TOTAL SOLAR ECLIPSE OVER HANGZHOU, ZHEJIANG PROVINCE, CHINA 22 JULY 2009

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Abstract:

On the 22 of July 2009 an expedition for the Total Solar Eclipse in Hangzhou city, China, carried out by Malaysian National Eclipse Tracking Team (NETT). The task of the expedition was to do imaging and recording the whole process of eclipse with high-resolution astronomical camera CCD/digital and video. The movement of the Sun in the sky with the changes of phases during the eclipse can be capture through multi-exposure technique imaging. Parameters such as the temperature, humidity, intensity and sky brightness recorded to see their changes with the environment. The gravity experiment of simple pendulum conducted before the first contact, during first and second contact, during totality, during third and fourth contact and after fourth contact and the results was 8.16 ms-^{2}, 9.97 ms^{-2}, 12.60 ms^{-2}, 11.18 ms^{-2}, and 9.75 ms^{-2} respectively. All the above experiments result were very successful as represented by graphical diagrams. The recording the light polarization and flash spectrum were partially successful. However, for recording corona spectrum and Eddington experiment were not successful due to cloudy condition during the critical moment of capturing the images

Introduction:

Total Solar Eclipse takes place when the Moon disc totally covers the whole surface of the Sun. This event will only occur when the Moon position is in between the Earth and the Sun. Furthermore, the three bodies must be in aligned or in the same plane i.e. having same longitude. For the year 2009, a total solar eclipse will takes place on 22nd of July. This is the longest duration of totality for the last century it is about 6 minutes. The solar eclipse begins at 08.21 am local time and ends at 10.59 am local time in Hang Zhou city, China. The totality is about 6 minutes and it is very crucial to do certain scientific experiments such as timing accuracy, and the atmosphere of the Sun particularly corona and chromospheres'.

After taking consideration of all factors involving observing solar eclipse the National Eclipse Tracking Team (NETT) had decided to observe the solar eclipse in Wildland Resort, Hangzhou city with coordinates latitude 30^0 $10.033^'$ N, longitude 120^0 $02.900^'$ E, altitude 130 meter above sea level and GMT difference of 8 hours. NETT team members comprise of Space Physics Research group, headed by Prof. Dr. Mohd Zambri Zainuddin, Department of Mufti Selangor State(JMNS), Department of Islamic Religious Selangor(JAIS), Department of Mufti State Government Negeri Sembilan(JMKNNS), Department of Islamic Development Malaysia(JAKIM), Department of Survey and Mapping Malaysia(JUPEM), Institute National Land and Survey(INSTUN), and Department of Mufti Terengganu(JMT). 35 researcher (10 of which from University of Malaya) were involved in the total solar eclipse expedition. All Travelling arrangement was handled by UC travel Cooperative Bookshop University Malaya.

Research conducted for the Solar Eclipse Expedition:

There are nine experiments to be conducted in this solar eclipse expedition. The experiments are:

1. Imaging the whole process of eclipse with high-resolution astronomical camera CCD /digital using telescope. Aim is to study the edge/limb structure of the Moon and test the accuracy of prediction time of solar eclipse occur.

2. Recording the whole process of solar eclipse with high-resolution video camera. Aim is to test the accuracy of contact timing of first, second, third and fourth compare to the predicted time.

3. Recording temperature, humidity and sky brightness. This is to see the changes of the environment before, during and after solar eclipse.

4.Landscape imaging with multiexposure technique. Aim is to show the movement of the Sun in the sky with the changes of phases during the eclipse process.

5.Recording the spectrum of the corona using specially designed spectrograph. Aim is to study the physical characteristics of the Sun corona through the emission lines observed.

6.Observing the light polarization in the Sun corona using specially designed equipment. Aim is to study the corona polarization pattern and understanding the existence of magnetic field.

7.Recording “flash” spectrum of the Sun, aim is to study the existence and characteristics of the Sun chromosphere.

8.Conducting gravity experiments with a simple pendulum technique. The aim is to determine whether there is a change in gravity magnitude before, during and after the solar eclipse.

9.Imaging the background star around the Sun during totality. This experiment conducted by Sir Eddington in 1919 to prove that Einstein theory on gravitation pull is correct.

All the above experiments carried out in China and analyzed at Space Physics Research Group, Physics Dept., Faculty of Science, and University of Malaya. The results of the research will be revealed, exhibit as posters during the International Year of Astronomy Seminar 2009 on 1st to 4th. December 2009 at Rumah University, University of Malaya. Finally, we will try to publish in research journal and as reference to the public.

The results of all the experiments conducted   below.

Imaging the whole process of eclipse with high-resolution astronomical CCD camera/digital camera using telescope. Aim is to study the edge/limb structure of the Moon and test the accuracy of prediction time of solar eclipse occur.

Whole process of total solar eclipse imaging was carried out using two small telescopes with diameter 60 mm and 101 mm respectively. Each telescope was equipped with SLR digital camera to capture the image of phases of eclipse. The image was process and analyzes using software called digital photo professional. Taking image of the whole process of solar eclipse enable scientist to observe the movement of the Moon, the structure of chromospheric and corona of the Sun. The main objective of this research is to study the characteristic structure of the limb/edge of the Moon disk, the Sun chromosphere and corona and the timing of contact during phases of eclipse.

According to data obtained from NASA website about solar eclipse in Hangzhou, Zhejiang Province, China and the prediction time of contact as given below:

Event	Date	Time (UT)	Alt	Azi
Start of partial eclipse (C1) :	2009/07/22	00:21:26.1	038.8°	087.4°
Start of total eclipse (C2) :	2009/07/22	01:34:14.8	054.5°	097.3°
Maximum eclipse :	2009/07/22	01:36:55.2	055.1°	097.8°
End of total eclipse (C3) :	2009/07/22	01:39:36.5	055.6°	098.2°
End of partial eclipse (C4) :	2009/07/22	02:59:21.9	072°	119.9°

Table 1: Timing contact

The table 1 show the eclipse phases in Event, Date, Time (UT: 8 hour zone difference), altitude and azimuth of the Sun.

There are 4 contact points for each occurence of solar eclipse as follow:

First contact (C1) :

The time where the limb of the Moon begin to touch the limb of the Sun for the first time

Second contact (C2) :

The time for totality begin

Third contact (C3) :

The time for totality end.

Fourth contact (C4) :

The time for the limb of the Moon finally leaving the limb of the Sun completely.

The above value are compared with the actually observation as shown in the table 2:

	PREDICTION TIME (UT)	OBSERVATON TIME (UT)	DIFFERENCE (second)
First contact	00:21:26.1	-	-
Second contact	01:34:14.8	01:34:12.5	-2.3
Maximum totality	01:36:55.2	01:36:22.5	-32.7
Third contact	01:39:36.5	01:39:32.5	-4.0
Fourth contact	02:59:21.9	10:58:44.0	-37.9

Table 2: Actual observation

The result show that we are unable to detect the first contact as it was cloudy. However the second, third and fourth contacts we are able to observe. The differences show within the limit of 1 minute precision. The observation show that the time of observation seem to be faster that the prediction time. The reason is due to the seeing condition is not ideal and the image quality is affected. However we can say that the edge/limb of the Moon has to be study in more detail in the future. Figure 1 are the images of the solar eclipse.

Figure 1: Images of Solar Eclipse

Solar eclipse is one of astronomy phenomenon that takes place when the Moon revolve around Earth and passing through between the Sun and Earth as shown in the diagram below:

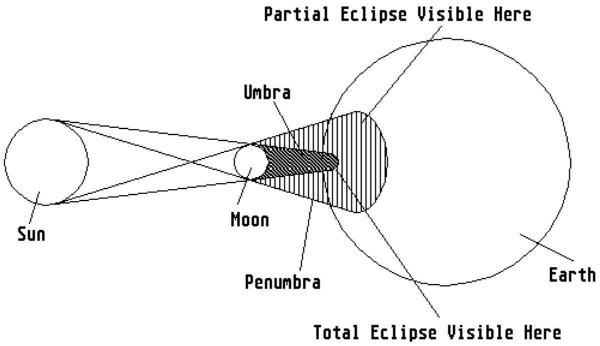


Figure 2: *Total solar eclipse*

The arrangement of the Sun, Moon and Earth in a line happens only when the Moon is in it new moon phase. If we look from Earth, the position of the Sun, Moon and Earth is in a line called conjunction. Based from figure 2, intensity of umbra and penumbra regions are darker compare to regions on Earth that are not visible of solar eclipse. Scattering of light in the Earth atmosphere are due to Mie and Rayleigh scattering that become weaker when the Sunlight is block by the Moon slowly and this definitely causes the brightness of the Sky fainter. Therefore, it is necessary to measure the changes in sky brightness, temperature, pressure and humidity of the environment during total solar eclipse. The measurement was conducted before, during and after solar eclipse. The measurement of timing, altitude and azimuth of the phases of solar eclipse are given in the table 3.

