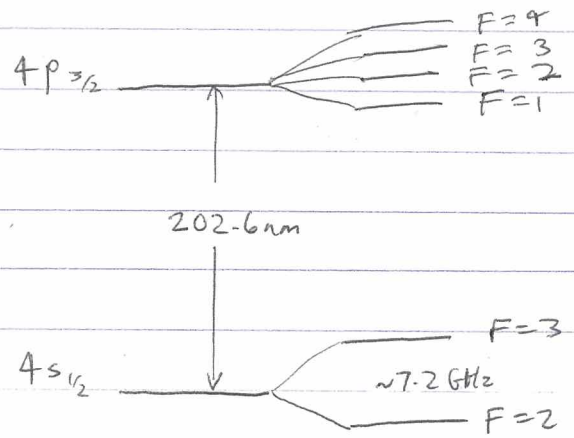
Matsubara ZnII 2026

+4.1 and −3.1 GHz. ?



Splitting of $^{67}Zn^+$ ($I = 5/2$)

with $A = 2.4$ GHz

$\Delta E_3 = \frac{5}{2} \times \frac{2.4}{2} = 3$ GHz

$\Delta E_2 = -4.2$ GHz.

$\Delta \nu_{hfs}^{3} = -3$ GHz

$\Delta \nu_{hfs}^{2} = +4.2$ GHz.

$4s_{1/2}$: $J(J+1) = 3/4$ $I(I+1) = 35/4$

$F=3$: $K = 12 - (3/4 + 35/4) = 12 - \frac{19}{2} = 5/2$

$F=2$: $K = 6 - \frac{19}{2} = -7/2$

$\Delta \nu_{Ca}^{IS} = \nu_P - \nu_a$

$\Delta \nu_{67,64}^{IS} = \nu_{67} - \nu_{64}$

$\Delta \nu(^{67}Zn^+_{F=2} - {}^{64}Zn^+) = \Delta \nu_{67,64}^{IS} + \Delta \nu_{F=2}^{hfs}$

$= 1.1 + 4.2 = +5.3$ GHz

$\Delta \nu(^{67}Zn^+_{F=3} - {}^{64}Zn^+) = 1.1 - 3.0 = -1.9$ GHz.

c.f. Panigrahy PRA 44, 121 (1991)

Dixit et al, JPB 41, 025001 (2008)

Zn II isotope shift.

Angeli	$\langle r^2 \rangle$
64	15.43
66	15.60
68	15.73
70	15.88

$\delta\langle r^2 \rangle$ (relative to 66, 64)		
	Angeli	Campbell
68,66	.76	.82(4)
70,68	.88	.95(3)

$$\delta\nu^{A',A} = (k_{NMS} + k_{SMS})\left(\frac{1}{A} - \frac{1}{A'}\right) + F\,\delta\langle r^2 \rangle^{A',A}$$

$$\delta\nu_{308}^{A',A} = (534.6 + k_{SMS})\,\text{GHz.amu}\left(\frac{1}{A} - \frac{1}{A'}\right) + (-1.51)\,\text{GHz/fm}^2\;\delta\langle r^2 \rangle^{A',A}$$

$$k_{308}^{SMS} = 2.64(9) \times k_{NMS}$$

$$k_{308}^{MS} = 1946(48)\ \text{GHz.amu}$$

$$\therefore \delta\nu_{308}^{67,66} = 1946(48)\left(\frac{1}{66} - \frac{1}{67}\right) - 1.51\,\delta\langle r^2 \rangle^{67,66}$$

$$0.3971(20) = +0.440(11) - 1.51\,\delta\langle r^2 \rangle^{67,66}$$

$$\therefore \delta\langle r^2 \rangle^{67,66} = \frac{-0.043(13)}{-1.51}$$

$$= 0.028(8)\ \text{fm}^2$$

Or using Angeli + Campbell

$$\delta\langle r^2 \rangle^{67,66} = 0.17 \times 0.19^{+0.06}_{-0.09} = 0.032^{+0.010}_{-0.015}$$

Zn II 4s - 4p$_{1/2}$ 2062.7 Å
4s - 4p$_{3/2}$ 2026 Å

2026 (4p$_{3/2}$)

$$\delta\nu^{66,64} = \left[-812 - 1266\,(69)\right]\left[\frac{1}{66} - \frac{1}{64}\right] + -1596\,\delta\langle r^2\rangle^{66,64}$$

$$= 0.984\,(33) - 1.596 \times 0.17\,(2)$$
$$\cdot 271\,(32)$$
$$= 0.713\,(33)(32)$$

exp: 0.676 (6) ~~diff~~ is (37)

$$\delta\nu^{68,64} = -2078\,(69) \times \left(\frac{1}{68} - \frac{1}{64}\right) - 1.596 \times 0.30$$

$$= 1.910\,(63) - 0.479\,(32)$$
$$= 1.431\,(63)(32)$$

exp: 1.346 (10) diff (85)

$$\delta\nu^{70,64} = 2.783\,(92) - 0.718\,(32)$$
$$= 2.065\,(92)(32)$$

exp: 1.914 (20) diff (151)

$$\delta\nu^{70,68} = 0.873\,(29) - 0.239\,(32) = 0.634\,(60)$$

exp: 0.568 (10) diff (66)

ksms from Matsubara

		F. $\delta\langle r^2\rangle$
66,64	-1363	-0.35
68,66	-1365	-0.30
70,68	-1378	-0.35

Angeli $\delta\langle r^2\rangle$

66,64	0.17
68,66	0.13
70,68	0.15

$\delta\nu^{67,64}$ [Julian]: 1.454 (48) - 1.596 × 0.20 (3) = 1.135 (100)

From Campbell:

$$\frac{F\,\delta\langle r^2\rangle^{67,66}}{F\,\delta\langle r^2\rangle^{66,64}} = 0.19$$

∴ Matsubara result

$$\delta\nu^{67,64} = \left[\begin{matrix}-812 \\ -2177\end{matrix} - 1365\,(20)\right]\left(\frac{1}{67} - \frac{1}{64}\right) - 0.35 \times 1.19$$

$$= 1.523\,(10) - 0.4165 = 1.106\,(40)$$

ZnII 2062 $(4s - 4p_{1/2})$

Berengut:

④ $$\delta\nu^{66,64} = \left[-797 - 1310\,(69)\right]\left(\frac{1}{66} - \frac{1}{64}\right) - 1.596 \times 0.17\,(2)$$

$$= -2107\,(69) \times \left(\frac{1}{66} - \frac{1}{64}\right) - 1.596 \times 0.17\,(2)$$

$$= 0.998\,(33) - 0.271\,(32)$$

$$= 0.727\,(33)(32)$$

① If we use Mats. 2026 $k_{MS} = -2177$

② If we use E-scaled 2026 $k_{MS} = -2138$

③ Scale SMS by berengut factor: $k_{MS} = -2209$

④ Berengut: $k_{MS} = -2107$

⑤ $$\delta\nu^{66,64} = 1.045 - 0.35 = 0.695$$

③ $$\delta\nu^{67,64} = 1.545 - 0.35 \times 1.19 = 1.129\,(47)(24)$$

④ $$\delta\nu^{67,64} = 1.474 - 1.596 \times 0.20 = 1.155\,(48)(48)$$

Relative to 64

		SMS	F	Total
66:	②:	1.046	-0.35	0.70
	④:	0.998	-0.271	0.727
68:	③:	2.030	-0.65	1.38
	④	1.937	-0.479	~~1.458~~ (
70:	③:	2.956	-1.00	1.956
	④:	2.822	-0.718	2.104 (92) (100)