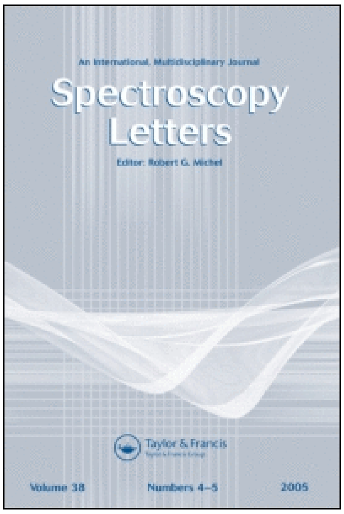

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New Classified Lines and Energy Levels in the Ne IV Spectrum

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New Classified Lines and Energy Levels in the Ne IV Spectrum

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Abstract: The spectrum of triply ionized neon, Ne IV, emitted by pulsed light sources has been studied. Ninety-three new classified lines are reported, and the wavelengths of 99 previously observed and classified lines are improved. Using these data, it was also possible to determine 7 new energy levels and to adjust the value for 32 previously reported levels.

Keywords: Atomic spectra, visible and ultraviolet spectra, properties of atoms and atomic ions

INTRODUCTION

The spectra of the noble gases are among the most widely observed spectra of all the elements because they occur in such a wide variety of applications. They appear commonly as buffer gases in laboratory spectral sources and in lighting discharges, in astrophysical spectra, in emission sources used for

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spectrochemistry, and in plasmas employed in industrial processing. Neon is abundant in the universe, and there is great interest in spectroscopy data from different ions of this noble gas due to applications in collision physics, plasma physics, laser physics, and so forth.

The three-times ionized neon, Ne IV, belongs to the nitrogen isoelectronic sequence. The first spectral observations of Ne IV are due to Boyce,[1] and afterward extended by Paul and Polster.[2] Different kinds of spectral sources were used by Kaufman et al.[3] Bockasten et al.[4], and Denis et al.[5] to study this ion. Many of the reported results below 2000 Å were compiled by Kelly.[6] A few years ago, a new critical compilation and extended analysis of the Ne IV spectrum was made by Kramida et al.[7]

The purpose of this work is to present 93 new Ne IV classified lines and improved values for 99 previously reported classified lines below 2000 Å, as is shown in Tables 1 and 2, respectively. Seven new levels and adjusted values corresponding with 32 energy levels are also reported in Table 3.

MATERIALS AND METHODS

To excite the neon spectra, a capillary pulsed discharge built at the Centro de Investigaciones Opticas to study ionized noble gases was used. It consist of a Pyrex tube 100 cm long and with an inner diameter of 0.6 cm. The electrodes, placed 80 cm apart, were made of indium. At one side of the tube there was an inlet connected via a pressure reduction system to the bottle of neon. Gas excitation was produced by discharging a bank of low-inductance capacitors of 100 nF and charged up to 16 kV through the tube. The gas pressure was measured by a thermocouple vacuum gauge before and after the exposures, and it was varied between 20 and 100 mTorr.

Light emitted axially was recorded in the 580–4900 Å region. The wavelength range above 2000 Å was observed using a diode array detector coupled to a 3.4-m Ebert plane grating spectrograph with 600 lines/mm and a plate factor of 5 Å/mm in the first diffraction order. In the vacuum ultraviolet (VUV) region, the light was analyzed using a 3-m normal incidence vacuum spectrograph with a concave diffraction grating with 1200 lines/mm, blazed for 1200 Å, with plate factor 2.77 Å/mm in the first diffraction order. The spectrograph was filled with neon at the same pressure of the Pyrex tube in order to obtain better stability for the discharge conditions. Presence of the gas inside the spectrograph precluded observation of the spectrum below 580 Å. Ilford Q plates and internal wavelength standards of Ne III[8] were used. These spectra were measured with a Grant semiautomatic comparator. The comparator readings were reduced to wavelengths by polynomial interpolation. The accuracy of the standard wavelength values used was of the order 0.005 Å, and the uncertainty in the determination of the wavelength values of unperturbed lines presented in this work was estimated to