Event	Local Time	Altitude	Azimuth
First contact (C1) :	08:21:14.9	+38.7°	87.2°
Second contact totality begin(C2) :	09:34:10.2	+54.4°	97.1°
Totality maximum :	09:36:41.8	+54.9°	97.5°
Third contact (C3) :	09:39:14.5	+55.5°	97.9°
Fourth contact (C4) :	10:59:09.3	+71.9°	119.3°

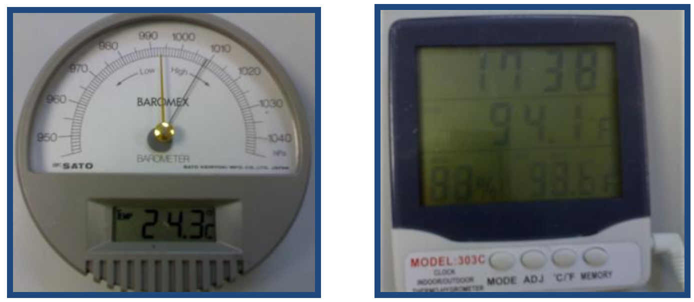
Table 3: *Phases of total solar eclipse*

Sky Brightness

SQM (Sky *Quality Meter*) is an instrument used to measure the sky brightness. The unit is in magnitude per arcsecond^2. Thermometer, barometer and hygrometer are used to measure temperature, pressure and humidity respectively.

a)

b)

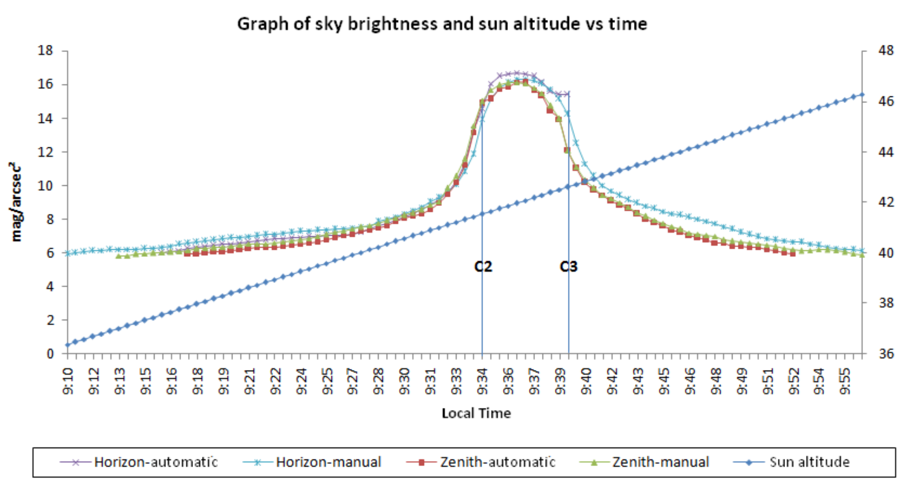


c) d)

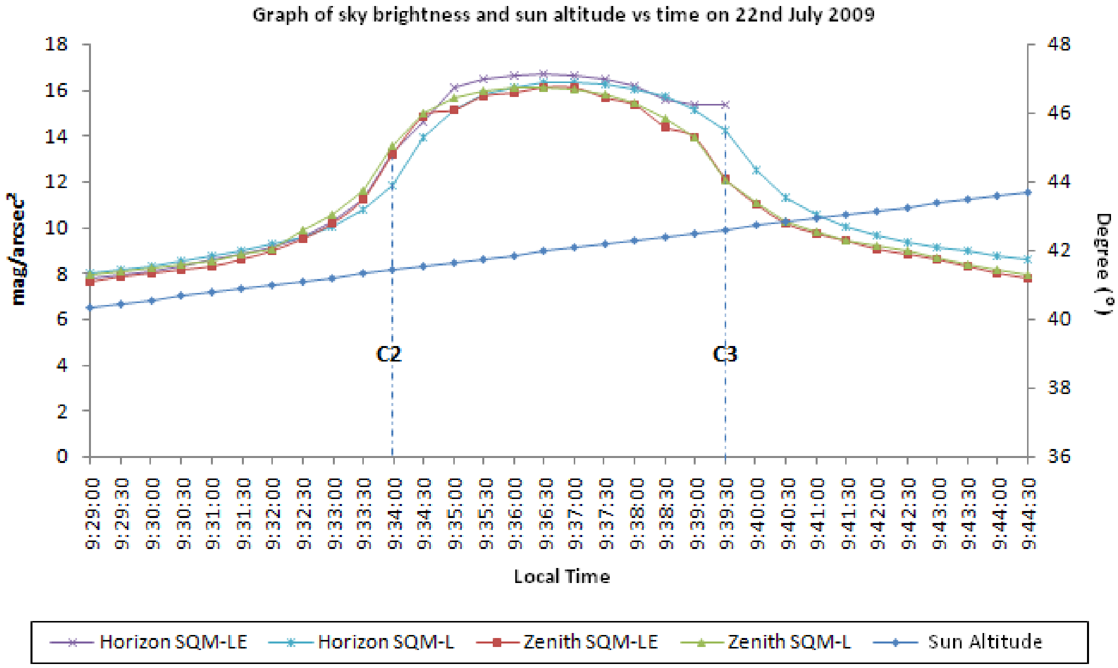
***Figure 3**: (a) SQM-L (b) SQM-LE c) Barometer d) Hygrometer*

Temperature and humidity reading are taken beginning at 7.30 am that is 51 minutes before the first contact. Readings are taken every 2 minutes until 8.21 am. Then readings are taken every minute until solar eclipse end that is after fourth contact. However, sky brightness reading cannot be recorded at 7.30 am because the sky is to bright that is the value is below 6 mag/per arcsecond^2. The reading can only be recorded at 9.10 am that is 24 minutes before maximum totality is achieved.

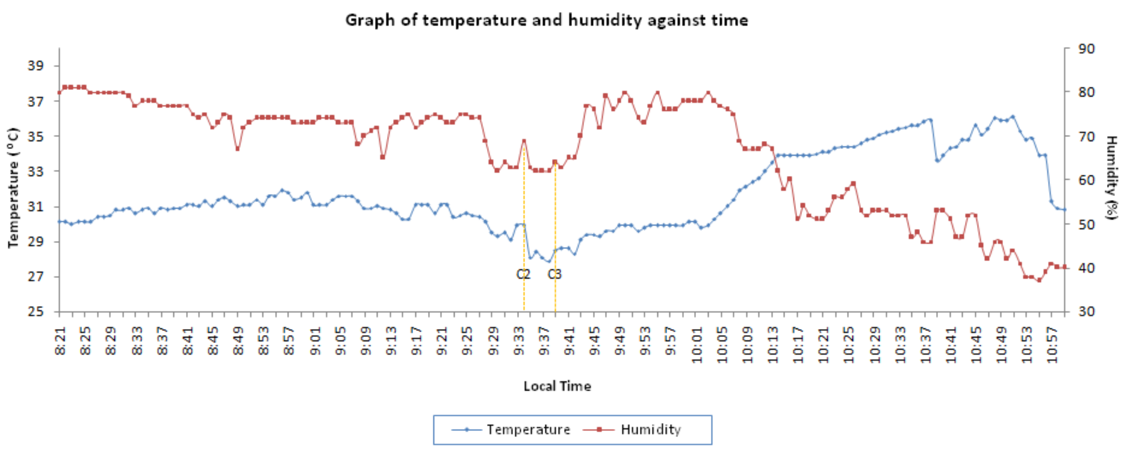
The results of distribution of changes in sky brightness, temperature, pressure and humidity during solar eclipse are plotted as the following:



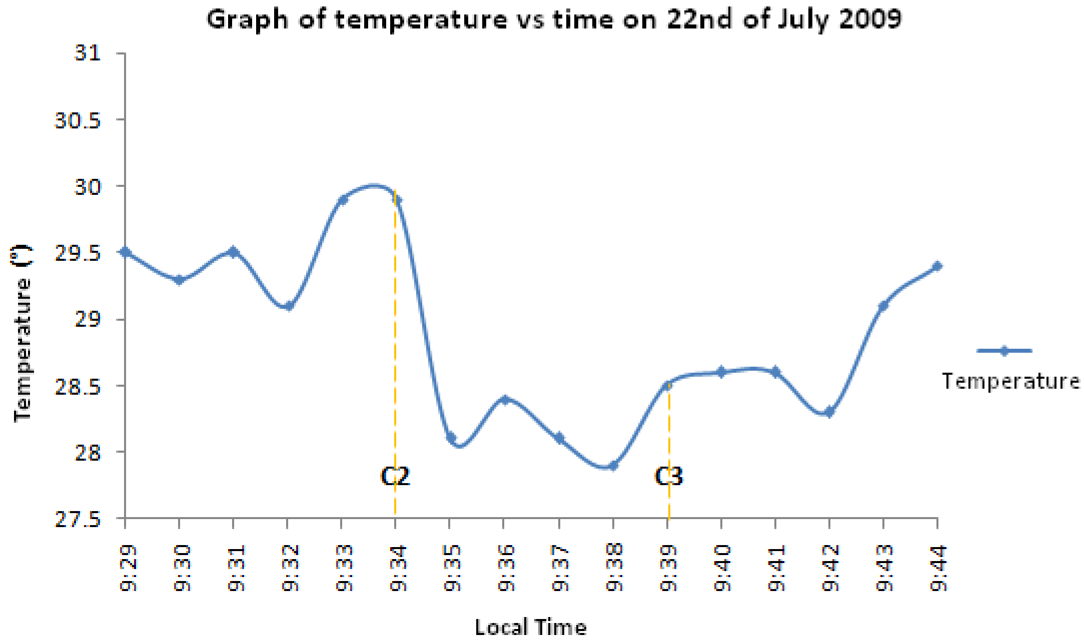
***Graph 1:** Distribution of sky brightness (mag/arcsec^2) and altitude of the Sun (degree) at the horizon and zenith against local time*



