Summer 8-2017

IWU Astronomy Expedition to Observe Solar Eclipse of 21 August 2017

University Communications
Illinois Wesleyan University

IWU Astronomy Expedition to Observe Solar Eclipse of 21 August 2017

by Thushara Perera

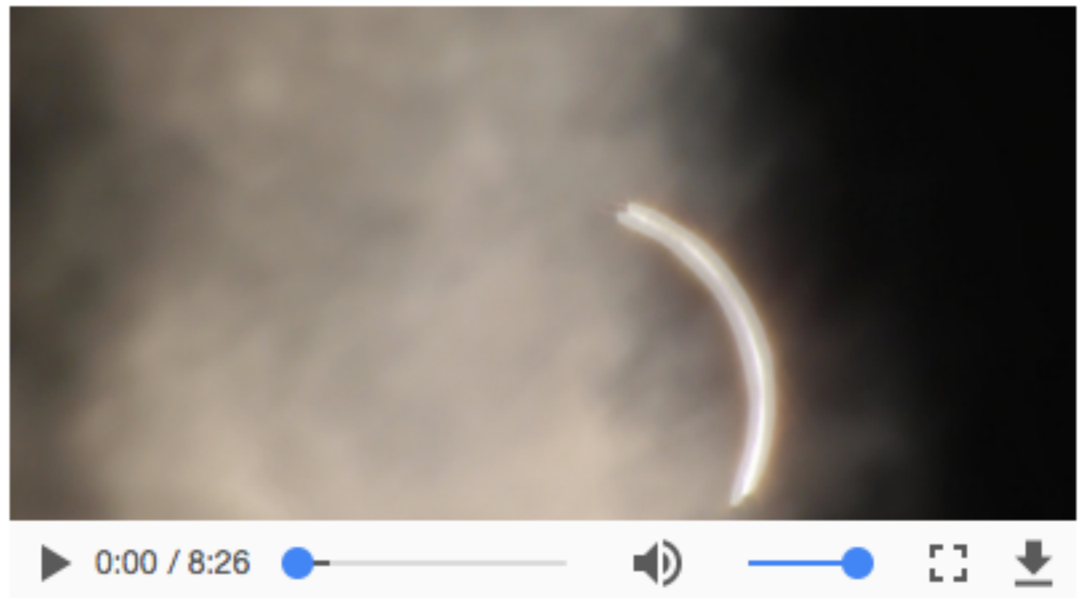
Early in the morning on the day of the Great American Eclipse, I and a team of current and former IWU students set off for Carbondale, IL to observe the total solar eclipse. The transportation was through a local company—Rasmussen Travels—owned by a former IWU physics student and my expenses were covered by the Mellon Center for Curricular and Faculty Development at IWU. We took with us a telescope and solar filters that belong to the IWU observatory and my personal DSLR camera. Below is a photo of our team and our instruments, at the SIU-Carbondale campus. We also brought with us a video recorder to document the experience.

People from left to right: Alex (Krystyna's brother), Krystyna Lopez (Physics Major, class of 2017), Ben Liao (Physics/Pre-Engineering Student, class of 2019), myself (Thushara Perera, Physics Faculty), Jordan (Alex Rasmussen's wife), Alex Rasmussen (former IWU Physics student and owner of tour company). The telescope on the left is a 6-inch Cassegrain Reflector with a makeshift counterweight and the camera on the right is a Cannon DSLR with a 400-mm telephoto lens. Both are equipped with solar filters.

We got to the SIU campus and set up our instruments soon after the eclipse began (11:50 AM). The following photo was taken with a phone placed at the eyepiece of the telescope (using some exposure control).

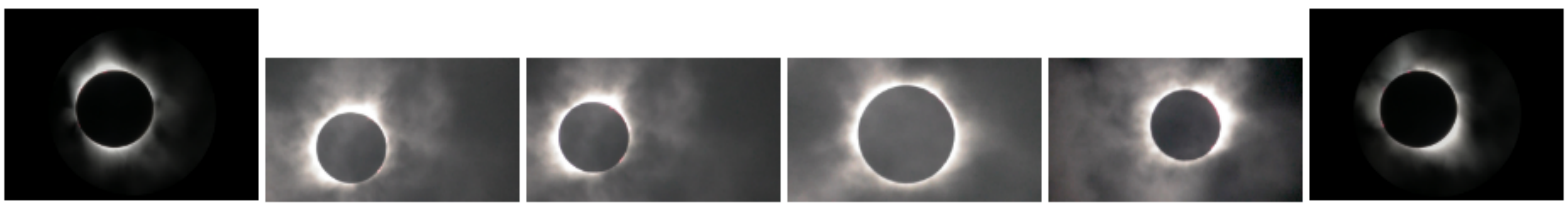
At this point about about 75% of the sun's diameter and about 50% of the sun's surface area has been eclipsed. i.e. the eclipse *magnitude* is about 0.75 and the *obscuration* is 50%. As a result of telescope optics, this image is a mirror reflection of what it would actually look like on the sky (as viewed through eclipse glasses, for example).

