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# Spectroscopic classification of the $5p^5n_1l_1n_2l_2n_3l_3$ autoionizing states in Ba atoms

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**Synopsis** The ejected-electron spectra of Ba atoms were measured in an electron impact energy range 15-100 eV. By comparative analysis of experimental and calculated data on excitation dynamics and excitation thresholds of lines the complete spectroscopic classification and decay channels for autoionizing states in $5p^55d6s^2$ and $5p^55d^26s$ configurations were determined.

The accurate spectroscopic classification of the $5p^5n_1l_1n_2l_2n_3l_3$ autoionizing states in Ba atoms faces the challenges of their multichannel decay to the $5p^6nl$ ionic states and of overlapping the lowest single- and double excited configurations (see e.g. [1], [2] and references therein). Consequently, the known spectroscopic classification of the atomic autoionizing states possesses substantially preliminary character [3].

In the present work the spectroscopic classification of lines in ejected-electron spectra of Ba atoms was carried out by comparative analysis of their excitation dynamics in a broad impact energy range and of calculated excitation thresholds, cross sections and decay rates of autoionizing states in $5p^55d6s^2$ and $5p^55d^26s$ configurations. The ejected-electron spectra were studied in an impact energy region from the excitation threshold of the $5p^6$ subshell up to 100 eV. The apparatus and measuring procedure were described in detail earlier [4]. The uncertainties of energy scales were estimated to be ±0.07 eV and ±0.05 eV for incident- and ejected electrons, respectively.

The calculations were performed by using singly $5p^66snl$ ($n$ =6,...12; $l$ =0,1,2 and $nl$ =4f,5f) and 5p-core $5p^5nln'l'n''l''$ ($nl$ =6s,5d; $n'l'$ =6s,7s,6p,5d,6d; $n''l''$ =7s,...,10s; 7p,...,10p; 5d,...,10d; 5f) excited configurations to take into account the correlation effects [5].

Of the 59 lines observed in spectra 17 were classified as corresponding to the multichannel electron decay of the $5p^55d6s^2, 5d^26s$ autoionizing states with excitation thresholds between 15.6 and 16.7 eV. The data for thirteen lowest states are presented in table 1.

The largest excitation efficiency possess the states from the $5p^55d^26s$ configuration. Most probable decay channel was transition into the $5p^66s\ ^2S_{1/2}$ $Ba^+$ state.

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**Table 1.** Experimental ($E_{exp}$) and calculated ($E_{calc}$) energies, classification, decay channels and Auger yields ($A^a$) of the $5p^55d6s^2$, $5d^26s$ $LSJ$ states of Ba atoms.

| $E_{exp}$ | $E_{calc}$ | State | Decay channel |
|---|---|---|---|
| 15.63 | 15.60 | $5d6s^2\ ^3P_0$ | $6s^2S_{1/2}$ |
| 15.72 | 15.78 | $5d^2(^3F)(^4D)6s^5D_0$ | $6s^2S_{1/2}$ |
| 15.81 | 15.79 | $5d6s^2\ ^3P_1$ | $6s^2S_{1/2}$ |
| | | | $5d^2D_{3/2}$ |
| 15.87 | 15.82 | $5d^2(^3F)(^4D)6s^5D_1$ | $6s^2S_{1/2}$ |
| 15.93 | 15.93 | $5d^2(^3F)(^4D)6s^5D_3$ | $6s^2S_{1/2}$ |
| | | | $5d^2D_{3/2}$ |
| 16.01 | 15.86 | $5d^2(^3F)(^4D)6s^5D_2$ | $5d^2D_{3/2}$ |
| 16.10 | 16.09 | $5d^2(^3F)(^4D)6s^5D_4$ | $6s^2S_{1/2}$ |
| | | | $5d^2D_{3/2}$ |
| 16.16 | 16.12 | $5d6s^2\ ^3P_2$ | $6s^2S_{1/2}$ |
| 16.25 | 16.27 | $5d6s^2\ ^3F_4$ | $6s^2S_{1/2}$ |
| 16.32 | 16.35 | $5d6s^2\ ^3F_3$ | $6s^2S_{1/2}$ |
| 16.42 | 16.48 | $5d6s^2\ ^1D_2$ | $6s^2S_{1/2}$ |
| 16.51 | 16.63 | $5d^2(^3F)(^4D)6s^3D_1$ | $6s^2S_{1/2}$ |
| 16.64 | 16.68 | $5d^2(^3P)(^4D)6s^3D_3$ | $6s^2S_{1/2}$ |
| | | | $5d^2D_{3/2}$ |

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