Solar Eclipse 2017 – Special Observing Award

This is Mike Hotka's submission for the Level 3 Solar Eclipse 2017 – Special Observing Award. I performed the calculations made from an internet image of the eclipsed Sun, showing 3 stars near the solar disk that were used to calculate the curvature of space due to the Sun's gravitational effect.

If all my calculates are in order, please have my name read Michael A. Hotka on my certificate. I am a member of the Longmont Astronomical Society. Email is mhotka@yahoo.com. My cell phone is 303-818-8956. Please send my certificate to my home at:

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I looked at several images taken of the totally eclipsed Sun from friends of mine. All but one image showed stars in the image and these were suspected to be hot pixels and not actual stars. Comparing this image with Rob's confirmed these were in fact hot pixels for these "stars" were not present in his image.

I decided to use Rob Ratkowski's image, captured on August 21, 2017 at 11:44:12 AM from Ayers Natural Bridge Park, near Casper, Wyoming. His observing location was at a latitude and longitude of 43^{o} 44.071' N and 105^{o} 36.648' W. Rob used a Nikon D810 camera (36.6 mpixels) with a Nikon 300 mm F4 lens attached. From the website, it said this image was taken near Casper, Wyoming. In using NASA's interactive eclipse map from https://eclipse.gsfc.nasa.gov/SEgoogle/SEgoogle2001/SE2017Aug21Tgoogle.html, I was able to find that Rob actually took this image from the Ayers Natural Bridge Park, east of Casper.

So with Rob's declared latitude, longitude, date and time, I used Stellarium to put in these values and it told me that the RA and Declination of the Sun at this location and time was 10h 3m 3.01s 11^{o} 57' 7.2" With these coordinates, I opened the Aladin program on my PC and used the Digital Sky Survey image for these coordinates to find the same image of the sky without the presence of the Sun, hence the stars are in their true positions.

The three stars I used in my measurements and calculations, which were on Rob's (see Picture 1) and Aladin's image (see Picture 2) were Regulus (magnitude 1.35, 10h 8m 22.01s 11^{o} 58' 2.9"), 31 Leo (magnitude 4.35 10h 7m 54.71s 9^{o} 59' 49.6") and 27 Leo (magnitude 5.5 at 9h 58m 13.35s 12^{o} 26' 41.1"). The stars on Rob's image diminished in intensity based on these magnitudes, so I felt confident I had the correct 3 stars identified in both images.

I opened Rob's image in Microsoft Paint and used the cursor to display the x,y image coordinates of the center of the Sun and the x,y image coordinates of the centers of each of the 3 stars. This can be seen in Figure 1.

