International Astronomical Union

Working Group on Solar Eclipses/Program Group on Public Education at Solar Eclipses

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Solar Annular Eclipse

"*Ring of Fire*"

- 26th December 2019; Saudi Arabia -

Report by:

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ABSTRACT

Since ancient times, Solar eclipses are considered to be fascinating natural phenomena during which the Moon obscures fully or partially the Sun's disk. Annular eclipses are relatively rare, and occur when the Moon covers the Sun's center, leading to a visible brilliant Sun's outer edges with a magnificent annulus ring-shaped, dubbed also "ring of fire".

Here we report some observational data of the annular last solar eclipse of the decade, 26th Dec. 2019, which began primary in Saudi Arabia, visible along a narrow path in other countries in the globe Eastern Hemisphere. Our observations are taken from the major urban region in the Al-Ahsa oasis in the eastern province of Saudi Arabia, located on the centre eclipse path line, namely in the Al-Hofuf city (at the Four Mountains desert area). The annularity occurred at sunrise and last roughly 3 minutes, immersed in a sandy horizon, making the view of the events particularly exceptional and attractive for astronomers and sky-watching enthusiasts.

Keywords: Solar eclipse, annular, observations.

Contents

Observation Site and Circumstances

1. The Four-Mountains location

On 26 December 2019 the Sun rose in state of partial eclipse in most of the regions of the Kingdom of Saudi Arabia (with various proportions). In Al-Hofuf city in the province of Al-Ahsa the Sun has risen at 6:25am, local time, until the annular eclipse peaked at 6:36am continuing for almost 3mn, then it turns into a partial eclipse, lasting till 7:49am.

For a better follow-up of the event, our observations were made at **Four-Mountains** area, Jabal Al-Arba'a in arabic, along the central main line of the eclipse track, situated on the road leading to Qatar country (See the site images in Fig. 1).

Figure 1: The Four-Mountains site, at AL-Hofuf city, where the observations were made.

Figure 2 highlights the visibility map of the solar eclipse, with the bold line marking the centre of the path and where the annular eclipse lasted longest. The shaded area refers to the annular solar eclipse; however, the eclipse duration gets shorter as we move closer to the edges (generated from NASA Goddard Space flight Center[1] [1]).

[1] Map sourced from NASA Goddard Space flight Center: GSFC Eclipse Web Site, displaying the visibility of the annular solar eclipse.

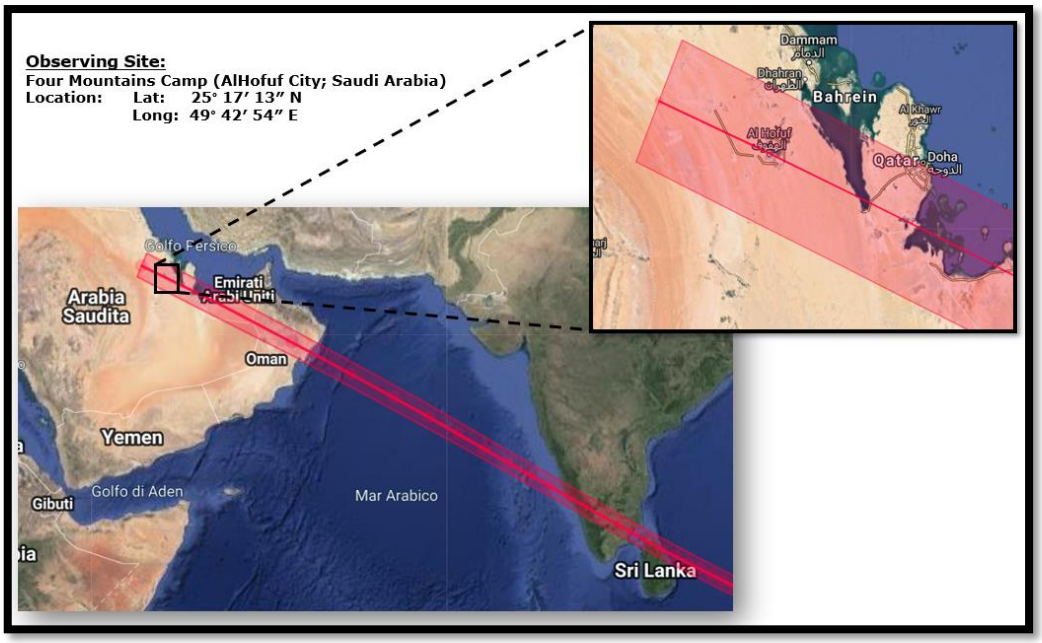

Figure 2: Map of the annular eclipse path across an east-southern strip in Saudi Arabia. The zoomed view-box highlights our observation site at Al-Hofuf city [1].

