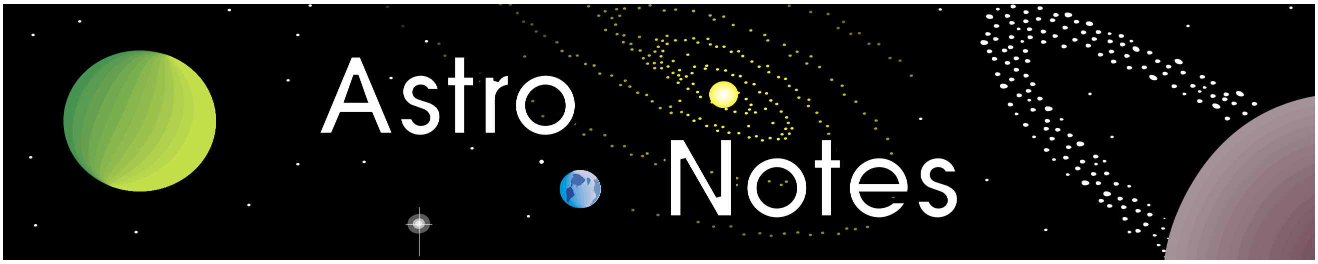
How big is our Sun?

Mark Moldwin

Citation: The Physics Teacher **38**, 115 (2000); doi: 10.1119/1.880444
View online: http://dx.doi.org/10.1119/1.880444
View Table of Contents: http://aapt.scitation.org/toc/pte/38/2
Published by the American Association of Physics Teachers



Column Editor: *Timothy F. Slater, Department of Physics, Montana State University, Bozeman, MT 59717-3840; tslater@physics.montana.edu*

How Big Is Our Sun?

Mark Moldwin, Department of Physics and Space Sciences, Florida Institute of Technology, Melbourne, FL 32901; moldwin@pss.fit.edu

Putting large numbers into human perspective by using ratios of a known quantity to an unknown quantity is an important scientific skill. An astronomy activity that encourages the use of estimation and helps students get a handle on large numbers is the making of a scale model of Earth and Sun that is relative in both size and distance.

To start, each student draws a circle to span an 8.5 x 11-in sheet of paper. I ask them to draw within that circle another circle representing what they think is the relative size of Earth. Then I show them a drawing with the correct ratio, where the diameter of the Sun is about 100 times that of Earth. This means that the correct "Earth circle" should be 0.085 inches (~2 mm).

Then we take the radius of Earth (~6400 km) and Sun (~700,000 km) and put these numbers into a human context by asking questions. How long would it take to drive around the equators of Earth and the Sun? (Hint: circumference is proportional to radius, so it would take 100 times longer to drive around the Sun.) How many Earths can fit in our Sun? (Hint: volume changes as the radius cubed and since the radius of the Sun is approximately 100 times that of Earth, about one million Earths would fit in the Sun. (Incidentally, there is no need for the student to use the formula for a sphere: $4/3\pi r^3$.)

Now that the students are beginning to acquire a feel for the relative sizes of Sun and Earth, we consider the relative separation of the two. The average distance between Earth and Sun is approximately 150,000,000 km (1.5 x 10^8 km or 93,000,000 miles. It's amazing how many students know this distance in miles!). Again we express these large numbers in terms of everyday experiences. How long would it take to drive to the Sun? How long would it take for a jet to fly to the Sun? Asking students to estimate which velocity values to use makes this a problem-solving activity rather than a calculator activity. These different values provide a departure point for class discussion and peer assessment.

My next comment to the class is that scientists like to simplify the math involved as much as possible. That is why physicists normalize quantities such as the radius of Earth and Sun and average distance between them by using units related to their special interests. Magnetospheric physicists talk of distances in terms of Earth radii (R_E), solar physicists in terms of solar radii (R_S), and planetary physicists use astronomical units (AU)—the distance between Earth and Sun. By describing a distance in such units, the scientist creates a feel for what size or distance is being discussed. You can often tell a physicist's field of interest by what distance unit is used. Condensed-matter physicists talk in nanometers (10^{-9} m), whereas extragalactic astronomers talk in megaparsecs (3 x 10^{22} m).

For the hands-on segment in this process of relating large numbers to a "human" perspective, we develop a scale model of Earth in orbit about the Sun. Instructions for a model I find useful is located at: www.howardcc.edu/tinyhcc/saturn/astronomy/IdeasWorkshop98.htm. [For information describing an elaborate solar system model, see *Phys. Teach.* **29**, 371-374 (Sept. 1991).]

For our model we usually go outside. I give the students a standard basketball (just under 10-in diameter) and ask them to calculate the size of Earth if the basketball is used as a model of the Sun. They have discovered in class that the Sun's diameter is about 100 times larger than Earth, so it turns out that a push-pin (0.1-in head diameter) makes a good Earth model in our solar system. The next step is to place this "pin Earth" at the approximate distance from the "basketball Sun." The distance is about 100 basketball diameters (200 solar radii), or roughly 9 m. It is instructive at that point for those students studying trigonometry to compute and measure the angular size of the basketball as seen from "pin Earth."

This study of relative sizes and distances demonstrates how scientists visualize large quantities and also provides students with a new tool for understanding unknown quantities by describing them in terms of known quantities. It encourages students to estimate large numbers by using powers of 10 (or orders of magnitude). This approach leads students to consideration of whether a number makes sense, instead of just taking a large (or small) number from a calculator at face value.

---

et cetera...

Rarest Naturally Occurring Element

"Researchers at SUNY-Stony Brook have successfully trapped the world's rarest naturally occurring element, francium ($Z = 87$) .... The Stony Brook team developed a technique to trap more than 10,000 francium atoms in a volume about the size of a head of a pin, using six laser beams and an inhomogeneous magnetic field.

"Francium is the heaviest alkalai and the least stable of the first 103 elements on the periodic table. Less than 30 grams of it exists on Earth at any one time, in uranium deposits. It appears atom by atom, as heavier atoms decay, and it disappears in less than 20 minutes as francium itself decays."[1]

---

[1] *A.P.S. News*, July 1996.

A^{2}B