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类碳离子(Z = 10, 14, 32, 36, 50) $1s^2 2s^2 2p^2$ 和 $1s^2 2s 2p^3$ 组态的能级和电偶极跃迁

胡木宏† 何纪铮

（辽宁师范大学物理与电子技术学院，大连 116029）

†通信作者.E-mail:humuhong@163.com

表 S1—表 S5 为类碳离子（Z = 10, 14, 32, 38, 50）$1s^2 2s^2 2p^2$, $1s^2 2s^2 p^3$ 组态的 15 个原子态在 AS2—AS7 活性空间的能级。随着活性空间的扩大，原子态能级收敛迅速、稳定，活性空间扩展至 AS7 时，已经较为全面地包含电子关联效应。

表 S1 Ne V 离子（Z = 10, 14, 32, 36, 50）$1s^2 2s^2 2p^2$ 和 $1s^2 2s 2p^3$ 组态在 AS2—AS7 活性空间的原子态能级

Table S1. Energies of atomic states for $1s^2 2s^2 2p^2$ and $1s^2 2s 2p^3$ configurations in Ne V ion (Z = 10, 14, 32, 36, 50) within AS2—AS7 active spaces.

Lv. No.	States	E_{AS2}/a.u.	E_{AS3}/a.u.	E_{AS4}/a.u.	E_{AS5}/a.u.	E_{AS6}/a.u.	E_{AS7}/a.u.
1	$1s^2 2s^2 2p^2\ ^3P_0$	-120.79410	-120.82751	-120.83972	-120.84535	-120.84811	-120.84951
2	$1s^2 2s^2 2p^2\ ^3P_1$	-120.79224	-120.82564	-120.83784	-120.84347	-120.84623	-120.84763
3	$1s^2 2s^2 2p^2\ ^3P_2$	-120.78908	-120.82246	-120.83465	-120.84028	-120.84304	-120.84444
4	$1s^2 2s^2 2p^2\ ^1D_2$	-120.64690	-120.68647	-120.70016	-120.70634	-120.70949	-120.71101
5	$1s^2 2s^2 2p^2\ ^1S_0$	-120.48406	-120.52863	-120.54349	-120.55022	-120.55385	-120.55545
6	$1s^2 2s 2p^3\ ^5S_2$	-120.40336	-120.43148	-120.44190	-120.44575	-120.44802	-120.44863
7	$1s^2 2s 2p^3\ ^3D_3$	-119.98436	-120.02513	-120.03869	-120.04426	-120.04727	-120.04851
8	$1s^2 2s 2p^3\ ^3D_2$	-119.98402	-120.02480	-120.03837	-120.04394	-120.04695	-120.04819
9	$1s^2 2s 2p^3\ ^3D_1$	-119.98391	-120.02469	-120.03826	-120.04383	-120.04684	-120.04808
10	$1s^2 2s 2p^3\ ^3P_2$	-119.82820	-119.87432	-119.88934	-119.89610	-119.89966	-119.90109
11	$1s^2 2s 2p^3\ ^3P_1$	-119.82817	-119.87430	-119.88932	-119.89607	-119.89963	-119.90107
12	$1s^2 2s 2p^3\ ^3P_0$	-119.82801	-119.87414	-119.88916	-119.89592	-119.89948	-119.90092

13	$1s^2 2s2p^3\ ^1D_2$	-119.53581	-119.58668	-119.60269	-119.60989	-119.61344	-119.61526
14	$1s^2 2s2p^3\ ^3S_1$	-119.50144	-119.54851	-119.56397	-119.57073	-119.57426	-119.57567
15	$1s^2 2s2p^3\ ^1P_1$	-119.37379	-119.43100	-119.44855	-119.45719	-119.46129	-119.46322

表 S2 Si IX 离子（Z = 10, 14, 32, 36, 50）$1s^2 2s^2 2p^2$ 和 $1s^2 2s2p^3$ 组态在 AS2—AS7 活性空间的原子态能级

Table S2. Energies of atomic states for $1s^2 2s^2 2p^2$ and $1s^2 2s2p^3$ configurations in Si IX ion (Z = 10, 14, 32, 36, 50) within AS2—AS7 active spaces.