Although it was a sunny day in Carbondale, there were some clouds in the sky and, as a result, we *almost* did not get to witness the sun (and moon) at totality. However, due to sheer luck, the clouds parted for a minute or so during totality and we were able to witness the full glory of a total solar eclipse! The drama leading up to this event and other parts of our trip are documented in the short (8.5-minute) movie below.



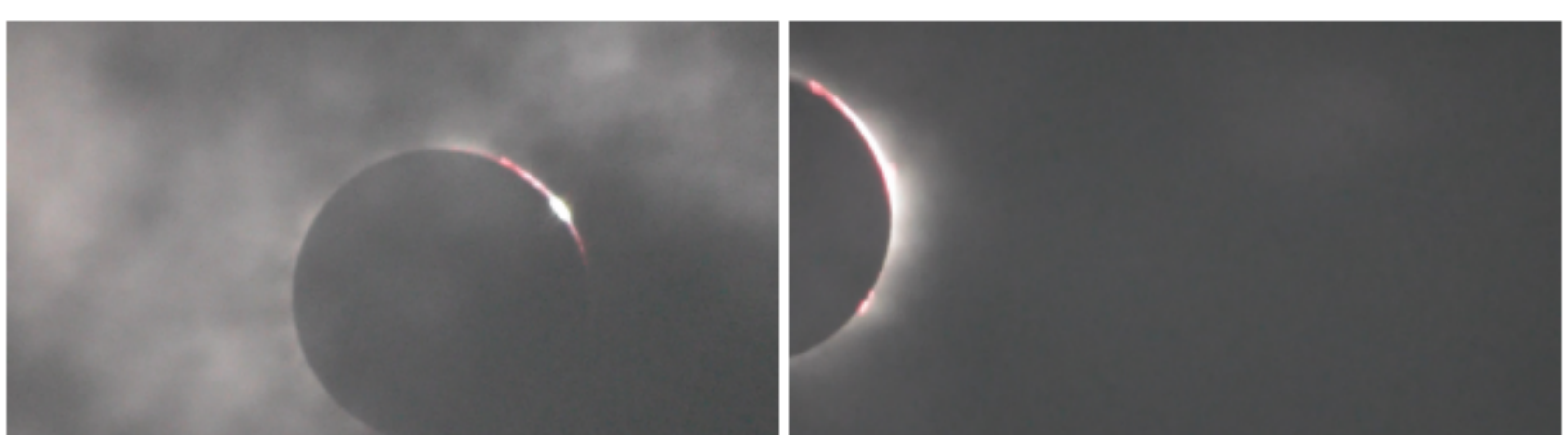
One perception-related inaccuracy in the video is due to the fact that the video recorder adapts very well (too well) to low-light situations. As a result the background illumination during totality appears brighter than it was; it really was quite dark. Even so, our surroundings weren't truly as dark as during nighttime mainly due to a sunset-like glow on the horizon in *all* directions. This effect is due to the finite size of the moon's complete shadow (the *umbra*), which had an approximate radius of 35 miles in Carbondale. What we see as the "360-degree sunset" is the illumination of the sky (at distances in excess of 35 miles) in regions not experiencing the total eclipse.

Below are some of the photos we took during totality.



