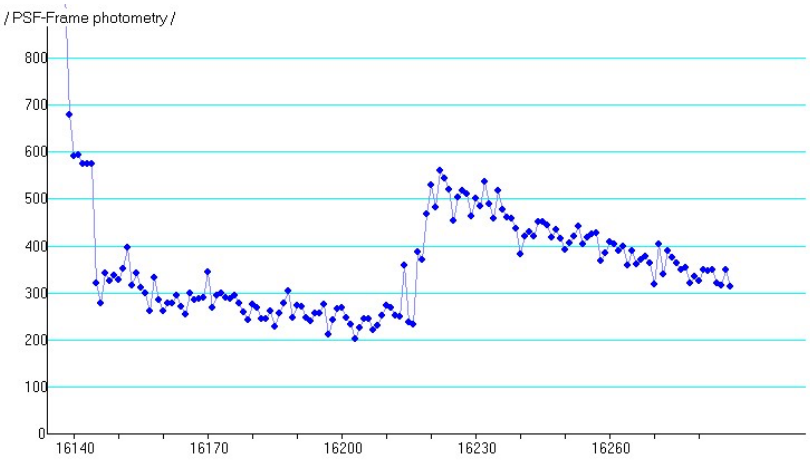

Figure 26- Bead 3

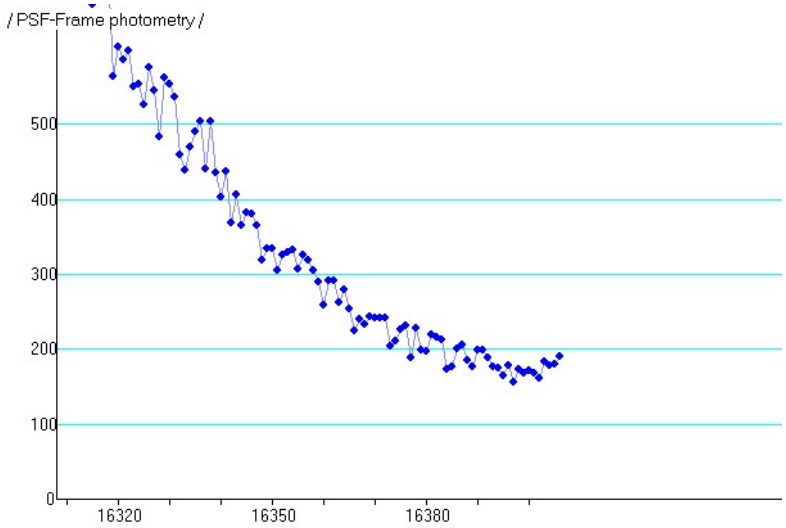

Figure 27- Bead 4

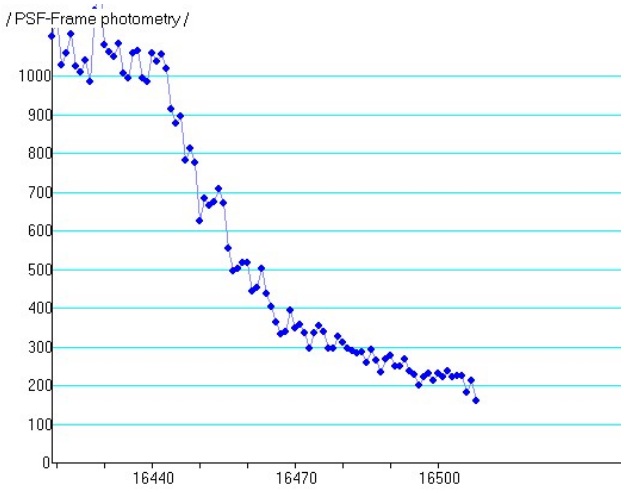

Figure 28- Bead 5

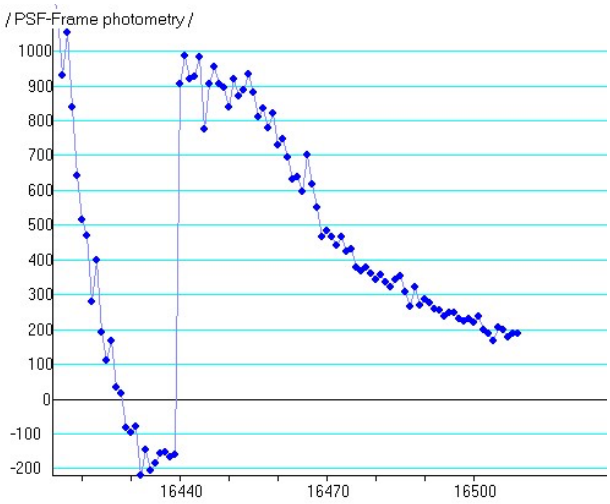

Figure 29- Bead 6

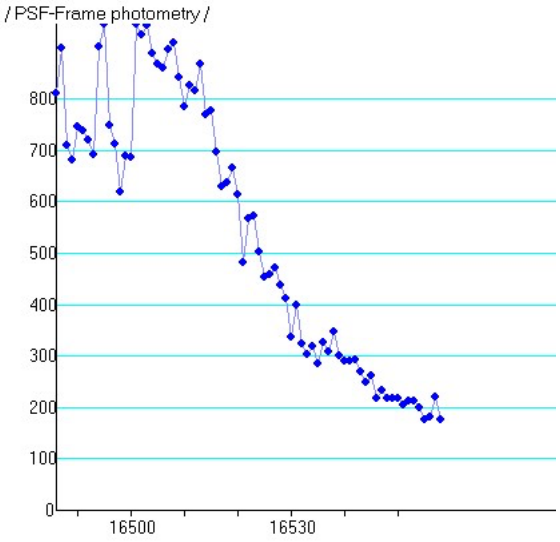

Figure 30- Bead 7

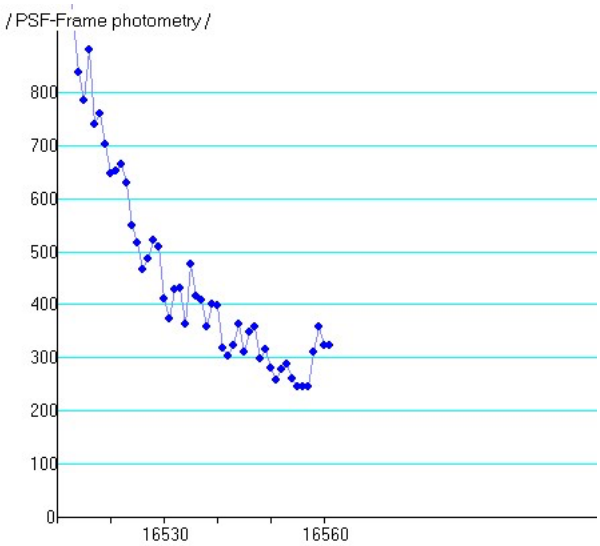

Figure 31- Bead 8

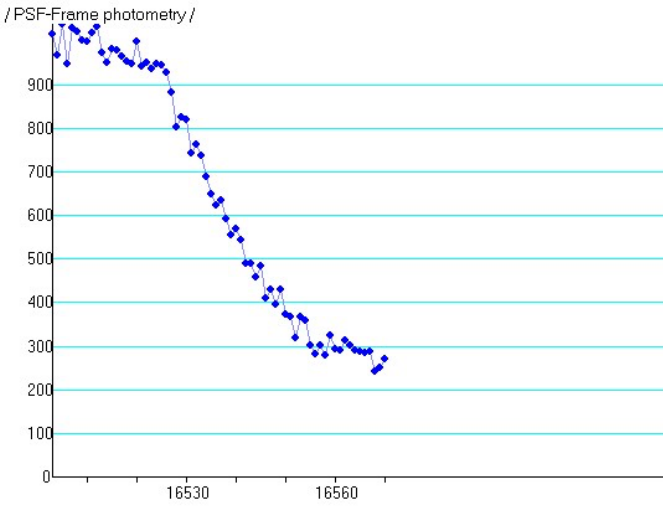

Figure 32- Bead 9

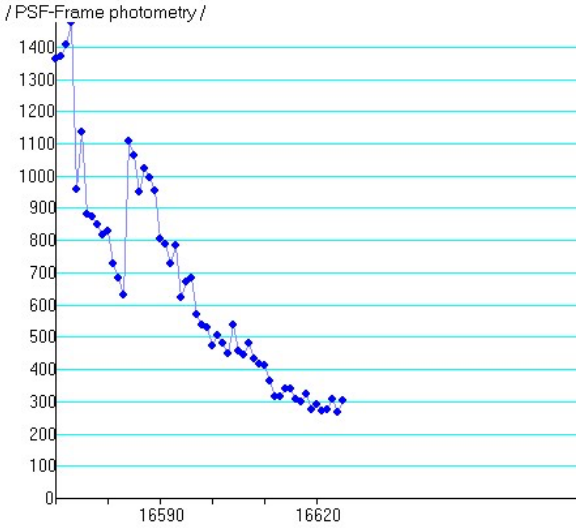

Figure 33- Bead 10

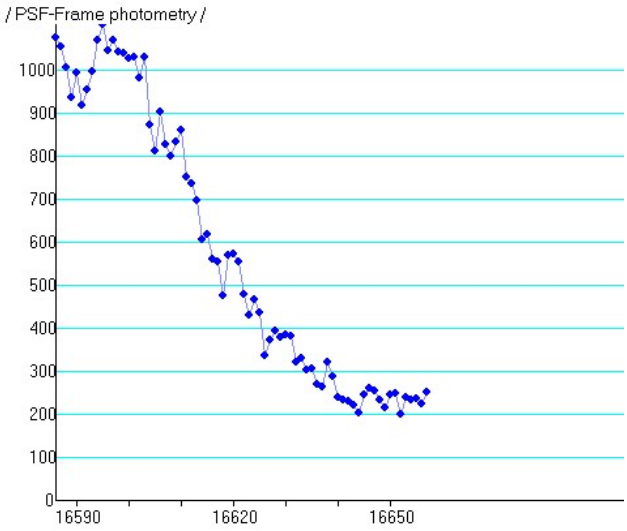

Figure 34- Bead 11