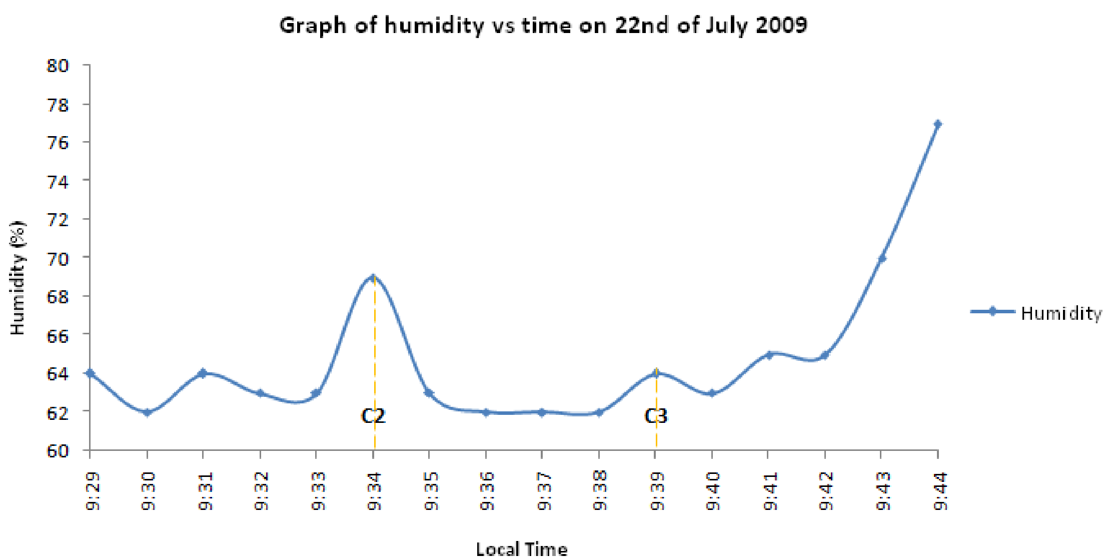
Graph 2: *Sky brightness (mag/arcsec^2) and altitude of the Sun (degree) against local time during totality phase*



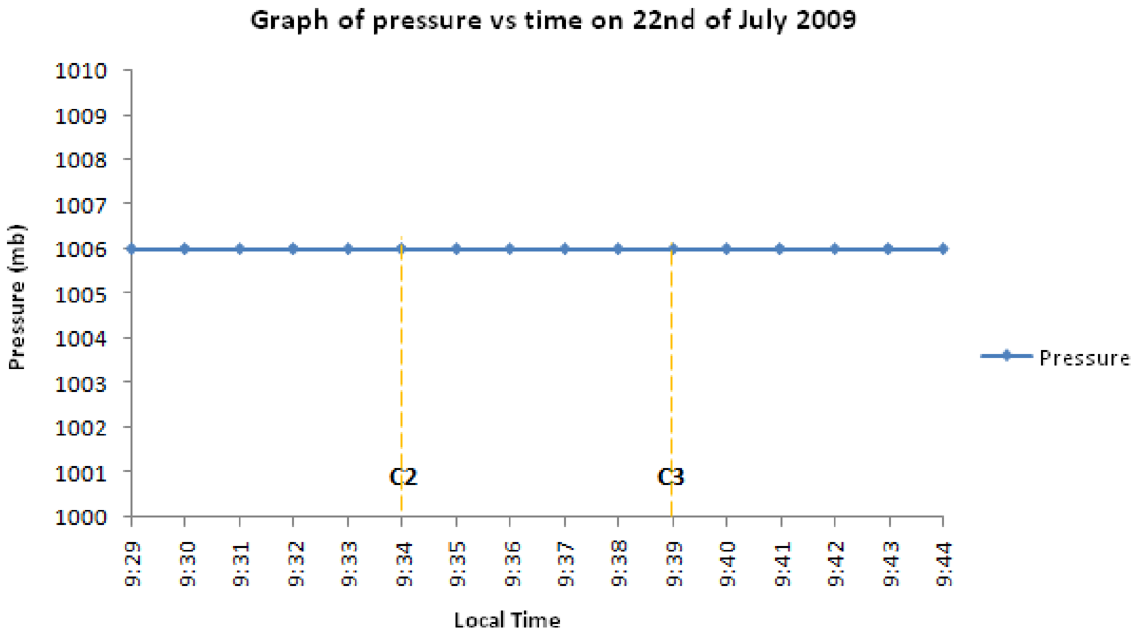
Graph 3: *Distribution of Temperature (°C) and humidity (%) against local time*



Graph 4: *Temperature (°C) against local time during totality*



Graph 5: *Humidity (%) against local time during totality*



Graph 6: *Pressure (mb) against local time during totality*

The results show that changes in sky brightness, temperature and humidity but not pressure. The lowest value of sky brightness was recorded at 9:36:30 is 16.71 mag/arcsec^2 for SQM-LE directed about 15^o above the horizon while SQM-L that is directed toward zenith gives reading of 16.13 mag/arcsec^2. This is taken during totality showing the minimum brightness of the sky. The reading of temperature from first contact to fourth contact is in the range of 36.1 °C until 27.9 °C. There is a drop of 8.2 °C while humidity value is between 62 % until 77 % with an average value of 63.67 %. The pressure is 1006 mb remain constant throughout the eclipse.

Flash Spectrum

Flash spectrum is an arrangement of spectrum display wavelength observed through radiation from the limb of the Sun during the flash period that is a few seconds at the beginning of totality phase or the end of totality phase. When the photosphere of the Sun is covered by the Moon, the atmosphere layer of the Sun emits prominence and the spectrum will exhibit bright lines due to hot gas burning. Studying the flash spectrum will give us information about the physical condition of the chromosphere of the Sun.

The first flash spectrum was recorded by an astronomer from America named Charles Augustus Young during the total solar eclipse on 22 December 1870.
Experimental result during totality at Hangzhou 2009 is not good because the sky was cloudy during the second contact period.

Figure 4: *Existence of the Sun spectrum for first and second order.*

However, the spectrum image for Sunlight was taken during the first contact by using a simple spectrograph comprising of diffraction grating and a camera. The sunlight has been scattered and divided into the order determined by the viewing angle. Typically, the first order will be adjacent to the object, and having a higher intensity.
During the Sun is slowing been covered by the Moon the light is reduced by the light cloud and the result coming through the spectrograph will give an absorption spectrum of the Sun when the sunlight come out from the cloud for a short time.

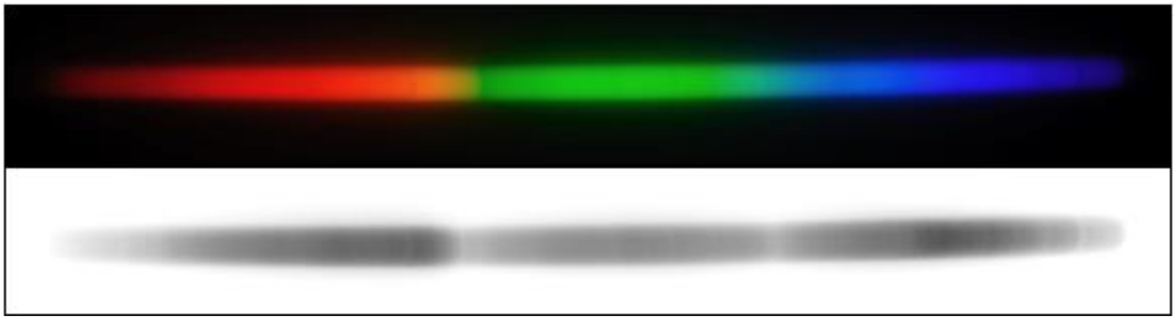


Figure 5: (above) Sun spectrum obtained after first contact (below) absorption lines from the Sun

The above figure shows the lines look curving due to the solar eclipse process when the Moon had covered the disk of the Sun and look like a crescent. Therefore, the line spectrum formed will follow the light source, which is curved.

Figure 6: *Sun shape before the spectrum in figure 4 was taken.*

There was no light observe coming out from the chromosphere because of the cloud covering the whole Sun during totality made the flash spectrum difficult to record from simple spectrograph..

Corona spectroscopy

Studying the Sun corona is toward one of the corona line having wavelength λ6374Å (FeX) at different height from the Sun disc (limb). Typically, the temperature of the corona is estimated from the full width half maximum (FWHM) of Aller equation:

$$\delta\lambda_a = 2\sqrt{\ln 2}\,\frac{\lambda}{c}\alpha = 7.16\times10^{-7}\lambda\sqrt{\frac{T}{M}} \qquad (1)$$

where $\delta\lambda_a$ is the FWHM, *c* is velocity of light, λ is wavelength, T is kinetic temperature in absolute unit and M is weight of the atom.