Table 1. New classified lines in Ne IV

Intensity	Wave-lengths λ_{obs} (Å)	Wavenumber σ_{obs} (cm^{-1})	Wavenumber σ_{cal} (cm^{-1})	Classification
1	597.95	167238.1	6.51	$2s^22p^2(^3P)3s\ ^2P_{3/2} - 2s^22p^2(^3P)4p\ ^2P_{3/2}$
2	606.40	164907.6	9.51	$2s^22p^2(^3P)3s\ ^2P_{3/2} - 2s^2p^2(^3P)4p\ ^2D_{5/2}$
1	641.21	155955.1	3.2	$2s^22p^2\ (^1D)3s^2D_{3/2} - 2s2p^3(^3D)3s\ ^2D_{3/2}$
1	690.95	144728.3	4.1	$2s^22p^2(^1D)3s\ ^2D_{5/2} - 2s^22p^2(^3P)4p\ ^2P_{3/2}$
1	692.80	144341.8	3.2	$2s^22p^2(^3P)3p\ ^4P_{1/2} - 2s^22p^2(^3P)4d\ ^4D_{3/2}$
2	694.74	143938.7	42.1	$2s^22p^2(^1D)3s\ ^2D_{5/2} - 2s^22p^2(^3P)4p\ ^4S_{3/2}$
2bl	701.08	142637.1	9.09	$2s^22p^2(^1D)3p^2F_{7/2} - 2s^22p^2(^1D)4d\ ^2F_{7/2}$
2bl	701.12	142628.9	5.1	$2s^22p^3\ ^2D_{5/2} - 2s2p^4\ ^4P_{5/2}$
2	728.11	137341.9	52.62	$2s^22p^2(^1D)3p\ ^2D_{5/2} - 2s2p^3(^3D)3p\ ^4D_{3/2}$
2	730.53	136886.9	3.6	$2s^22p^2(^1D)3p\ ^2D_{3/2} - 2s^2\ 2p^2(^1D)4d\ ^2F_{5/2}$
2	891.17	112212.0	11.6	$2s^22p^2(^3P)3p\ ^4D_{3/2} - 2s^2\ 2p^2(^3P)4s\ ^4P_{1/2}$
1	905.90	110387.5	402.6	$2s^22p^2(^1D)3p\ ^2D_{5/2} -2s^2\ 2p^2(^3P)4d\ ^2F_{7/2}$
1	912.05	109643.1	4.6	$2s^22p^2(^1D)3p\ ^2D_{5/2} - 2s^2\ 2p^2(^3P)4d\ ^2F_{5/2}$
2	914.68	109327.9	8.29	$2s^22p^2(^3P)3s\ ^4P_{1/2} - 2s\ 2p^3(^5S)3s\ ^4S_{3/2}$
2	917.88	108946.7	6.49	$2s^22p^2(^3P)3s\ ^4P_{3/2} - 2s\ 2p^3(^5S)3s\ ^4S_{3/2}$
4	919.44	108761.9	1.77	$2s^22p^2(^3P)3p\ ^4P_{3/2} - 2s^2\ 2p^2(^3P)4s\ ^4P_{1/2}$
2	938.10	106598.4	7.7	$2s^22p^2(^3P)3p\ ^2D_{3/2} - 2s^2\ 2p^2(^3P)4s\ ^2P_{3/2}$
4	944.48	105878.4	7.7	$2s^22p^2(^3P)3p\ ^2D_{3/2} - 2s^2\ 2p^2(^3P)4s\ ^2P_{1/2}$
1	978.25	102223.4	2.8	$2s^22p^2(^3P)3d\ ^4F_{5/2} - 2s^2\ 2p^2(^3P)4f\ 2[4]_{7/2}$