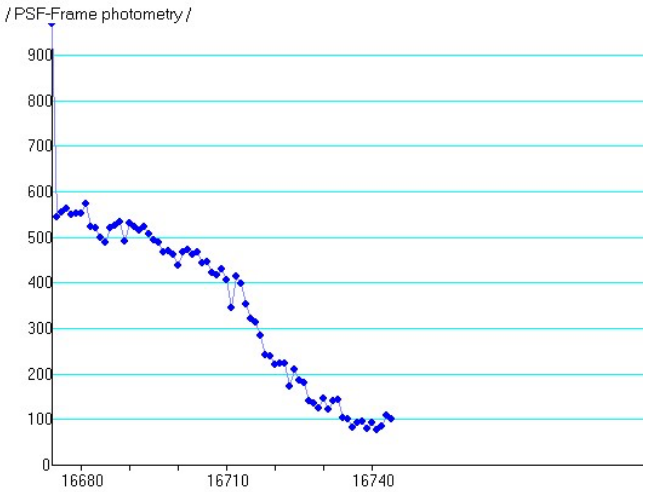

Figure 35- Bead 12

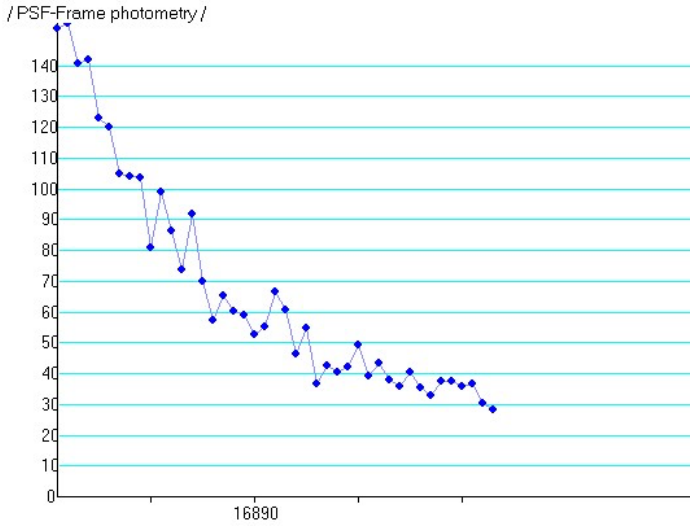

Figure 36- Bead 13

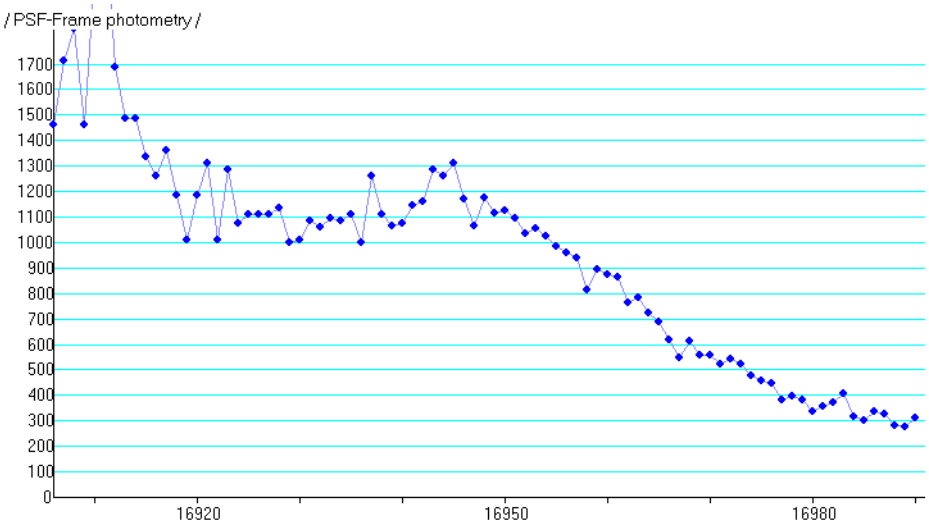

Figure 37- Bead 14

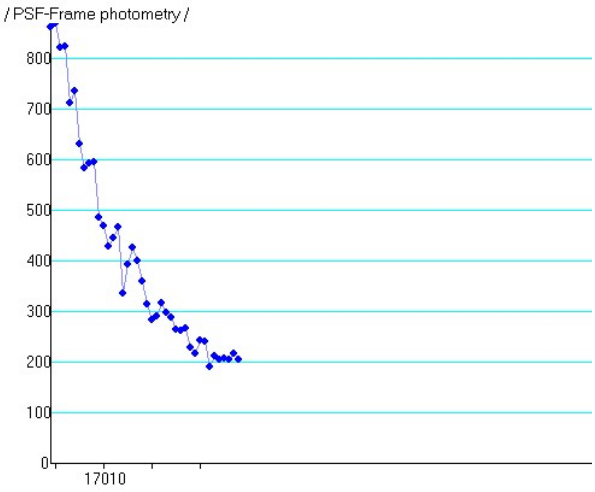

Figure 38- Bead 15

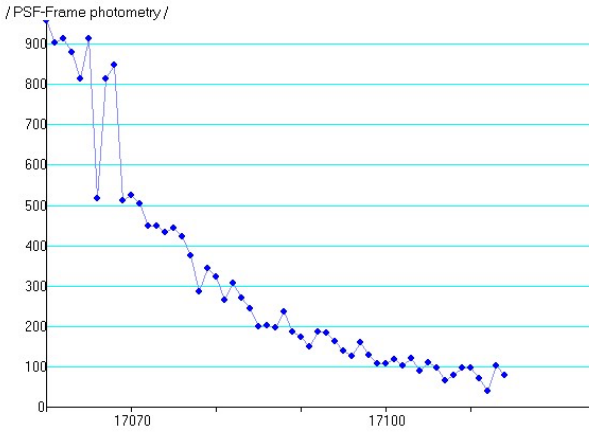

Figure 39- Bead 16

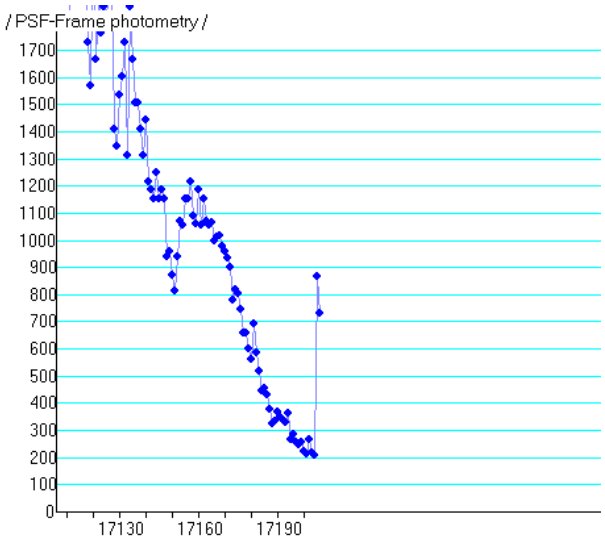

Figure 40- Bead 17

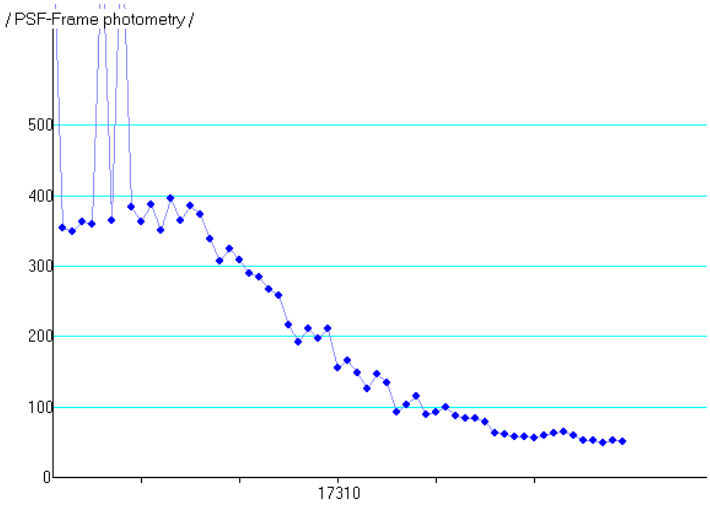

Figure 41- Bead 18

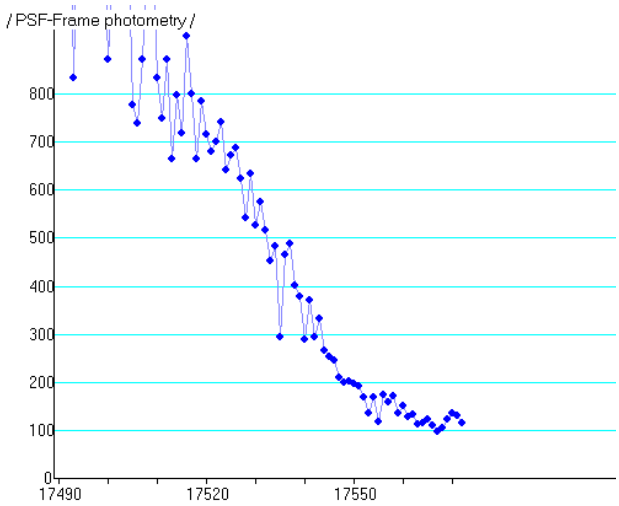

Figure 42- Bead 19

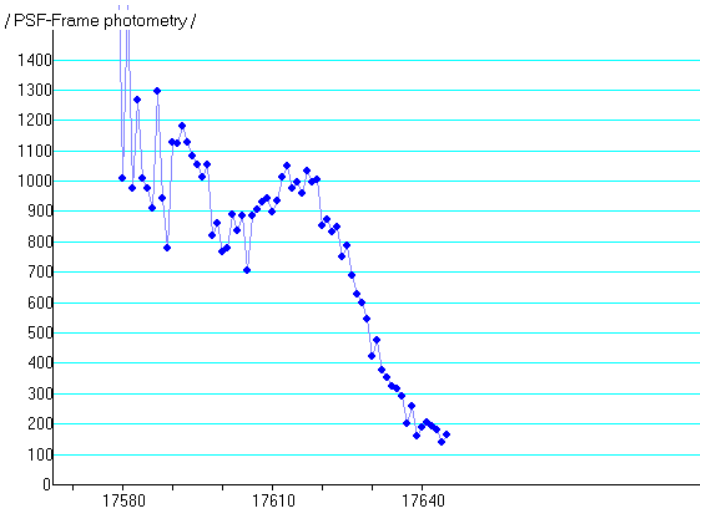

Figure 43- Bead 20

