Yb Isotope Data

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0.1 definitions

linewidth $\Gamma = \frac{1}{2\pi\tau}$
saturation intensity $I_{sat} = \frac{\hbar\omega^3\Gamma}{12\pi c^2}$
Landé g-factor † $g_J = 1 + \frac{j(j+1)-l(l+1)+s(s+1))}{2j(j+1)}$

1 Yb transitions

1.1 399 nm: $^1S_0 \rightarrow {}^1P_1$

lifetimes
$\tau = 5.7$ ns
$\Gamma = 28$ MHz [1]

approximate absolute frequencies

^{170}Yb	$f = 752\ 048\ 370$ MHz
^{172}Yb	$f = 752\ 048\ 010$ MHz
^{174}Yb	$f = 752\ 047\ 190$ MHz ‡
^{176}Yb	$f = 752\ 046\ 620$ MHz [2]

precision isotope shifts

^{174}Yb $\rightarrow$ ^{168}Yb	Δf = 1887.400(50) MHz
^{174}Yb $\rightarrow$ ^{170}Yb	Δf = 1192.393(66) MHz
^{174}Yb $\rightarrow$ ^{172}Yb	Δf = 533.309(53) MHz
^{174}Yb $\rightarrow$ ^{176}Yb	Δf = -509.310(50) MHz [1]

saturation intensity
$I_{sat} \approx 92$ mW/cm^2

Landé g-factor
$^1P_1$ $\quad g_J = 1$

†Bracket states can be written as superpositions of LS states, ie. $|bracket\rangle = c_i\,|LS\rangle_i$. Their corresonding g-factors are the weighted sum of the LS state g-factors, ie. $g_{bracket} = |c_i|^2 g_{LS_i}$.

‡Our wavemeter consistently reads 751.52640 THz.

2 Yb^+ transitions

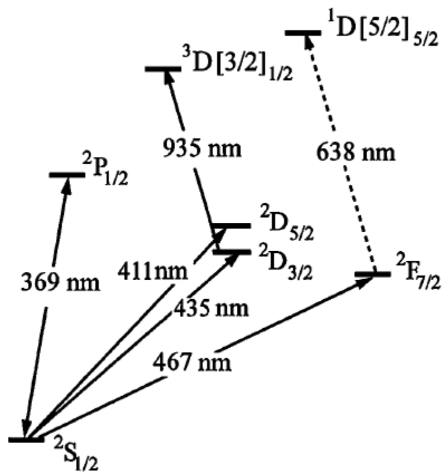

FIG. 1. Partial term scheme of Yb^+.

2.1 369 nm: $^2S_{1/2} \rightarrow {}^2P_{1/2}$

lifetimes
$\tau = 8.12 \pm 0.02$ ns
$\Gamma = 19.6$ MHz [3]

branching ratios
$^2P_{1/2} \rightarrow {}^2S_{1/2} = 99.5\%$
$^2P_{1/2} \rightarrow {}^2D_{3/2} = 0.501(15)\%$
$^2P_{1/2} \rightarrow {}^2F_{7/2} =$ very small [4]

approximate absolute frequencies
$^{170}Yb^+$ f = 811 856 040 MHz
$^{172}Yb^+$ f = 811 854 480 MHz
$^{174}Yb^+$ f = 811 853 190 MHz §
$^{176}Yb^+$ f = 811 851 960 MHz [2]

precision isotope shifts
$^{172}Yb^+ \rightarrow {}^{170}Yb^+$ Δf = 1.623 3(8) GHz
$^{172}Yb^+ \rightarrow {}^{174}Yb^+$ Δf = -1.275 3(7) GHz
$^{172}Yb^+ \rightarrow {}^{176}Yb^+$ Δf = -2.492 8(10) GHz [5]

saturation intensity
$I_{sat} \approx 81$ mW/cm^2

§Our wavemeter consistently reads 811.29120 THz.

Landé g-factor
$^2S_{1/2}$ $g_J = 2$
$^2P_{1/2}$ $g_J = 2/3$

2.2 935 nm: $^2D_{3/2} \rightarrow {}^3D[3/2]_{1/2}$

lifetimes
$\tau = 37.7 \pm 0.5$ ns
$\Gamma = 4.22$ MHz [6]

branching ratios
$^3D[3/2]_{1/2} \rightarrow {}^2S_{1/2} = 98.2\%$
$^3D[3/2]_{1/2} \rightarrow {}^2D_{3/2} = 1.8\%$ [7]

approximate absolute frequencies
$^{170}Yb^+$ $f = 320\ 787\ 850$ MHz
$^{172}Yb^+$ $f = 320\ 791\ 330$ MHz
$^{174}Yb^+$ $f = 320\ 793\ 940$ MHz ¶
$^{176}Yb^+$ $f = 320\ 796\ 420$ MHz [2]

saturation intensity
$I_{sat} \approx 1.1$ mW/cm^2

Landé g-factor
$^2D_{3/2}$ $g_J = 0.8$
$^3D[3/2]_{1/2} = \frac{4}{\sqrt{21}} |^2P_{1/2}\rangle + \frac{1}{3}\sqrt{\frac{6}{7}} |^4P_{1/2}\rangle + \frac{1}{\sqrt{7}} |^4D_{1/2}\rangle$ $g_J = 0.7619$

