PH 105 – Quantum Mechanics

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41)

(a) Δp = [ <p2>]1/2

Δp. Δx ≥ ħ

<p2> = [ħ/ Δx]2

For Δx = 10-14

<p2> = 1.11 x 10-40

E2 = <p2>c2 + m2c4

For an electron

E = 20 MeV  
 **KE = E - mc2 = 19.5 MeV**

For a proton E= 950 MeV and **KE = 10 MeV**

The Binding Energy required to confine the electron within the nucleus would be too high.

(b) Δp. Δx ≥ ħ

<p2> = [ħ/ Δx]2 with Δx = L

E2 = <p2>c2 + m2c4 = ħ2/ L2 c2 + m2 c4

**KE = E - mc2 = [ħ2/ L2 c2 + m2 c4]1/2 - mc2**

(c) The Bohr Model violates the uncertainty principle , since the angular momentum quantization assumes that we simultaneously know the momentum and the position with complete certainty .

L = rp= n ħ

This is in clear violation of the uncertainty principle.

Overlooking this aspect and simply taking into account the Coulombic interaction,

KE = <p2>/2m = ħ2/2mr2   
 E = ħ2/2mr2 - Ze2/4πϵ0r

Differentiate and set the derivative = 0.

- ħ2/mr3 + Ze2 /4πϵ0r2 = 0

Rmin = 4πϵ0 ħ2/m Ze2 = 0.53 Å

This matches the actual value observed. This validates the uncertainty principle but not the Bohr model as explained before.