Approved by the CIPM in October 2007

RECOMMENDED VALUES OF STANDARD FREQUENCIES FOR APPLICATIONS INCLUDING THE PRACTICAL REALIZATION OF THE METRE AND SECONDARY REPRESENTATIONS OF THE DEFINITION OF THE SECOND

IODINE ($\lambda \approx 532$ nm)

Absorbing molecule $^{127}I_2$, a_{10} component, R(56) 32-0 transition[(1)]

1. CIPM recommended values

The values f = 563 260 223 513 kHz
λ = 532 245 036.104 fm
with a relative standard uncertainty of 8.9×10^{-12} apply to the radiation of a frequency-doubled Nd:YAG laser, stabilized with an iodine cell external to the laser, subject to the conditions:

- cold-finger temperature (–15 ± 1) °C[(2)]
- frequency modulation width, peak-to-peak, (1 ± 0.2) MHz for 3*f* detection cases;
- saturating beam intensity of (17 ± 11) mW cm^{-2}

2. Source data

Adopted value :	f = 563 260 223 513 (5) kHz	$u_c/y = 8.9 \times 10^{-12}$
	for which:	
	λ = 532 245 036.104 (5) fm	$u_c/y = 8.9 \times 10^{-12}$

calculated from

f / kHz	u_c/y	source data
563 260 223 515.0	9.2×10^{-12}	2.1
563 260 223 514.5	8.9×10^{-12}	[1, 2]
563 260 223 510.1	5×10^{-13}	[3]
Unweighted mean:	f = 563 260 223 513.2 kHz	

The standard uncertainty calculated from the dispersion of the three values is 2.7 kHz . Taking into account the frequency dependence on the cell quality and other effects, the CCL preferred to adopt a standard uncertainty of 5 kHz, corresponding to a relative standard uncertainty of 8.9×10^{-12}.

(1) All transitions in I_2 refer to the $B^3\Pi\, 0_u^+ - X^1\Sigma_g^+$ system

(2) For the specification of operating conditions, such as temperature, modulation width and laser power, the symbols ± refer to a tolerance, not an uncertainty.

Since 2001, it was noted that the global mean has changed from …..513.2 to …..511.5 kHz, with a standard deviation of 2.6 kHz. Given the possible shifts due to beam alignment, etalon effects and other technical effects, it was decided not to change the 2001 value or uncertainty but rather to define more comprehensively the operating conditions as follows:

- cold-finger temperature (–15 ± 1) °C [(2)]
- frequency modulation width, peak-to-peak, (1 ± 0.2) MHz for 3*f* detection cases;
- saturating beam intensity of (17 ± 11) mW cm^{-2}

Other $^{127}I_2$ absorbing transitions close to this transition may also be used by making reference to the following frequency differences, using the a_{10} component of the R(56) 32-0 transition as a reference, see also source data 2.2:

line no	transition	comp.	f_{xy} = [$f(y, x) - f(a_{10}$, R(56) 32-0)] / kHz	
	x	*y*	f_{xy}	u_c / kHz
1111	P(53) 32-0	a_1	2 599 708.0	5.0
1110	R(56) 32-0	a_{10}	0.0	—
1109	P(83) 33-0	a_{21}	–15 682 075.2	5.0
	R(134) 36-0	a_1	–17 173 681.7	5.0
1108	R(106) 34-0	a_1	–30 434 763.4	5.0
1107	R(86) 33-0	a_1	–32 190 406.0	5.0
1106	P(119) 35-0	a_1	–36 840 163.0	5.0
1105	P(54) 32-0	a_1	–47 588 897.1	5.0
1104	R(57) 32-0	a_1	–50 946 884.7	5.0
1103	P(132) 36-0	a_1	–73 517 088.1	5.0
1101	R(145) 37-0	a_1	–84 992 177.6	5.0
	R(122) 35-0	a_1	–90 981 724.1	5.0
1100	P(84) 33-0	a_1	–95 929 863.0	5.0
1099	P(104) 34-0	a_1	–98 069 775.0	5.0
	P(55) 32-0	a_1	–98 766 591.0	5.0
1098	R(58) 32-0	a_1	–102 159 978.2	5.0
1097	R(87) 33-0	a_1	–111 935 173.1	5.0

where $f(y,x)$ represents the frequency of the transition denoted *y,x* and $f(a_{10}$, R(56) 32-0) the frequency of the reference transition. The CCL preferred to assign an uncertainty of 5 kHz to all listed frequency differences, regarding the possible influence of the quality of the iodine cell, background slopes and the small number of data for each frequency difference available.