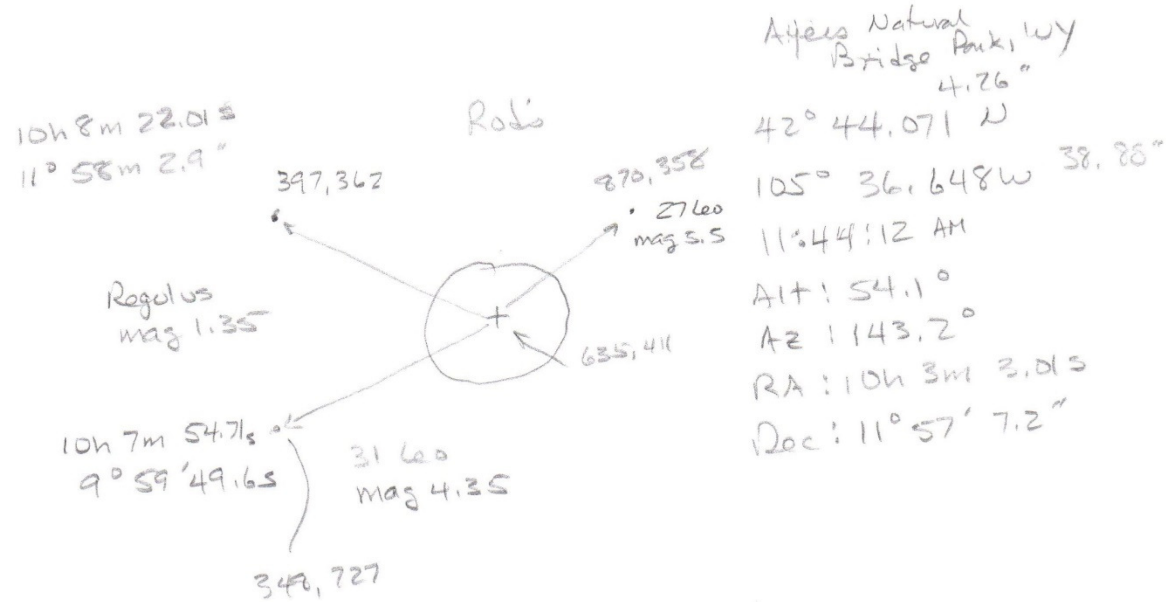


Figure 1

I opened the Aladin image in MS Paint and did the same measuring of the x,y image coordinates from the center of the Sun as marked on the image by the red cross and the centers of the 3 corresponding stars as found on Rob's image. These measurements can be seen in Figure 2. The Aladin image had a scale included in the image, which I used. By measuring the x,y coordinates of the width of this scale, I determined that 92 pixels was 1 degree.

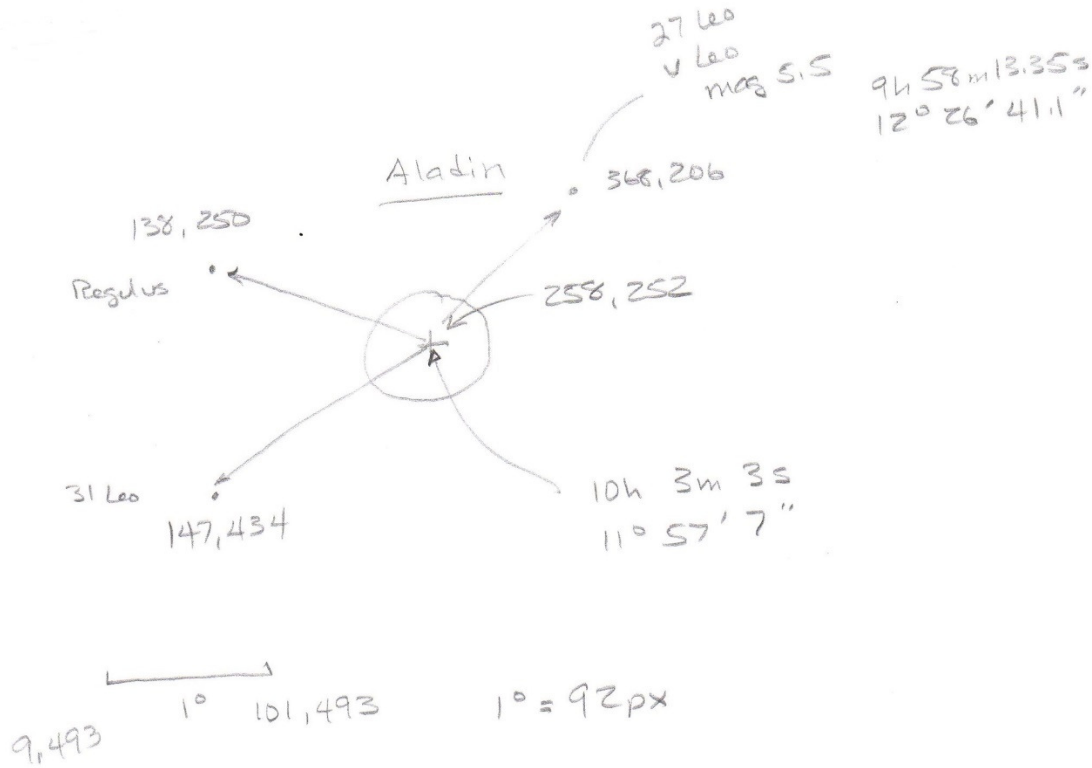


Figure 2

To determine the scale of Rob's image, I carefully measured the x,y image coordinates of the enlarged Sun as see in Figure 3. I determined that 100 pixels was a ½ degree, so 200 pixels was 1 degree. That is the assumption that I made, that the image of the Sun in Rob's image was ½ degree in width.