2	981.00	101936.8	40.9	$2s^22p^2(^3P)3d\ ^4F_{7/2} - 2s^2\ 2p^2(^3P)4f\ 2[4]_{7/2}$
1	989.50	101061.1	4.8	$2s^22p^2(^3P)3p\ ^4F_{3/2} - 2s^2\ 2p^2(^3P)4f\ 1[2]_{3/2}$
3	992.00	100806.5	6.61	$2s^22p^2(^3P)3p\ ^4S_{3/2} - 2s^2\ 2p^2(^3P)4s\ ^4P_{3/2}$
2	996.05	100396.6	7.2	$2s^22p^2(^3P)3p\ ^2P_{3/2} - 2s^2\ 2p^2(^3P)4s\ ^2P_{3/2}$
4c	998.31	100169.3	72.3	$2s2p^3(^5S)3d\ ^6D_{5/2} - 2s2p^3(^5S)4f\ ^6F$
4c	998.31	100169.3	65.3	$2s2p^3(^5S)3d\ ^6D_{3/2} - 2s2p^3(^5S)4f\ ^6F$
4	998.39	100161.3	1.3	$2s2p^3(^5S)3d\ ^6D_{1/2} - 2s2p^3(^5S)4f\ ^6F$
5	1003.25	99676.1	7.2	$2s^22p^2(^3P)3p\ ^2P_{3/2} - 2s^2\ 2p^2(^3P)4s\ ^2P_{1/2}$
1	1013.61	98657.3	7.8	$2s^22p^2(^3P)3d\ ^2P_{3/2} - 2s^2\ 2p^2(^3P)4f\ 2[2]_{5/2}$
3	1022.93	97758.4	9.0	$2s^22p^2(^3P)3d\ ^4D_{5/2} - 2s^2\ 2p^2(^3P)4f\ 2[2]_{5/2}$
5	1023.34	97719.2	8.4	$2s^22p^2(^1D)3d\ ^2F_{7/2} - 2s^22p^2(^1D)4f\ 2[3]_{5/2}$
2	1024.86	97574.3	6.2	$2s^22p^2(^1D)3d\ ^2F_{5/2} - 2s^22p^2(^1D)4f\ 2[3]_{5/2}$
2bl	1024.92	97568.6	4.4	$2s^22p^2(^3P)3d\ ^4D_{7/2} - 2s^2\ 2p^2(^3P)4f\ 2[2]_{5/2}$
4	1026.83	97387.1	7.8	$2s^22p^2(^1D)3d\ ^2G_{7/2} - 2s^2\ 2p^2(^1D)4f\ 2[5]$
2	1028.71	97209.1	7.3	$2s^22p^2(^3P)3p\ ^2P_{1/2} - 2s^2\ 2p^2(^3P)4f\ 1[2]_{3/2}$
1	1029.20	97162.8	2.4	$2s^22p^2(^3P)3d\ ^4D_{7/2} - 2s^2\ 2p^2(^3P)4f\ 2[5]_{9/2}$
5	1029.81	97105.3	5.8	$2s^22p^2(^1D)3p\ ^2P_{3/2} - 2s^2\ 2p^2(^1D)4s\ ^2D_{5/2}$
1	1030.16	97072.3	69.7	$2s^22p^2(^3P)3d\ ^4D_{1/2} - 2s^2\ 2p^2(^3P)4f\ 2[1]_{1/2}$
2	1031.38	96957.5	8.3	$2s^22p^2(^3P)3d\ ^4D_{1/2} - 2s^2\ 2p^2(^3P)4f\ 2[1]_{3/2}$
4	1036.11	96514.8	7.0	$2s^22p^2(^3P)3d\ ^4D_{5/2} - 2s^2\ 2p^2(^3P)4f\ 1[3]_{7/2}$
2	1038.18	96322.4	2.4	$2s^22p^2(^3P)3d\ ^4D_{7/2} - 2s^2\ 2p^2(^3P)4f\ 1[3]_{7/2}$

(*continued*)

