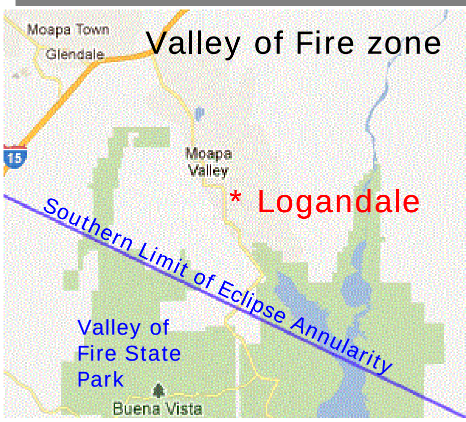
Lessons Learned From A Ring of Fire

- Larry Krumenaker



The Classroom Astronomer's first-ever event tour took us to the edge of the geologically spectacular Valley of Fire, Nevada, in 105-degree heat to view the May 20th annular eclipse of the Sun. The Valley of Fire is not on the center line (see the map to the left) where most eclipse tours go and where the real, true New Moon would make a perfect hole dead center in the Sun's face. This tour went to the southern edge of annularity in order to see if certain phenomena associated with total solar eclipses could be measured or viewed at the edge that would not be seen on the center line

All tour participants are involved in formal or informal astronomy education and we were here to show that science can be done by even non-scientists. Our observational goals were:

Total Eclipse Phenomena:

> Can Baily's Beads and shadow bands be detected, and for a longer time, from the southern edge of annularity? Can the flash spectrum of the chromosphere be detected from the slit-like edges of the Sun during annularity?

Environmental Phenomena:

> We know the sky will darken but are color changes perceived in eclipses measureable and real? What kind of changes in light intensity and temperature can be seen when the Sun is never completely covered by the Moon? This eclipse will leave 11% of the Sun still exposed, about the maximum possible because the Moon was near its farthest possible apogee while the Sun was nearly at its greatest distance from Earth.

The Ring of Fire tour observed from the very fine Clark County Fairgrounds, in the small desert-surrounded town of Logandale, Nevada. Surrounded by distant mountains on all sides but in a flat area with views down to just about 3-4 degrees above the horizon, we had respite from the heat under widely spaced, high and full trees, and a view over a large parking lot to our West.

To view the eclipse we had polymer eclipse glasses for all, telescopes to project magnified images, filters to place over cameras and various pinhole projectors and pinhole reflectors (see page 19). To measure temperature, sky brightness and color, and to try to detect shadow bands besides by eyeball, we used a variety of Vernier sensors attached to a laptop and three LabQuest units. The sensors were mounted on a flat stick taped to a camera tripod (see Figure 1). Three of the sensors were aimed to the one point in the sky that would always be equally distant from the Sun, the North Celestial Pole. The fourth was aimed 180 degrees away, downwards towards a white sheet on the ground, to be used to detect shadow bands. The first three sensors were on continuously, taking measurements every one to ten minutes. The laptop and LabQuest sensor interface-recorders were on a table nearby, shaded with an umbrella. Though capable of running on batteries, an extension cord provided power for them from a convenient outlet. Only the sky spectrum sensor, SpectroVis, had to be manually operated in recording its measures as a data file, every ten minutes.

Elsewhere, observers were photographing the eclipse with film and digital cameras and making records of Baily's Beads, and other phenomena, on cardboard sheets (Figure 2).

Figure 1. Jackie Sparks mans the laptop recording sky spectra. On the table are Vernier LabQuests connected by wires to sensors to the tripod's wood slat. Three sensors on top face the North Celestial Pole to record temperature, light and sky spectra. One at the bottom was to record shadow bands via light reflected off a white sheet.

Figure 2. Eyes and camera protected, we're ready to observe and record the eclipse.

