

How Do We Know Venus Orbits the Sun?

How Do We Know That Mars, Jupiter, etc. Are  
Further From The Sun Than We Are?

How Far Is Jupiter From The Sun?

How Big Is Jupiter?

How Far Away Are Stars?

Can We Measure The Distances To the Stars?

How Do We Know That The Stars, As We See  
Them, Don't Extend Out To Infinity?

# Olbers' Paradox



A New Discovery... Do You See It?



Robert J. Vanderbei

# The Earth Is Not Flat

An Analysis of a Sunset Photo

Can a photo of the sunset  
over Lake Michigan reveal the  
shape of our planet?

Robert J. Vanderbei

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I will show you how we can...

measure something *BIG* (the size of the Earth)

by first measuring something *small* (my height),  
and measuring an *angle* (off from a photograph)

and then doing some *geometry*.



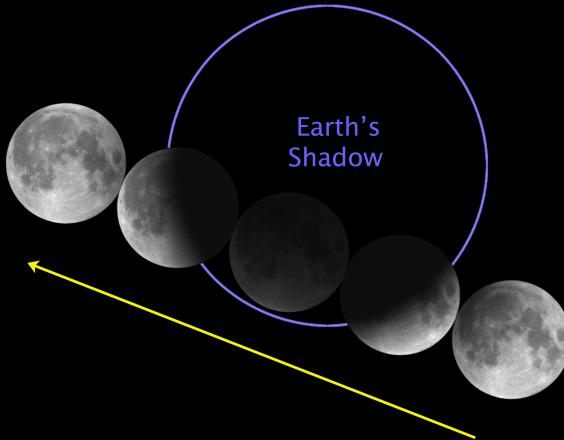
The Earth is a big sphere. How do we know?  
Several ways. One way is to look at a Lunar eclipse...



Photo taken March 3, 2007, at about 8pm.  
Check out what astronomer Fritz Zwicky has to say about it:  
click [here](#) and search for "bastard"



From a lunar eclipse, we can determine that the Earth is about 3 or 4 times larger than the Moon. But, how big is the Earth?



Next total lunar eclipse visible from here in NJ is on March 14, 2025.



How big is the Earth? How can we find out?

First Method: Look it up on Wikipedia.

You'll get the right answer  
(radius = 3,960 miles). But no satisfaction.

Second Method: Air travel.

I've flown to Bangkok Thailand.

It's about a 17 hour flight.

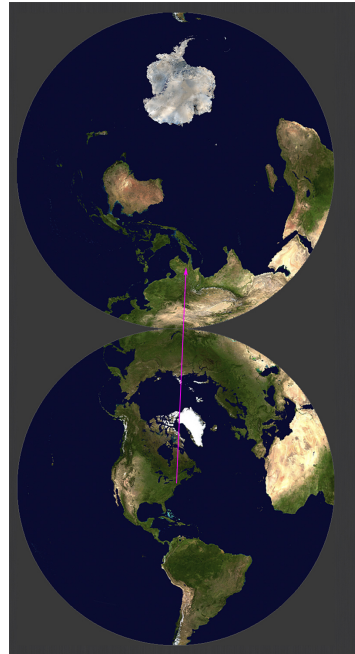
It's roughly halfway around the Earth.

Jets fly at about 600 mph.

So, the distance I flew is *about*

$17 \text{ hours} \times 600 \text{ miles/hour} = 10,200 \text{ miles.}$

Bangkok's latitude is about  $10^\circ$  north and NJ is about  $40^\circ$  north. So, the trip wasn't halfway around. It was just  $130/360 \approx 0.36$  around. So, the circumference is then about  $10,200/0.36 \approx 28,000$  and the radius is about  $28,000/2\pi = 4,500$  miles.



IS THERE AN EASIER WAY?



A picture I took of a sunset over Lake Michigan.





A close-up.

Using this picture, some geometry, and a little trigonometry, I was able to compute that the Earth's radius is about 5000 miles.



A smooth lake is supposed to act like a mirror.



Credit: Lorene Lavora

The Sun's reflection should have looked something like this...



Or not!

What's going on?



Lake Michigan  
is not a flat mirror.

Its surface is curved  
because the Earth is a  
sphere.

That's why we can't see  
the shore on the opposite  
side—it's below the  
horizon!