The kinetic temperature, T_k is related to average speed of gas or molecule or atom or ion. However the temperature obtained from using the FWHM value in equation (1) normally very high and not consistent with value, obtain from other method. Therefore, an assumption for turbulence is applied to explain the wide line width by this equation.

$$\alpha^2 = \left(\frac{2kT}{M}\right) + \zeta^2 \qquad (2)$$

where ξturbulence velocity k is is Boltzmann constant compared to equation below

$$\alpha^2 = \left(\frac{2kT}{M}\right)^{1/2} \qquad (3)$$

Adjustment of values for T and ξ in equation (2) is said to be consistence with observational value. (Peraiah et.al, 1989).

Analysis for line λ6374Å has been done with measuring the width of the line at half its intensity and its strength. The difference at this width and intensity for this study is compare with previous studies. The value of FWHM and its line profile λ6374Å at different position was compared and the kinetic temperature is calculated using equation (1).

Figure 7: *Instruments used to obtain spectrum image of corona*

Figure 7 shows the experimental set-up for the corona spectrum measurement. It comprises of 8” telescope, spectrograph SGS with slit width 100 μm and diffraction grating 600 lines/mm. The image is recorded with camera CCD ST8-XME.

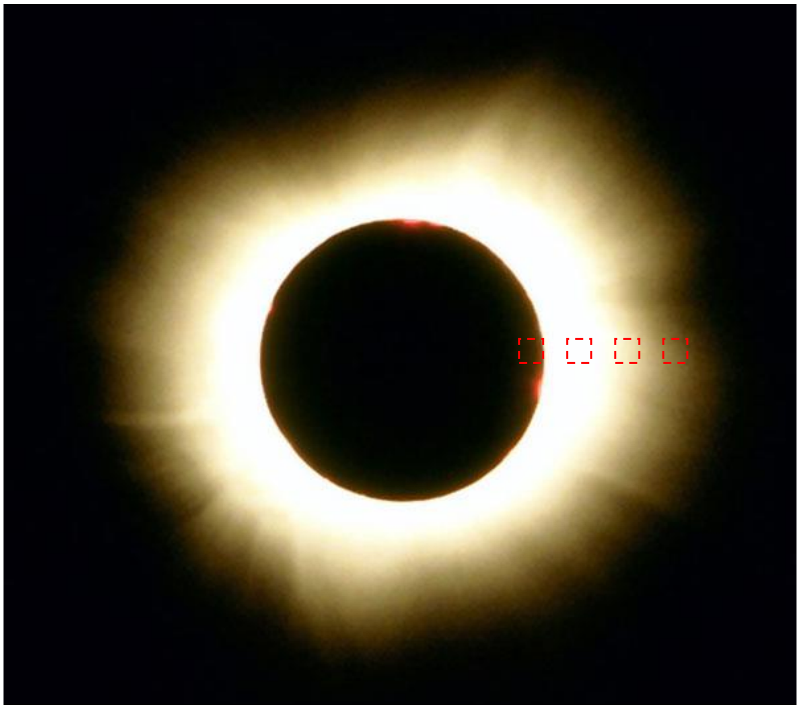
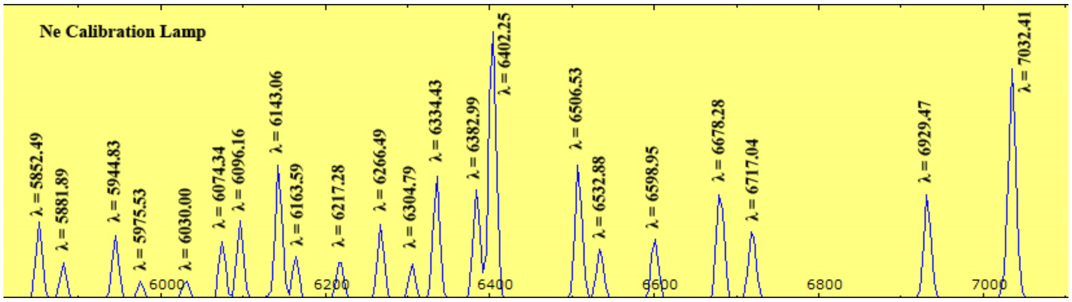
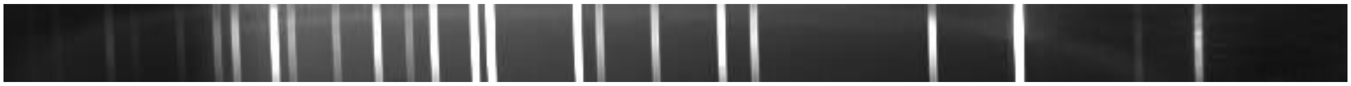


Figure 8: *Red boxes show the regions for corona spectrum to be observed. Sun corona picture is courtesy from raphaelfernandez.com.*

Experimental result:

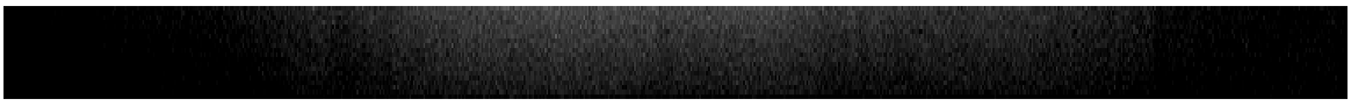
During totality phase, there was thick cloud therefore only the inner corona seen for a few second. Hence, the experiment to record the corona spectrum in not successful. Figure 8 shows spectrum image of the photosphere recorded for 5 seconds before totality and the inner corona spectrum during totality. The spectrum of the photosphere shows some absorption lines while the inner corona spectrum does not display clearly the absorption line. However, we could not record the spectrum further away from the surface of the Sun because of cloud coverage.





Reference spectrum Neon

Photosphere spectrum



Inner Corona spectrum

Figure 9: *Neon spectrum (above), photosphere spectrum (middle) and inner corona spectrum*

Sky illumination

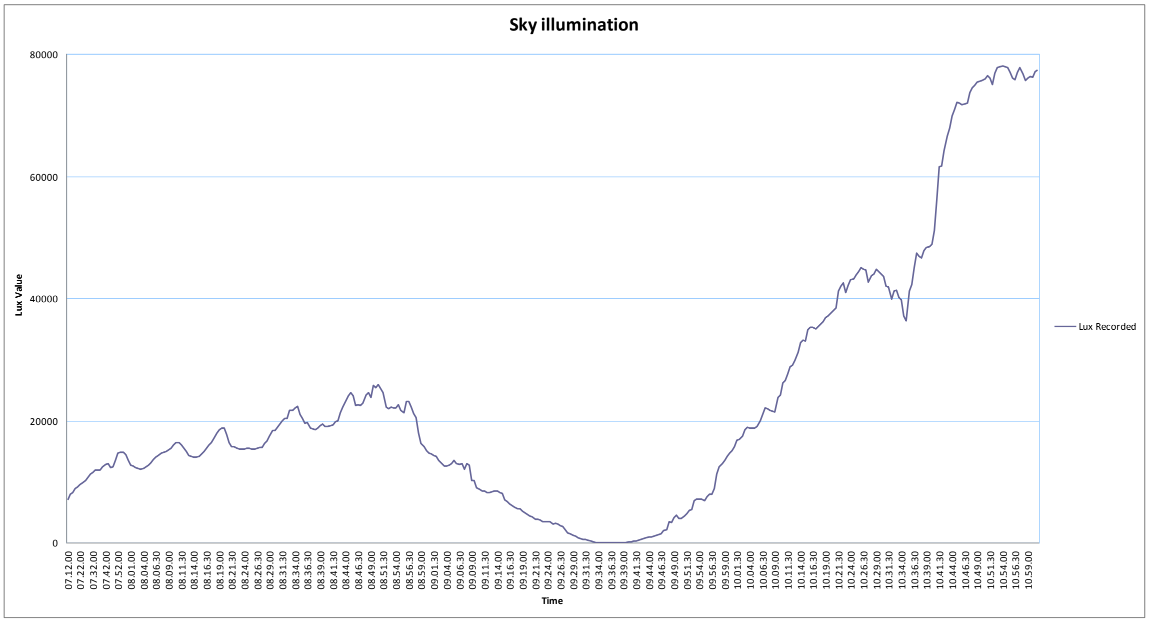
The changes of light illumination during solar eclipse can be measured using light meter. Digital light meter was used to measure the light intensity of the sky. The meter had reading range from 0.1 lux until 200,000 lux, very accurate and had fast reaction.