Temperature, Light and Color

All electronic observations began at the moment the Moon touched the Sun. Looking at Figure 3a, there's no apparent influence of the eclipse on temperature until about .80 hours into the eclipse. The temperature declines steadily simply as the Sun lowers in the West, until two thirds of the way into the opening partial phases (annularity is for 1.72 minutes at the 1.2 hours, M, mark on the chart). It drops rapidly but then stays fairly steady until the line rejoins the normal diurnal temperature line at .55 hours before the eclipse ends. Any increase in temperature due to less coverage of the Sun by the Moon must be balanced out by cooling due to lowering solar altitude. Unlike the author's previous measures at total solar eclipses, this minimum temperature occurs *before* maximum coverage.

The light variation, Figure 3b, on the other hand, is quite a smooth curve with the deepest drop about 6 minutes before maximum eclipse. This and the temperature graph could indicate a systematic error in our sensors' start times. Recovery to normal light times out at the same time that the temperature sensor returns to normal as well. Clearly an annular eclipse, and therefore a partial eclipse, will not have any effect on local lighting or temperature until it reaches a certain depth, somewhere between 45 and 66% coverage of the Sun's visible surface.

On the other hand, the distribution of colors of the sky, its spectrum (Figure 3c), despite a common qualitative assertion that it gets perhaps bluer, showed no changes whatsoever beyond the uncertainties of measurement. The relative intensities of the different peaks of the sky spectrum

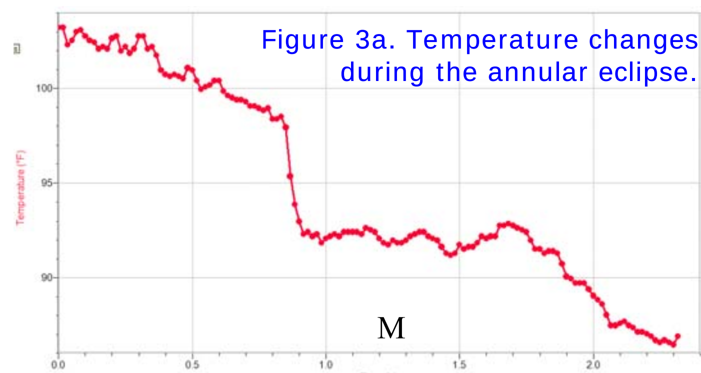


Figure 3a. Temperature changes during the annular eclipse.

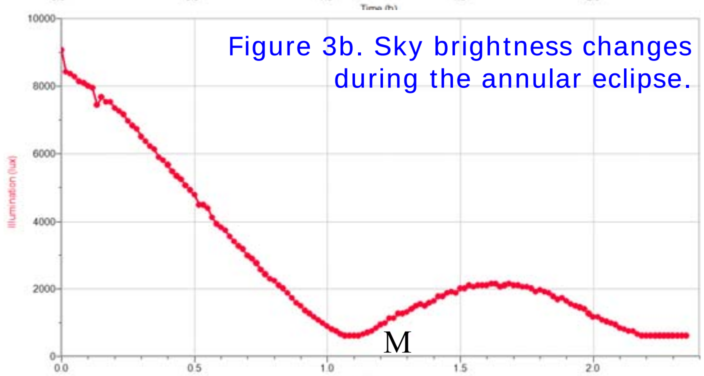


Figure 3b. Sky brightness changes during the annular eclipse.

did not waver at all. Logically, that should be true, as the sky may darken but it's still the Sun's light illuminating us and that and the scattering effects of the atmosphere should not change the relative amounts of color we see. Any bluishness must be attributable to human eye color response due to the darkening conditions but not to any real effects of the eclipse.

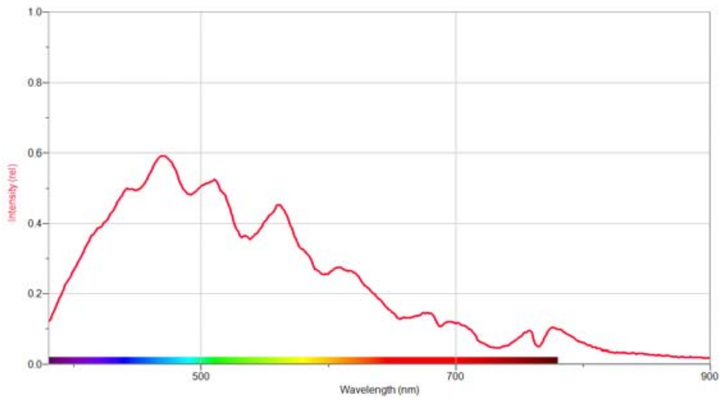


Figure 3c. The spectrum of the sky never changed during the eclipse, disproving color shifting sky during any eclipse.