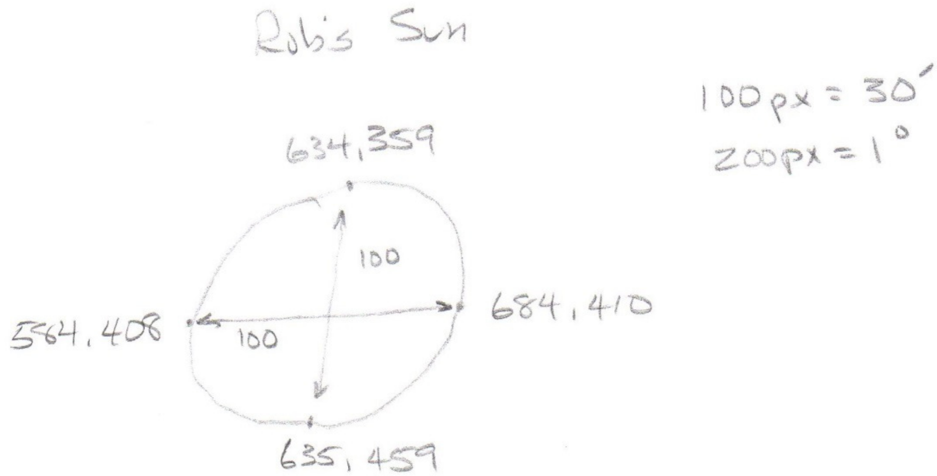


Figure 3

The following illustration shows the calculations I made, using Pythagorean's theorem to find the distance from the center of the Sun in Rob's image to each star, then using 200 pixels as 1 degree, found the distance from the Sun's center to each star in degrees, as displayed in the last column of the Rob's table.

I did the same process in the Aladin image as seen in the Aladin table, with the last column showing the distance from the RA and Dec (center) of the Sun in this image to each star in degrees. I used the scaling factor of 92 pixels as 1 degree.

The last table, labeled Distance from the Sun's Center, recaps the distances I calculated for each star (in degrees) from the other two tables, in the same row. The last column of this table is the difference between the star's distance from the Sun's center with the Sun in the image (Rob's image) as compared to when the Sun is not in the image (Aladin's image). This is the *Δ deg* column and these numbers are in degrees.

My numbers are very high, compared to Einstein's value of a maximum effect of 1.7" or .00047°. Off by over a factor of 100.

Rob's	px Δx	px ΔY	px X^2	px Y^2	px distance	deg distance
Regulus	238	49	5644	2401	242.992	1.21496
31 Leo	287	316	82944	99856	427.551	2.137755
27 Leo	235	53	55225	2809	240.902	1.20451

Aladin	px Δx	px Δy	px X^2	px Y^2	px distance	deg distance
Regulus	120	2	14400	4	120.017	1.30453
31 Leo	111	182	12321	33124	213.178	2.31716
27 Leo	110	46	12100	2116	119.23	1.29599

Distance from Sun's Center

	Rob's deg	Aladin deg	Δ deg
Regulus	1.21496	1.30453	0.08957
31 Leo	2.13776	2.31716	0.1794
27 Leo	1.20451	1.29599	0.09148
	with Sun Present	without Sun Present	Star moved due to curvature of space because of Sun's Gravity

So I re-measured all the Sun centers and stars in the images, as seen in Figure 4. I got almost identical values, so this is not why my numbers were high.

I then decided to work the problem backwards. I had high confidence in my scaling of the Aladin image, for it was right there on the image. So by using Einstein's maximum effect of 1.7", Regulus should have been at a distance of 1.30436° in Rob's image. Working this backwards on Rob's image, in order to get this value, 186 pixels should be 1 degree. This makes the diameter of the Sun .538° and not my assumed value of 0.5° for scaling Rob's image.