In 2007 the CIPM [24] at its 96th meeting on a proposition of the CCL [25] recommended (Recommendation 1; CI-2007) that the above list shall be extended to the following lines

transition	comp.	$f_{xy} = [\ f(y\ ,\ x) - f(a_{10}$, R(56) 32-0)] / kHz		Ref.
x	y	f_{xy}	u_c / kHz	
P(142) 37-0	a_1	20 123 511.4	5.0	[26]
R(121) 35-0	a_1	27 539 228.6	5.0	[26]
R(85) 33-0	a_1	46 496 559.1	5.0	[27]

Source data

2.1 Holzwarth et al. [4] give

f_{a10} = 563 260 223 508.7 kHz u_c = 5.2 kHz

at a cold-finger temperature of – 5 °C (iodine pressure = 2.46 Pa)(3).

Nevsky et al. [5] give

f_{a10} = 563 260 223 507.8 kHz $u_c/y = 2.0 \times 10^{-12}$

at a cold-finger temperature of – 5 °C (iodine pressure = 2.46 Pa).

These two measurements have been carried out with the same iodine cell. Therefore, the CCL decided to consider the arithmetic mean of these two data, i.e.

f_{a10} = (563 260 223 508.7 + 563 260 223 507.8)/2 = 563 260 223 508.25 kHz

For a reference temperature of –15 °C (iodine pressure = 0.83 Pa), using a pressure dependence of –4.2 kHz/Pa [5], a correction of +6.8 kHz has to be applied, giving

f_{a10} = 563 260 223 515.0 kHz $u_c/y = 9.2 \times 10^{-12}$.

(3) For the iodine cold-finger temperature to iodine pressure conversion the formula derived by Gillespie and Fraser [6] has been used.

2.2 The following values have been obtained for the frequency differences between several $^{127}I_2$ absorbing transitions and the R(56) 32-0 transition, at an iodine cold-finger temperature of –15 °C (iodine pressure = 0.83 Pa):

line no	transition	comp.	[$f(y, x) - f(a_{10}$, R(56) 32-0)] / kHz					
	x	*y*	[7]	[8]	[4]	[5]	unw. mean	*u* / kHz
1111	P(53) 32-0	a_1	2 599 708.0	2 599 708.0			2 599 708.0	0.0
1110	R(56) 32-0	a_{10}	0.0	0.0	0.0		0.0	0.0
1109	P(83) 33-0	a_{21}	–15 682 074.1	–15 682 076.2			–15 682 075.2	1.5
	R(134) 36-0	a_1	–17 173 680.4	–17 173 682.9			–17 173 681.7	1.8
1108	R(106) 34-0	a_1	–30 434 761.5	–30 434 765.2			–30 434 763.4	2.6
1107	R(86) 33-0	a_1	–32 190 404.0	–32 190 408.0			–32 190 406.0	2.8
1106	P(119) 35-0	a_1	–36 840 161.5	–36 840 164.4			–36 840 163.0	2.1
1105	P(54) 32-0	a_1	–47 588 892.5	–47 588 898.2	–47 588 899.8	–47 588 898.0	–47 588 897.1	3.2
1104	R(57) 32-0	a_1	–50 946 880.4	–50 946 886.4	–50 946 887.2		–50 946 884.7	3.7
1103	P(132) 36-0	a_1		–73 517 088.1				
1101	R(145) 37-0	a_1		–84 992 177.6				
	R(122) 35-0	a_1		–90 981 724.1				
1100	P(84) 33-0	a_1		–95 929 863.0				
1099	P(104) 34-0	a_1		–98 069 775.0				
	P(55) 32-0	a_1		–98 766 590.0	–98 766 591.9		–98 766 591.0	1.4
1098	R(58) 32-0	a_1		–102 159 977.4	–102 159 979.0		–102 159 978.2	1.2
1097	R(87) 33-0	a_1		–111 935 173.1				

where $f(y,x)$ represents the frequency of the transition denoted y,x and $f(a_{10}$, R(56) 32-0) the frequency of the reference transition.