Figure 10: Sky Meter

The measurement was conducted during all the phases of the solar eclipse as provided from NASA website as the table shown below

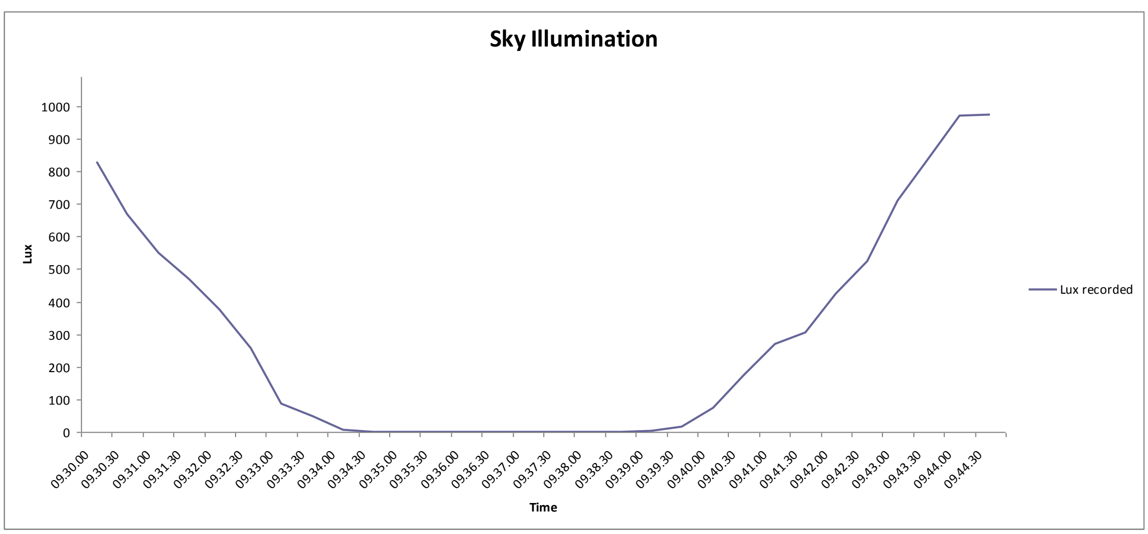
Event	Date	Time (UT)	Alt	Azi
Start of partial eclipse (C1) :	2009/07/22	00:21:15.2	038.7°	087.2°
Start of total eclipse (C2) :	2009/07/22	01:34:10.3	054.4°	097.1°
Maximum eclipse :	2009/07/22	01:36:42.0	054.9°	097.5°
End of total eclipse (C3) :	2009/07/22	01:39:14.7	055.5°	097.9°
End of partial eclipse (C4) :	2009/07/22	02:59:09.3	071.9°	119.3°

The result of the experiment was plotted as shown in the graph 7. The reading was taken from 07:12:00 am until 11:00:00 am local time. The graph show the reading seems to fluctuate early on from 07:12:00 am until 08:54:00 and this is due to cloudy situation. Similar reading also from 10:26:00 am until 10:41:00 am.



Graph 7: *Graph of sky illumination*

At the first contact timing, 08:21:00 am, weather is cloudy therefore, instrument gives unstable reading. However, we can see the graph show the sky illumination seems to be decreasing little by little during the second contact at 09:34:30 am. After 09:38:00 am, the lux reading increases rapidly until the fourth contact. This show that the sky illumination is increasing because the Moon is slowly moving away from the Sun. For further analysis to see the time of beginning of totality to the end of totality we focus at the timing for duration of totality.



Graph 8: *An enhancement of duration of totality*

The above graph is plotted to compare the observational data and theoretical data during the maximum eclipse phase. Generally based on theoretical calculation, eclipse phase reach maximum for about 5 minutes from 09:34 am until 09:39 am. During that period, the situation becomes dark as if like nighttime. However, base on observational data obtained the maximum duration is 4 minutes. The difference is due to the reading is being taken with an interval of 30 seconds and the determination of time of contact is difficult because of cloudiness condition.

Polarization

Stenflo and Keller (1996, 1997) discovered the Sun spectrum exhibit light linearly polarization structure without the presence of magnetic field on the Sun. The sun light linearly polarization structure is known as “second Sun spectrum”. The Sun linearly polarize is due to light scattering is coherent and anisotropic geometry at the Sun atmosphere and the amplitude of polarization seem to increase when reaching the edge of the Sun disc (Stenflo 2004). Furthermore, the sunlight polarization phenomenon seems to incline not to follow the characteristics given in atomic, molecule theories, and quantum mechanic that we understand.

In 2000, 2002 and 2005, Gandorfer had published an atlas spectrum of linear polarization of the Sun ranging from wavelength 316.0nm until 699.5nm with spectrograph slit 5” (arc second) is place directly onto the edge of the Sun disc and the slit position is parallel to it. However, light polarization information obtained might have influenced from the photospheric layer. Therefore, to obtain the light polarization information from the Sun atmosphere almost “pure”, the slit spectrograph must be directed toward outside edge of the Sun disc.

Total solar eclipse will give an opportunity to do observation toward the Sun atmosphere (chromosphere and corona) from Earth surface. When the photosphere of the Sun was covered with Moon, the Sun atmosphere layers will be visible and its spectrum show bright emission lines due to ionizations of gases from different elements. Without solar eclipse the spectrum will be, brighten-up due to the Sun disk glowing and the Earth atmosphere causes it not visible.

The study is to focus the upper layer of the Sun chromosphere. The layer of the Sun chromosphere is thin, and can only be seen less than 10 seconds after the formation of totality and 10 seconds after the totality end. This phenomenon is known as “flash” because it appearance is to short.

The first “flash” appearance, during total solar eclipse phase formed, flash spectrum was not able to record. However, the second time “flash” spectrum appears we were able to record it in the wavelength range about 486nm until 588nm.

The experimental set-up is shown in the diagram below

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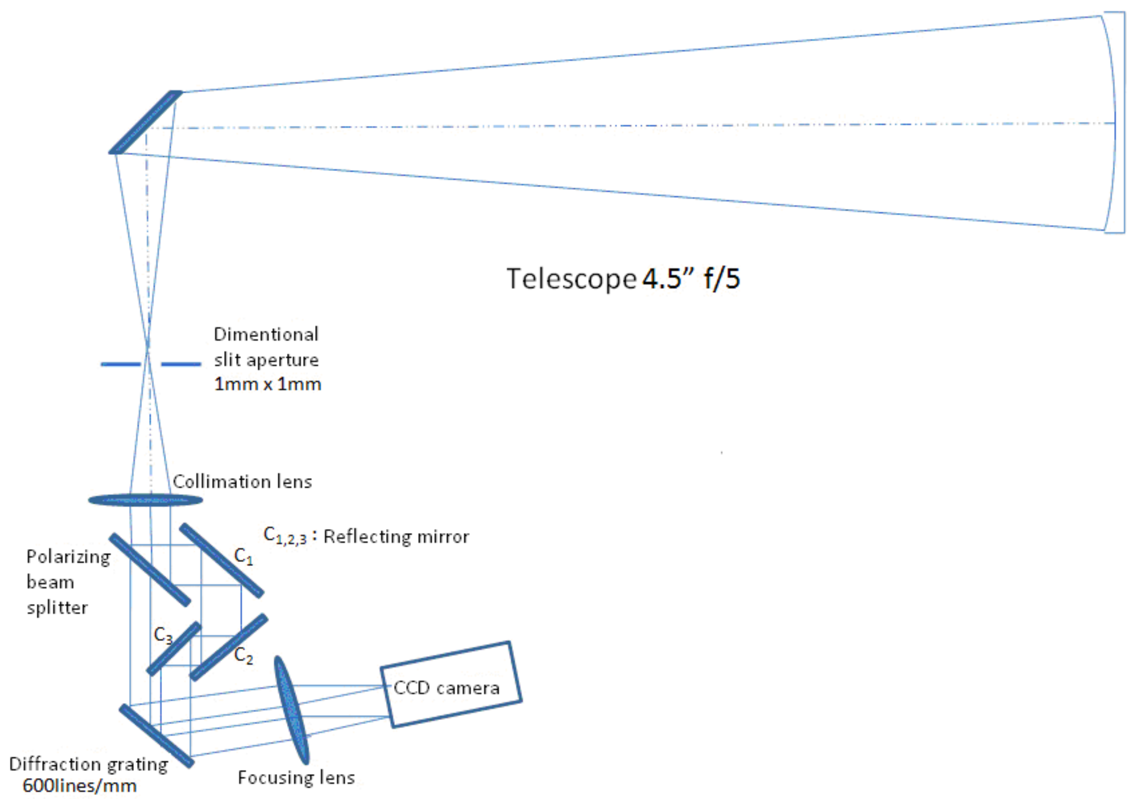


Figure 11: *Experimental set-up*

The result of the experiment as follows

1) 9:39:47am.

