Classification of XeII Lines

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Synopsis. There are a number of unclassified XeII lines in the spectral table reported by Striganov and Sventitskii. Among them, electronic transitions of 52 XeII lines can be assigned with reference to the Moore's atomic energy diagram. The table presented here complements the spectral table of Striganov and Sventitskii.

Since elementary reactions between rare gas metastable atoms and rare gas ions have been believed to play an important role as pumping processes of rare gas ion lasers operated in the visible region,[1—3] we have recently studied excitation-transfer reactions and charge-transfer reactions between metastable rare gas atoms and rare gas ions by using a flowing afterglow method. In our previous papers,[4—6] results for the following reactions have been reported:

$$He(2^3S) + Ar^+(^2P^\circ_{3/2}) \rightarrow Ar^+(4p) + He, \quad (1)$$

$$He(2^3S) + Kr^+(^2P^\circ_{3/2}) \rightarrow Kr^+(5p, 5p', 6s) + He, \quad (2a)$$

$$He(2^3S) + Kr^+(^2P^\circ_{1/2}) \rightarrow Kr^+(5p, 5p', 5d, 6s, 6s'') + He, \quad (2b)$$

$$Ne(^3P^\circ_{0,2}) + Xe^+(^2P^\circ_{3/2}) \rightarrow Xe^+(6p, 6p', 7s, 6) + Ne, \quad (3)$$

$$He^+ + Ar(^3P^\circ_2) \rightarrow Ar^+(4p) + He. \quad (4)$$

More recently, our spectroscopic study has been extended to the $He(2^3S)+Xe^+(^2P^\circ_{3/2})$ reaction:[7]

$$He(2^3S) + Xe^+(^2P^\circ_{3/2}) \rightarrow Xe^{+*} + He. \quad (5)$$

206 XeII lines resulting from reaction (5) have been identified with reference to spectral table reported by Striganov and Sventitskii (SS),[8] which complied spectral data of XeII lines measured by Humphreys[9] and Boyce.[10] Among them, electronic transitions of 163 XeII lines could be assigned according to the SS table. However, it was difficult to assign the remaining 43 bands, because their electronic transitions have not been classified. In addition to these 43 unclassified XeII lines, there are 252 unclassified XeII lines in the SS table, which prevents us from a detailed analysis of ionization mechanism of Xe^{+*}. To the best of our knowledge, no attempt has been made to classify these unknown XeII lines. In the present study, we have succeeded in assigning 52 XeII lines.

Analysis

The identification of unclassified XeII lines in the SS table have been carried out with reference to the energy-level diagram of Xe^+ reported by Moore.[11] All possible transitions among 110 Xe^+ levels given in the Moore's table were taken into consideration in our computer fitting program. The wavelengths of XeII lines measured in air were converted to the corresponding wavenumbers in vacuum by using Edlén's relation.[12] When the transition energies of classified XeII lines given in the SS table were compared with those calculated from the Moore's table, most of them agreed with each other within ca. 0.5 cm^{-1} in the 4000—10220 Å region, within ca. 1.0 cm^{-1} in the 3000—4000 Å, and within ca. 1.5 cm^{-1} in the 2000—3000 Å region. On the basis of such findings, we have picked up all transitions which fit the calculated values within ±0.5 cm^{-1} in the 4000—10220 Å region, ±1 cm^{-1} in the 3000—4000 Å, and ±1.5 cm^{-1} in the 2000—3000 Å region, as possible transitions. When more than two transitions satisfy the above conditions, the best fit transition was adopted. In our analysis, electronic transitions of 52 unclassified XeII lines are assigned. In Table 1 are given the wavelengths and wavenumbers of classified XeII lines and the differences between the observed wavenumbers and the calculated ones. Thirteen XeII lines marked with * are observed in the $He(2^3S)+Xe^+(^2P^\circ_{3/2})$ reaction.