3. Absolute frequency of the other transitions related to those adopted as recommended and frequency intervals between transitions and hyperfine components

These tables replace those published in BIPM Com. Cons. Long., 2001, **10**, 151-167 and *Metrologia*, 2003, **40**, 116-120.

The notation for the transitions and the components is that used in the source references. The values adopted for the frequency intervals are the weighted means of the values given in the references.

For the uncertainties, account has been taken of:

- the uncertainties given by the authors;
- the spread in the different determinations of a single component;
- the effect of any perturbing components;
- the difference between the calculated and the measured values.

In the tables, u_c represents the estimated combined standard uncertainty (1 σ).

All transitions in molecular iodine refer to the B-X system.

Table 1

$\lambda \approx 532$ nm $^{127}I_2$ R(87) 33-0 [no 1097]

a_n	$[f(a_n) - f(a_1)]$/MHz	u_c/MHz	a_n	$[f(a_n) - f(a_1)]$/MHz	u_c/MHz
a_1	0	—	a_{12}	582.6721	0.0020
a_2	51.5768	0.0020	a_{13}	622.8375	0.0020
a_3	101.4407	0.0020	a_{14}	663.9140	0.0020
a_4	282.4331	0.0020	a_{15}	730.3226	0.0020
a_5	332.2313	0.0020	a_{16}	752.4797	0.0020
a_6	342.2223	0.0020	a_{17}	778.0522	0.0020
a_7	390.3168	0.0020	a_{18}	799.4548	0.0020
a_8	445.6559	0.0020	a_{19}	893.1211	0.0020
a_9	462.0620	0.0020	a_{20}	907.5209	0.0020
a_{10}	497.5450	0.0020	a_{21}	923.5991	0.0020
a_{11}	511.9546	0.0020			

Frequency referenced to a_{10}, R(56) 32-0, $^{127}I_2$: f = 563 260 223 513 kHz [9]

$f(a_1$, R(87) 33-0) – $f(a_{10}$, R(56) 32-0) = –111 935 173 (5) kHz [9]

Ref. [10]

Table 2

$\lambda \approx 532$ nm $^{127}I_2$ R(58) 32-0 [no 1098]

a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz	a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz
a_1	0	—	a_{10}	571.5686	0.0020
a_2	259.1938	0.0020	a_{11}	697.9347	0.0020
a_5	311.8933	0.0020	a_{12}	702.8370	0.0020
a_6	401.3702	0.0020	a_{13}	726.0151	0.0020
a_7	416.7177	0.0020	a_{14}	732.3220	0.0020
a_8	439.9735	0.0020	a_{15}	857.9730	0.0020
a_9	455.4891	0.0020			

Frequency referenced to a_{10}, R(56) 32-0, $^{127}I_2$: f = 563 260 223 513 kHz [9]

$f(a_1$, R(58) 32-0) – $f(a_{10}$, R(56) 32-0) = –102 159 978 (5) kHz [9]

Ref. [11]

Table 3

$\lambda \approx 532$ nm $^{127}I_2$ P(55) 32-0					
a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz	a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz
a_1	0	—	a_{13}	609.4478	0.0020
a_2	37.8987	0.0020	a_{14}	648.9064	0.0020
a_3	73.8521	0.0020	a_{15}	714.0690	0.0020
a_4	272.2124	0.0020	a_{16}	739.8350	0.0020
a_7	373.1260	0.0020	a_{17}	763.0081	0.0020
a_8	437.4166	0.0020	a_{18}	788.2234	0.0020
a_9	455.3851	0.0020	a_{19}	879.7357	0.0020
a_{10}	477.0210	0.0020	a_{20}	893.4676	0.0020
a_{11}	490.5588	0.0020	a_{21}	910.3088	0.0020
a_{12}	573.0377	0.0020			

Frequency referenced to a_{10}, R(56) 32-0, $^{127}I_2$: f = 563 260 223 513 kHz [9]
$f(a_1$, P(55) 32-0) – $f(a_{10}$, R(56) 32-0) = – 98 766 591 (5) kHz [9]

Ref. [11]

