Evaluation of a Transit photo (Example)

U. Backhaus, Universität Essen

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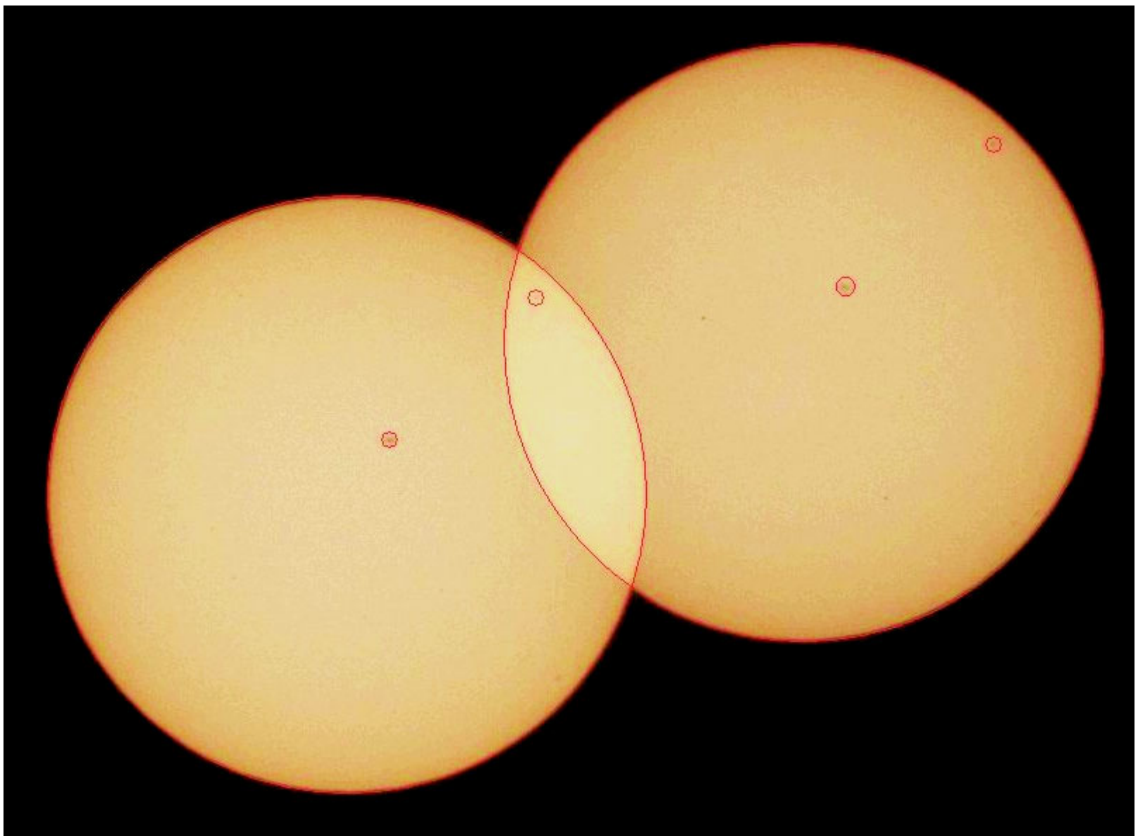

The picture showing Mercury in front of the Sun is taken from Essen, Germany. It is exposed at 10:00:00 UT (exactly) and 10:01:40 UT (roughly). The original slide is scanned to a pixel size of about 4050*2700. The pixel radius of the Sun on the original scan is 426.

In order to measure the pixel radius of the Sun and the positions of the two discs and of Mercury we have written a little program[1] which allows to fit an appropriate circle around the sun, Mercury or the sun spot, respectively. The pixel coordinates and the radius of the actual circle are shown in the upper left edge. The picture above shows all of the circles used for the evaluation.

1. Both discs have a radius of $R = 426$[2]. The respective centers are

[1] This program may be ordered in Essen.
[2] The picture on our "First impressions" site is half as large.

$$M_1 = (449, 653);\ M_2 = (1095, 436)$$

2. The displacement vector showing the east west direction is, therefore,

$$\Delta_1 = (646, 217)$$

3. For control reasons, we measured additionally the displacement of the sun spot:

$$F_1 = (510, 574);\ F_2 = (1155, 359) \quad \Longrightarrow \quad \Delta_2 = (645, 215)$$

4. Mercury's positions on the both discs are

$$P_1 = (718, 372);\ P_2 = (1365, 153) \qquad (\quad \Longrightarrow \quad \Delta_3 = (647, 219))$$

5. The mean displacement, therefore, is

$$\Delta = (646, 217)$$

   It includes with the lower edge an angle of

$$\alpha = \arctan\left(\frac{217}{646}\right) = 18.57°.$$

   The length of this displacement allows an exact scaling of the picture if the exact time difference is known. Instead of this method, we measured roughly the Sun's size on the original slide (7.3mm) which leeds together with the effective focal length of 800mm to an angular radius of $\rho_S = 15.7'$[3].

6. Mercury's position relative to the first center is

$$M_1P_1 = (269, 281)$$

   including with the lower edge the angle

$$\beta = \arctan\left(\frac{281}{269}\right) = 46.25°.$$

7. Therefore, the relative distance r', the position angle θ' and the rectangular coordinates are

$$\begin{aligned} r' &= \frac{\sqrt{269^2 + 281^2}}{R} = 0.913 \\ \theta' &= \beta - \alpha = 27.68° \\ x' &= r' \cos\theta' = 0.8085 \\ y' &= r' \sin\theta' = 0.4211 \end{aligned}$$

[3]The exact value is $\rho_S = 15.85'$.

The excel sheet, therefore, should contain the following row:

Time (UT)	$\boldsymbol{\Delta t}$ **in** $\boldsymbol{s}$	$\boldsymbol{r' = r/R}$	**pos. angle** $\boldsymbol{\theta'}$	$\boldsymbol{x' = x/R}$	$\boldsymbol{y' = y/R}$
10.00	**7200**	**0.913**	**27.68°**	**0.8085**	**0.4211**

According to calsky, the exact values are $r' = 0.9175$ and $\theta' = 26.9°$. Calculating the rectangular coordinates and using the angular radius ρ_S of the sun we get a difference between the calculated position of Mercury and our measurement of

$$\mathbf{10''.8}$$

For the first trial this is an excellent result for a single picture. It shows that the method is exact enough to measure at least Venus' parallaxe, but perhaps Mercury's, too!