Lv. No.	States	E_{AS2}/a.u.	E_{AS3}/a.u.	E_{AS4}/a.u.	E_{AS5}/a.u.	E_{AS6}/a.u.	E_{AS7}/a.u.
1	$1s^2 2s^2 2p^2\ ^3P_0$	-252.15395	-252.18931	-252.20215	-252.20788	-252.21083	-252.21243
2	$1s^2 2s^2 2p^2\ ^3P_1$	-252.14278	-252.17808	-252.19089	-252.19662	-252.19957	-252.20117
3	$1s^2 2s^2 2p^2\ ^3P_2$	-252.12503	-252.16031	-252.17311	-252.17883	-252.18178	-252.18338
4	$1s^2 2s^2 2p^2\ ^1D_2$	-251.90392	-251.94520	-251.95960	-251.96589	-251.96924	-251.97100
5	$1s^2 2s^2 2p^2\ ^1S_0$	-251.64493	-251.69062	-251.70618	-251.71310	-251.71691	-251.71873
6	$1s^2 2s2p^3\ ^5S_2$	-251.48251	-251.51136	-251.52262	-251.52635	-251.52888	-251.52969
7	$1s^2 2s2p^3\ ^3D_3$	-250.81441	-250.85677	-250.87149	-250.87712	-250.88042	-250.88184
8	$1s^2 2s2p^3\ ^3D_2$	-250.81405	-250.85646	-250.87119	-250.87683	-250.88014	-250.88155
9	$1s^2 2s2p^3\ ^3D_1$	-250.81338	-250.85581	-250.87053	-250.87617	-250.87949	-250.88090
10	$1s^2 2s2p^3\ ^3P_2$	-250.57107	-250.61784	-250.63380	-250.64064	-250.64417	-250.64576
11	$1s^2 2s2p^3\ ^3P_1$	-250.57078	-250.61757	-250.63353	-250.64037	-250.64391	-250.64550
12	$1s^2 2s2p^3\ ^3P_0$	-250.57064	-250.61738	-250.63334	-250.64017	-250.64370	-250.64529
13	$1s^2 2s2p^3\ ^1D_2$	-250.12207	-250.17503	-250.19228	-250.19964	-250.20349	-250.20541
14	$1s^2 2s2p^3\ ^3S_1$	-250.09823	-250.14722	-250.16358	-250.17072	-250.17431	-250.17598
15	$1s^2 2s2p^3\ ^1P_1$	-249.87552	-249.93338	-249.95187	-249.96048	-249.96455	-249.96656

表 S3 Ge XXVII 离子（Z = 10, 14, 32, 36, 50）$1s^22s^22p^2$ 和 $1s^22s2p^3$ 组态在 AS2—AS7 活性空间的原子态能级

Table S3. Energies of atomic states for $1s^22s^22p^2$ and $1s^22s2p^3$ configurations in Ge XXVII ion (Z = 10, 14, 32, 36, 50) within AS2—AS7 active spaces.

Lv. No.	States	E_{AS2}/a.u.	E_{AS3}/a.u.	E_{AS4}/a.u.	E_{AS5}/a.u.	E_{AS6}/a.u.	E_{AS7}/a.u.
1	$1s^22s^22p^2\,^3P_0$	-1454.10079	-1454.14307	-1454.16034	-1454.16743	-1454.17263	-1454.17467
2	$1s^22s^22p^2\,^3P_1$	-1453.10195	-1453.14197	-1453.15849	-1453.16527	-1453.17032	-1453.17228
3	$1s^22s^22p^2\,^3P_2$	-1452.78799	-1452.83052	-1452.84779	-1452.85486	-1452.86009	-1452.86214
4	$1s^22s^22p^2\,^1D_2$	-1451.53539	-1451.57840	-1451.59571	-1451.60281	-1451.60804	-1451.61011
5	$1s^22s^22p^2\,^1S_0$	-1450.76903	-1450.81702	-1450.83602	-1450.84417	-1450.84969	-1450.85198
6	$1s^22s2p^3\,^5S_2$	-1450.28531	-1450.31956	-1450.33517	-1450.34021	-1450.34444	-1450.34582
7	$1s^22s2p^3\,^3D_1$	-1448.73688	-1448.78565	-1448.80540	-1448.81262	-1448.81780	-1448.81986
8	$1s^22s2p^3\,^3D_2$	-1448.57279	-1448.61893	-1448.63791	-1448.64468	-1448.64969	-1448.65163
9	$1s^22s2p^3\,^3D_3$	-1448.19745	-1448.24367	-1448.26262	-1448.26932	-1448.27433	-1448.27629
10	$1s^22s2p^3\,^3P_0$	-1447.52469	-1447.57456	-1447.59476	-1447.60251	-1447.60777	-1447.60988
11	$1s^22s2p^3\,^3P_1$	-1447.39793	-1447.44735	-1447.46733	-1447.47490	-1447.48012	-1447.48222
12	$1s^22s2p^3\,^3P_2$	-1447.18261	-1447.23273	-1447.25287	-1447.26044	-1447.26570	-1447.26784
13	$1s^22s2p^3\,^3S_1$	-1446.63584	-1446.69039	-1446.71173	-1446.72030	-1446.72580	-1446.72816
14	$1s^22s2p^3\,^1D_2$	-1446.02983	-1446.08429	-1446.10553	-1446.11376	-1446.11928	-1446.12166
15	$1s^22s2p^3\,^1P_1$	-1445.07774	-1445.13513	-1445.15726	-1445.16628	-1445.17197	-1445.17447