Table 4

$\lambda \approx 532$ nm $^{127}I_2$ P(104) 34-0 [no 1099]					
a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz	a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz
a_1	0	—	a_9	466.6137	0.0020
a_2	238.8227	0.0020	a_{10}	570.8323	0.0020
a_3	277.4934	0.0020	a_{11}	688.5193	0.0020
a_4	293.3463	0.0020	a_{12}	699.1488	0.0020
a_5	331.4333	0.0020	a_{13}	727.8544	0.0020
a_6	389.0585	0.0020	a_{14}	739.2895	0.0020
a_7	405.6376	0.0020	a_{15}	856.7001	0.0020
a_8	450.2193	0.0020			0.0020

Frequency referenced to a_{10}, R(56) 32-0, $^{127}I_2$: f = 563 260 223 513 kHz [9]
$f(a_1$, P(104) 34-0) – $f(a_{10}$, R(56) 32-0) = – 98 069 775 (5) kHz [9]

Ref. [11]

Table 5

$\lambda \approx 532$ nm $^{127}I_2$ P(84) 33-0 [no 1100]					
a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz	a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz
a_1	0	—	a_9	459.8476	0.0020
a_2	249.8445	0.0020	a_{10}	571.2806	0.0020
a_3	281.2957	0.0020	a_{11}	694.0020	0.0020
a_4	290.0304	0.0020	a_{12}	701.7501	0.0020
a_5	320.9041	0.0020	a_{13}	726.3808	0.0020
a_6	396.5400	0.0020	a_{14}	735.0562	0.0020
a_7	411.5392	0.0020	a_{15}	857.4151	0.0020
a_8	444.9362	0.0020			

Frequency referenced to a_{10}, R(56) 32-0, $^{127}I_2$: f = 563 260 223 513 kHz [9]
$f(a_1$, P(84) 33-0) – $f(a_{10}$, R(56) 32-0) = – 95 929 863 (5) kHz [9]

Ref. [12]

Table 6

$\lambda \approx 532$ nm $^{127}I_2$ R(122) 35-0					
a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz	a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz
a_1	0	—	a_9	475.9553	0.0020
a_2	224.7302	0.0020	a_{10}	570.3004	0.0020
a_3	273.2394	0.0020	a_{11}	681.2572	0.0020
a_4	297.0396	0.0020	a_{12}	695.4307	0.0020
a_5	344.9343	0.0020	a_{13}	730.2395	0.0020
a_6	378.8637	0.0020	a_{14}	745.1865	0.0020
a_7	398.2113	0.0020	a_{15}	855.9386	0.0020
a_8	456.8479	0.0020			

Frequency referenced to a_{10}, R(56) 32-0, $^{127}I_2$: f = 563 260 223 513 kHz [9]
$f(a_1$, R(122) 35-0) – $f(a_{10}$, R(56) 32-0) = – 90 981 724 (5) kHz [9]

Ref. [12]

Table 7

$\lambda \approx 532$ nm $^{127}I_2$ R(145) 37-0 [no 1101]					
a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz	a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz
a_1	0	—	a_{12}	608.2166	0.0020
a_2	111.3681	0.0020	a_{13}	680.6255	0.0020
a_3	220.5695	0.0020	a_{14}	752.7967	0.0020
a_4	298.7582	0.0020	a_{15}	769.5347	0.0020
a_5	376.9445	0.0020	a_{16}	799.1414	0.0020
a_6	414.9517	0.0020	a_{17}	846.4138	0.0020
a_7	469.8127	0.0020	a_{18}	874.8758	0.0020
a_8	491.2288	0.0020	a_{19}	940.0615	0.0020
a_9	495.5179	0.0020	a_{20}	964.5342	0.0020
a_{10}	580.7013	0.0020	a_{21}	990.2893	0.0020
a_{11}	605.3833	0.0020			

Frequency referenced to a_{10}, R(56) 32-0, $^{127}I_2$: f = 563 260 223 513 kHz [9]
$f(a_1$, R(145) 37-0$) - f(a_{10}$, R(56) 32-0$) = -$84 992 178 (5) kHz [9]

Ref. [10]

Table 8

$\lambda \approx 532$ nm $^{127}I_2$ P(132) 36-0 [no 1103]					
a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz	a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz
a_1	0	—	a_9	482.3956	0.0020
a_2	215.0115	0.0020	a_{10}	569.8339	0.0020
a_3	270.3841	0.0020	a_{11}	676.1016	0.0020
a_4	299.4166	0.0020	a_{12}	692.6715	0.0020
a_5	354.1318	0.0020	a_{13}	731.8283	0.0020
a_6	371.6729	0.0020	a_{14}	749.1808	0.0020
a_7	393.0781	0.0020	a_{15}	855.2633	0.0020
a_8	461.2856	0.0020			

