Observations and experiments during the total solar eclipse on July 22, 2009, China

Stoeva P.[1], Stoev A.[2], Kuzin S.[3], Stoyanov N.[2], Pertsov A.[3]

[1] Solar-Terrestrial Influences Institute, Bulgarian Academy of sciences, St. Zagora, Bulgaria, penm@abv.bg
[2] Yuri Gagarin Public Astronomical Observatory and Planetarium, St. Zagora, Bulgaria, stoev52@abv.bg
[3] Lebedev Physical Institute, Moscow, Russia, kuzin@sci.lebedev.ru

Results from the scientific expedition for observation of the July 22, 2009 total solar eclipse are shown in this work. The equipment of the Solar-Terrestrial Influences Institute "acad. D.Mishev" and the Yuri Gagarin Public Astronomical Observatory was displaced near the observing station of the Shanghai Observatory, which belongs to the Chinese Academy of Sciences and is very close to the central line of the eclipse.

White-light corona was investigated by observations with 250 mm objective and 2000 mm Macsutov - Cassegrain telescope. Intensity of the red coronal line FeX 6374A was also observed with a spectrogrph designed and developed by specialists from STIL-BAS "Acad. D. Mishev", Stara Zagora Department, Bulgaria, Lebedev Physical Institute, Moscow, Russia and Yuri Gagarin Public Astronomical Observatory, Stara Zagora, Bulgaria, mounted on the telescope.

Atmospheric response during the eclipse was determined using measurements of the temperature of both the air at three different levels - 10 cm, 50cm and 200cm and the soil, and humidity.

The absolute luminosity of the sky during the eclipse was measured by three photometers - horizontal, in zenith and in the plane of the Sun.

The July 22, 2009 total solar eclipse was the longest one for this century. We succeeded to observe it but the weather conditions were not good. All the time cirrus clouds were on the sky. We obtained good images of the inner solar corona in white light taken with a short exposition and several long exposure images of the outer solar corona taken between the clouds.

Introduction

Total solar eclipses are still regarded as a unique possibility to observe the inner solar corona in details. They give an invaluable information about heating, structure and dynamics of the corona, and temperature distribution of quasi-stable coronal structures (active regions, coronal holes, bright points etc.). Comparisons with the information from space-based coronographs can reveal the mechanisms of energy release and energy balance in fast processes (flares, coronal eruptions, etc.) and the mechanisms of solar wind generation and acceleration.

Fig. 1 Observational site – upper reservoir of the Pumped Storage Power Station at Tianhuangping, China

Characteristics of the total solar eclipse on July 22, 2009:

- maximum duration is 6 min 39 sec;
- this is the longest totality for the last 2000 years;
- path of the totality: India, Nepal, Bangladesh, Bhutan, Myanmar, China, Japanese Islands and Pacific Ocean.

Observational site:

The observations of the July 22, 2009 total solar eclipse were conducted near the town of TianHuangPing, China, close to the central line of the eclipse.

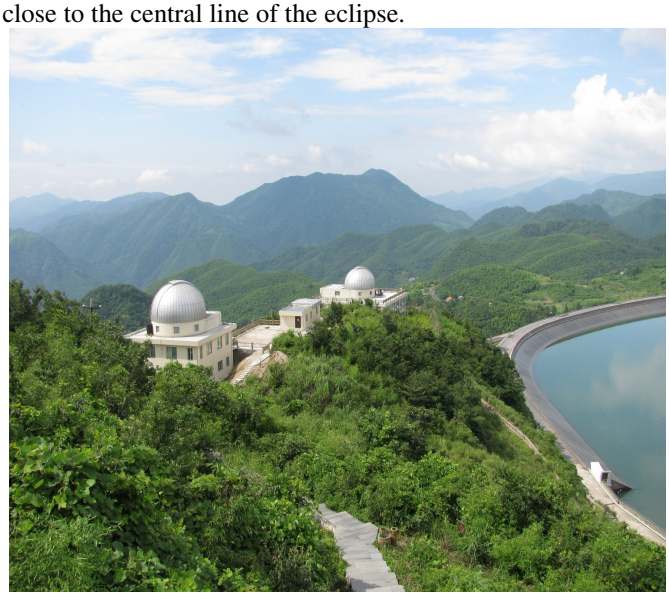

Fig. 2 Observational site – Shanghai Observatory of the Chinese Academy of Sciences at Tianhuangping, China

Co-ordinates of the site – near the upper reservoir of the Pumped Storage Power Station - are as follows:

$\varphi = 30°28'14.2''$ N, $\lambda = 119°35'29.0''$ E, Alt. = 909m.

The Tianhuangping Power Station is the biggest of its type in Asia. It is located in Anji County in Zhejiang, about 175km from Shanghai and lies in a green bamboo forest regarded as one of the main bamboo production bases in China. The area is registered as "Green Resource" by the UN. The upper

reservoir is a huge artificial lake on the top of the mountain with a unique magnificent scenic view, which is so called as "A Wonder in Tianmushan Mountains". The Tianhuangping Pumped Storage Power Station is one of tourist attractions in Zhejiang Province. Shanghai Observatory, which belongs to Chinese Academy of Science, built an observing station on Tianhuangping. The station has two observatories, one for public education and the other for professional research. The international code for the station is D32.