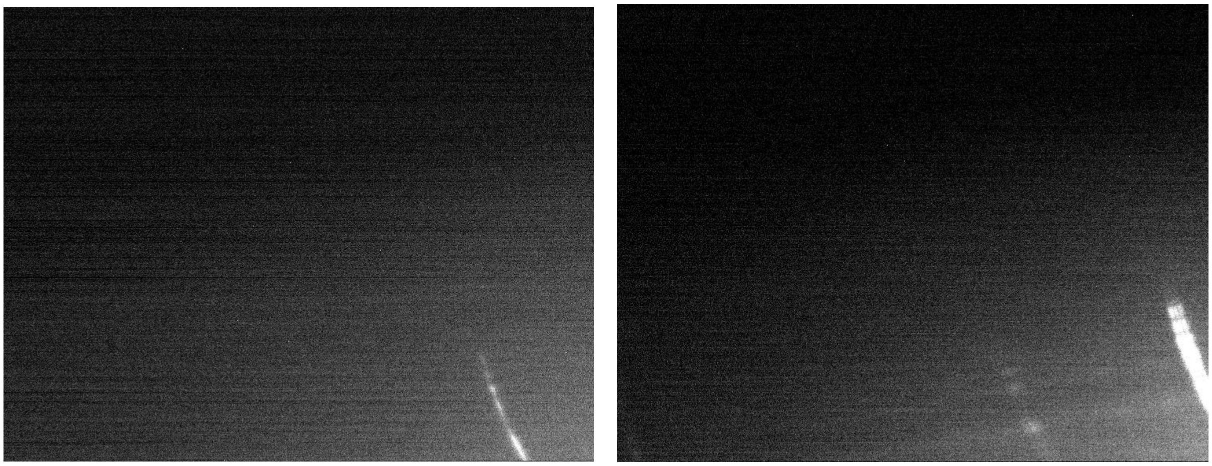


***Figure 12**: "Flash" spectrum formed at 9:39:39am (left) and 9:39:44am (right)*

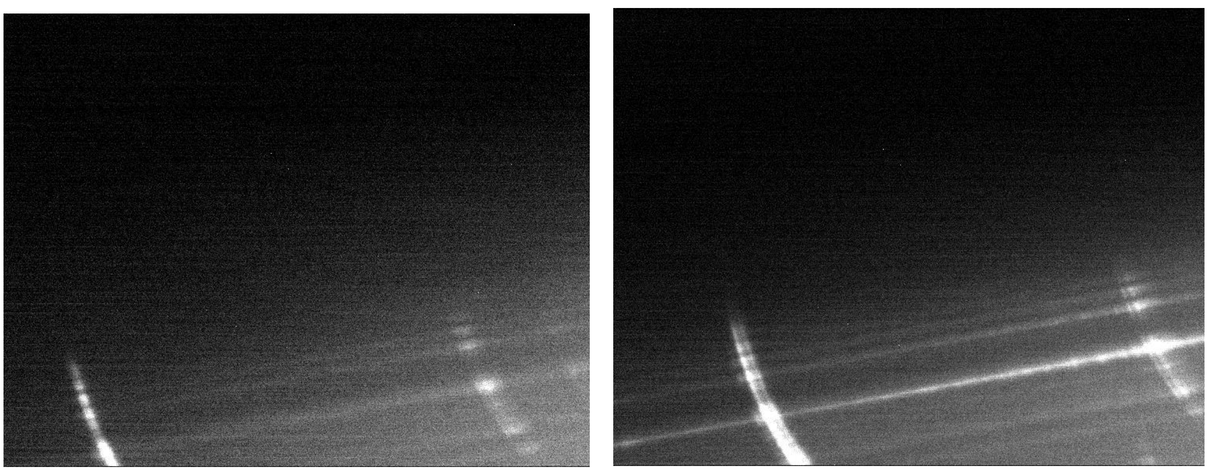


***Figure 13**: "Flash" spectrum formed at 9:39:45am (left) and 9:39:47am (right)*

The weather during solar eclipse observation was cloudy. Cloud at higher altitude is expected to influence the efficiency of light polarization coming from the Sun chromosphere. Overall, the data of "flash" spectrum of polarized Sun obtained for total solar eclipse 2009 is not successful.

Eddington Experiment

In 1911, a German scientist named Albert Einstein had put forward a theory of general relativity; generally, most scientist during that time cannot except and proved it. However, in 1919 a British scientist named Eddington had proved that the theory put forward by Einstein had complement classical relativistic theory of Newton. In 1919 Eddington leading a group of expedition to track and record total solar eclipse that take place in Principe Island, Africa. The total solar eclipse is used to proof that the Sun possessing very large mass able to divert/bias starlight. Solar eclipse phenomenon is chosen because this is the only opportunity to record the position of the star closes to the Sun for further study. Comparing the two pictures taken 6 months apart before solar eclipse and during solar eclipse will proof Einstein theory. Based on astrometry analysis using the Sky6 software positions of stars relative to the Sun position during total solar eclipse maximum phase can be refer to diagram below:

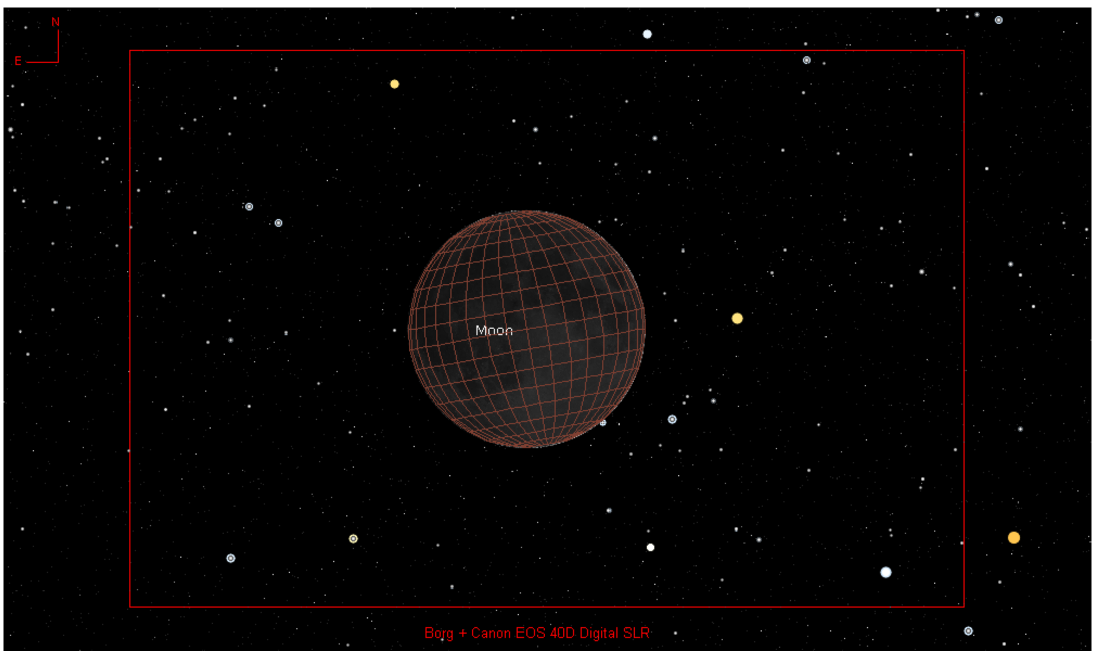


Figure 14: Sun position during totality

The position of the Sun (during eclipse) is between cancer and Gemini constellations. Stars that are near the Sun such as SAO79899; SAO79912; SAO79953; SAO97570; SAO79969; and SAO97491. All this stars had apparent magnitude ranging from 7.5 until 9.0.

Experimental result is shown below

- Images taken during the solar eclipse

Figure 15: Images of eclipse

Cloudy condition that is changing causes various exposure time is being used. However, four images of solar eclipse during maximum totality could be recorded. The word “able” means that condition during imaging was done is not conducive whereby cloud covered most part of the Sun disc especially during the 5 minutes period.

Image of solar eclipse during maximum/totality is recorded using exposure time 1/10 second and ISO.

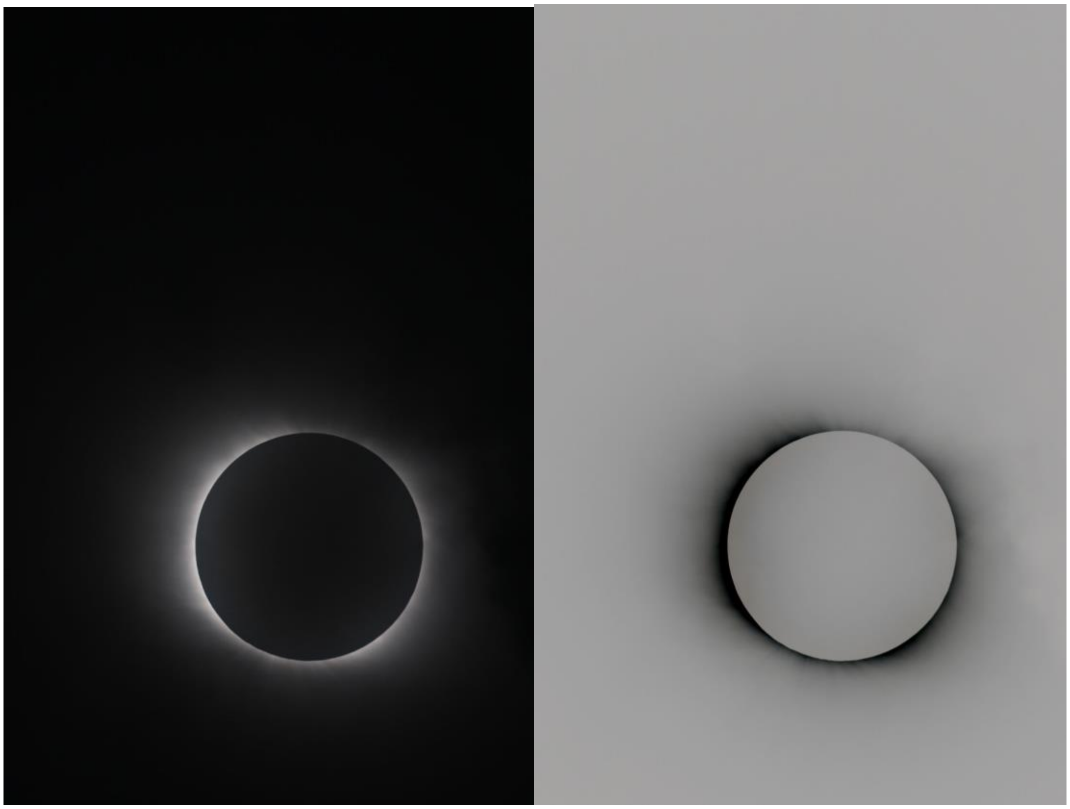


Figure 16: Images taken during totality

Imaging result shows that the condition of variable cloud including thin cloud had reduced the intensity of the star, which is already dim. This causes difficulty in recording the position of the stars.