Frequency referenced to a_{10}, R(56) 32-0, $^{127}I_2$: f = 563 260 223 513 kHz [9]
$f(a_1$, P(132) 36-0$) - f(a_{10}$, R(56) 32-0$) = -$73 517 088 (5) kHz [9]

Ref. [10]

Table 9

$\lambda \approx 532$ nm $^{127}I_2$ R(57) 32-0 [no 1104]					
a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz	a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz
a_1	0	—	a_{13}	610.925	0.001
a_2	39.372	0.001	a_{14}	650.805	0.001
a_3	76.828	0.001	a_{15}	715.550	0.001
a_4	273.042	0.001	a_{16}	741.175	0.001
a_7	375.284	0.001	a_{17}	764.716	0.001
a_8	438.243	0.001	a_{18}	789.777	0.001
a_9	456.183	0.001	a_{19}	881.116	0.001
a_{10}	479.201	0.001	a_{20}	895.016	0.001
a_{11}	492.915	0.001	a_{21}	911.901	0.001
a_{12}	573.917	0.001			

Frequency referenced to a_{10}, R(56) 32-0, $^{127}I_2$: f = 563 260 223 513 kHz [9]
$f(a_1$, R(57) 32-0$) - f(a_{10}$, R(56) 32-0$) = -50\,946\,885\,(5)$ kHz [9]

Ref. [7, 13]

Table 10

$\lambda \approx 532$ nm $^{127}I_2$ P(54) 32-0 [no 1105]					
a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz	a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz
a_1	0	—	a_9	454.563	0.001
a_2	260.992	0.001	a_{10}	571.536	0.001
a_3	285.008	0.001	a_{11}	698.614	0.001
a_4	286.726	0.001	a_{12}	702.935	0.001
a_5	310.066	0.001	a_{13}	725.834	0.001
a_6	402.249	0.001	a_{14}	731.688	0.001
a_8	417.668	0.001	a_{15}	857.961	0.001
a_8	438.919	0.001			

Frequency referenced to a_{10}, R(56) 32-0, $^{127}I_2$: f = 563 260 223 513 kHz [9]
$f(a_1$, P(54) 32-0$) - f(a_{10}$, R(56) 32-0$) = -47\,588\,897\,(5)$ kHz [9]

Ref. [7, 13]

Table 11

$\lambda \approx 532$ nm $^{127}I_2$ P(119) 35-0 [no 1106]

a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz	a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz
a_1	0	—	a_{13}	645.617	0.002
a_2	75.277	0.002	a_{14}	697.723	0.002
a_3	148.701	0.002	a_{15}	747.389	0.003
a_4	290.376	0.003	a_{16}	771.197	0.003
a_5	349.310	0.002	a_{17}	804.769	0.003
a_6	371.567	0.002	a_{18}	827.641	0.003
a_9	474.953	0.004	a_{19}	912.125	0.002
a_{10}	530.727	0.002	a_{20}	930.053	0.002
a_{11}	548.787	0.002	a_{21}	949.288	0.003

Frequency referenced to a_{10}, R(56) 32-0, $^{127}I_2$: f = 563 260 223 513 kHz [9]
$f(a_1$, P(119) 35-0$) - f(a_{10}$, R(56) 32-0$)$ = –36 840 163 (5) kHz [9]

Ref. [14, 15]

Table 12

$\lambda \approx 532$ nm $^{127}I_2$ R(86) 33-0 [no 1107]

a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz	a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz
a_1	0	—	a_9	460.973	0.002
a_2	248.206	0.002	a_{10}	571.262	0.002
a_3	280.802	0.002	a_{11}	693.205	0.002
a_4	290.502	0.002	a_{12}	701.377	0.002
a_5	322.524	0.002	a_{13}	726.710	0.002
a_6	395.386	0.002	a_{14}	735.795	0.002
a_7	410.696	0.002	a_{15}	857.383	0.002
a_8	445.759	0.002			

Frequency referenced to a_{10}, R(56) 32-0, $^{127}I_2$: f = 563 260 223 513 kHz [9]
$f(a_1$, R(86) 33-0$) - f(a_{10}$, R(56) 32-0$)$ = –32 190 406 (5) kHz [9]

