

Mercury transit at the rotonda of Santa Maria degli Angeli on May 9th 2016

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Abstract

Image quality simulations were made for a Mercury image on the solar disc for the sun position on the sky respect the Summer lens of the “Divinità in Luce” glasswork at Santa Maria degli Angeli in Rome. It is shown the image quality of the lens will be enough to show the Mercury shadow on the solar disc but only for the first 30 minutes from the transit's first contact.

Introduction

The coordinates of Rome are: $41^{\circ}54' \text{ N}$; $12^{\circ}30' \text{ E}$. (41.9°)

The Sun declination (May 9th at local noon): $17^{\circ}32'12.2''$ (17.5367°). Sun transits at 13:06:30 (Daylight Saving Time).

At the summer solstice the Sun position is such that the image produced by the summer lens is at the center of the rotonda. Deviation is 18.4°

Solstice Sun position $23^{\circ} 27'$, (23.45°)

Mercury Transit Sun declination: 17.5367°

$23.45 - 17.53 = 5.92^{\circ}$

Summer lens and position of the solar image

The lens parameters are

EFL= 23240 mm; BFL= 23124 mm; the Back Focal length BFL is the distance from the lens prism to the lens focal plane.

The distance from the back of the lens to the Church's floor is the required BFL for summer lens: 23344 mm: this distance has been measured on site, at Santa Maria deli Angeli.

The prism length is 178.620 mm (only for information). The floor image is defocused (extrafocal) of $23344 - 23124 = 220$ mm

Position respect to the rotonda center

At the meridian passage the image is located $23.344 \cdot \sin(5.92) = 2407$ mm (to the North)

At intervals of 15 minutes the positions change according to the angle of the Sun relative to the summer lens:

- a) 11:12 UTC (13:12 local) (0.1° , 5.92°) (0.04 m, 2.41 m)
- b) 11:27 UTC (13:27 local) (3.85° , 5.92°) (1.57 m, 2.41 m)
- c) 11:42 UTC (13:42 local) (7.6° , 5.92°) (3.09 m, 2.41 m)
- d) 11:57 UTC (13:57 local) (11.26° , 5.92°) (4.56 m, 2.41 m)
- e) 12:12 UTC (14:12 local) (11.51° , 5.92°) (4.66 m, 2.41 m)

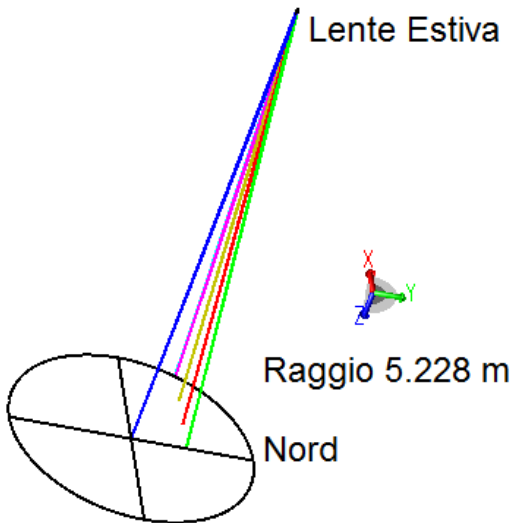


Fig. 1 The Solar image is projected 2.4 m from the rotonda centre on the green ray (ray a), on N-S axis) the other rays are the situation b), c) and d). The ray e) is out of the 5.3 m radius.

The rotonda at the central door of Santa Maria degli Angeli has a central circle of 2.90 m diameter, while the external one has a radius of 6.65m.¹

¹ S. Cuevas, Lentes prismáticas del Lucernario, Il Cigno GG ed. 2009

Mercury's image

For Mercury transit, the apparent planet image diameter will 1.13 mm, while Sun image will be 200 mm.

The sampling at the image level must be at least 256x256 points. The sampling at pupil is 1024 points.

Simulations

Image simulations were performed for the Summer lens using Zemax Optic studio. By means ray tracing the lens aberrations were calculated for an array of points (9X9) inside the solar image. The lens aberrations information was used for a point spread function (PSF) calculation using a Huygens Transform for the lens array. The convolution of the input image and the PSF was plotted. Furthermore, a seeing of 0.5 mm on the sun image (4.4arcsec of seeing) was simulated along the above simulations. The results are show on the next figures (fig.3).