Table 1. Continued

Intensity	Wave-lengths λ_{obs} (Å)	Wavenumber σ_{obs} (cm^{-1})	σ_{cal} (cm^{-1})	Classification
3bl	1039.14	96233.4	1.8	$2s^22p^2(^1D)3d\ ^2G_{7/2} - 2s^22p^2(^1D)4f\ 2[4]_{7/2}$
4	1045.10	95684.6	3.8	$2s^22p^2(^3P)3d\ ^4P_{5/2} - 2s^2\ 2p^2(^3P)4f\ 2[3]_{7/2}$
3	1046.18	95585.8	5.8	$2s^22p^2(^3P)3d\ ^4P_{5/2} - 2s^2\ 2p^2(^3P)4f\ 2[2]_{5/2}$
1	1047.98	95421.7	3.6	$2s^22p^2(^3P)3d\ ^2F_{5/2} - 2s^2\ 2p^2(^3P)4f\ 2\ [3]_{5/2}$
5	1049.19	95311.6	1.9	$2s^22p^2(^3P)3d\ ^4P_{3/2} - 2s^2\ 2p^2(^3P)4f\ 2[2]_{5/2}$
4	1054.68	94815.5	3.3	$2s^22p^2(^3P)3d\ ^2F_{7/2} - 2s^2\ 2p^2(^3P)4f\ 2\ [4]_{7/2}$
3	1055.71	94723.0	14.3	$2s^22p^2(^3P)3d\ ^2F_{7/2} - 2s^2\ 2p^2(^3P)4f\ 2\ [3]_{5/2}$
3	1056.28	94671.9	70.3	$2s^22p^2(^3P)3d\ ^2F_{7/2} - 2s^2\ 2p^2(^3P)4f\ 2[4]_{9/2}$
1	1056.96	94611.0	3.9	$2s^22p^2(^3P)3d^4P\ _{3/2} - 2s^2\ 2p^2(^3P)4f\ 2[1]_{1/2}$
4	1057.08	94600.2	601.9	$2s^22p^2(^3P)3d\ ^4P_{3/2} - 2s^2\ 2p^2(^3P)4f\ 2[1]_{3/2}$
4	1057.63	94551.0	50.8	$2s^22p^2(^3P)3d\ ^4P_{5/2} - 2s^2\ 2p^2(^3P)4f\ 1[2]_{5/2}$
3	1058.52	94471.5	70.3	$2s^22p^2(^3P)3d\ ^4P_{1/2} - 2s^2\ 2p^2(^3P)4f\ 2[1]_{1/2}$
3	1058.68	94457.2	8.3	$2s^22p^2(^3P)3d\ ^4P_{1/2} - 2s^2\ 2p^2(^3P)4f\ 1[2]_{3/2}$
5	1060.71	94276.5	6.9	$2s^22p^2(^3P)3d\ ^4P_{3/2} - 2s^2\ 2p^2(^3P)4f\ 1[2]_{5/2}$
2	1061.07	94244.5	2.9	$2s^22p^2(^3P)3d\ ^4P_{3/2} - 2s^2\ 2p^2(^3P)4f\ 1\ [2]_{3/2}$
4	1069.51	93500.8	498.3	$2s^22p^2(^3P)3d\ ^2F_{7/2} - 2s^2\ 2p^2(^3P)4f\ 1[4]_{9/2}$
5	1134.84	88118.1	8.1	$2s^22p^2(^3P)3d\ ^2D_{3/2} - 2s^2\ 2p^2(^3P)4f\ 2\ [3]_{5/2}$
5	1136.35	88001.1	0.1	$2s^22p^2(^3P)3d\ ^2D_{5/2} - 2s^2\ 2p^2(^3P)4f\ 2\ [4]_{7/2}$
2	1137.23	87933.0	1.0	$2s^22p^2(^3P)3d\ ^2D_{3/2} - 2s^2\ 2p^2(^3P)4f\ 2[2]_{5/2}$