In conclusion, we could assign a number of unclassified XeII lines in the 2350—10220 Å region. The assignment of XeII lines listed in Table 1 complements the SS Table, which has been widely used for the identification of XeII lines. There are 20 classified XeII lines in the 740—1245 Å region in the SS table. Although the XeII lines at 1169.63 and 1158.474 Å were assigned to the 5d $^4P_{3/2}\rightarrow5p^5\ ^2P^\circ_{1/2}$ and 5d $^4P_{1/2}\rightarrow5p^5\ ^2P^\circ_{1/2}$ transitions, they should be re-assigned as the 5d $^4D_{3/2}\rightarrow5p^5\ ^2P^\circ_{1/2}$ and 5d $^4D_{1/2}\rightarrow5p^5\ ^2P^\circ_{1/2}$ ones, respectively, based upon the Moore's energy-level diagram.[11] These two transitions are involved in Table 1. We found that transition energies of 20 classified XeII lines in the 740—1245 Å region in the SS table are lower than those calculated from the Moore's diagram by 21.40—36.67 cm^{-1}. Although there are 10 unclassified XeII lines in the vacuum ultraviolet (VUV) region in the SS table, no possible assignment could be obtained in the present analysis by using the relation $|\Delta\nu|<1.5$ cm^{-1}. This is probably because the discrepancy between observed and calculated values is much larger than 1.5 cm^{-1}, as in the cases of classified XeII lines in the VUV region. Further detailed studies will be necessary to classify the XeII lines in the VUV

