

## Zeeman effect

Hydrogen energy levels  $E$  in a weak magnetic field  $B = |\mathbf{B}|$  are approximately

$$E = -\frac{\alpha^2 \mu c^2}{2n^2} \left[ 1 + \frac{\alpha^2}{n^2} \left( \frac{n}{j + \frac{1}{2}} - \frac{3}{4} \right) \right] + g_J m_j \mu_B B$$

where

$$j = \left| l \pm \frac{1}{2} \right|, \quad l = 0, 1, 2, \dots, n-1$$

and

$$m_j = -j, -j+1, \dots, j-1, j$$

Symbol  $g_J$  is the Landé  $g$ -factor

$$g_J = 1 + \frac{j(j+1) - l(l+1) + \frac{3}{4}}{2j(j+1)}$$

For principal quantum number  $n = 2$  and magnetic field  $B \neq 0$  there are eight energy levels.

$n$	$l$	$j$	$m_j$	$E$
2	1	$\frac{3}{2}$	$\frac{3}{2}$	$E_2(1 + \frac{1}{16}\alpha^2) + 2\mu_B B$
2	1	$\frac{3}{2}$	$-\frac{3}{2}$	$E_2(1 + \frac{1}{16}\alpha^2) - 2\mu_B B$
2	1	$\frac{3}{2}$	$\frac{1}{2}$	$E_2(1 + \frac{1}{16}\alpha^2) + \frac{2}{3}\mu_B B$
2	1	$\frac{3}{2}$	$-\frac{1}{2}$	$E_2(1 + \frac{1}{16}\alpha^2) - \frac{2}{3}\mu_B B$
2	1	$\frac{1}{2}$	$\frac{1}{2}$	$E_2(1 + \frac{5}{16}\alpha^2) + \frac{1}{3}\mu_B B$
2	1	$\frac{1}{2}$	$-\frac{1}{2}$	$E_2(1 + \frac{5}{16}\alpha^2) - \frac{1}{3}\mu_B B$
2	0	$\frac{1}{2}$	$\frac{1}{2}$	$E_2(1 + \frac{5}{16}\alpha^2) + \mu_B B$
2	0	$\frac{1}{2}$	$-\frac{1}{2}$	$E_2(1 + \frac{5}{16}\alpha^2) - \mu_B B$

where

$$E_2 = -\frac{\alpha^2 \mu c^2}{8}$$