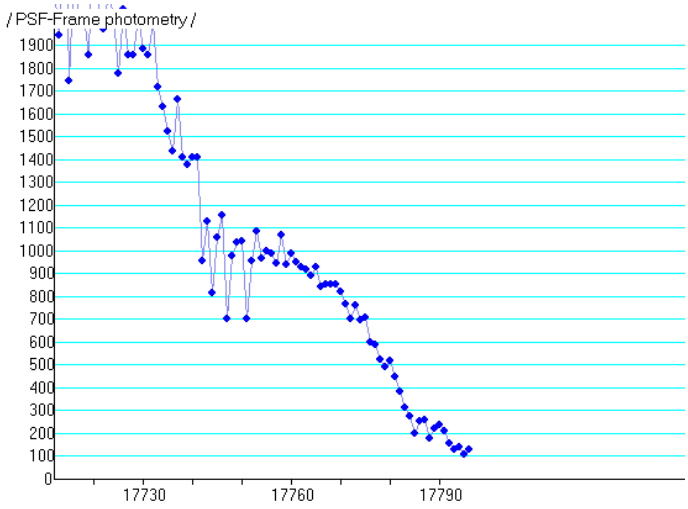

Figure 44- Bead 21

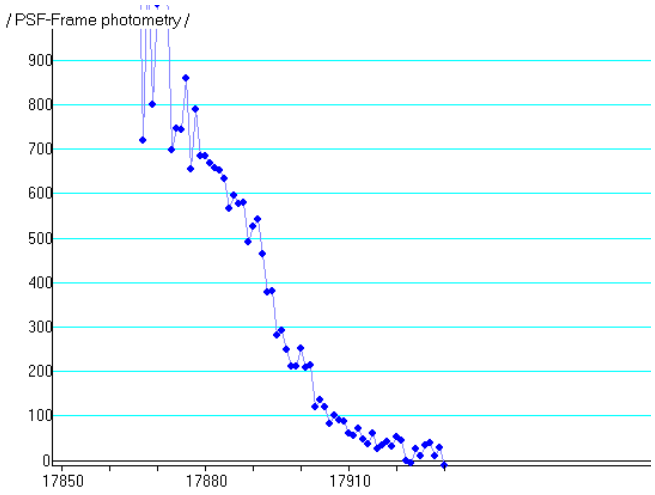

Figure 45- Bead 22

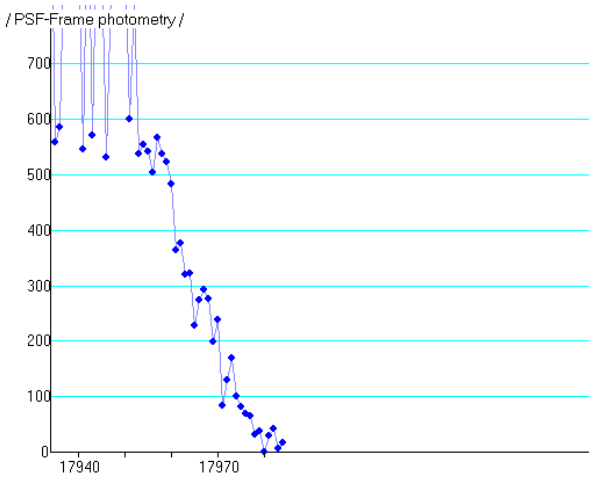

Figure 46- Bead 23

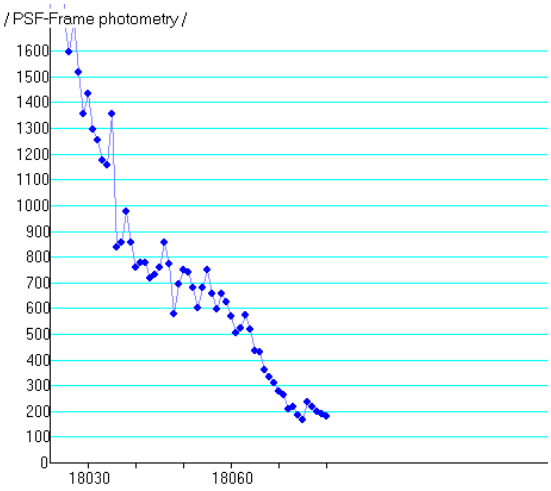

Figure 47- Bead 24

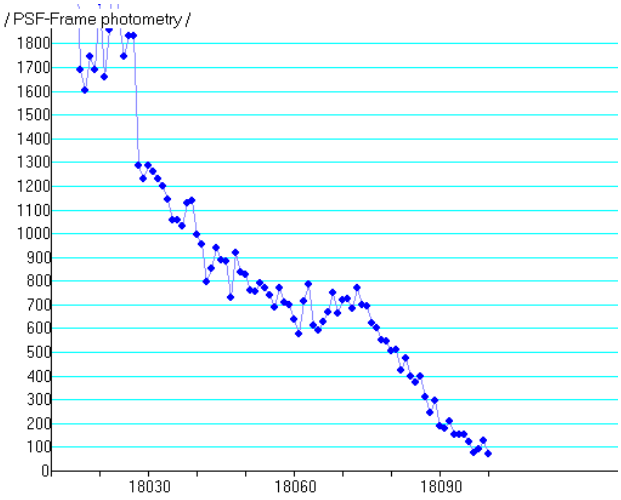

Figure 48- Bead 25

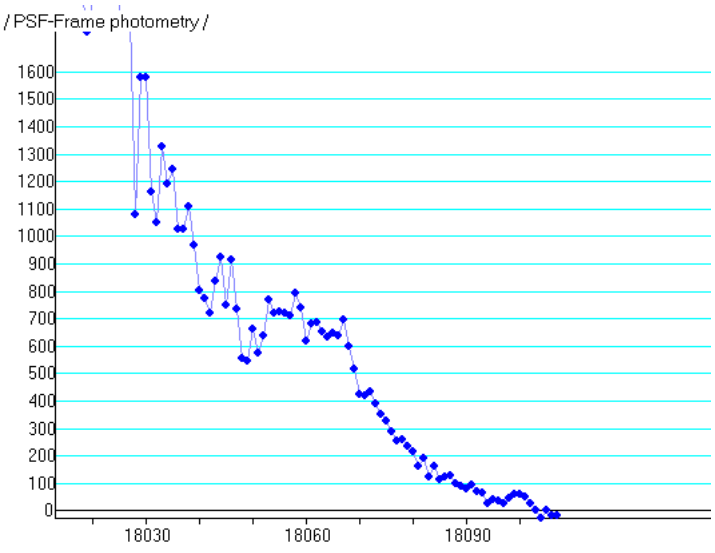

Figure 49- Bead 26

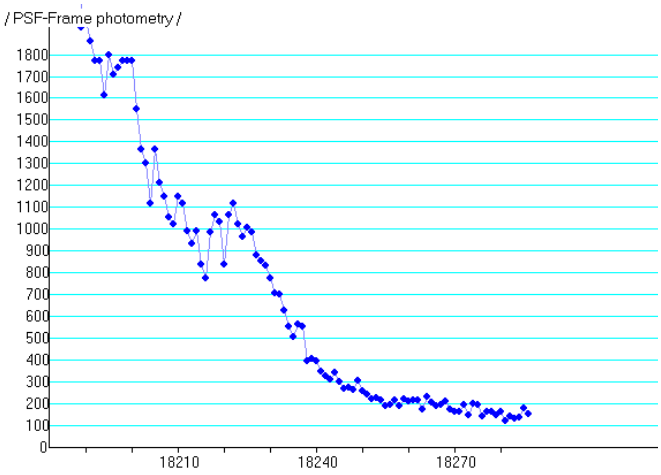

Figure 50- Bead 27

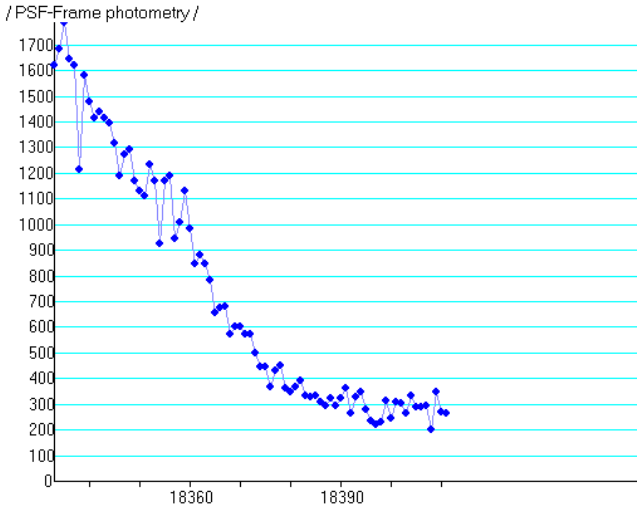

Figure 51- Bead 28

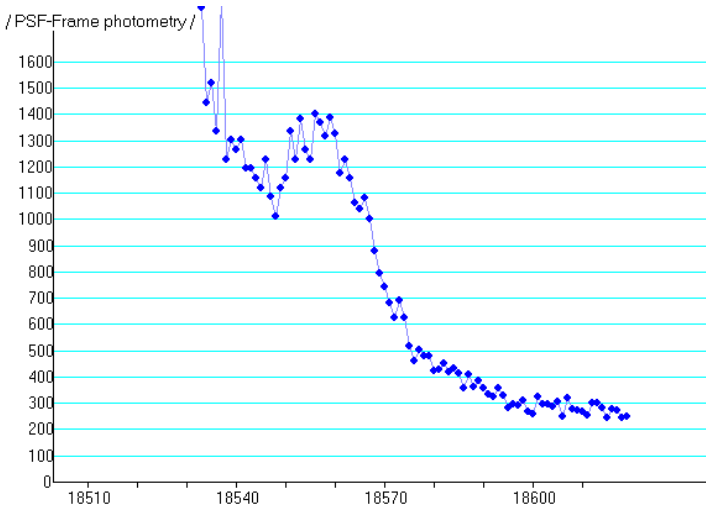

Figure 52- Bead 29