Table 1. Classified XeII Lines

λ_{air} a)	Transition	ν_{vac} (Obsd) a)	ν_{vac} (Calcd) b)	$\Delta\nu$ c)
Å		cm^{-1}		
10220.8	$6p'\,^2F^\circ_{5/2}\rightarrow 5d''\,^2D_{5/2}$	9781.29	9781.69	−0.40
9837.8	$7s'\,^2D_{3/2}\rightarrow 6d\,^4F_{3/2}$	10162.09	10162.1	−0.01
9820.90	$29^\circ_{3/2}\rightarrow 4f'\,^2F^\circ_{5/2}$	10179.58	10179.42	0.16
9615.71	$6s''\,^2S_{1/2}\rightarrow 6p\,^4P^\circ_{1/2}$	10396.80	10397.24	−0.44
9259.60	$7s'\,^2D_{3/2}\rightarrow 3^\circ_{7/2}$	10796.65	10797.0	−0.35
8636.4	$6d'\,^2D_{3/2}\rightarrow 16_{3/2}$	11575.73	11575.95	−0.22
8316.2	$29^\circ_{3/2}\rightarrow 6d\,^4D_{5/2}$	12021.43	12021.6	−0.17
8213.50	$7^\circ_{3/2}\rightarrow 5d'\,^2P_{1/2}$	12171.75	12172.22	−0.47
8142.13	$6s''\,^2S_{1/2}\rightarrow 6p\,^4P^\circ_{3/2}$	12278.44	12278.01	0.43
8115.94	$7s\,^2P_{3/2}\rightarrow 6p'\,^2F^\circ_{7/2}$	12318.06	12318.17	−0.11
8070.97	$6p\,^4P^\circ_{3/2}\rightarrow 5d\,^4F_{9/2}$	12386.70	12387.18	−0.48
8038.26	$10_{5/2}\rightarrow 6p\,^2D^\circ_{3/2}$	12437.10	12437.0	0.10
8008.45	$27^\circ_{5/2}\rightarrow 7s\,^4P_{1/2}$	12483.40	12483.7	−0.30
7072.43	$37^\circ_{5/2}\rightarrow 6d\,^4D_{5/2}$	14135.55	14135.7	−0.15
7052.57	$37^\circ_{5/2}\rightarrow 6d\,^4D_{7/2}$	14175.35	14175.5	−0.15
6632.44	$5d\,^2P_{1/2}\rightarrow 5p^6\,^2S_{1/2}$	15073.29	15073.71	−0.42
6595.01	$6d\,^2P_{1/2}\rightarrow 6p'\,^2F^\circ_{7/2}$	15158.84	15158.67	0.17
6461.48	$20_{1/2}\rightarrow 6p\,^2P^\circ_{3/2}$	15472.10	15471.79	0.31
5754.18	$6d\,^2D_{5/2}\rightarrow 5d'\,^2P_{1/2}$	17373.93	17374.3	−0.37
5746.88	$5d''\,^2D_{3/2}\rightarrow 5d\,^4P_{1/2}$	17396.00	17396.07	−0.07
5572.19*d)	$6p\,^2P^\circ_{3/2}\rightarrow 5d\,^2P_{3/2}$	17941.37	17941.28	0.09
5327.90	$6d\,^4D_{5/2}\rightarrow 6p\,^4D^\circ_{3/2}$	18764.00	18763.89	0.11
5001.01	$25^\circ_{3/2}\rightarrow 5d'\,^2P_{3/2}$	19990.50	19990.6	−0.10
4796.53	$6d'\,^2F_{5/2}\rightarrow 7s\,^4P_{3/2}$	20842.72	20843.1	−0.38
4649.17	$5d''\,^2D_{3/2}\rightarrow 6s\,^2P_{3/2}$	21503.35	21503.12	0.23
4571.85	$5d'\,^2S_{1/2}\rightarrow 5d\,^4P_{3/2}$	21867.02	21866.75	0.27
4473.85	$5^\circ_{3/2}\rightarrow 6p\,^4D^\circ_{3/2}$	22346.01	22345.73	0.28
4462.19*	$4f'\,^2G^\circ_{9/2}\rightarrow 5d'\,^2F_{7/2}$	22404.41	22404.25	0.16
4448.13*	$4f'\,^2F^\circ_{5/2}\rightarrow 5d'\,^2F_{7/2}$	22475.22	22475.22	0.00
4427.52	$4f'\,^2F^\circ_{7/2}\rightarrow 5d'\,^2F_{7/2}$	22579.85	22579.79	0.06
3770.12*	$15^\circ_{5/2}\rightarrow 6p\,^4D^\circ_{5/2}$	26517.12	26517.82	−0.70
3280.48	$6d\,^4P_{5/2}\rightarrow 6s'\,^2D_{3/2}$	30475.03	30474.7	0.33
3196.22	$7^\circ_{3/2}\rightarrow 5d\,^2D_{3/2}$	31278.43	31278.42	0.01
3164.44	$31^\circ_{3/2}\rightarrow 6p\,^4D^\circ_{3/2}$	31592.55	31591.79	0.76
3116.78	$4f'\,^2F^\circ_{5/2}\rightarrow 5d\,^2P_{3/2}$	32075.65	32075.85	−0.20
3047.76*	$6p'\,^2D^\circ_{5/2}\rightarrow 5d\,^4F_{9/2}$	32802.04	32802.78	−0.74
3020.29	$6p'\,^2D^\circ_{3/2}\rightarrow 5d\,^4F_{7/2}$	33100.38	33101.1	−0.72
2999.21	$6d'\,^2D_{3/2}\rightarrow 5d'\,^2F_{5/2}$	33333.02	33334.12	−1.10
2942.10*	$6d\,^2D_{3/2}\rightarrow 6p\,^4P^\circ_{5/2}$	33980.06	33981.26	−1.20
2827.90	$16_{3/2}\rightarrow 6s\,^4P_{1/2}$	35352.29	35351.74	0.55
2807.55*	$35^\circ_{5/2}\rightarrow 6p\,^4P^\circ_{1/2}$	35608.53	35608.15	0.38
2782.73	$20_{1/2}\rightarrow 6s\,^2P_{3/2}$	35926.14	35927.34	−1.20
2621.39*	$41^\circ_{3/2}\rightarrow 5d''\,^2D_{5/2}$	38137.30	38136.6	0.70
2605.54*	$6d'\,^2D_{5/2}\rightarrow 5d'\,^2D_{3/2}$	38369.30	38370.37	−1.07
2598.42	$7s'\,^2D_{3/2}\rightarrow 5d'\,^2D_{3/2}$	38474.43	38475.47	−1.04
2469.46*	$6d\,^4D_{5/2}\rightarrow 6s\,^4P_{3/2}$	40483.64	40482.66	0.98
2466.60	$4f'\,^2F^\circ_{5/2}\rightarrow 5d\,^4D_{1/2}$	40530.58	40531.04	−0.46
2425.05*	$7s\,^2P_{3/2}\rightarrow 6s\,^4P_{1/2}$	41225.02	41224.69	0.33
2421.27*	$10_{5/2}\rightarrow 5d\,^4D_{7/2}$	41289.38	41288.9	0.48
2392.15	$6d'\,^2D_{5/2}\rightarrow 5d\,^2D_{3/2}$	41792.00	41792.8	−0.80
2386.14	$7s'\,^2D_{3/2}\rightarrow 5d\,^2D_{3/2}$	41897.26	41897.9	−0.64
2356.72*	$7s'\,^2D_{3/2}\rightarrow 5d\,^4P_{3/2}$	42420.29	42420.65	−0.36
1169.63	$5d\,^4D_{3/2}\rightarrow 5p^5\,^2P^\circ_{1/2}$	85473.82	85496.14	−22.32
1158.474	$5d\,^4D_{1/2}\rightarrow 5p^5\,^2P^\circ_{1/2}$	86296.93	86320.84	−23.91

a) Ref. 8. b) Calculated by using atomic energy diagram given in Ref. 11. c) ν_{vac}(Obsd)$-\nu_{vac}$(Calcd). d) Observed in the $He(2^3S)+Xe^+(^2P^\circ_{3/2})$ reaction.

region and many other XeII lines in the ultraviolet and visible region.

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