表 S4 Kr XXXI 离子（Z = 10, 14, 32, 36, 50）$1s^22s^22p^2$ 和 $1s^22s2p^3$ 组态在 AS2—AS7 活性空间的原子态能级

Table S4. Energies of atomic states for $1s^22s^22p^2$ and $1s^22s2p^3$ configurations in Kr XXXI ion (Z = 10, 14, 32, 36, 50) within AS2—AS7 active spaces.

Lv. No.	States	E_{AS2}/a.u.	E_{AS3}/a.u.	E_{AS4}/a.u.	E_{AS5}/a.u.	E_{AS6}/a.u.	E_{AS7}/a.u.
1	$1s^22s^22p^2\,^3P_0$	-1861.56151	-1861.60560	-1861.62435	-1861.63204	-1861.63807	-1861.64038
2	$1s^22s^22p^2\,^3P_1$	-1859.75712	-1859.79831	-1859.81605	-1859.82334	-1859.82916	-1859.83136
3	$1s^22s^22p^2\,^1D_2$	-1859.37952	-1859.42371	-1859.44237	-1859.45002	-1859.45605	-1859.45838
4	$1s^22s^22p^2\,^3P_2$	-1857.30056	-1857.34410	-1857.36240	-1857.36994	-1857.37588	-1857.37817

5	$1s^2 2s^2 2p^2\ ^1S_0$	-1856.41418	-1856.46294	-1856.48307	-1856.49168	-1856.49795	-1856.50049
6	$1s^2 2s2p^3\ ^5S_2$	-1856.21811	-1856.25577	-1856.27332	-1856.27915	-1856.28423	-1856.28593
7	$1s^2 2s2p^3\ ^3D_1$	-1854.57783	-1854.62889	-1854.65031	-1854.65819	-1854.66416	-1854.66649
8	$1s^2 2s2p^3\ ^3D_2$	-1854.02497	-1854.07072	-1854.09051	-1854.09748	-1854.10309	-1854.10518
9	$1s^2 2s2p^3\ ^3D_3$	-1853.42728	-1853.47463	-1853.49484	-1853.50197	-1853.50769	-1853.50987
10	$1s^2 2s2p^3\ ^3P_0$	-1852.64544	-1852.69654	-1852.71806	-1852.72627	-1852.73225	-1852.73458
11	$1s^2 2s2p^3\ ^3P_1$	-1852.43863	-1852.48938	-1852.51066	-1852.51867	-1852.52461	-1852.52694
12	$1s^2 2s2p^3\ ^1D_2^a$ ($1s^2 2s2p^3\ ^3P_2$)	-1852.14350	-1852.19611	-1852.21786	-1852.22601	-1852.23208	-1852.23450
13	$1s^2 2s2p^3\ ^3S_1$	-1851.74091	-1851.79651	-1851.81920	-1851.82819	-1851.83442	-1851.83700
14	$1s^2 2s2p^3\ ^1D_2^b$ ($1s^2 2s2p^3\ ^1D_2$)	-1850.47133	-1850.52479	-1850.54678	-1850.55518	-1850.56129	-1850.56378
15	$1s^2 2s2p^3\ ^1P_1$	-1849.27920	-1849.33674	-1849.35991	-1849.36921	-1849.37556	-1849.37824

表 S5 Sn XLV 离子（Z = 10, 14, 32, 36, 50）$1s^2 2s^2 2p^2$ 和 $1s^2 2s2p^3$ 组态在 AS2—AS7 活性空间的原子态能级

Table S5. Energies of atomic states for $1s^2 2s^2 2p^2$ and $1s^2 2s2p^3$ configurations in Sn XLV ion (Z = 10, 14, 32, 36, 50) within AS2—AS7 active spaces.

