2. HOW THE PLATES WERE MEASURED: FROM GLASS PLATE TO *x*, *y* COORDINATES

One star followed through the complete process

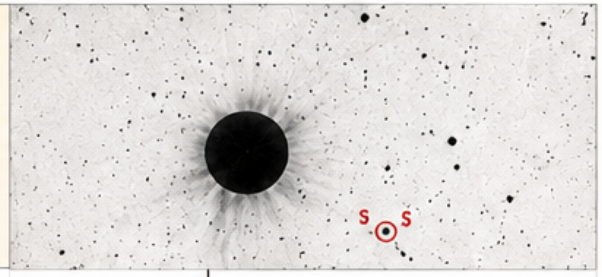
A. ECLIPSE PLATE – 29 MAY 1919 (SOBRAL)
Sun in the field

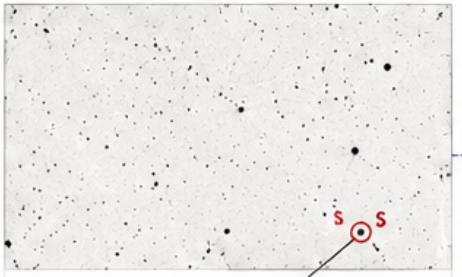
B. COMPARISON PLATE – JULY 1919 (SOBRAL)
Same field, Sun absent

C. DIFFERENCES FOR THIS STAR

1. On the glass plate (negative)

The star is recorded as a small dark image on the light background.

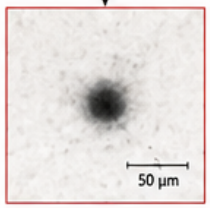


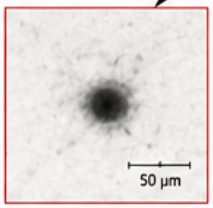


The same star in both plates. Its true position is fixed; any apparent change is due to the Sun's gravity plus plate effects.

2. Magnified view of the star image

Typical stellar image diameter on the plate ≈ 20–30 micrometres (0.02–0.03 mm).



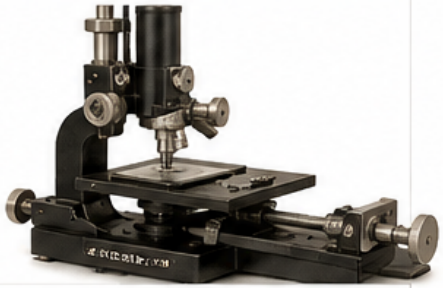


3. Measuring microscope / plate-measuring machine

The plate is on the stage. The microscope is moved in *x* and *y* by finely spaced screws.

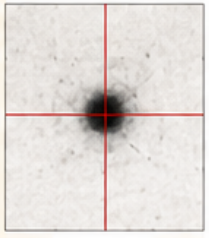
Greenwich used a measuring microscope (Repsold type) with bracket micrometers.

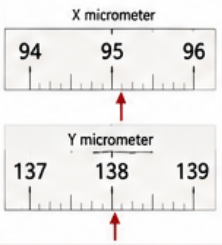
One revolution of the micrometer screw = 0.01 mm on the plate.



4. Centring the cross-wires and reading the coordinates

The operator centres the cross-wires on the star image (best bisecting in *x* and *y*) and reads the micrometers.

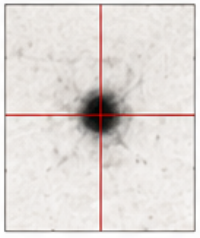


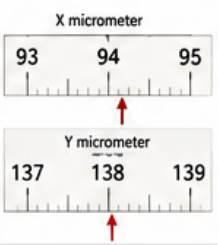


Example readings (eclipse plate)

x_E = 95.18 mm
y_E = 138.42 mm

(origin is an arbitrary reference on the plate)





Example readings (comparison plate)

x_C = 93.23 mm
y_C = 137.56 mm

(same arbitrary origin as eclipse plate)

Raw coordinate differences

$\Delta x = x_E - x_C = 95.18 - 93.23 = +1.95$ mm
$\Delta y = y_E - y_C = 138.42 - 137.56 = +0.86$ mm

Convert to angular measure on the sky

Plate scale: 1 arcsecond (″) ≈ 28 micrometres (µm)
Therefore 1 mm = 1000 µm ≈ 35.7″

$\Delta x = +1.95$ mm ≈ +69.7″
$\Delta y = +0.86$ mm ≈ +30.7″

} Not the gravitational deflection yet!

IMPORTANT

Δ*x*, Δ*y* are NOT the gravitational deflection.

They also include the effects of:

- translation of the plate (shift in *x* and *y*)
- rotation of the plate field
- change of plate scale (magnification)

These must be removed mathematically using all the stars on the plate simultaneously.

These are the raw measurements that were made for each of the seven stars on the Sobral 4-inch plates. The same procedure was used for the Principe 4-inch plates.

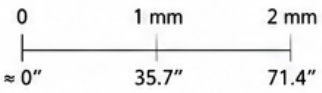
Historical note

After the plates returned to Greenwich, Davidson and H. H. Furner began the measurements in September 1919 under the supervision of Frank Dyson.

ABOUT THE MEASUREMENTS

Each coordinate was read several times with the micrometers and the mean value taken. The typical precision of a single setting was a few micrometres, i.e. a few hundredths of an arcsecond.

PLATE SCALE



1 arcsecond (″) ≈ 28 µm on these plates. The predicted deflection at the solar limb (1.75″) corresponds to ≈ 49 µm (0.049 mm) on the plate.

THE COMPLETE DATA SET

The same operations were carried out for all seven measured stars on each plate. The resulting *x*, *y* coordinates were then reduced together to remove plate effects and to obtain the gravitational deflection of starlight.