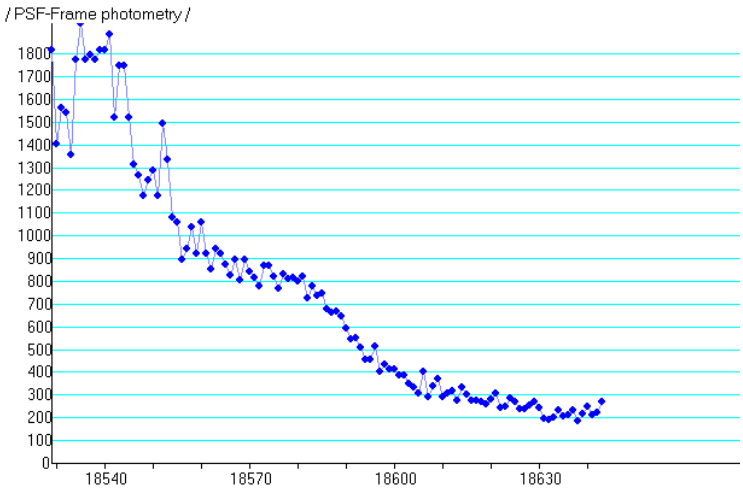

Figure 53- Bead 30

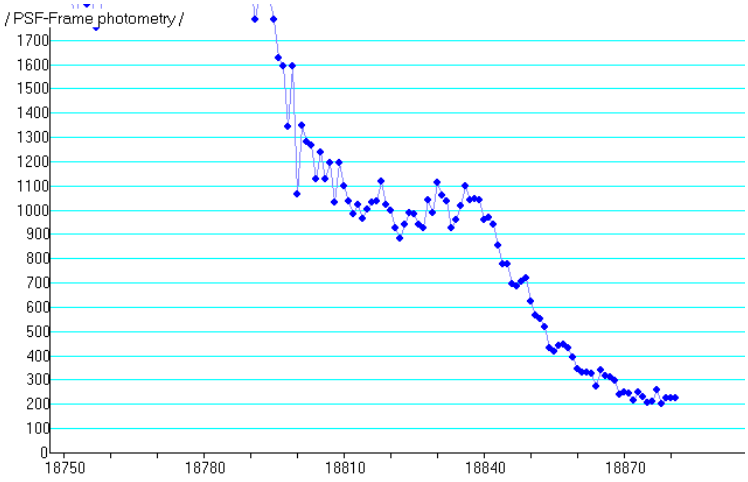

Figure 54- Bead 31

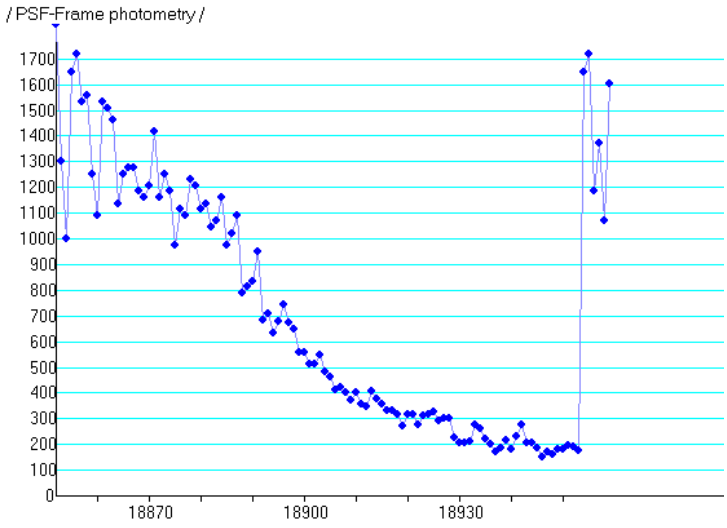

Figure 55- Bead 32

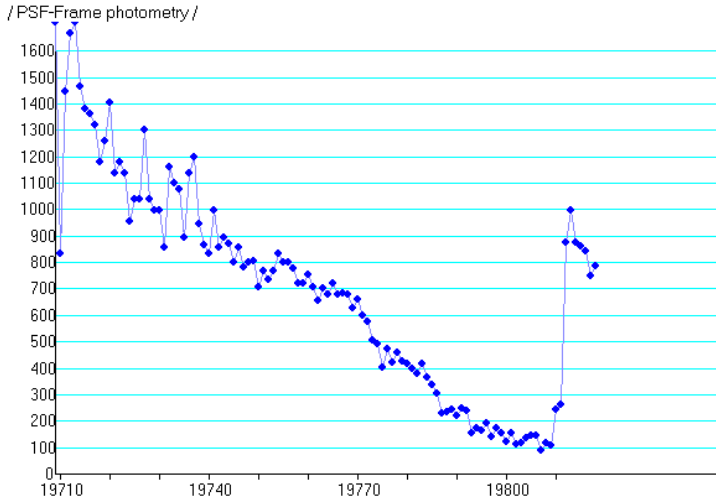

Figure 56- Bead 33

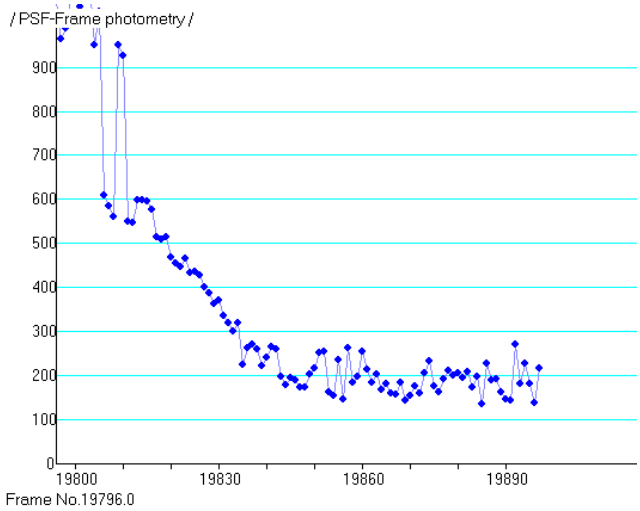

Figure 57- Bead 34

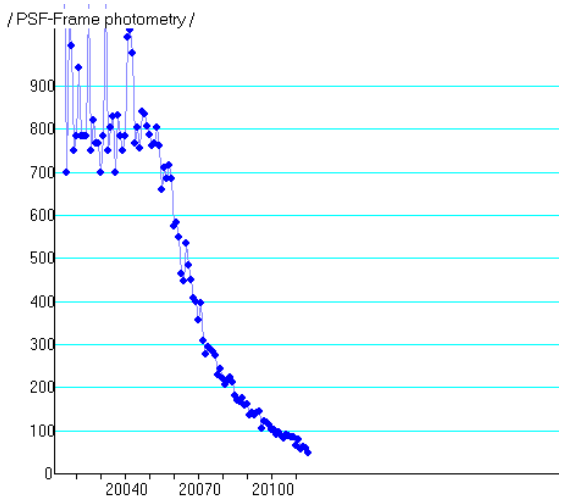

Figure 58- Bead 35

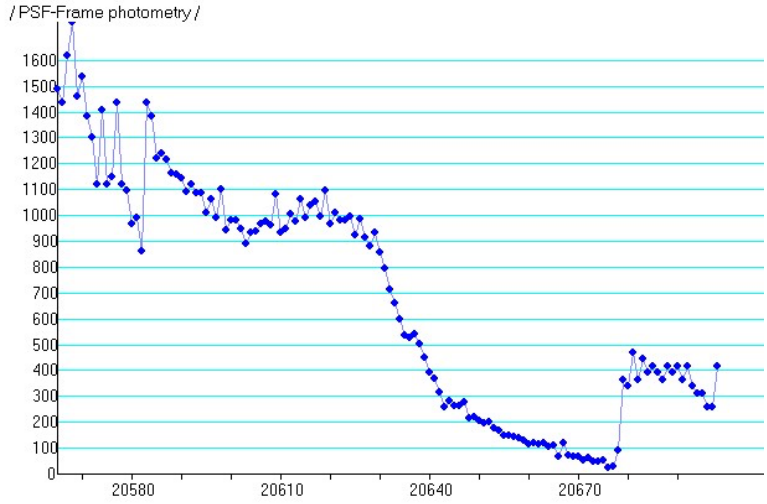

Figure 59- Bead 36

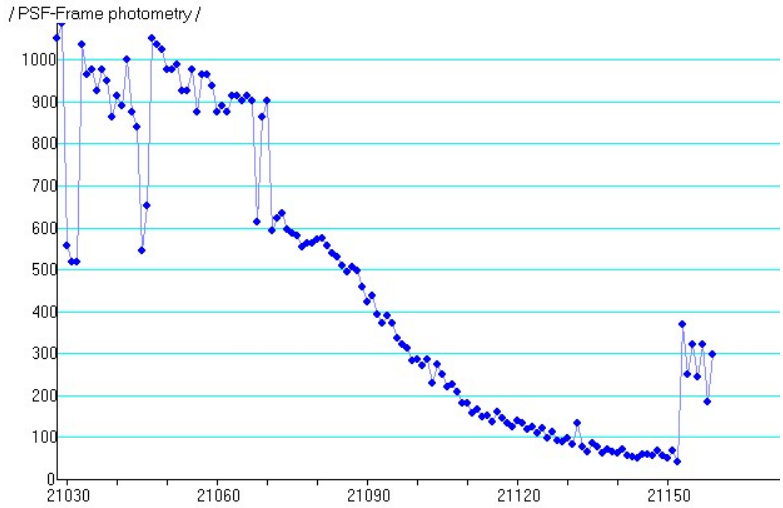

Figure 60- Bead 37

The disappearing frames of the beads were given in the following table.