Lv. No.	States	E_{AS2}/a.u.	E_{AS3}/a.u.	E_{AS4}/a.u.	E_{AS5}/a.u.	E_{AS6}/a.u.	E_{AS7}/a.u.
1	$1s^2 2s^2 2p^2\ ^3P_0$	-3718.67573	-3718.72761	-3718.75354	-3718.76491	-3718.77451	-3718.77886
2	$1s^2 2s^2 2p^2\ ^3P_1$	-3710.09251	-3710.13935	-3710.16324	-3710.17387	-3710.18302	-3710.18713
3	$1s^2 2s^2 2p^2\ ^1D_2$	-3709.54675	-3709.59733	-3709.62247	-3709.63358	-3709.64302	-3709.64729
4	$1s^2 2s2p^3\ ^3P_2^a$ ($1s^2 2s2p^3\ ^5S_2$)	-3704.00426	-3704.05462	-3704.08080	-3704.09038	-3704.09880	-3704.10330
5	$1s^2 2s2p^3\ ^3D_1$	-3701.92161	-3701.98187	-3702.01100	-3702.02220	-3702.03131	-3702.03627
6	$1s^2 2s^2 2p^2\ ^3P_2$	-3700.55275	-3700.60034	-3700.62417	-3700.63477	-3700.64383	-3700.64792
7	$1s^2 2s^2 2p^2\ ^1S_0$	-3699.20097	-3699.25462	-3699.28068	-3699.29246	-3699.30198	-3699.30638
8	$1s^2 2s2p^3\ ^3D_2$	-3695.86768	-3695.91436	-3695.93885	-3695.94773	-3695.95582	-3695.95981
9	$1s^2 2s2p^3\ ^3D_3$	-3694.68488	-3694.73762	-3694.76403	-3694.77380	-3694.78232	-3694.78666
10	$1s^2 2s2p^3\ ^3P_0$	-3693.45937	-3693.51678	-3693.54478	-3693.55576	-3693.56463	-3693.56911

11	$1s^2 2s2p^3\ ^3S_1$	-3692.98094	-3693.03801	-3693.06571	-3693.07645	-3693.08525	-3693.08974
12	$1s^2 2s2p^3\ ^1D_2$	-3692.60294	-3692.66348	-3692.69221	-3692.70334	-3692.71240	-3692.71708
13	$1s^2 2s2p^3\ ^3P_1$	-3692.45644	-3692.51749	-3692.54662	-3692.55827	-3692.56736	-3692.57210
14	$1s^2 2s2p^3\ ^3P_2^b$ ($1s^2 2s2p^3\ ^3P_2$)	-3684.80095	-3684.85516	-3684.88199	-3684.89234	-3684.90090	-3684.90516
15	$1s^2 2s2p^3\ ^1P_1$	-3682.88893	-3682.94955	-3682.97832	-3682.98984	-3682.99885	-3683.00340

表 S6—表 S10 为本文计算的类碳离子（Z = 10, 14, 32, 36, 50）$1s^2 2s^2 2p^2$ 和 $1s^2 2s2p^3$ 组态中原子态的混合成分及寿命 τ。 本文计算的 Ne V 和 Kr XXXI 离子的寿命与其他理论结果[S1,S2]非常接近，其中 Ne V 离子的寿命与有限的实验数据[S3]符合得也比较好，二者相差范围为 0.0151—0.22 ns。

表 S6 Ne V 离子（Z = 10, 14, 32, 36, 50）$1s^2 2s^2 2p^2$ 和 $1s^2 2s2p^3$ 组态的混合系数和寿命

Table S6. Mixing coefficients and lifetimes of $1s^2 2s^2 2p^2$ and $1s^2 2s2p^3$ configurations in Ne V ion with Z = 10, 14, 32, 36, 50.