Ref. [15, 16]

Table 13

$\lambda \approx 532$ nm $^{127}I_2$ R(106) 34-0 [no 1108]

a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz	a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz
a_1	0	—	a_9	467.984	0.002
a_2	236.870	0.002	a_{10}	570.799	0.002
a_3	276.941	0.002	a_{11}	687.539	0.002
a_4	293.861	0.002	a_{12}	698.663	0.002
a_5	333.350	0.002	a_{13}	728.261	0.002
a_6	387.636	0.002	a_{14}	740.185	0.002
a_7	404.635	0.002	a_{15}	856.675	0.002
a_8	451.175	0.002			

Frequency referenced to a_{10}, R(56) 32-0, $^{127}I_2$: f = 563 260 223 513 kHz [9]
$f(a_1$, R(106) 34-0) – $f(a_{10}$, R(56) 32-0) = –30 434 763 (5) kHz [9]

Ref. [15-17]

Table 14

$\lambda \approx 532$ nm $^{127}I_2$ R(134) 36-0

a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz	a_n	$[f(a_n) - f(a_1)]$ / MHz	u_c / MHz
a_1	0	—	a_8	462.603	0.009
a_2	212.287	0.007	a_9	484.342	0.007
a_3	269.634	0.022	a_{11}	674.703	0.009
a_4	300.097	0.011	a_{12}	691.951	0.008
a_5	356.801	0.008	a_{13}	732.405	0.008
a_6	369.644	0.008	a_{14}	750.434	0.009
a_7	391.684	0.009			

Frequency referenced to a_{10}, R(56) 32-0, $^{127}I_2$: f = 563 260 223 513 kHz [9]
$f(a_1$, R(134) 36-0) – $f(a_{10}$, R(56) 32-0) = –17 173 682 (5) kHz [9]

Ref. [15, 16]

Table 15

$\lambda \approx 532$ nm $^{127}I_2$ P(83) 33-0 [no 1109]					
a_n	[$f(a_n) - f(a_1)$] / MHz	u_c / MHz	a_n	[$f(a_n) - f(a_1)$] / MHz	u_c / MHz
a_1	0	—	a_{11}	507.533	0.004
a_2	48.789	0.004	a_{13}	620.065	0.004
a_3	95.839	0.008	a_{14}	659.930	0.004
a_4	281.343	0.010	a_{15}	728.070	0.004
a_5	330.230	0.004	a_{16}	750.131	0.004
a_6	338.673	0.004	a_{17}	774.805	0.004
a_7	385.830	0.004	a_{18}	796.125	0.004
a_8	444.365	0.006	a_{19}	890.709	0.005
a_9	460.503	0.004	a_{20}	904.712	0.005
a_{10}	493.533	0.006	a_{21}	920.475	0.004

Frequency referenced to a_{10}, R(56) 32-0, $^{127}I_2$: f = 563 260 223 513 kHz [9]
$f(a_{21}$, P(83) 33-0) – $f(a_{10}$, R(56) 32-0) = –15 682 075 (5) kHz [9]

Ref. [15, 16]

Table 16

$\lambda \approx 532$ nm $^{127}I_2$ R(56) 32-0 [no 1110]					
a_n	[$f(a_n) - f(a_1)$] / MHz	u_c / MHz	a_n	[$f(a_n) - f(a_1)$] / MHz	u_c / MHz
a_1	–571.542	0.0015	a_{10}	0	—
a_2	–311.844	0.0015	a_{11}	126.513	0.0015
a_5	–260.176	0.0015	a_{12}	131.212	0.0015
a_6	–170.064	0.0015	a_{13}	154.488	0.0015
a_7	–154.548	0.0015	a_{14}	160.665	0.0015
a_8	–131.916	0.0015	a_{15}	286.412	0.0015
a_9	–116.199	0.0015			

Frequency referenced to a_{10}, R(56) 32-0, $^{127}I_2$: f = 563 260 223 513 kHz [9]

Ref. [15, 16, 18–23]

