A Fortuitous Sighting of an Earthlit Moonrise

by William Romanishin

A serendipitous night at an observatory in the Chilean Andes led to a celestial spectacle I'll never forget.

In 2013, I traded my hoard of frequent flyer miles for a ticket to Chile to spend time on the 0.9-meter (36-inch) telescope at Cerro Tololo Inter-American Observatory (CTIO). While there I observed, totally by accident, a very unusual moonrise of the earthlit moon. This moonrise was very memorable, as I had never seen such a dramatic example of earthshine before or since. Here I describe what I saw and how you might see such a moonrise for yourself.

People are sometimes surprised to learn that astronomers who travel thousands of kilometers to dark and remote mountaintops to observe on large telescopes don't always get to see the night sky properly. If the sky is clear, the astronomer spends the night staring at multiple computer monitors in a lit-up control room, monitoring weather satellite images and examining the incoming data from the CCD camera or other detector attached to the telescope. The astronomer is preoccupied keeping a detailed logsheet and making important decisions such as how much more time to spend on the current object, what to observe next, where to fit in calibration images, and when to eat night lunch. Observing plans carefully formulated days before are invariably scuttled and have to be redone in "real time" due to equipment or computer malfunction, high humidity, high winds, bad seeing, or a passing band of clouds. The lights of the control room and computer screen are antithetical to proper dark-adaptation. So, the observer may not have time to see the dark sky in its true glory with completely dark-adapted eyeballs.

An example of an "earthlit moon" over the ESO's Paranal Observatory in Chile. *[ESO/B. Tafreshi]*

On the beautifully clear night of 3-4 May 2013, I was doing long automatic sequences of CCD images. The telescope and CCD were working very well. Around 2 a.m. I decided to turn off the control room lights and turn down the brightness on the computer moni-

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tors to get at least somewhat dark-adapted so I could take a proper look at the magnificent southern sky. After a half hour or so sitting in the near dark, I stood in the completely dark foyer of the dome for a few minutes, then went outside to see the wonders of the sky visible from 30 degrees south latitude. I first looked directly east, towards the main part of the Andes Mountains and I immediately noticed a faint, almost half disk of light on the horizon defined by a distant ridge. My sleep-deprived brain was stumped for a few seconds—what was this ghostly apparition?

I remember thinking it may have been a telescope dome on a neighboring peak, but that didn't seem quite right. As I watched, two bright points of light appeared which slowly grew into small triangles of light. Then of course it hit me—I was watching the moon rise, earthlit half first! Soon I was seeing the crescent moon just above the horizon. The moon's disk was 31 percent illuminated by sunlight, about 1.7 days after third quarter and 5.8 days before the next new moon. The little triangles of light were, of course, the cusps of the rising crescent moon. The line between the cusps and slight slope of the horizon fortuitously matched up so that the two cusps peaked over the horizon almost simultaneously.

The domes of the CTIO telescopes at sunset. *[CTIO]*

Seeing this unusual moonrise was most definitely a case of (accidentally!) being in the right place at the right time! The time from when the first part of the moon peeks over the horizon until half the disk is risen is about one minute. If I had looked a few minutes before I did, I would not have seen the moon and if I had looked a few minutes later, I would had seen the brightly lit crescent above the horizon and missed the ghostly earthlit moonrise. Also, of course, the observing venue was an ideal one to see the earthlit moonrise. Looking east from CTIO, which is at an altitude of 2,200 meters, the horizon is defined by the higher terrain of the backbone of the Andes. I used a topography map and knowledge of the direction of moonrise (azimuth of 93 degrees, almost due east) to plot an altitude profile along the direction of moonrise. In this direction, the horizon is defined by an almost flat-topped treeless ridge about 1,200 meters higher than CTIO, located about 20 kilometers from CTIO. A little trigonometry—considering a slight correction for the curvature of the Earth—reveals that the horizon defined by the ridge/sky intersection in this direction was 86.5 degrees from the zenith, or 3.5 degrees above the true horizon.

Can you see such a ghostly earthlit only moonrise? I suspect that it is fairly challenging to see from most observing sites. At the "true" horizon (90 degrees from the zenith), one must look through a lot of air- roughly 38 times as much air compared to looking towards the zenith! The absorption of light traveling through all this air, as well as the airglow and artificial light scattering along the long path

through the air, makes seeing a faint extended object at the horizon difficult. And your observing site is probably not next to the completely dark Andes Mountains! There are absolutely no artificial lights visible to the east from CTIO. Satellite imagery shows some scattered small farming settlements east of CTIO, but these are in deep valleys and probably not very much lit up at night, so are not visible from the observatory.

The fact that the horizon in the direction of moonrise was 3.5 degrees above the true horizon was undoubtedly a big help in seeing the faint earthlit moon. Near the horizon, the amount of air you look through drops rapidly with increasing angle above the horizon. However, at 3.5 degrees above the horizon, one must still look through about 13 times as much air as looking straight up.

If you are looking for an observing challenge and want to look for the earthlit moonrise, don't randomly go out in the dark and hope to get lucky like I did. Do a little planning! Use your favorite planetarium program to predict when and where along the horizon the moon will rise. Unless you have customized your program with the details of the topography of your local horizon, the actual time of moonrise may differ from the predicted time by a number of minutes. If your eastern horizon is less than 90 degrees from zenith, as is the case for CTIO, the actual time of moonrise will be later than predicted (for CTIO on 3-4 May 2013 the difference was almost 8 minutes). If you are on a high point with an eastern horizon defined by lower terrain, the actual moonrise will be earlier than predicted.

A related but easier observation is to look for the setting earthlit-only portion of the moon a few days before first quarter moon. In this case, you will know exactly when and where to look for the setting earthlit only portion of the moon as you can follow the lit-up crescent towards and below the western horizon.

Another obvious challenge would be to get a good image of the earthlit only moonrise. I wish I had had a good camera and telephoto lens at CTIO, but of course I didn't.

Time to start stockpiling those frequent flyer miles again! ✪

Dr. Romanishin stands in front of the Discovery Channel Telescope at Lowell Observatory in Arizona. *[Steve Tegler]*

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