Lv. No.	State	LS-composition	τ_l/ns	τ_v/ns	$\tau^{[S1]}$/ns	$\tau^{[S2]}$/ns	$\tau^{[S3]}$/ns
1	$1s^2 2s^2 2p^2\ ^3P_0$	0.98	—	—	—	—	—
2	$1s^2 2s^2 2p^2\ ^3P_1$	0.98	—	—	7.87^{11}	—	—
3	$1s^2 2s^2 2p^2\ ^3P_2$	0.98	—	—	2.20^{11}	—	—
4	$1s^2 2s^2 2p^2\ ^1D_2$	0.97	—	—	1.99^{9}	—	—
5	$1s^2 2s^2 2p^2\ ^1S_0$	$0.94+0.05\ 2p^4(^1_0S\ )^1S$	—	—	1.43^{8}	—	—
6	$1s^2 2s2p^3\ ^5S_2$	1	1.22^{5}	7.94^{4}	1.15^{5}	—	—
7	$1s^2 2s2p^3\ ^3D_3$	0.99	8.71^{-1}	8.70^{-1}	8.70^{-1}	—	—
8	$1s^2 2s2p^3\ ^3D_2$	0.99	8.60^{-1}	8.61^{-1}	8.59^{-1}	—	1.08
9	$1s^2 2s2p^3\ ^3D_1$	0.99	8.53^{-1}	8.55^{-1}	8.52^{-1}	—	—
10	$1s^2 2s2p^3\ ^3P_2$	0.99	3.22^{-1}	3.20^{-1}	3.15^{-1}	—	3.80^{-1}
11	$1s^2 2s2p^3\ ^3P_1$	0.99	3.20^{-1}	3.18^{-1}	3.14^{-1}	—	—
12	$1s^2 2s2p^3\ ^3P_0$	0.99	3.19^{-1}	3.18^{-1}	3.13^{-1}	—	—
13	$1s^2 2s2p^3\ ^1D_2$	0.98	1.03^{-1}	1.05^{-1}	1.04^{-1}	—	1.44^{-1}
14	$1s^2 2s2p^3\ ^3S_1$	0.98	4.59^{-2}	4.71^{-2}	4.59^{-2}	—	6.10^{-2}
15	$1s^2 2s2p^3\ ^1P_1$	0.98	6.09^{-2}	6.20^{-2}	6.01^{-2}	—	8.90^{-2}

注：表中 $a\times10^b$ 表示为 a^b。

表 S7 Si IX 离子（Z = 10, 14, 32, 36, 50）$1s^22s^22p^2$ 和 $1s^22s2p^3$ 组态的混合系数和寿命

Table S7. Mixing coefficients and lifetimes of $1s^22s^22p^2$ and $1s^22s2p^3$ configurations in Si IX ion with Z = 10, 14, 32, 36, 50.

Lv. No.	State	LS-composition	τ_l/ns	τ_v/ns	$\tau^{[S1]}$/ns	$\tau^{[S2]}$/ns	$\tau^{[S3]}$/ns
1	$1s^22s^22p^2\ ^3P_0$	0.98	—	—	—	—	—
2	$1s^22s^22p^2\ ^3P_1$	0.98	—	—	—	—	—
3	$1s^22s^22p^2\ ^3P_2$	0.98	—	—	—	—	—
4	$1s^22s^22p^2\ ^1D_2$	0.98	—	—	—	—	—
5	$1s^22s^22p^2\ ^1S_0$	0.95 + 0.05 $2p^4(^1_0S)^1S$	—	—	—	—	—
6	$1s^22s2p^3\ ^5S_2$	1	4.77^3	3.65^3	—	—	—
7	$1s^22s2p^3\ ^3D_3$	0.99	4.42^{-1}	4.43^{-1}	—	—	—
8	$1s^22s2p^3\ ^3D_2$	0.99	4.23^{-1}	4.26^{-1}	—	—	—
9	$1s^22s2p^3\ ^3D_1$	0.99	4.12^{-1}	4.15^{-1}	—	—	—
10	$1s^22s2p^3\ ^3P_1$	0.99	1.66^{-1}	1.66^{-1}	—	—	—
11	$1s^22s2p^3\ ^3P_0$	1	1.65^{-1}	1.64^{-1}	—	—	—
12	$1s^22s2p^3\ ^3P_2$	0.99	1.70^{-1}	1.69^{-1}	—	—	—
13	$1s^22s2p^3\ ^1D_2$	0.99	5.59^{-2}	5.66^{-2}	—	—	—
14	$1s^22s2p^3\ ^3S_1$	0.99	2.71^{-2}	2.75^{-2}	—	—	—
15	$1s^22s2p^3\ ^1P_1$	0.99	3.48^{-2}	3.51^{-2}	—	—	—

注：表中 $a\times10^b$ 表示为 a^b。

表 S8 Ge XXVII 离子（Z = 10, 14, 32, 36, 50）$1s^22s^22p^2$ 和 $1s^22s2p^3$ 组态的混合系数和寿命

Table S8. Mixing coefficients and lifetimes of $1s^22s^22p^2$ and $1s^22s2p^3$ configurations in Ge XXVII ion with Z = 10, 14, 32, 36, 50.