The gravity experiment

An English mathematician, Sir Isaac Newton, would like to define a force due to an apple falling on his head, and he had summarize it first time in a book entitled '*Philosophiae Naturalis Principia Mathematica*' published in 5th. July 1687.

After the general idea about gravity had been explained, therefore celestial objects will have an influence on each other. For example, the Sun tends to impart its gravitational pull toward Earth and maintain the Earth in orbit. Similarly, the Earth gravitational pull had an influence on the moon and its orbit .The three celestial objects do impose their gravitational force on object in Earth. As we already know that, the Earth gravity hold the atmosphere together so that living and non-living things on Earth can exist. The Moon and the Sun also influences the sea tides, which covers almost 70% of Earth surface. However, during total solar eclipse the Moon, Earth and Sun with gravity of 1.625 m/s^2, 9.81 m/s^2 and 274.1 m/s^2 respectively will be in a straight line with the Moon blocking the surface of the Sun totally. Therefore, an experiment of a simple pendulum to determine the gravity on Earth during total solar eclipse will be conducted.

The period of oscillation for a simple pendulum is dependent on the length, gravity acceleration and the maximum angle for the pendulum oscillation from vertical position, θ_0, called the amplitude. If the amplitude is small, period T for the simple pendulum given as

$$T \approx 2\pi\sqrt{\frac{L}{g}} \qquad \theta_0 << 1$$

where *L* is the length of the string, *g* is acceleration due to gravity.

Therefore, from this equation, knowing *L* and *T*, we can determine the acceleration due to gravity, *g*, if there is changes during total solar eclipse.

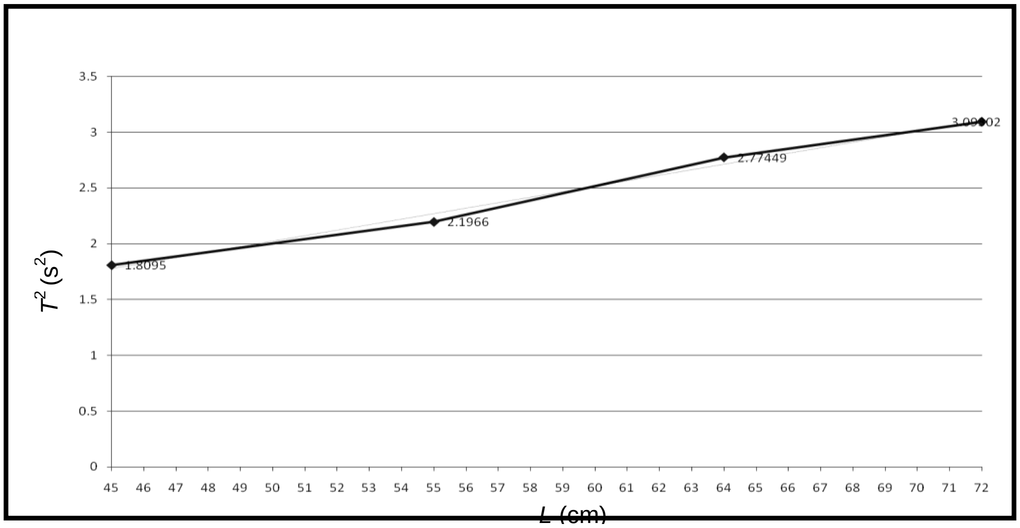
$$g = 4\pi^2\left(\frac{T^2}{L}\right)$$

Experimental results

The experiments for simple pendulum was conducted in stages following the total solar eclipse phases. There are 5 stages beginning from before the first contact until after the fourth contact.

Before First Contact (C1)

$L \pm 0.5$ (cm)	L (m)	T^2 (s^2)
45.0	0.450	1.8095
55.0	0.550	2.1966
64.0	0.640	2.77449
72.5	0.725	3.09302



Graph 9: *Data T^2 (s^2) against L (cm) before first contact*

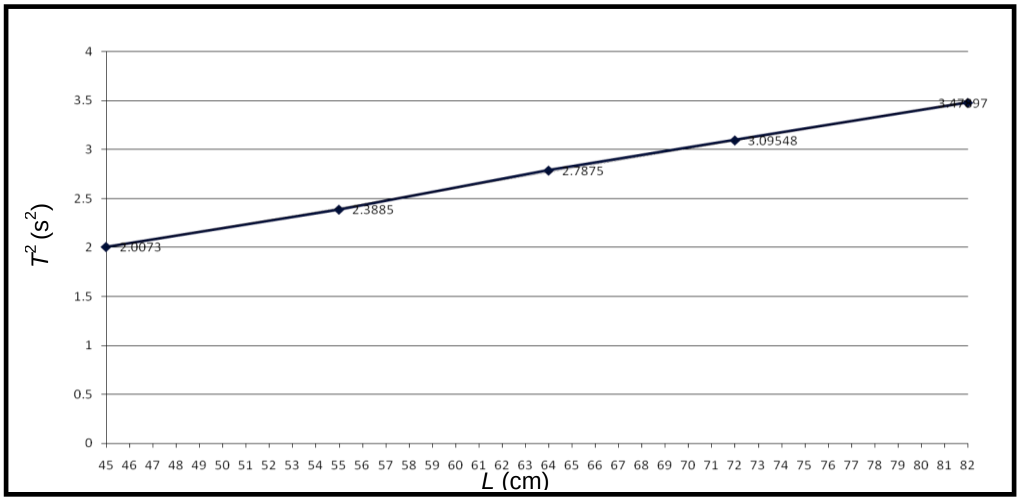
Gradient, T^2/L = 0.048366 s^2/cm

= 4.8366 s^2/m

Gravity, g = 8.16 m/s^2

Between first and second contact (C1 – C2)

$L \pm 1$ (cm)	L (m)	T^2 (s^2)
45.0	0.450	2.0073
55.0	0.550	2.3885
64.5	0.645	2.7875
72.5	0.725	3.09548
82.33	0.8233	3.47897



Graph 10: *Data T^2 (s^2) against L (cm) for between first and second contact*

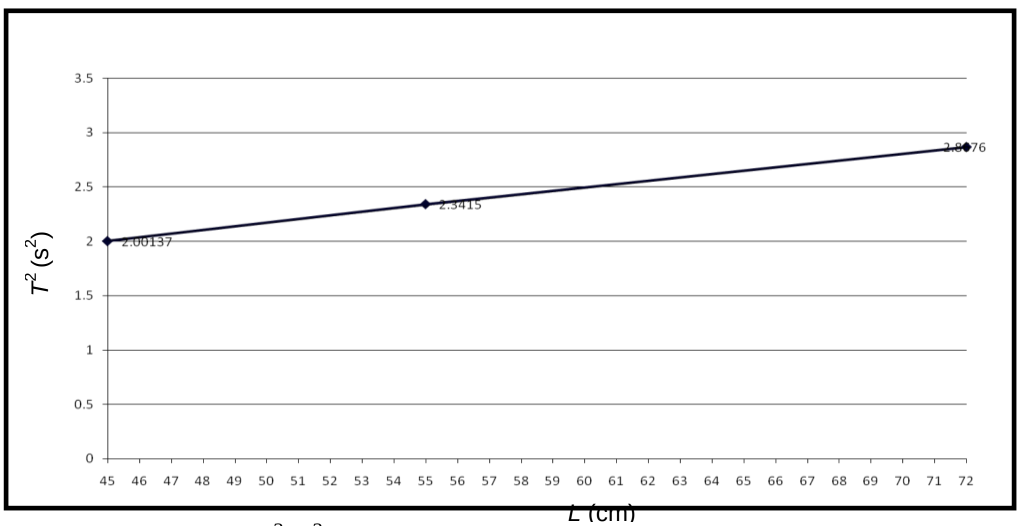
Gradient, T^2/L = 0.039609 s^2/cm

= 3.9609 s^2/m

Gravity, g = 9.97 m/s^2

Between second and third contact (C2 – C3)

$L \pm 1$ (cm)	L (m)	T^2 (s^2)
45.0	0.450	2.00137
55.0	0.550	2.3415
72.5	0.725	2.8676