4	1137.64	87901.3	1.1	$2s^22p^2(^3P)3d\ ^2D_{5/2} - 2s^2\ 2p^2(^3P)4f\ 2\ [3]_{5/2}$
2	1146.51	87221.2	21.1	$2s^22p^2(^3P)3d\ ^2D_{3/2} - 2s^2\ 2p^2(^3P)4f\ 2[1]_{3/2}$
2	1150.79	86896.8	6.1	$2s^22p^2(^3P)3d\ ^2D_{3/2} - 2s^2\ 2p^2(^3P)4f\ 1[2]_{5/2}$
2	1151.22	86864.4	2.1	$2s^22p^2(^3P)3d\ ^2D_{3/2} - 2s^2\ 2p^2(^3P)4f\ 1\ [2]_{3/2}$
3	1152.84	86742.3	1.1	$2s^22p^2(^3P)3d\ ^2D_{5/2} - 2s^2\ 2p^2(^3P)4f\ 1[4]_{7/2}$
2	1159.27	86261.2	60.1	$2s^22p^2(^3P)3d\ ^2D_{5/2} - 2s^2\ 2p^2(^3P)4f\ 0[3]_{7/2}$
2bl	1247.09	80186.7	9.8	$2s^22p^2(^3P)3d\ ^2P_{1/2} - 2s^22p^2(^3P)4p\ ^2P_{3/2}$
4	1269.97	78742.0	40.2	$2s^22p^2(^3P)3p\ ^2D_{3/2} - 2s^2\ 2p^2(^1D)3d\ ^2D_{3/2}$
3	1280.59	78089.0	6.65	$2s^22p^2(^3P)3p\ ^2D_{5/2} - 2s^2\ 2p^2(^1D)3d\ ^2D_{5/2}$
1	1309.98	76337.0	5.8	$2s^22p^2(^3P)3d\ ^4P_{5/2} - 2s^22p^2(^3P)4p\ ^4S_{3/2}$
2	1314.70	76063.0	1.9	$2s^22p^2(^3P)3d\ ^4P_{3/2} - 2s^22p^2(^3P)4p\ ^4S_{3/2}$
2	1337.40	74771.9	3.9	$2s^22p^2(^3P)3d\ ^4F_{7/2} - 2s^2\ 2p^2(^3P)4p\ ^4D_{7/2}$
2	1338.93	74686.5	6.8	$2s^22p^2(^3P)3d\ ^4F_{5/2} - 2s^2\ 2p^2(^3P)4p\ ^4D_{5/2}$
5	1342.25	74501.8	3.8	$2s^22p^2(^3P)3d\ ^4F_{3/2} - 2s^2\ 2p^2(^3P)4p\ ^4D_{1/2}$
5c	1344.03	74403.1	3.4	$2s^22p^2(^3P)3d\ ^4F_{9/2} - 2s^2\ 2p^2(^3P)4p\ ^4D_{7/2}$
5c	1344.03	74403.1	4.9	$2s^22p^2(^3P)3d\ ^4F_{7/2} - 2s^2\ 2p^2(^3P)4p\ ^4D_{5/2}$
4	1356.64	73711.5	2.6	$2s^22p^2(^3P)3d\ ^2F_{5/2} - 2s^2\ 2p^2(^3P)4p\ ^2D_{3/2}$
2	1368.42	73077.0	70.4	$2s^22p^2(^3P)3d\ ^4D_{7/2} - 2s^2\ 2p^2(^3P)4p\ ^4P_{5/2}$
3	1373.92	72784.4	4.7	$2s^22p^2(^3P)3d\ ^4D_{3/2} - 2s^2\ 2p^2(^3P)4p\ ^4P_{1/2}$
2	1375.81	72684.5	4.7	$2s^22p^2(^3P)3d\ ^4D_{1/2} - 2s^2\ 2p^2(^3P)4p\ ^4P_{1/2}$
2	1377.49	72595.8	5.5	$2s^22p^2(^3P)3p\ ^2P_{3/2} - 2s^2\ 2p^2(^1D)3d\ ^2D_{5/2}$