Experiments

Fig. 3 Equipment of the expedition

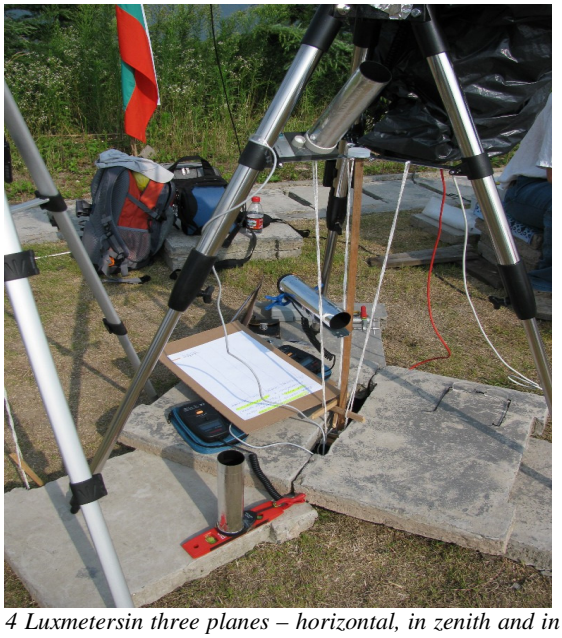

Fig. 4 Luxmetersin three planes – horizontal, in zenith and in the plane of the Sun

1. Determination of the absolute intensity of the red coronal line FeX 6374A with a spectrogrph (designed and prepared in the frames of the Bulgarian–Russian project of joint scientific research "CORONA") mounted together with a 130/2000 Macsutov - Cassegrain telescope with a 20mm eyelense. The aim of the experiment is to obtain images of the inner corona in the visible region of the spectrum simultaneously with images in the X ray region from the THESIS telescope on CORONAS - PHOTON heliospheric satellite (launched in January 2009). This will give the unique possibility of determining the distribution of the light emission of the plasma with the temperature (detailed diagnostics of the thermal and nonthermal heating of the solar corona).

2. Investigation of the white-light corona from photographs with 250 mm and 2000mm objectives.

3. Investigation of the response of the Earth's atmosphere during the particular sircumstances in which solar light is totally being blocked by the Moon. Atmospheric temperature and pressure rapidly change during total solar eclipses which produce meteorological anomalies typical in this kind of phenomena. That is why the basic climatic parameters have to be measured with high sensitive meteorological instruments. Conducting measurements of the temperature of the soil and the air at three different levels - 10 cm, 50cm and 200cm, and of the humidity.

4. Determination of the absolute luminosity of the sky during the eclipse using three photometers - horizontal, in zenith and in the plane of the Sun.

5. Astrometric determination of the Ist and IVth contact of the eclipse.

Results

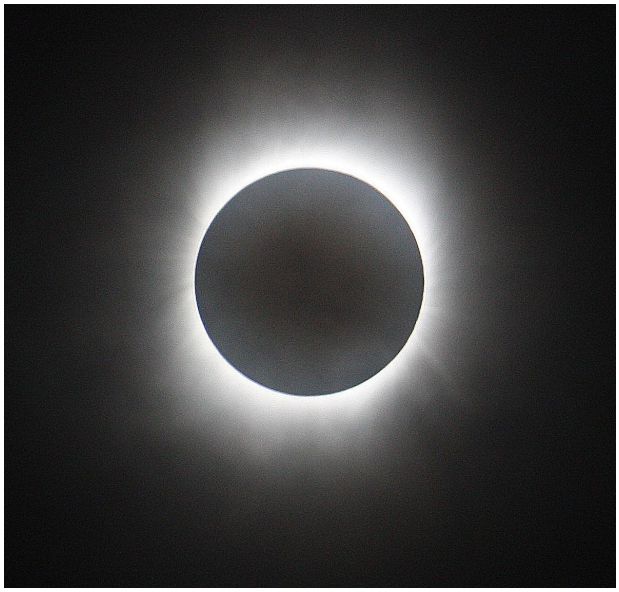

Fig.5. White light solar corona during the July 22, 2009 total solar eclipse, China, photogtaphed with a 250 mm objective.

White light corona is photographed with a Canon 450D EOS with a 250mm objective. The diaphragm f/d is 7.5 and the film sensitivity is ISO 200. The exposition times vary from 1sec to 0.004sec for the different parts of the corona. Forty eight images are obtained. Before and after the total phase are measured the dark current and the flat field.

Microclimatic changes

Changes in the physical state of the 2m ground atmospheric layer owing to a sharp drop in the direct solar radiation have been observed during the July 22, 2009 total

solar eclipse (TSE). Temperature at three levels, humidity and luminocity were measured with high resolution. In addition, temperature in the 10 cm soil layer was also measured.