Graph 11: *Data T^2 (s^2) against L (cm) for between second and third contact*

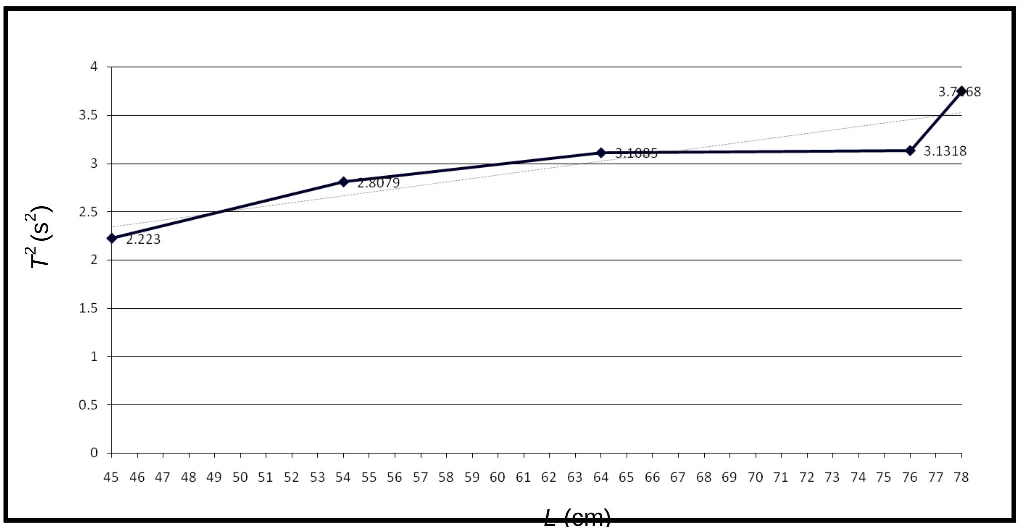
Gradient, T^2/L = 0.031337 s^2/cm

= 3.1337 s^2/m

Gravity, *g* = 12.60 m/s^2

Between third and fourth contact (C3 – C4)

$L \pm 1$ (cm)	L (m)	T^2 (s^2)
45.0	0.450	2.223
54.0	0.550	2.8079
64.5	0.645	3.1085
76.5	0.765	3.1318
78.5	0.785	3.7468



Graph 12: *Data T^2 (s^2) against L (cm) between third and fourth contact*

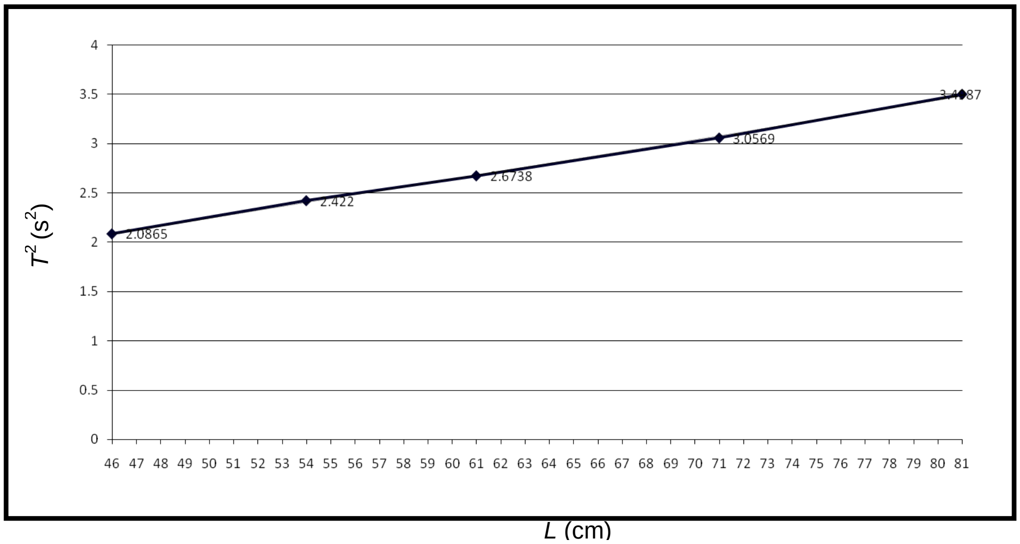
Gradient, T^2/L = 0.035319 s^2/cm

= 3.5319 s^2/m

Gravity, *g* = 11.18 m/s^2

After Fourth, contact (C4)

$L \pm 1$ (cm)	L (m)	T^2 (s^2)
4.65	0.465	2.0865
54.5	0.545	2.422
61.0	0.610	2.6738
71.0	0.710	3.0569
81.0	0.810	3.4987



Graph 13: *Data T^2 (s^2) against L (cm) after fourth contact*

Gradient, T^2/L = 0.040496 s^2/cm

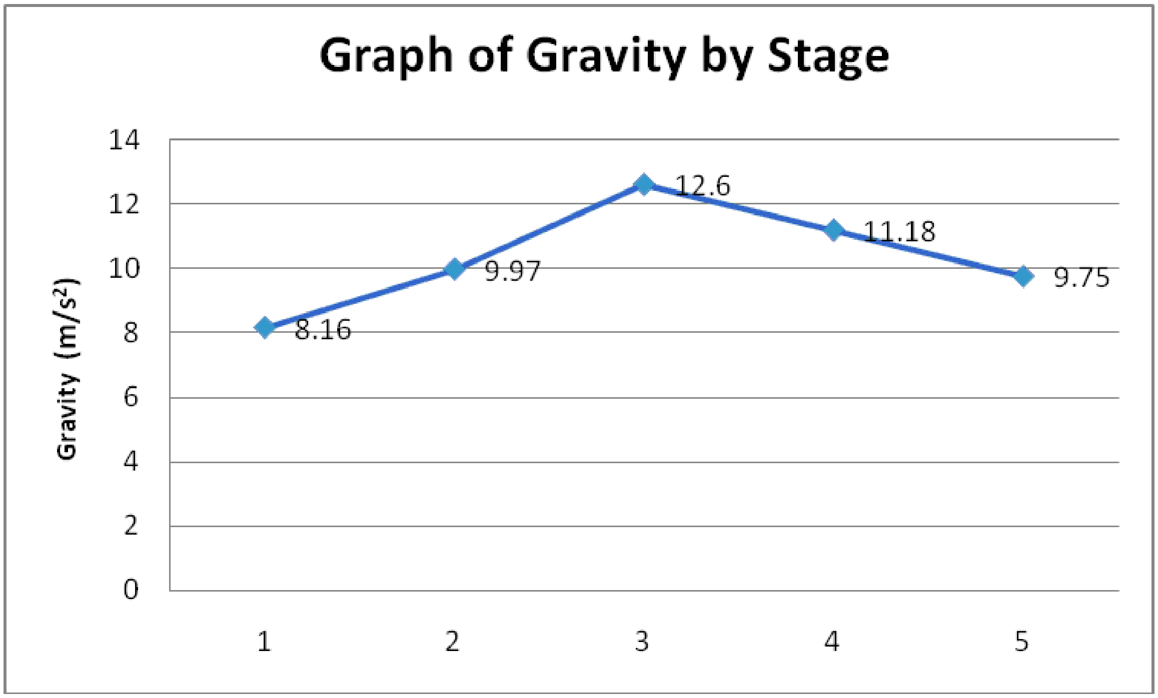
= 4.0496 s^2/m

Gravity, g = <u>9.75 m/s^2</u>

Analysis from all the stages show that there is significant changes of gravity values indicating that total solar eclipse do have an effect on Earth gravity. Graph show the relationship acceleration due to gravity for all the 5 stages as the following:

1. Before C1

2. C1 – C2
3. C2 – C3
4. C3 – C4
5. After C4



Graph 14: *gravity, g (m/s^2) following the stages*

Another experiment done during total solar eclipse to test the gravity condition by trying to make an egg stand on a flat surface. This experiment was successful during the total solar eclipse in China.

Figure 17: *An egg stand on a pillar of wood.*

The value of acceleration due to gravity for the various stages are 8.16 m/s^2, 9.97 m/s^2, 12.60 m/s^2, 11.18 m/s^2 and 9.75 m/s^2 8.16 respectively.

Conclusion:

All the nine experiments conducted during the total solar eclipse in China some had been successful, partially successful and some failed due to cloudy conditions as described below: (a) Imaging the whole process of eclipse with high-resolution astronomical CCD camera/digital camera using telescope. (b) Recording the whole process of solar eclipse with high-resolution video camera. (c) Recording temperature, humidity and sky brightness. (d) Recording sky illumination (e) Conducting gravity experiments with a simple pendulum technique. (f) Observing the light polarization in the Sun corona using specially designed equipment. (g) Recording “flash” spectrum of the Sun, (h) Recording the spectrum of the corona using specially designed spectrograph and (i) Imaging the background star around the Sun during totality. All the experiments for (a), (b), (c), (d) and (e) had been successful. Experiments (f) and (g) were partially successful. Experiments (h) and (i) were failure due to cloudy condition during totality.

Team Members:

35 researcher including 10 researcher from Space Physics Laboratory, University of Malaya involved in this expedition and various government agencies such as Department of Mufti Selangor State (JMNS), Department of Mufti government of Negeri Sembilan(JMKNNS), Department of Mufti Terengganu(JMT), Department of Islamic Religious Selangor (JAIS), Malaysian Islamic Development Department [(JAKIM) from Falaq and media units], Department of survey and mapping Malaysia (JUPEM) and National land survey Institute (INSTUN) . The name of team members are as follow:

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