(*continued*)

Table 1. Continued

Intensity	Wave-lengths λ_{obs} (Å)	Wavenumber σ_{obs} (cm^{-1})	σ_{cal} (cm^{-1})	Classification
2	1413.81	70730.9	2.8	$2s^22p^2(^3P)3d\ ^4P_{5/2} - 2s^2\ 2p^2(^3P)4p\ ^4P_{3/2}$
2	1414.76	70683.4	3.4	$2s^22p^2(^3P)3d\ ^4D_{7/2} - 2s^2\ 2p^2(^3P)4p\ ^4D_{7/2}$
4c	1422.20	70313.6	5.3	$2s^22p^2(^3P)3d\ ^4P_{1/2} - 2s^2\ 2p^2(^3P)4p^4P_{3/2}$
4c	1422.20	70313.6	4.4	$2s^22p^2(^3P)3d\ ^4D_{7/2} - 2s^2\ 2p^2(^3P)4p\ ^4D_{5/2}$
2c	1439.66	69460.8	3.1	$2s^22p^2(^3P)3d\ ^2D_{3/2} - 2s^22p^2(^3P)4p\ ^2P_{3/2}$
2c	1439.66	69460.8	59.4	$2s^22p^2(^1D)3d\ ^2F_{7/2} - 2s^2\ 2p^2(^3P)4f\ 2\ [3]_{5/2}$
1	1442.60	69319.3	7.2	$2s^22p^2(^1D)3d\ ^2F_{5/2} - 2s^2\ 2p^2(^3P)4f\ 2\ [3]_{5/2}$
3	1444.13	69245.8	6.1	$2s^22p^2(^3P)3d\ ^2D_{5/2} - 2s^22p^2(^3P)4p\ ^2P_{3/2}$
1d	1465.37	68242.4	3.4	$2s^22p^2(^1D)3d\ ^2F_{7/2} - 2s^2\ 2p^2(^3P)4f\ 1[4]_{9/2}$
1	1467.20	68156.9	7.2	$2s^22p^2(^1D)3d\ ^2F_{5/2} - 2s^2\ 2p^2(^3P)4f\ 1[4]_{7/2}$
4	1800.73	55533.0	3.4	$2s^22p^2(^1D)3s\ ^2D_{3/2} - 2s^2\ 2p^2(^1D)3p\ ^2P_{3/2}$
1	1990.72	50233.1	3.2	$2s2p^3(^5S)3p\ ^6P_{7/2} - 2s2p^3(^5S)3d\ ^6D_{5/2}$
3bl	1990.99	50226.3	6.3	$2s2p^3(^5S)3p\ ^6P_{7/2} - 2s2p^3(^5S)3d\ ^6D_{7/2}$

bl, blended line; d, diffuse line; c, double classification.

be ±0.01 Å. To distinguish among different states of ionization, we studied the behavior of the spectral lines intensity as a function of pressure.

RESULTS

We did not obtain new information on Ne IV spectral lines above 2000 Å. All the spectral lines presented in Tables 1 and 2 are based on recordings of the neon spectra between 580 and 2000 Å. In these tables, the intensity values of the observed lines are based on visual estimates of blackening of the photographic plates. σ_{cal} means calculated wavenumber obtained from the energy level values given in Ref. [7] and the adjusted energy values presented in Table 3 by means of the Ritz combination principle. Only the part that differs from the observed is given.

In Table 1, the designation of the energy levels is taken from Ref. [7], and in the new list of classified lines, we included some predicted lines reported in the same reference.

In Table 2, we present wavelength values of several lines improved compared with the values compiled by Kramida et al.[7] In the last column of this table, we present only the assignments for the transitions that we observe, corresponding with the multiple possible assignments in Ref. [7]. The other assignments taken from the same reference, not considered in Table 2, are included in Table 1 or discarded.