Lv. No.	State	LS-composition	τ_l/ns	τ_v/ns	$\tau^{[S1]}$/ns	$\tau^{[S2]}$/ns	$\tau^{[S3]}$/ns
1	$1s^22s^22p^2\ ^3P_0$	0.82 + 0.17 $2s^2\ 2p^2(^1_0S)\ ^1S$	—	—	—	—	—
2	$1s^22s^22p^2\ ^3P_1$	0.99	—	—	—	—	—
3	$1s^22s^22p^2\ ^3P_2$	0.56 + 0.43 $2s^2\ 2p^2(^1_2D)\ ^1D$	—	—	—	—	—
4	$1s^22s^22p^2\ ^1D_2$	0.56 + 0.43 $2s^2\ 2p^2(^3_2P)\ ^3P$	—	—	—	—	—
5	$1s^22s^22p^2\ ^1S_0$	0.80 + 0.17 $2s^2\ 2p^2(^3_2P)\ ^3P$+0.03 $2p^4(^1_0S)\ ^1S$	—	—	—	—	—
6	$1s^22s2p^3\ ^5S_2$	0.86 + 0.12 $2s\ ^2S\ 2p^3(^2_1P)\ ^3P)$	1.67	1.56	—	—	—
7	$1s^22s2p^3\ ^3D_1$	0.68 + 0.22 $2s\ ^2S\ 2p^3(^2_1P)\ ^3P)\ p$ + 0.22$^2S\ 2p^3(^2_1P)\ ^1P)$	3.03^{-2}	3.03^{-2}	—	—	—
8	$1s^22s2p^3\ ^3D_2$	0.70 + 0.20 $2s\ ^2S\ 2p^3(^2_1P)\ ^3P)\ p$ + 0.20$^2S\ 2p^3(^4_3S)\ ^5S)$	6.20^{-2}	6.14^{-2}	—	—	—
9	$1s^22s2p^3\ ^3D_3$	1	8.34^{-2}	8.24^{-2}	—	—	—
10	$1s^22s2p^3\ ^3P_0$	1	2.39^{-2}	2.39^{-2}	—	—	—
11	$1s^22s2p^3\ ^3P_1$	0.63 + 0.24 $2s\ ^2S\ 2p^3(^2_3D)\ ^3D)\ p$ + 0.24$^2S\ 2p^3(^4_3S)\ ^3S)$	1.91^{-2}	1.91^{-2}	—	—	—
12	$1s^22s2p^3\ ^3P_2$	0.43 + 0.28 $2s\ ^2S\ 2p^3(^2_3D)\ ^3D)\ p$ + 0.s $^2S\ 2p^3(^2_3D)\ ^3D)$	1.91^{-2}	1.91^{-2}	—	—	—
13	$1s^22s2p^3\ ^3S_1$	0.60 + 0.26 $2s\ ^2S\ 2p^3(^2_1P)\ ^1P)\ p$ + 0.26$^2S\ 2p^3(^2_1P)\ ^3P)$	6.95^{-3}	6.95^{-3}	—	—	—
14	$1s^22s2p^3\ ^1D_2$	0.70 + 0.25 $2s\ ^2S\ 2p^3(^2_1P)\ ^3P)\ p$ + 0.25$^2S\ 2p^3(^2_3D)\ ^3D)$	1.26^{-2}	1.26^{-2}	—	—	—
15	$1s^22s2p^3\ ^1P_1$	0.66 + 0.25 $2s\ ^2S\ 2p^3(^4_3S)\ ^3S)\ p$ + 0.25$^2S\ 2p^3(^2_3D)\ ^3D)$	6.61^{-3}	6.61^{-3}	—	—	—

注：表中 $a\times10^b$ 表示为 a^b。

表 S9 Kr XXXI 离子（Z = 10, 14, 32, 36, 50）$1s^2 2s^2 2p^2$ 和 $1s^2 2s 2p^3$ 组态的混合系数和寿命

Table S9. Mixing coefficients and lifetimes of $1s^2 2s^2 2p^2$ and $1s^2 2s 2p^3$ configurations in Kr XXXI ion with Z = 10, 14, 32, 36, 50.