Bead Number	Disappearing frame
1	16100
2	16166
3	16278
4	16399
5	16495
6	16508
7	16548
8	16555
9	16564
10	16619

11	16650
12	16736
13	16906
14	16993
15	17033
16	17099
17	17197
18	17326
19	17563
20	17640
21	17793
22	17914
23	17976
24	18074
25	18089
26	18093
27	18260
28	18383
29	18602
30	18616
31	18869
32	18918
33	19793
34	19843
35	20102
36	20660
37	21134

Table 3- Disappearing frames

CHAPTER VI

6 CHAPTER VI - DISCUSSION AND CONCLUSION

6.1 Discussion

Limovie was the best software to complete the project but the major problem faced at the beginning with the software was the limitations of it; the maximum file size of the video should be less than 1GB for DV files and the file should be in AVI format with compatible Codecs. But the original clip was 5GB in size. Hence several methods were carried out to convert the video file into a supportable AVI file using software such as **VLC** and **Davinci Resolve**. As the size of some of the videos converted by these software were bigger than the allowed limit, those videos were trimmed into several pieces using **Davinci Resolve.**

Nevertheless all those attempts the video was still not compatible. So some literature was referred and got to know about the video Codecs. Then it was found that the VirtualDub application was the best match for the conversion process. But the original video was not compatible with VirtualDub too. After referring some literature the reason was found that the suitable plugins were not available in the VirtualDub folder. Hence those plugins were searched on the internet and installed. Then the video was compatible to convert using VirtualDub and the converted file was compatible with the Limovie.

