The SunSketcher Eclipse Project

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SunSketcher™

What is SunSketcher?

We are preparing a new, free, smartphone App to record eclipse images of Baily's Beads at 2nd and 3rd contacts and thus get a definitive description of the solar limb – its height, shape, and variability. We will beta-test the App during the annular eclipse of October 2023 and hope to involve a huge (~million user) community during the total eclipse in April 2024.

This effort builds on Eclipse Megamovie 2017 and complements Eclipse Megamovie 2024, which focuses on crowd-sourced coronal imagery (Peticolas et al. 2022; Hudson et al. 2022).

What determines the shape of the Sun?

The "thickness" of the Sun's photosphere is of order one scale height, 150 km, which cannot be well resolved even with the best optical telescopes. This fuzzy edge can be very well defined statistically, though (see, e.g., Brown & Christensen-Dalsgaard 1998). The Sun's rotationally-induced oblateness can also be observed (e.g., Fivian et al., 2008), but only at a level that still permits a wide range of models for the solar internal structure.

Baily's Beads

Through time-lapse exposures, the ESO image here captures Baily's Beads at 2nd and 3rd contacts, with high image resolution.

The smartphone resolution will be much lower than this excellent example, but huge oversampling of the phenomenon will improve the overall accuracy of the results.

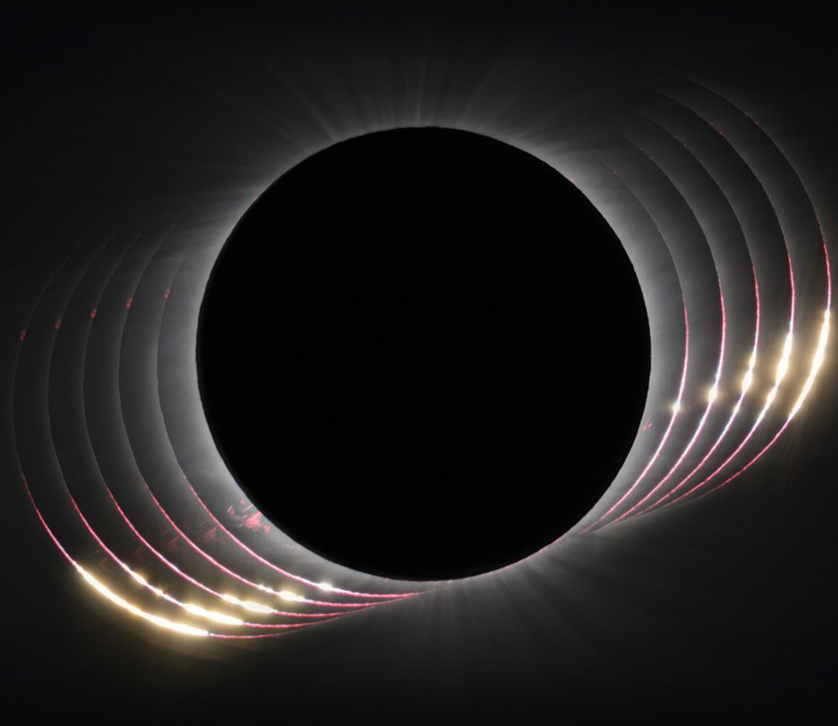
The SunSketcher App

- Educational eclipse information
- Autonomous operation; photo sequences at 2nd and 3rd contacts activated using eclipse ephemerides and location of phone (GPS)
- Audible cues to alert user to upcoming time of 2nd contact
- Pointing check for altitude and azimuth (see Figure; this is not critical)
- Upload to NASA database; ~1 GB per phone, ~1 PB total

Is it safe ?

While photographing total eclipses is safe, leaving your phone out in the sun before or after the eclipse may not be. Research is ongoing on the best way to keep phones safe while maintaining the quality of the photos.

The figure on the right shows an array of iPhones during the 2017 eclipse in Corvallis, OR. All survived very nicely despite long exposure to direct sunlight. A concerned user could use their phone in conjunction with a standard solar eclipse filter.



A beautiful example of Baily's Beads, eclipse of 2 July 2019 as seen at La Silla *(Credit P. Horalék/ESO).*

The science

1) Solar internal dynamics: Just as the height of the Earth's sea surface reflects the ocean's currents, the shape of the solar limb reflects sub-photospheric flows of all sorts. Does the Sun bulge at active latitudes? Does the dynamo action result in shape signatures? Are there giant convection cells?
2) Solar external gravity: The celebrated 43" per century deficiency between the orbital precession rate of Mercury and the rate predicted by Newtonian gravity was, of course, nicely resolved using General Relativity. Other scalar-tensor theories of gravity predict slightly different values for the deficiency, and their viability thus depends on a precise measure of the orbital precession produced by an oblate Sun.
3) Gravitational waves: The SunSketcher data will also provide the first characterization of heliospheric gravitational waves – establishing possibly important noise levels for a thrilling new field of astronomy.

The LRO/SELENE database

Millisecond timing of Baily's Beads, together with the hyper-accurate measurements of the lunar topography made possible by the LRO and SELENE spacecraft, permit the location of the solar limb to be determined to a precision of about a few kilometers (*e.g.*, Wang et al. 2023).

Data analysis: Challenges and Opportunity

Starting with a haystack of several million low-grade solar images, in short-exposure sequences of 10-20 frames each, we must search for a few needles - at a minimum, the oblateness parameter. Is this feasible?

The "weak link" is the GPS phone location, which is only accurate to about 10 m. This corresponds to about 10 milliseconds of eclipse shadow travel and to 4 km on the Sun. This accuracy is still an order of magnitude better than current uncertainties.

References

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