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Ellipses, Leaves, and Solar Crescents

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Fermi Questions

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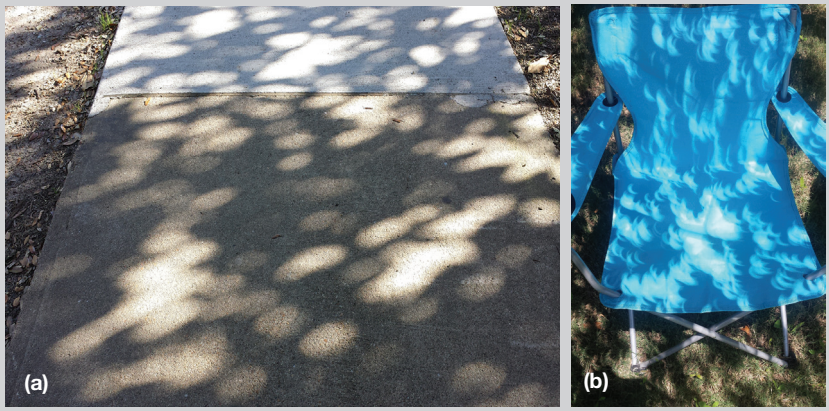

Fig. 1.

On sunny days, we may notice bright elliptical patches on the ground while walking under a tree [(Fig. 1(a)]. They are caused by small gaps in the leaf canopy, which act as "pinhole cameras."

Suppose a typical elliptical patch has major and minor axes a and b, respectively (Fig. 2). The particular pinhole (approximately circular) is at height H in the canopy, and the distance from there to the center of the patch is L. The angular diameter of the Sun at the pinhole is α radians; the diameter of the Sun is D; its distance is R, and the solar altitude is β. Note that $\alpha \ll \beta$.

Question 1: Pick several different isolated elliptical patches in Fig. 1(a), and find a typical aspect ratio for b/a.

- ***(i)*** Infer the altitude of the Sun at the time of the picture.
- ***(ii)*** What is a typical height of the leaf pinholes in the picture? Obviously, there will be a range of values since the tree canopy will be quite large. The square sidewalk slab is ~2 m on a side.

Question 2: The solar crescents in Fig. 1(b) were photographed on August 21, 2017, whilst the total solar eclipse was in progress. The lawn chair is of standard size. What is the typical height of a leaf pinhole in this case?

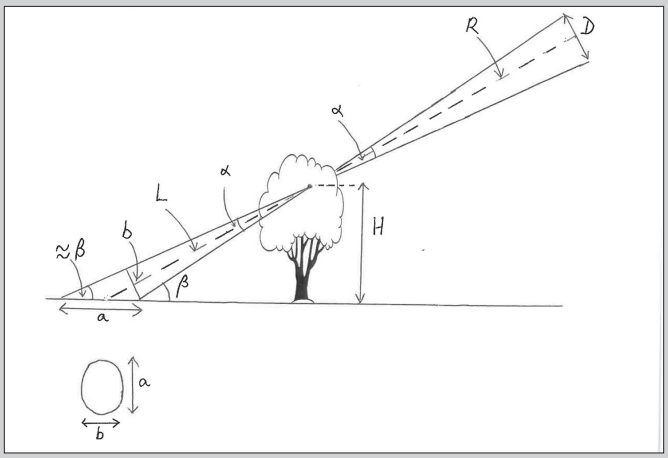

Fig. 2.

Fermi Questions *are brief questions with answers and back-of-the-envelope estimation techniques. To submit ideas, please email John Adam (jadam@odu.edu).*

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