As Limovie is not compatible with high-quality videos, when tracking the targets there were errors into some extent. This could be minimized if the developers upgraded the software. But yet the software hasn't been upgraded as it is not an application that is used by many. Also, it would be better if the tracking code could be developed more to analyze the variations of the targets smaller than current limits because when tracking the smaller targets, the target point was changing in between nearby beads if they were very closer. This error was overcome to a satisfying level by changing the shape of the target to Meteor/Lunar Limb or Avoid Sunlit Face options. That was helped to keep the tracking point steady on selected targets preventing the interference of nearby objects.

To execute the tracking process more accurately, the Star Image [3D] feature was used from time to time when tracking to check the position of the tracking point and made sure it was kept at the same target. Also at the end of the tracking, the intensity peak of the target was observed with the same feature to make sure whether the bead was completely disappeared.

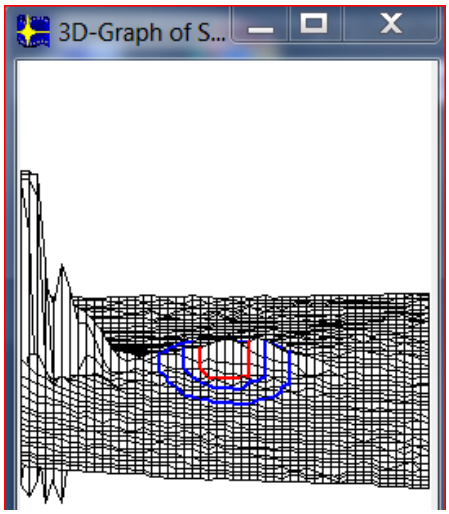

Figure 61- Intensity of the peak at the end of tracking

The intensity of the tracking point of the bead should be closer to the background intensity as same as possible at the moment where the tracking was stopped. And to make sure this the Graph feature was used time to time when tracking as well to see whether the intensity has become a constant.

There were some errors when tracking the intensities as sometimes the tracking point was not fixed on the targets. But that didn't affect much on the final results as the nearest disappearing frame was enough for further analysis.

6.2 Conclusion

Limovie is an effective application for astronomical projects regarding intensity data analysis. Using the software, 37 disappearing beads were detected successfully, and their disappearing frames were determined as much as accurately with the features of the Limovie. It would facilitate the astronomy field much more if the software could be developed further to track more accurately when tracking small points and points which are closer to other light sources.

Also, there are certain limitations of the Limovie and to have a compatible video file to run in there, assistance of other 3rd party applications like VirtualDub has to be taken. VirtualDub can successfully convert the video files into files with Codecs that are compatible with Limovie after installing suitable plugins.

6.3 Future Work

As the internship period was limited to three months the determination of the solar radius using the detected disappearing frames of Baily's beads couldn't be proceeded. Hence in the future, the next stage of the project could be done to determine the solar radius using the results and it could be determined more accurately as the number of data points was large because there were 37 beads detected.

CHAPTER VII

7 CHAPTER VII - FEEDBACK AND SUMMARY

7.1 Feedback

The project was conducted during the Covid19 global pandemic. So some hardships were come across when getting the video clips for the project. Also, I was managed to visit the ACCIMT a few times only, during the period of the internship as there were travel restrictions and restrictions imposed by the institute itself. So online meetings were held through the Zoom platform with Dr.Adassuriya to discuss the problems aroused when doing the project and with Mr. Manathunga to discuss the progress of the project.

The three months period was very valuable for me academic vise as well as carrier vise as astronomy is one of my favorite fields to work with. I was able to gather a sound knowledge about the intensity tracking in astronomical projects and about the Baily's beads. Also, I was able to gather the skill to use Limovie, which is very useful software in astronomy. Beyond the project tasks, I was able to gather a good understanding of the video Codecs when trying to overcome the drawbacks I faced while doing the project. Thus, I hope all those works will be very valuable in the future.

I would like to mention the huge support and guidance given by Dr. Adassuriya, my industrial supervisor, and the valuable advises given by my academic supervisor, Mr. Manathunga. And I am very grateful for them for holding my back and I won't be able to end the project successfully without them.

It was a huge opportunity to do the internship collaborating with the astronomy department of the ACCIMT. And it was very valuable for me to work in ACCIMT which is one of the best leading research institutes in Sri Lanka. So, I was very grateful for the opportunity and highly recommend the ACCIMT for the undergraduates who intend to have a valuable internship period.

7.2 Summary

Baily's beads effect is a phenomenon that happened during solar eclipses and using this effect some astronomical data can be determined. In this project frames of disappearing beads were detected using the open-source application Limovie, which is used for intensity tracking analysis projects. A video footage of the solar eclipse that happened on 26th December 2019 was used in the project to detect beads and it was converted to AVI format using another open-source application, VirtualDub.

There were 37 disappearing beads detected during the project and the disappearing frames were determined for each bead successfully. The final results will be used to determine the radius of the sun more accurately.

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ANNEXES

Part of a data set

FileName : E:\Cap1226_017-2 copy (2).avi									
Video System : NTSC , FrameRate=29.97									
	Time	Result						Object 1	
	Detect	Measurement	-Value		FWHM/HFD			Pixel Value	
No.	Signal1	Object1	Object2	Object3	Object1	Object2	Object3	EstimatedPeak'sHeight	Background
15912.0		962.3			5.6987			117.7	0
15913.0		977.7			5.6987			119.6	0
15914.0		945.3			5.6987			115.6	0
15915.0		950.4			5.6987			116.2	0
15916.0		918.8			5.6987			112.4	0
15917.0		977.9			5.6987			119.6	0
15918.0		926.3			5.6987			113.3	0
15919.0		902.2			5.6987			110.3	0
15920.0		919.6			5.6987			112.5	0
15921.0		912.4			5.6987			111.6	0
15922.0		963.7			5.6987			117.9	0
15923.0		840.1			5.6987			102.7	0
15924.0		920.5			5.6987			112.6	0
15925.0		838.6			5.6987			102.6	0
15926.0		901.7			5.6987			110.3	0
15927.0		893.4			5.6987			109.3	0
15928.0		875.8			5.6987			107.1	0
15929.0		806.7			5.6987			98.6	0
15930.0		851.8			5.6987			104.2	0
15931.0		857.2			5.6987			104.8	0