Lv. No.	State	LS-composition	τ_l/ns	τ_v/ns	$\tau^{[S1]}$/ns	$\tau^{[S2]}$/ns	$\tau^{[S3]}$/ns
1	$1s^2 2s^2 2p^2\ ^3P_0$	0.79 + 0.20 $2s^2\ 2p^2(^1_0S)\ ^1S$	—	—	—		—
2	$1s^2 2s^2 2p^2\ ^3P_1$	0.99	—	—	—	1.144^3	—
3	$1s^2 2s^2 2p^2\ ^1D_2$	0.51 + 0.49 $2s^2\ 2p^2(^3_2P)\ ^3P$	—	—	—	2.413^5	—
4	$1s^2 2s^2 2p^2\ ^3P_2$	0.50 + 0.49 $2s^2\ 2p^2(^1_2D)\ ^1D$	—	—	—	4.996^2	—
5	$1s^2 2s^2 2p^2\ ^1S_0$	0.77 + 0.21 $2s^2 2p^2(^3_2P)\ ^3P$+0.02 $2p^4(^1_0S)\ ^1S$	—	—	—	2.300^2	—
6	$1s^2 2s 2p^3\ ^5S_2$	0.73 + 0.21 $2s\ ^2S2p^3(^2_1P)\ ^3P)$ 3 + 0.21^{2}S $2p^3(^2_3D)\ ^3D)$	5.57^{-1}	5.24^{-1}	—	5.797^{-1}	—
7	$1s^2 2s 2p^3\ ^3D_1$	0.58 + 0.24 $2s\ ^2S\ 2p^3(^2_1P)\ ^3P)\ p$ + 0.24^{2}S $2p^3(^2_1P)\ ^1P)$	1.60^{-2}	1.60^{-2}	—	1.569^{-2}	—
8	$1s^2 2s 2p^3\ ^3D_2$	0.63 + 0.19 $2s\ ^2S\ 2p^3(^4_3S)\ ^5S)\ p$ + 0.19^{2}S $2p^3(^2_1P)\ ^3P)$	4.40^{-2}	4.36^{-2}	—	4.246^{-2}	—
9	$1s^2 2s 2p^3\ ^3D_3$	1	5.64^{-2}	5.56^{-2}	—	5.481^{-2}	—
10	$1s^2 2s 2p^3\ ^3P_0$	1	1.51^{-2}	1.51^{-2}	—	1.461^{-2}	—
11	$1s^2 2s 2p^3\ ^3P_1$	0.51 + 0.30 $2s\ ^2S\ 2p^3(^2_3D)\ ^3D)\ p$ + 0.30^{2}S $2p^3(^4_3S)\ ^3S)$	1.07^{-2}	1.07^{-2}	—	1.048^{-2}	—
12	$1s^2 2s 2p^3\ ^1D_2^a$ ($1s^2 2s 2p^3\ ^3P_2$)	0.46 + 0.25 $2s\ ^2S\ 2p^3(^2_3D)\ ^3D)\ p$ + 0.25^{2}S $2p^3(^2_1P)\ ^3P)$	9.95^{-3}	9.94^{-3}	—	9.784^{-3}	—
13	$1s^2 2s 2p^3\ ^3S_1$	0.48 + 0.29 $2s\ ^2S\ 2p^3(^2_1P)\ ^1P)\ p$ + 0.29^{2}S $2p^3(^2_1P)\ ^3P)$	5.31^{-3}	5.30^{-3}	—	5.100^{-3}	—
14	$1s^2 2s 2p^3\ ^1D_2^b$ ($1s^2 2s 2p^3\ ^1D_2$)	0.51 + 0.38 $2s\ ^2S\ 2p^3(^2_1P)\ ^3P)\ p$ + 0.38^{2}S $2p^3(^2_3D)\ ^3D)$	1.01^{-2}	1.00^{-2}	—	9.607^{-3}	—
15	$1s^2 2s 2p^3\ ^1P_1$	0.58 + 0.28 $2s\ ^2S\ 2p^3(^4_3S)\ ^3S)\ p$ + 0.28^{2}S $2p^3(^2_3D)\ ^3D)$	4.52^{-3}	4.52^{-3}	—	4.369^{-3}	—

注：表中 $a\times10^b$ 表示为 a^b。

表 S10 Sn XLV 离子（Z = 10, 14, 32, 36, 50）$1s^2 2s^2 2p^2$ 和 $1s^2 2s 2p^3$ 组态的混合系数和寿命

Table S10. Mixing coefficients and lifetimes of $1s^2 2s^2 2p^2$ and $1s^2 2s 2p^3$ configurations in Sn XLV ion with Z = 10, 14, 32, 36, 50.

