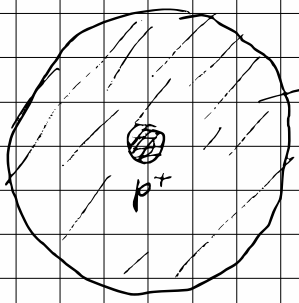
The hydrogen spin-flip transition.



The electron has a spin $\vec{S}_e$ $\left(\frac{1}{2}\hbar\right)$
The proton has a spin $\vec{S}_p$

The corresponding magnetic momenta are

$$\vec{m}_1 = \gamma_p \vec{S}_p \qquad \vec{m}_2 = \gamma_e \vec{S}_e$$

where γ_p, γ_e are the gyromagnetic ratios.

The electron spends some time "inside" the proton and thus we get dipole-dipole interaction. It is this interaction which gives rise to the 21-cm line

Let us first consider electric dipole (which is analogous but not exact) to magnetic dipole.

$$V(r) = \frac{1}{4\pi\varepsilon_0} \frac{\vec{p}\cdot\hat{r}}{r^2}$$

$$E(r) = \frac{1}{4\pi\varepsilon_0} \frac{1}{r^3} \left[3(\vec{p}\cdot\hat{r})\hat{r} - \vec{p} \right]$$