2.3 638 nm: $^2F_{7/2} \rightarrow {}^1D[5/2]_{5/2}$

lifetimes
$\tau = ?$
$\Gamma = ?$

branching ratios
$^1D[5/2]_{5/2} \rightarrow {}^2F_{7/2} =?\%$
$^1D[5/2]_{5/2} \rightarrow {}^2D_{5/2} =?\%$
$^1D[5/2]_{5/2} \rightarrow {}^2D_{3/2} =?\%$ [8]

precision isotope shifts
$^{172}Yb^+ \rightarrow {}^{168}Yb^+$ $\Delta f = 6.04(2)$ GHz
$^{172}Yb^+ \rightarrow {}^{170}Yb^+$ $\Delta f = 2.93(2)$ GHz
$^{172}Yb^+ \rightarrow {}^{174}Yb^+$ $\Delta f =$ -2.26(2) GHz
$^{172}Yb^+ \rightarrow {}^{176}Yb^+$ $\Delta f =$ -4.41(2) GHz [9]

¶Our wavemeter consistently reads 320.57200 THz.

saturation intensity
?

Landé g-factor
$^2F_{7/2}$ $g_J = 1.1429$
$^1D[5/2]_{5/2} = \sqrt{\frac{6}{7}}\,|^2D_{5/2}\rangle + \frac{1}{\sqrt{7}}\,|^2F_{5/2}\rangle$ $g_J = 1.1374$

2.4 411 nm: $^2S_{1/2} \rightarrow {}^2D_{5/2}$

lifetimes
$\tau = 7.2 \pm 0.3$ ms
$\Gamma = 22$ Hz [8]

branching ratios
$^2D_{5/2} \rightarrow {}^2F_{7/2} = 83 \pm 3\%$
$^2D_{5/2} \rightarrow {}^2S_{1/2} = 17 \pm 4\%$ [8]

precision absolute frequencies
$^{171}Yb^+$ $f = 729\ 487\ 779\ 566(153)$ kHz [10]
$^{172}Yb^+$ $f = 729\ 476\ 869.\ 13(0.42)$ MHz [8]

saturation intensity
$I_{sat} \approx 66$ nW/cm^2

Landé g-factor
$^2S_{1/2}$ $g_J = 2$
$^2D_{5/2}$ $g_J = 1.2$

2.5 435 nm: $^2S_{1/2} \rightarrow {}^2D_{3/2}$

lifetimes
$\tau = 52.7$ ms
$\Gamma = 3.02$ Hz [4]

branching ratios
?

precision absolute frequencies
$^{171}Yb^+$ $f = 688\ 358\ 979\ 309\ 306.\ 62(73)$ Hz [11]
$= 688\ 358\ 979\ 309\ 201 \pm 9$ Hz [12]

saturation intensity
$I_{sat} \approx 7.6$ nW/cm^2

Landé g-factor
$^2S_{1/2}$ $g_J = 2$
$^2D_{3/2}$ $g_J = 0.8$

2.6 467 nm: $^2S_{1/2} \rightarrow {}^2F_{7/2}$

lifetimes
$\tau = 3700$ days
$\Gamma = 5 \times 10^{-10}$ Hz [13]

branching ratios
?

precision absolute frequencies
$^{171}\mathrm{Yb}^+$ $f = 642\ 121\ 496\ 772\ 646.\ 22(67)$ Hz [14]
$= 642\ 121\ 496\ 772\ 645.15(52)$ Hz [15]
$^{172}\mathrm{Yb}^+$ $f = 642\ 116\ 785.\ 3(0.7)$ MHz [13]

saturation intensity
$I_{sat} \approx 10^{-9}$ nW/cm^2

Landé g-factor
$^2S_{1/2}$ $g_J = 2$
$^2F_{7/2}$ $g_J = 1.1429$

3 Final notes

When in the $^2D_{3/2}$ level, collisions with background gas can cause a transition into the $^2F_{7/2}$ level, on the order of once per hour. [13]

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