Lv. No.	State	LS-composition	τ_l/ns	τ_v/ns	$\tau^{[S1]}$/ns	$\tau^{[S2]}$/ns	$\tau^{[S3]}$/ns
1	$1s^2 2s^2 2p^2\ ^3P_0$	0.72+0.28 $2s^2\ 2p^2(^1_0S)\ ^1S$	—	—	—	—	—
2	$1s^2 2s^2 2p^2\ ^3P_1$	1	—	—	—	—	—
3	$1s^2 2s^2 2p^2\ ^1D_2$	0.61+0.38 $2s^2 2p^2(^3_2P)\ ^3P$	—	—	—	—	—
4	$1s^2 2s 2p^3\ ^3P_2^a$ ($1s^2 2s 2p^3\ ^5S_2$)	0.43+0.38 $2s\ ^2S\ 2p^3(^4_3P)\ ^5S)\ p$+0.38 $2^2S\ 2p^3(^2_3D)\ ^3D)$	9.11^{-2}	8.31^{-2}	—	—	—
5	$1s^2 2s 2p^3\ ^3D_1$	0.39+0.24 $2s\ ^2S\ 2p^3(^2_1P)\ ^1P)\ p$+0.24 $2^2S\ 2p^3(^2_1P)\ ^3P)$	2.08^{-3}	2.07^{-3}	—	—	—
6	$1s^2 2s^2 2p^2\ ^3P_2$	0.61+0.38 $2s^2\ 2p^2(^1_2D)\ ^1D$			—	—	—
7	$1s^2 2s^2 2p^2\ ^1S_0$	0.70+0.28 $2s^2\ 2p^2(^3_2P)\ ^3P$			—	—	—
8	$1s^2 2s 2p^3\ ^3D_2$	0.49+0.45 $2s\ ^2S\ 2p^3(^4_3S)\ ^5S)\ p$+0.45 $2^2S\ 2p^3(^2_3D)\ ^1D)$	9.44^{-3}	9.33^{-3}	—	—	—
9	$1s^2 2s 2p^3\ ^3D_3$	1	1.01^{-2}	1.00^{-2}	—	—	—
10	$1s^2 2s 2p^3\ ^3P_0$	1	2.51^{-3}	2.50^{-3}	—	—	—
11	$1s^2 2s 2p^3\ ^3S_1$	0.40+0.39 $2s\ ^2S\ 2p^3(^2_3D)\ ^3D)\ p$+0.39 $2^2S\ 2p^3(^2_1P)\ ^3P)$	1.37^{-3}	1.37^{-3}	—	—	—
12	$1s^2 2s 2p^3\ ^1D_2$	0.71+0.22 $2s\ ^2S\ 2p^3(^2_3D)\ ^3D)\ p$+0.22 $2^2S\ 2p^3(^4_3S)\ ^5S)$	1.36^{-3}	1.35^{-3}	—	—	—
13	$1s^2 2s 2p^3\ ^3P_1$	0.48+0.31 $2s\ ^2S\ 2p^3(^2_1P)\ ^1P)\ p$+0.31 $2^2S\ 2p^3(^4_3S)\ ^3S)$	1.56^{-3}	1.56^{-3}	—	—	—
14	$1s^2 2s 2p^3\ ^3P_2^b$ ($1s^2 2s 2p^3\ ^3P_2$)	0.51+0.21 $2s\ ^2S\ 2p^3(^2_3D)\ ^1D)\ p$+0.21 $2^2S\ 2p^3(^2_3D)\ ^3D)$	2.52^{-3}	2.51^{-3}	—	—	—
15	$1s^2 2s 2p^3\ ^1P_1$	0.43+0.27 $2s\ ^2S\ 2p^3(^4_3S)\ ^3S)\ p$+0.27 $2^2S\ 2p^3(^2_3D)\ ^3D)$	9.42^{-4}	9.40^{-4}	—	—	—

注：表中 $a\times10^b$ 表示为 a^b。

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