2. Eclipse characteristics

In table 1, we summarize the main important annular eclipse circumstances and characteristics. Some of the shown data are generated from Google map Solar Eclipses Xavier-Jubier website [2].

Table1: Basic Solar Annular Eclipse Circumstances

Observing Site & Location	• Site: Four Mountains Camp [Jabal Al-Arba] (AlHofuf City-AlAhsa Region; Saudi Arabia) • Location Lat: 25° 17′ 13″ N Long: 49° 42′ 54″ E
Timing Sequence (local time: UT +3h) 26th December 2019	• Start of partial eclipse (1st contact C1): 05:32 • Sunrise (with partial eclipse in progress): 06:28 • Start of annular eclipse (2nd contact C2): 06:34 • Maximum annular eclipse: 06:36 • End of annular eclipse (3rd contact C3): 06:37 • End of partial eclipse (4th contact C4): 07:48
Annular Solar Eclipse duration	2m 59.2s (2m 52.5s with lunar limb corrected)
"Moon/Sun" size ratio (at the maximum Eclipse)	~0.956
The obscured Sun's disk surface at maximum eclipse	~91.53%

Equipment and Tools

1. Setup description

To image the Sun during both the annular and partial phases, three main instruments are used in our setup, namely:

a) iOptron Solar 60, 60mm refractor, GoTo GPS portable computerized Telescope with Solarlite solar filter and electronic eyepiece, and with the following key features,
   - Removable Front Solar Filter
   - 60mm (aperture) Achromatic Doublet Refractor
   - 360mm Focal Length, f/6 Focal Ratio
   - Resolution Power: 1.93 arc sec

b) The Orion StarShoot Solar System Color Imager IV: consists of 1/3" format CMOS imaging sensor with a 1280 x 1024 pixel layout. Each pixel is a mere 3.6µm x 3.6µm in size for image resolution in 24-bit RGB color. The imager is accompanied with an image processing software. The Orion StarShoot imager is mainly used through the telescope eyepiece, allowing to view real-time target images on the computer screen.

c) The digital Sony Alpha 58 camera also known as Sony A58 (model name SLT-A58 with 20.1-megapixel resolution across the 100-16000 ISO range).

2. Imaging the event

We follow and document the eclipse during both the annular and partial phases. Figure 3 reports a sample of our observations covering the main phases, starting from the rising crescent Sun (left upper image-just slightly greater than 1degree from the horizon). The maximum annular phase is highlighted in the zoomed middle panel, with the magnificent and impressive ring-like shape.
The partial phase is displayed in the bottom-line image sequence, until the last contact around 07:48 pm (local time).

