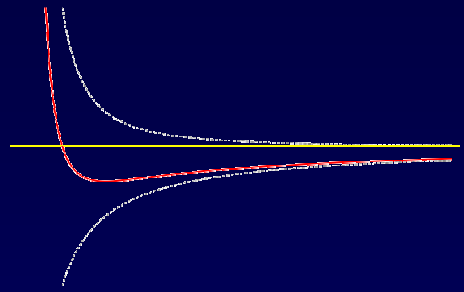
Hydrogen Atom - Qualitative

Why doesn't the electron collapse into the nucleus, where its potential energy is lowest?



We must balance two effects:

- As the electron moves closer to the nucleus, its potential energy decreases (more negative): $U = -\frac{\kappa e^2}{r}$

- However, as it becomes more and more confined, its kinetic energy increases: $p \approx \frac{\hbar}{r} \Rightarrow KE \approx \frac{\hbar^2}{2mr^2}$

Therefore, the total energy is: $E = KE + PE \approx \frac{\hbar^2}{2mr^2} - \frac{\kappa e^2}{r}$

E has a minimum at: $r \approx \frac{\hbar^2}{m\kappa e^2} \equiv a_0 = 0.053 \text{ nm}$ The "Bohr radius" of the H atom.

At this radius, $E \approx -\frac{m\kappa^2 e^4}{2\hbar^2} = -13.6 \text{ eV}$ The ground state energy of the hydrogen atom.

One factor of e or e^2 comes from the proton charge, and one from the electron.

Heisenberg's uncertainty principle prevents the atom's collapse.