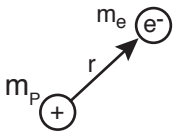
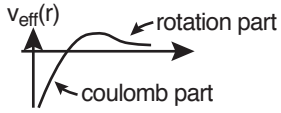
The hydrogen atom: same Hamiltonian as a diatomic molecule, with one "atom" very light

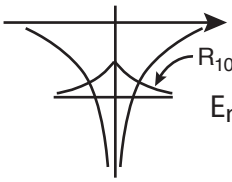


$$m = \frac{m_e m_P}{m_e + m_P} \approx m_e$$

Like the rotating molecule, the effective potential has the original potential (Coulomb in this case) in it, and also the 'centrifugal potential' when angular momentum of the electron increases and\ tugs at the 'bond' to the proton.

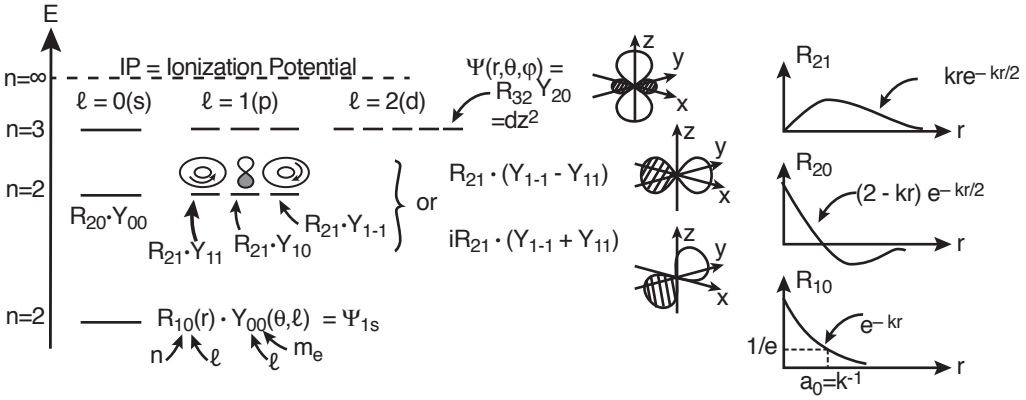


The lowest energy solution looks similar to the harmonic oscillator gaussian and the particle in a box sine wave, but has a 'cusp' at r=0 because the potential goes to -∞ there:



$E_{n\ell M}=E_n=E_{1s}$ could depend on all three quantum numbers, but depends only on n !

The energy $E_{n\ell m}$ depends only on n. This is an accident of symmetry for hydrogen atom, for other atoms the energy depends on n and on ℓ (just like it depended on ℓ for the rotating molecule)



note: $|\psi|^2$ = probability per unit volume is high, but
$P = r^2 dr \sin\theta d\theta d\ell |\psi|^2 \to 0$ as $r \to 0$