Uncertainty Principle and Science Fiction (12.7, 12.8, 12.9)

Story so far….

Light – once thought to be clearly a wave – composed of photons (particles) that had momentum (particles)

Electrons – once thought to clearly be a particle – have a wavelength (de Broglie) and orbit at certain distances based on this wave property.

Bohr's model suggests we can determine, accurately, the orbital distance of an electron. But in 1927, Heisenberg proposed that this isn't necessarily so. There is always some degree of uncertainty inherent. This is not experimental error; this is the weird world of quantum physics!

Although an electron seems like a particle, it also behaves light a wave. We cannot therefore say we know exactly where it is **and** how fast it is going. We have to be satisfied by saying it's has a high probability of being here or there. So electron orbits are really just high probability rings around the nucleus!

Heisenberg's Uncertainty Principal – the better you know the position of a particle, the less you know about the momentum and vice versa.

The photons of light we use to see things affect the small thing we're seeing. The photons have momentum and can bounce around other small things changing the position and momentum. Or…our observing of a thing…changes that thing!

Now…if the sizes are drastically different, there isn't any discernible affect. For example, refer to Fig. 12.26 on page 616 of your text. If I'm observing a yacht from a distance, small waves do not affect my perception of where it is. But when the waves approach the size of the yacht, I can see that its position is changing!

The medicine ball analogy www.howstuffworks.com

Or…consider this analogy. You can't open your eyes, but you want to determine where objects are by throwing a small medicine ball at them.

→ So…throw the medicine ball at a wall that's close and it bounces back. Because it doesn't take too much time to return, you know the ball is close (position).

→ But if you throw the ball at a lab stool, a little farther away, the ball may have enough momentum to move the school and perhaps bounce back to you. Farther away means it takes longer to return. You know the stool was farther away than the wall.

> →Trouble is…you don't know where the stool is now!
>
> →Also..you may have the tools to measure how fast the stool was going just after you hit it but you don't know how fast it was moving before you hit it (momentum)

We are not throwing medicine balls, but photons of energy can change the behavior of equally small things.

<u>Quantum tunneling</u>

So..there is a chance that an electron could pass through a barrier because there is a low, low probability that it could exist there. In your text (12.9) is a demonstration of quantum tunneling of some light photons.

Now..can we teleport like Star Trek? No. This would mean every one of your approx. 10^{23} molecules that make up you would all have to be in the same low probability space. Not going to happen.