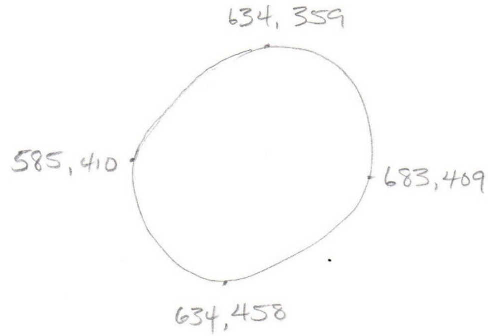
effect
Max is 1.7"

Remeasured Sun

.00047°

Regulus needs to be:

1.30436°



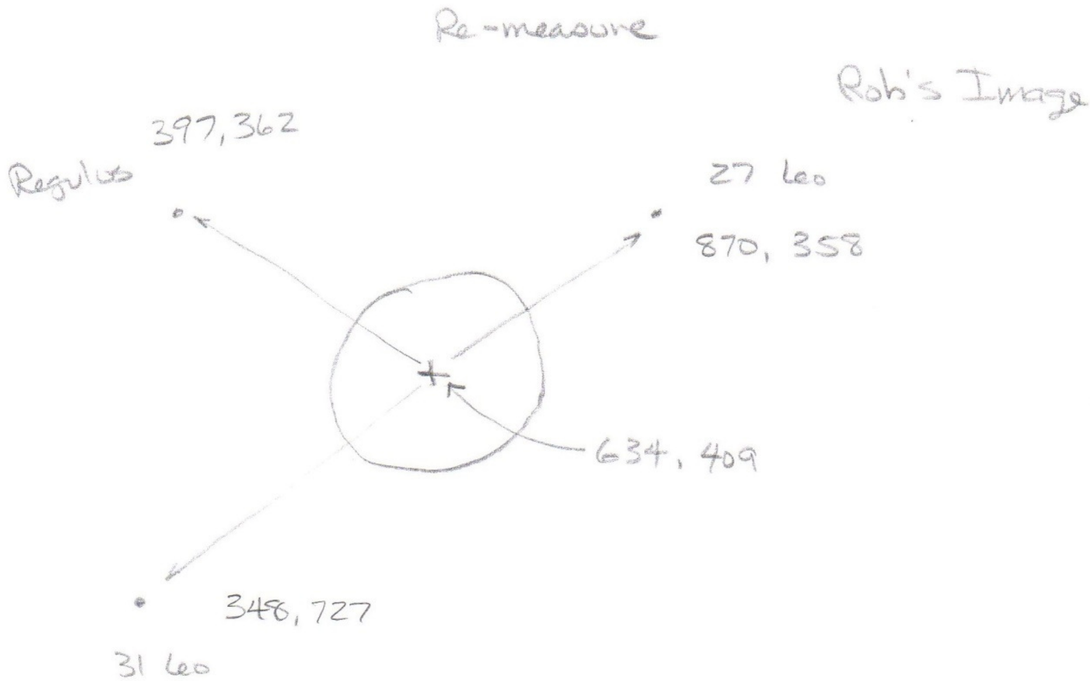
186 pixels = 1° Rob's Sun needs to be

or 200 pixels = 1.076°

Sun is .538°

	Aladin deg	Rob Adjusted deg	Δ deg
Regulus	1.30453	1.30373	.00080
31 Leo	2.31716	2.29866	.0185
27 Leo	1.29599	1.29517	.00082

The above table shows the calculations if I used 186 pixels per degree in Rob's image and not 200 pixels per degree, I get values are much closer to what they should be. I used the *Px Distance* values in Rob's table, Column 6, and divided this pixel distance by 186 pixels/degree to get the value in the *Rob Adjusted* column.