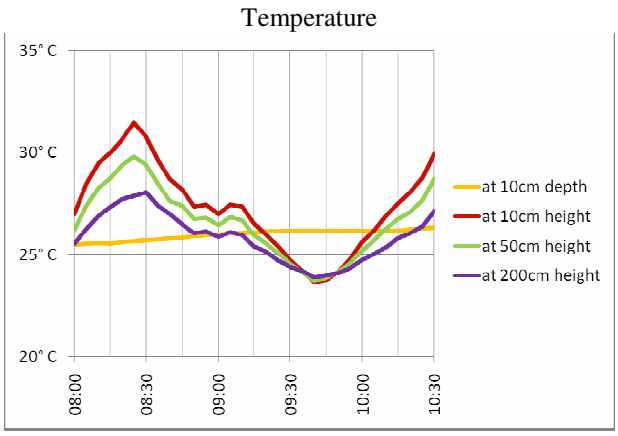

Fig.6. Dynamics of the temperature during the July 22, 2009 total solar eclipse. China. measured with a 0.1 ℃ resolution.

The difference in temperature changes at different heights before, during and after the total phase was about 10°C. Minimum of the air temperature during the TSE was measured 1 min after the end of the total phase.

The relative humidity increases from 60 % up to ~72% after the total phase. This is because of the cloudiness – 80% of the sky was covered with cirrus clouds.

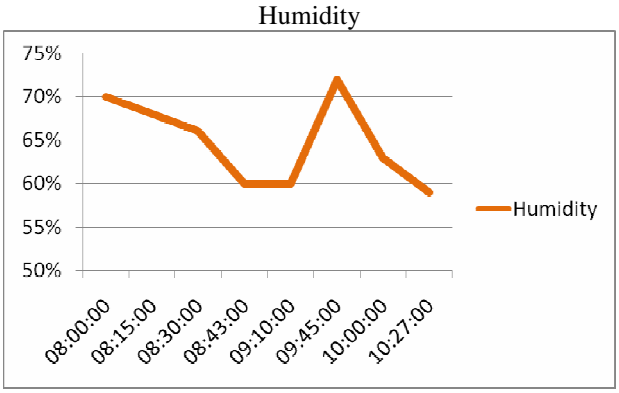

Fig.7. Dynamics of the humidity during the July 22, 2009 total solar eclipse, China.

Illumination

Variations of the sky illumination during the eclipse were measured with the help of 3 luxmeters LUX-PU-150 in zenith, in the horizontal plane and in the plane of the sun near it. Decreasing of the illumination was generally gradual in the early stages following the first contact, but was rapid around totality. The graph shows that the first significant decreasing occurred around 09:00, that is to say 40 minutes after the first contact and reached a minimum at maximum eclipse (09:34). Recovery of illumination levels was then rapid.

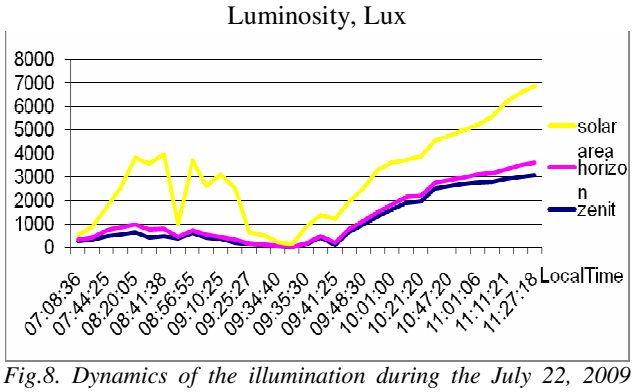

Fig.8. Dynamics of the illumination during the July 22, 2009 total solar eclipse, China.

Astrometric determination of the Ist and IVth contact

Contacts are visually determined using 130/2000 Macsutov - Cassegrain telescope with a 20mm eyelense and a 99% neutral filter.

1st contact – LT 8:20:45 start of partial eclipse

4th contact – LT 10:57:58 end of parcial eclipse

Conclusions

Solar-Terrestrial Influences Institute “acad. D.Mishev” and the Yuri Gagarin Public Astronomical Observatory organized and conducted a scientific expedition for observation of the July 22, 2009 total solar eclipse at a place very close to the central line of the eclipse - at Tianhuangping, Anji County in Zhejiang, China. This total eclipse was the longest for the last 2000 years and we had the chance to see it but the weather conditions were not good.

At images taken with a short exposition we can see the inner solar corona in white light. The outer solar corona is not very good expressed on the long exposure images because of the cirrus clouds.

Temperature decrease during the total phase was about 10°C. Minimum of the air temperature during the TSE was measured 1 min after the end of the total phase. We can compare our measurements with those of the observational teams of Slovakia and Venezuela conducted at the same place. The relative humidity increases from 60 % up to ~72% after the total phase.

Sky illumination reaches its minimum exactly at the time of the total phase. Solar area is the most sensitive region - we see minima in the course of the luminocity due to the clouds.

Acknowledgements

The authors express their special thanks to Dipl. Eng. Evgenij Hristov and Dr Rumyana Kazandzhieva for their cooperation in preparing, tuning up of the automatic meteorological station and data processing.