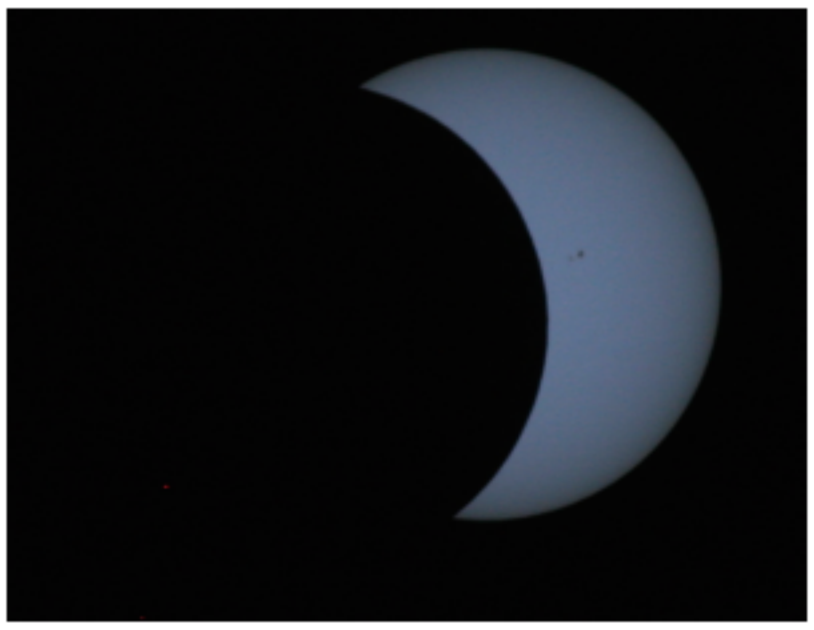
These images are in chronological order. You can click on an image to make it larger. The two bookend images, which have higher contrast, were taken with a phone camera at the eyepiece of the telescope. They show the sun's *corona* (its outer atmosphere) and coronal "streamers" that point outward from the sun. These are magnetically guided flows of ions, which source the solar wind. In the lower contrast frames obtained from the video recording (the middle images), the corona blends in with the thin cloud cover to give a unique visual effect. In most of these images, you see small crimson-colored "beads" of light at a few points on the moon's circumference (click on an image to see them clearly). These are called *Bailey's Beads* and are chance views of the *chromosphere,* the solar atmospheric layer that lies within the corona, afforded by valleys on the lunar surface. The corona and chromosphere are usually not visible to us because they are dimmer than the sky itself during daytime.

The following photos were taken just as the sun was re-emerging from totality.



The fist image is usually called the "diamond ring," which shows just a single spot of the sun's *photosphere* (though lunar valleys), as the total eclipse is just ending (or beginning). The photosphere is the innermost layer of the sun's atmosphere, which is what we usually recognize as the sun during daytime, and lies within the chromosphere.

With the excitement of totality behind us we were able to take some good-quality photos of the partially eclipsed sun using the camera.




You can blow up these images by clicking on them. The part of the sun visible in these images is the *photosphere,* which is responsible for the glow we recognize as the sun in the daytime sky, on a regular day. During this eclipse, the presence of a line of *sunspots,* right through the middle, made it easy to focus telescopes/cameras on the sun. As you can see in this time sequence, more and more sunspots are revealed as the sun comes out of the moon's shadow. Two other notable aspects of the photosphere are its sharp outer edge, as if the sun is a solid sphere rather than a gaseous object. In reality the sun *is* a ball of gas, but the gas that comprises the photosphere has a high opacity, with an optical depth of only 400 km. The edges appear sharp because 400 km is very small compared to the solar diameter (about 1.4 million km). Another notable feature is *limb darkening,* which refers to the darker shade of the sun near the edges, as if the sun is a solid ball illuminated from the front. In reality, this effect is due to a steep temperature gradient within the 400-km thickness of the photosphere, from 5800 Kelvin at the bottom to about 4400 Kelvin at the top. *The photo parameters, for future reference, were, sensitivity: ISO 400, lens focal length: 400 mm, filter: ND 1/100000 equivalent, f-stop: 8, shutter speed: 1/2500 seconds.*

A fun effect to observe during partial eclipse phases is shown below. The tiny holes in the hat result in a splash of circular patches on the ground on a regular day. However, during an eclipse, the patches take on the shape of the eclipsed sun!


The box of crackers acts as a flat screen here. Each tiny hole in the hat works as a pin-hole projector. A small pin hole in front of a very bright source acts as an arbitrary focus for light rays from the source. i.e. the light rays cross paths at that point and, as a result, the projected image is a mirror reflection of the actual scene.

After an exciting day of observing, we went for lunch/dinner at a restaurant in Carbondale and witnessed the following recreation of the day's events!

A *Corona* peeking out from behind a *Blue Moon*.