How small is it?

By Keith S. Brown

Modern physics and technology are wonderful subjects. Listen to a couple of electronics engineers talking about the latest and greatest integrated circuit ("chip") and they will probably speculate about chips that work with single electrons. *Individual electrons!* That's small, right?

Small things are measured in Angstroms and nanometers (a billionth of a meter). Really small things are measured in picometers (a trillionth of a meter). All that sounds very un impressive. To twist a phrase, a trillionth of a meter is smaller than I can imagine, and subatomic particles are even smaller.

However, as my daughter likes to ask, "How small is small?"

That's a good question. How small is small?

While it may be convenient to work with Angstroms and nanometers when dealing with technology, neither measurement gives me the sense of how small, small really is.

I find that when numbers become too big or too small, I get a better understanding if I scale the problem. So let's scale a portion of our universe so that a proton is 1 one-hundredth of an inch in diameter. That's small, but large enough to see with the naked eye. One one-hundredth of an inch is approximately the thickness of two sheets of paper from a typical paperback novel.

Object	Unscaled size, Angstroms	Scaled Size (inches)	Scaled Size (feet)	Scaled Size (miles)
proton	0.000012	0.01	0.000833	--
electron	0.0001	0.08	0.006944	--
atomic nucleus	0.0001	0.08	0.006944	--
Hydrogen atom	0.60	500.00	41.670000	0.01
Uranium atom	2.80	2333.33	194.000000	0.04
Water molecule	3.00	2500.00	208.000000	0.04
smallest virus	100	83333.00	6944.000000	1.32
Red blood cell	76000	--	--	1,000.00
US penny 0.75"	1.90e+8	--	--	2,499,000.00
Person 6'2" tall	1.87e+10			246,450,000.00

[References: Keenan & Wood's "General College Chemistry" & Dull's "Modern Physics"]

So, an electron is about 8 times larger than a proton and about the same size as the nucleus of an atom. If the scaled diameter of a proton is two sheets of paper, then the diameters of an electron and the atomic nucleus are about 16 sheets of paper.

If atoms are spherical, then the Hydrogen atom is nearly 42 feet in diameter. However, its nucleus contains but a single proton and it is “orbited” by a single electron. (Modern theory says electrons do not orbit. They are not miniature planets -- regardless of appealing that mental image might be. Instead, a probability density function describes an electron's location. So take “orbit” as a short-hand way of describing where we think the electron probably is.)

The Uranium atom (which is one of the heavier atoms, though not the largest) would be almost 200 feet in diameter. The largest atoms are slightly more than 5 Angstroms in diameter and in our scaled universe would be nearly 350 feet in diameter.

A water molecule is a bit over 200 feet in diameter.

The smallest virus would be about one and a third miles in diameter and the largest virus would be a bit over 3 miles in diameter. In comparison, a human red blood cell would be about a thousand miles in diameter.

The US penny, which in the normal universe is three-quarters of an inch in diameter, would be almost two and a half million miles in diameter. That is more than ten times the distance from the earth to the moon.

A person who in the normal universe would be 6 feet 2 inches or 187 centimeters tall would find his toes in the sun and his hair continually parted by the asteroid belt.

That’s a picture I can visualize! I’m over two hundred forty million miles tall and in comparison a proton’s diameter is 0.01 inches. Now, that’s a ***small*** I can understand!