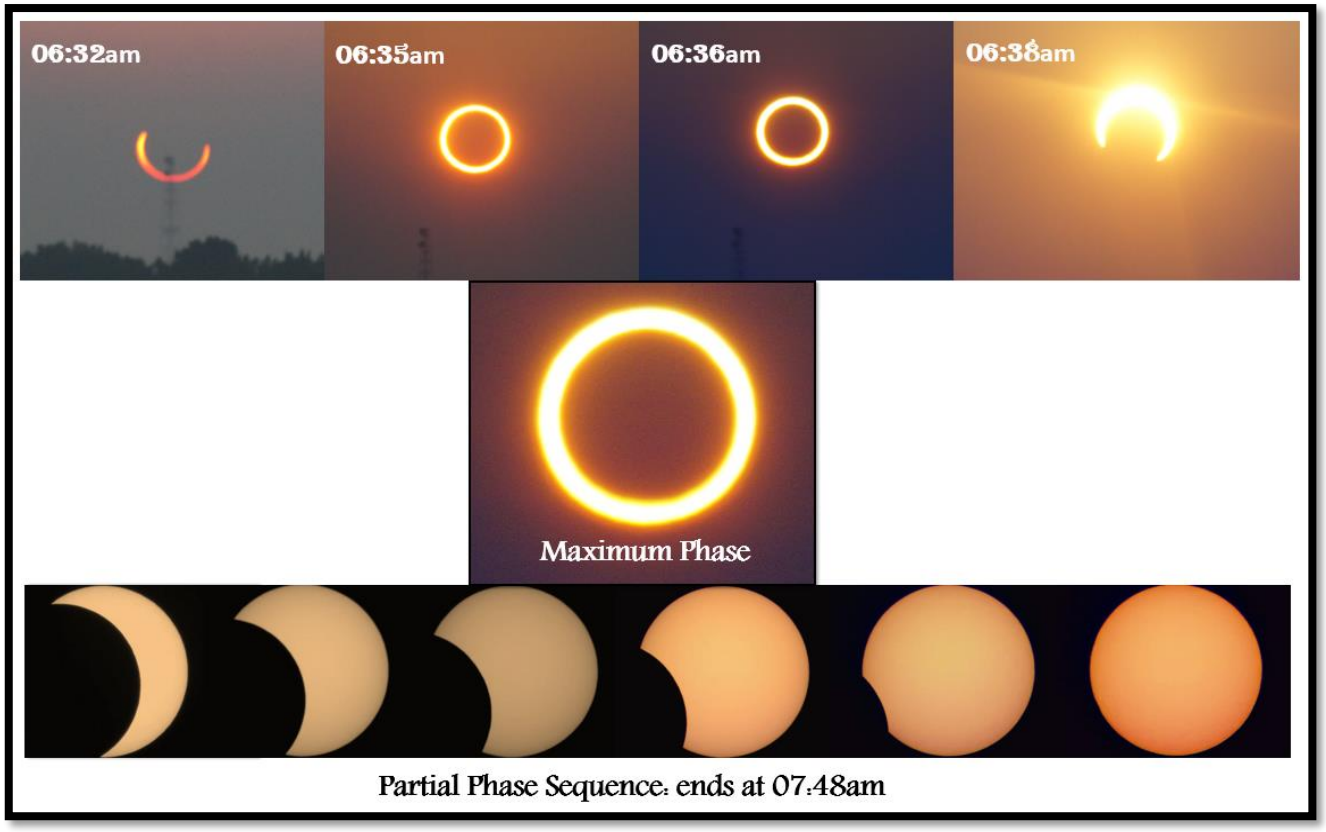

Figure 3: Sample of image sequence of the annular phase (upper line panels) and the partial phase (bottom line panels) of the 26 Dec 2019 solar eclipse, observed in the Four-Mountains area, Al-Hofuf city in the Kingdom of Saudi Arabia. The middle panel is a zoomed view of the ring-like obscured Sun at maximum annularity.

Summary

Solar eclipses, in particular total and annular, give scientists the opportunity to make significant scientific measurements. For example, allow understand the patterns and structures of the solar corona that cannot usually be studied during day observations. Also, observations during such events help to measure accurately the diameter of the Sun and as well its variations over time. In addition, eclipses enable the analysis of the shape of the Moon.
Importantly, in order to reveal significant information about the scattering process in the atmosphere, and hence decide on the quality of a given site for solar Coronal observations (coronagraph site survey purposes), some scientific investigations efforts successfully utilized the sky brightness monitor (SBM) to measure the sky brightness and thus test its performance and sensitivity, during the solar annular eclipse phenomenon [3].

The present report describes the occurrence of the peculiar annular solar eclipse in Al-Hofuf city area in the eastern province of Saudi Arabia on 26th December 2019. Such annular eclipse event happened rarely over the country. Indeed, and according to historical data, the latest observed annular eclipse was about 97 years ago (22 March 1922). The 26th December 2019 eclipse belongs to Solar eclipse Saros 132[2] [4].

[2] The periodicity and recurrence of solar eclipses is governed by the Saros cycle, a period of approximately 6,585.3 days (18 years 11 days 8 hours). Any two eclipses separated by one Saros cycle share very similar characteristics and geometries [4].

Solar annular eclipses are one of the most spectacular astronomical phenomena, that occurs when the Moon is so far away from the Earth, resulting the Moon's apparent diameter to be smaller than that of the Sun, blocking most of the central Sun's light, and causing the Sun's outer edge to be still visible and forms an annulus-like shape "ring of fire" around the Moon. The eclipse event in the Four-Mountains location consists the earliest observed in its path. Right after the sunrise, under good weather conditions, the Sun's disk appeared obscured by the Moon's shadow with a reddish amazing panoramic view owing to the sandy desert location. The visible eclipse, from sunrise, lasted about 1h20mn with approximately 3mn in the annular phase.

It is undoubtedly interesting to coordinate and conduct further observational campaigns during future lunar and solar eclipses. Such activities and follow-up of these fascinating astronomical natural phenomena might play an important role not only from a research and scientific point of views but also in the context of attracting public interests in the sky, astronomy science and space mysteries.

References

[1] "NASA Goddard Space flight Center: GSFC Eclipse Web Site", https://eclipse.gsfc.nasa.gov/eclipse.html

[2] "Xavier Jubier Google map Solar Eclipses Web Site", http://xjubier.free.fr/en/site_pages/Solar_Eclipses.html

[3] "Using a New Sky Brightness Monitor to Observe the Annular Solar Eclipse on 15 January 2010" Y. Liu, Y.-D. Shen, X.-F. Zhang, N.-P. Liu; 2012, *Solar Phys.* **279**, 561.

[4] "NASA Saros Series Catalog of Solar Eclipses Web Site" https://eclipse.gsfc.nasa.gov/SEsaros/SEsaros132.html