Table 2. Improved wavelength values for Ne IV lines

Intensity	Wavelengths λ_{obs} (Å)	λ^a (Å)	Wavenumber σ_{obs} (cm^{-1})	σ_{cal} (cm^{-1})	Assignment
4	583.53	0.61	171370.8	70.29	$2s^2\ 2p^2(^3P)3s^4P_{1/2} - 2s^2\ 2p^2(^3P)4p^4P_{3/2}$
2	584.83	0.87	170989.9	8.49	$2s^2\ 2p^2(^3P)3s^4P_{3/2} - 2s^2\ 2p^2(^3P)4p^4P_{3/2}$
2bl	586.82	0.92	170410.0	10.95	$2s^2\ 2p^2(^3P)3s^4P_{5/2} - 2s^2\ 2p^2(^3P)4p^4P_{3/2}$
4	592.72	0.67	168713.7	4.29	$2s^2\ 2p^2(^3P)3s^4P_{1/2} - 2s^2\ 2p^2(^3P)4p^4D_{3/2}$
6c	593.14	0.18	168594.3	3.29	$2s^2\ 2p^2(^3P)3s^4P_{1/2} - 2s^2\ 2p^2(^3P)4p^4D_{1/2}$
6c	593.14	0.18	168594.2	1.49	$2s^2\ 2p^2(^3P)3s^4P_{3/2} - 2s^2\ 2p^2(^3P)4p\ ^4D_{5/2}$
6	593.88	0.92	168384.2	2.95	$2s^2\ 2p^2(^3P)3s^4P_{5/2} - 2s^2\ 2p^2(^3P)4p^4D_{7/2}$
2	632.61	0.66	158075.3	4.51	$2s^2\ 2p^2(^3P)3s^4P_{3/2} - 2s^2\ 2p^2(^3P)4p^4D_{1/2}$
2	678.11	7.97	147468.7	9.54	$2s^2\ 2p^2(^3P)3p^4D^0_{5/2} - 2s^2\ 2p^2(^3P)4d^4D_{5/2}$
3	679.19	0.24	147234.2	3.71	$2s^2\ 2p^2(^3P)3p^4D^0_{7/2} - 2s^2\ 2p^2(^3P)4d^4D_{7/2}$
4c	684.37	0.42	146119.8	107.4	$2s^22p^2(^3P)3p^4D_{1/2} - 2s^2\ 2p^2(^3P)4d^4F_{3/2}$
4c	684.37	0.42	146119.8	104.6	$2s^22p^2(^3P)3p^4D_{3/2} - 2s^22p^2(^3P)4d^4F_{5/2}$
7c	684.69	0.76	146051.5	33.54	$2s^22p^2(^3P)3p^4D_{7/2} - 2s^22p^2(^3P)4d\ ^4F_{9/2}$
7c	684.69	0.76	146051.5	33.71	$2s^22p^2(^3P)3p^4D_{5/2} - 2s^22p^2(^3P)4d\ ^4F_{7/2}$
4	692.66	0.72	144371.0	70.77	$2s^22p^2(^3P)3p^4P_{3/2} - 2s^22p^2(^3P)4d\ ^4D_{5/2}$
5	693.15	0.23	144268.9	8.86	$2s^2\ 2p^2(^3P)3p^4P_{5/2} - 2s^2\ 2p^2(^3P)4d^4D_{7/2}$
3	696.69	0.74	143535.9	5.8	$2s^22p^2(^1D)3p\ ^2F_{5/2} - 2s^2\ 2p^2(^1D)4d\ ^2G_{7/2}$
5	697.31	0.41	143408.2	8.09	$2s^22p^2(^1D)3p\ 2F_{7/2} - 2s^2\ 2p^2(^1D)4d\ ^2G_{9/2}$
4	712.87	0.89	140278.0	6.7	$2s^2\ 2p^2(^3P)3p^2D_{3/2} - 2s^2\ 2p^2(^3P)4d^2F_{5/2}$
2	713.21	0.10	140211.2	1.35	$2s^2\ 2p^2(^3P)3p^2D_{5/2} - 2s^2\ 2p^2(^3P)4d^2F_{7/2}$
1	720.61	0.75	138771.3	2.62	$2s^2\ 2p^2(^1D)3p^2D_{5/2} - 2s^2\ 2p^2(^1D)4d^2D_{5/2}$
2	729.64	0.63	137053.9	4.2	$2s^2\ 2p^2(^3P)3p^2P_{3/2} - 2s^2\ 2p^2(^3P)4d^2D_{5/2}$