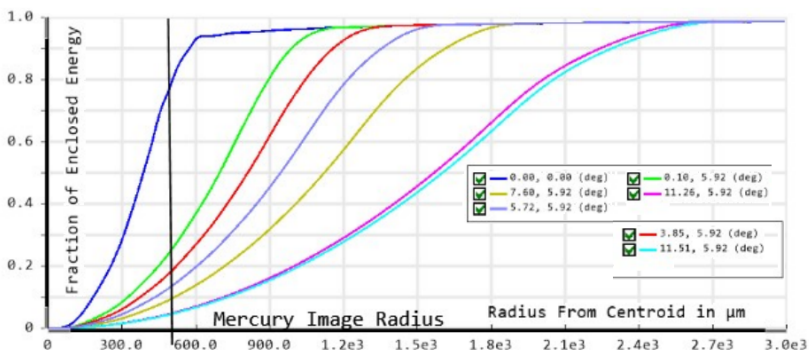


Fig. 2 Fraction of Enclosed Energy (EE) of a Point Spread Function (PSF) for the above positions of the Sun image. The seeing considered for this simulation is 5 arcsec. EE for the position (a) is of the order of than 0.25 within 0.5 mm, while for an ideal zenital image would be 0.8, or 80%. With a value of $EE < 0.2$ the contrast is poor, as it is visible in the four simulated images in fig. 3. These value of EE are computed for Mercury near the solar limb (ingress near the spot if fig 2).

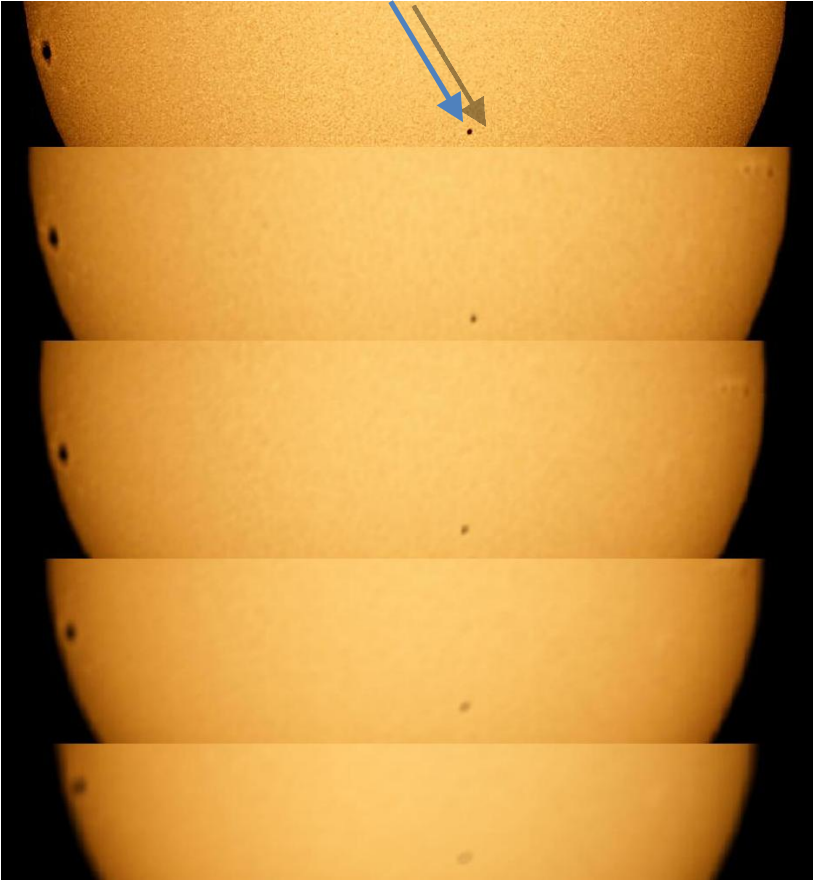


Fig. 3 Composition at 512x512 sampling of simulations of Mercury transit on Sun image from the image (1024x1024 pixels, wikimedia) of the transit of Mercury (blue arrow) on Nov 8, 2006 with a sunspot on the left. Positions on the SMA floor and times corresponding to rays a, b, c, d. It includes seeing. Granulation, Mercury and solar spot's visibility on the solar disc image get worse from a to d (from top to down).

Conclusions Mercury will be visible on the solar disc image at S. Maria degli Angeli from first contact at 13:12 to about 13:42