Table 17

$\lambda \approx 532$ nm $^{127}I_2$ P(53) 32-0 [no 1111]					
a_n	[$f(a_n) - f(a_1)$] / MHz	u_c / MHz	a_n	[$f(a_n) - f(a_1)$] / MHz	u_c / MHz
a_1	0	—	a_{17}	762.623	0.006
a_2	37.530	0.006	a_{18}	788.431	0.008
a_3	73.060	0.007	a_{19}	879.110	0.006
a_4	271.326	0.016	a_{20}	892.953	0.009
a_{15}	712.935	0.012	a_{21}	910.093	0.006
a_{16}	739.274	0.008			

Frequency referenced to a_{10}, R(56) 32-0, $^{127}I_2$: f = 563 260 223 513 kHz [9]
$f(a_1$, P(53) 32-0) – $f(a_{10}$, R(56) 32-0) = 2 599 708 (5) kHz [9]

Ref. [15, 16]

Table 18

$\lambda \approx 532$ nm $^{127}I_2$ P(142) 37-0 [no 1112]

a_n	[$f(a_n) - f(a_1)$] / kHz	u_c / kHz	a_n	[$f(a_n) - f(a_1)$] / kHz	u_c / kHz
a_1	0	---	a_8	467 369.1	2
a_2	201 862.3	2	a_9	491 394.9	2
a_3	266 700.6	2	a_{10}	569 318.6	2
a_4	302 571.3	2	a_{11}	669 162.1	2
a_5	361 836.0	2	a_{12}	688 963.6	2
a_6	366 696.9	2	a_{13}	734 239.7	2
a_7	386 204.6	2	a_{14}	754 848.4	2
			a_{15}	854 522.3	2

Frequency referenced to a_{10}, R(56) 32-0, $^{127}I_2$: f = 563 260 223 513 kHz [9]
$f(a_{21}$, P(142) 37-0) – $f(a_{10}$, R(56) 32-0) = 20 123 511.4 (5.0) kHz [25, 26]

Ref. [25, 26]

Table 19

$\lambda \approx 532$ nm $^{127}I_2$ P(121) 35-0 [no 1113]

a_n	[$f(a_n) - f(a_1)$] / kHz	u_c / kHz	a_n	[$f(a_n) - f(a_1)$] / kHz	u_c / kHz
a_1	0	—	a_{11}	553 248.7	2
a_2	78 094.0	2	a_{12}	594 812.8	2
a_3	154 328.5	2	a_{13}	594 812.8	2
a_4	291 034.5	2	a_{14}	702 090.3	2
a_5	351 499.2	2	a_{15}	749 153.7	2
a_6	374 970.5	2	a_{16}	773 429.2	2
a_7	433 704.3	2	a_{17}	808 079.0	2
a_8	456 783.2	2	a_{18}	831 410.9	2
a_9	476 593.6	2	a_{19}	914 362.6	2
a_{10}	534 662.3	2	a_{20}	932 813.8	2
			a_{21}	952 564.0	2

Frequency referenced to a_{10}, R(56) 32-0, $^{127}I_2$: f = 563 260 223 513 kHz [9]
$f(a_{21}$, P(121) 35-0) – $f(a_{10}$, R(56) 32-0) = 27 539 228.6 (5.0) kHz [25, 26]

Ref. [25, 26]

Table 20

$\lambda \approx 532$ nm $^{127}I_2$ R(85) 33-0					
a_n	$[f(a_n) - f(a_1)]$ / kHz	u_c / kHz	a_n	$[f(a_n) - f(a_1)]$ / kHz	u_c / kHz
a_1	0	—	a_{11}	510 619.4	2
a_2	50 732.5	2	a_{12}	582 132.0	2
a_3	99 742.3	2	a_{13}	621 988.5	2
a_4	281 946.2	2	a_{14}	662 825.5	2
a_5	331 678.7	2	a_{15}	729 463.3	2
a_6	341 087.6	2	a_{16}	751 718.8	2
a_7	389 099.9	2	a_{17}	777 078.3	2
a_8	445 205.3	2	a_{18}	798 584.8	2
a_9	461 608.4	2	a_{19}	892 318.3	2
a_{10}	496 293.9	2	a_{20}	906 642.5	2
			a_{21}	922 692.5	2

Frequency referenced to a_{10}, R(56) 32-0, $^{127}I_2$: f = 563 260 223 513 kHz [9]

$f(a_1$, R(85) 33-0$) - f(a_{10}$, R(56) 32-0$)$ = 46 496 559.1 (5.0) kHz [25, 27]

Ref. [25, 27]

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