Total Eclipse Phenomena

At the limit of annularity the Moon will cause a slit-like presentation of light on one side of the Sun, which then rotates as the Moon skirts the northern edge of the Sun until the Moon moves off, as seen in the three photos over this article's title. Thus we should have had nearly two minutes of "slits" which, during total solar eclipses, are the times when shadow bands, flash spectra and Baily's Beads can be seen. The research question we had was simple: can these phenomena be seen at all during the annularity time and, if so, can they be seen for longer periods than during a total eclipse's slit-like phase?

The answers for us for the three phenomena were, No, No and Sort Of.

No one visually saw any light variation on the surrounding landscape from shadow bands, which are believed to be distorted images of the slit-like solar light just outside the umbra due to lensing effects of bubbles of moving air high in the atmosphere. Regrettably, our Vernier sensor aimed at the white sheet was inconclusive. Observations were begun five minutes before annularity, with measurements every .002 seconds. These showed a step-like lowering of light consistent with the drop in overall light and with rising and falling values during each step, but inexplicably the sensor shut down after just two minutes. The variation in the light curve's steps could be shadow bands but we have no way to support that idea.

Using our *Classroom Astronomer* Spectrum Viewers the Sun's spectrum was vainly sought in both the first and second order diffraction spectra. Typically the flash spectrum is photographed or seen visually as ring- or crescent-shaped emission lines mimicking the moment's solar image, over a continuous spectrum. Either the wider part of the uncovered solar surface was so bright as to wash out any spectral "crescents" or the chromosphere was not visible long enough. No evidence for the flash spectrum was seen.

Some of the participants observed what appeared to be momentary Baily's Beads at the beginning of annularity but any Beads seen were difficult. Photographically, our 35mm film exposures of about 1/1000th of a second, when contrast adjusted, do actually seem to show gaps in the thinnest part of the visible solar surface (Figure 4). So it may be possible to claim that Baily's Beads can be seen even in this least covering of a solar disk during an annular eclipse; Beads have been previously photographed on annular eclipses when the Moon was essentially the same size of the Sun (when the Moon is more than 99% of the size of the Sun's disk) but this Moon was only 89%, showing more of the solar surface.

Figure 4. The moment just before annularity, are there Beads here?

Participants in this eclipse observing included the author, John, Marilyn and Heather Woolley of Canada, and Jackie Sparks and Pam Maher of the College of Southern Nevada, Las Vegas. TCA

All photos by L. Krumenaker except annular eclipse images and upper right on p. 19 (J. Woolley).

Watching The Eclipse Let Us Count The Ways!

"It isn't research until you bring out the duct tape," said John Woolley. His duct tape was holding a mirror onto the back of a paper plate into which he had punched a dime-sized hole (photos start in the upper left corner and proceed clockwise). This projected an image of the crescent-shaped eclipsed Sun onto a nearby screen. Pam Maher countered with an easier device; she used Heather Woolley's makeup compact mirror to project a "pinhole reflector" image onto a tree in the distance.

Pinhole images were in abundance. Make a crescent appear with a hole between fingers. Interestingly, the crescent-shaped Sun made shadow and diffraction effects around the fingernails and between fingers of a hand's shadow. Can't get enough pinhole crescents? Try a hamburger flipper with holes. Want crescents but don't want to do any work? Let the holes between leaves in a tree project two-foot sized crescents on the ground!

A more productive way of viewing the Sun, in or out of eclipse, is to use a telescope to project a magnified image onto any convenient screen or surface, at that moment, Marilyn Woolley.