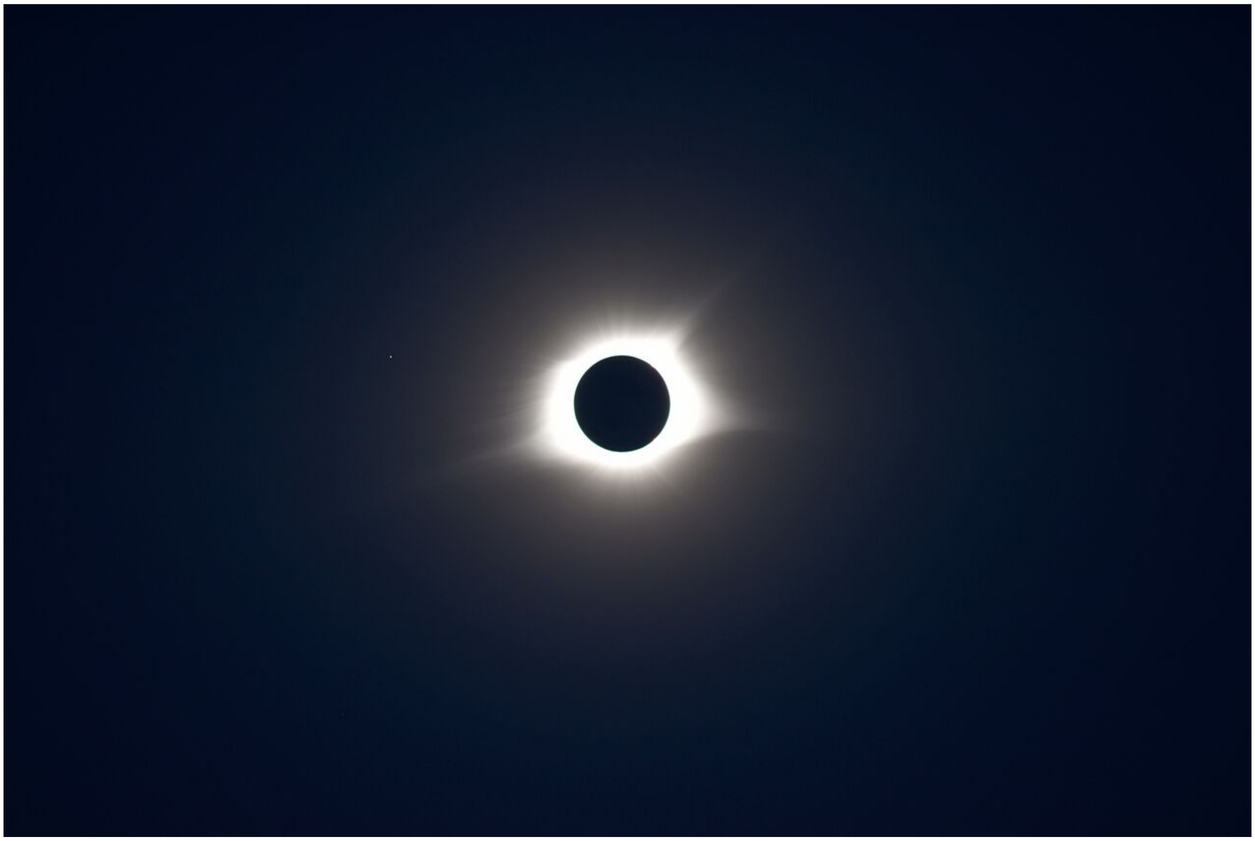


Aladin Same as before

Figure 4

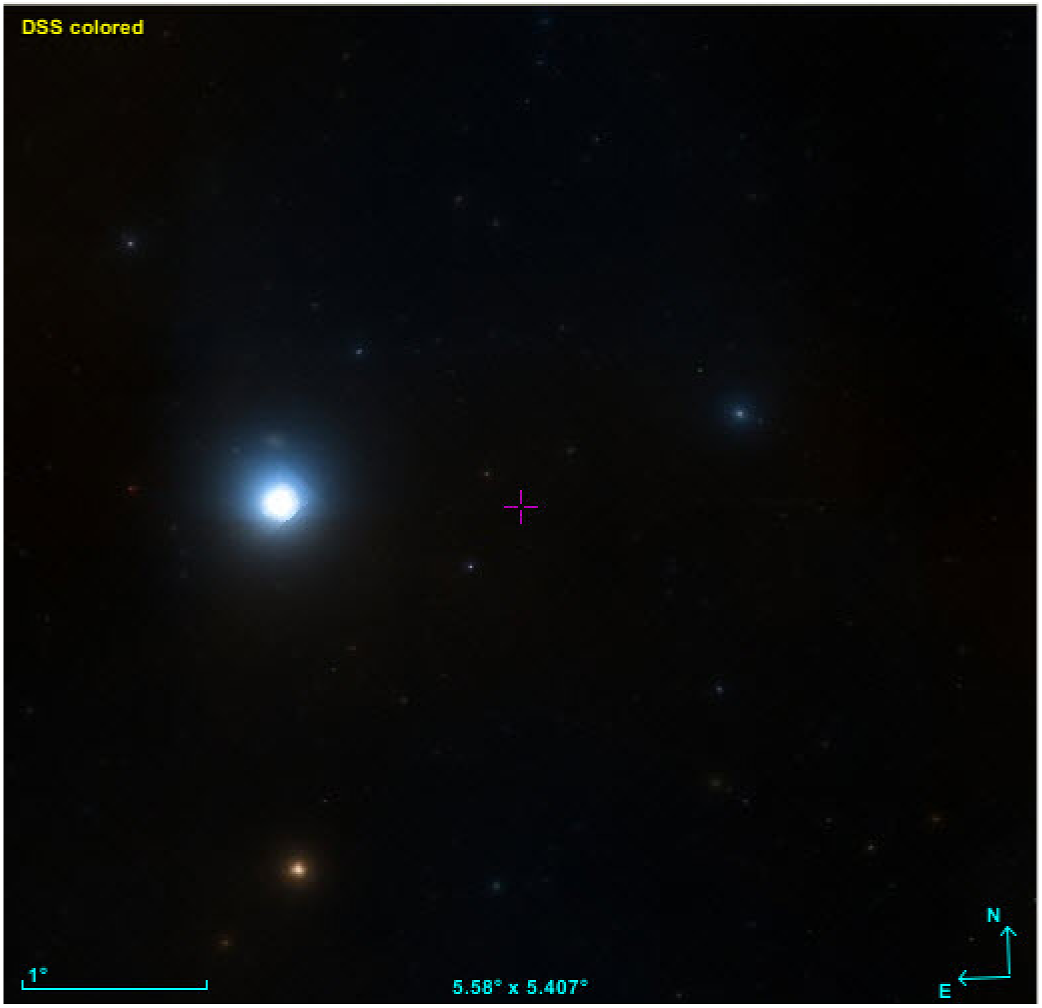
In conclusion, I cannot determine why my numbers for the first set of calculations were off by such a large factor. I carefully used MS Paint to measure the centers and verified all my measurements and calculations. BUT is does show that the 3 stars in Rob's image are closer to the Sun than in the Aladin image, so Einstein's predicted effect of the Sun's gravity curving space is present in Rob's image.

I enjoyed this Observing Program for I do like to repeat the experiments throughout history of the pioneering professionals of my hobby. When I saw this Program appear on the Astronomical League's website a while ago, I was all prepared to take a before image of that part of the sky where the Eclipse will happen with my Pentax film camera, 800 ASA Tri-X file and a 50mm lens. I was told that the 50mm lens would not be enough magnification to capture stars as those that are seen by the use of a 300mm lens Rob used. Hence, I did not take before and during images with my own camera and performed Level 3 of this Observing Award instead, using someone's image from the internet to do my calculations.



Picture 1

Rob Ratkowski's image, showing Regulus to the left of the Sun. A much fainter 31 Leo is below Regulus and to the left of the Sun and 27 Leo is above and to the right of the Sun and is very faint. Both 31 Leo and 27 Leo were seen on the image when I magnified the image by 400x.



Picture 2

The Aladin image I made, using Snagit 8 to capture this image into a JPG file. The red cross shows the RA and Dec coordinates of the Sun from Rob's viewing location, on August 21, 2017 at 11:45:12 AM as generated by Stellarium. The 3 brighter stars are Regulus, 31 Leo below and 27 Leo to the right. Aladin superimposed the scaling factor in the lower left corner, which I used to determine 1 degree was 92 pixels.