2a	730.24	0.44	136941.3	38.62	$2s^22p^2(^1D)3p\ ^2D_{5/2} - 2s^22p^2(^1D)4d\ ^2F_{7/2}$
1	809.25	0.25	123571.2	3.6	$2s^22p^2(^3P)3d\ ^2F_{5/2} - 2s^2\ 2p^2(^1D)4f\ 2[4]_{7/2}$
1c	819.43	0.44	122036.0	9.0	$2s^22p^3\ ^2P_{1/2} - 2s2p^4\ ^4P_{3/2}$
1c	819.43	0.44	122036.0	2.66	$2s^22p^3\ ^2P_{3/2} - 2s2p^4\ ^4P_{3/2}$
2	825.92	0.95	121077.1	8.5	$2s^2\ 2p^2(^3P)3p^2S_{1/2} - 2s^2\ 2p^2(^3P)4s^2P_{1/2}$
4	886.51	0.52	112801.9	1.54	$2s^22p^2(^3P)3p^4D_{5/2} - 2s^22p^2(^3P)4s^4P_{5/2}$
5	888.28	0.22	112577.1	8.5	$2s^2\ 2p^2(^3P)3p^4D_{3/2} - 2s^2\ 2p^2(^3P)4s^4P_{3/2}$
4	889.49	0.53	112424.0	4.4	$2s^2\ 2p^2(^3P)3p^4D_{1/2} - 2s^2\ 2p^2(^3P)4s^4P_{1/2}$
4	890.30	0.25	112321.7	1.71	$2s^2\ 2p^2(^3P)3p^4D_{7/2} - 2s^2\ 2p^2(^3P)4s^4P_{5/2}$
5	891.06	0.05	112255.7	6.54	$2s^2\ 2p^2(^3P)3p^4D_{3/2} - 2s^2\ 2p^2(^3P)4s^4P_{1/2}$
6	906.90	0.88	110265.7	5.5	$2s\ 2p^3(^5S)3p^6P_{5/2} - 2s\ 2p^3(^5S^0)4s^6S_{5/2}$
4	907.56	0.54	110185.6	6.1	$2s\ 2p^3(^5S)3p^6P_{7/2} - 2s\ 2p^3(^5S^0)4s^6S_{5/2}$
2	911.56	0.54	109702.0	2.77	$2s^2\ 2p^2(^3P)3p^4P_{3/2} - 2s^2\ 2p^2(^3P)4s^4P_{5/2}$
5	914.44	0.39	109356.5	6.86	$2s^2\ 2p^2(^3P)3p^4P_{5/2} - 2s^2\ 2p^2(^3P)4s^4P_{5/2}$
3	914.95	0.93	109295.6	6.2	$2s^2\ 2p^2(^3P)3p^4P_{1/2} - 2s^2\ 2p^2(^3P)4s^4P_{3/2}$
2	916.37	0.35	109126.2	7.77	$2s^2\ 2p^2(^3P)3p^4P_{3/2} - 2s^2\ 2p^2(^3P)4s^4P_{3/2}$
2	916.99	0.97	109052.4	50.8	$2s^2\ 2p^2(^1D)3p^2F_{5/2} - 2s^2\ 2p^2(^1D)4s^2D_{3/2}$
5	919.28	0.35	108780.8	1.86	$2s^22p^2(^3P)3p\ ^4P_{5/2} - 2s^2\ 2p^2(^3P)4s\ ^4P_{3/2}$
2	922.78	0.73	108368.2	8.95	$2s^2\ 2p^2(^3P)3p^4P_{5/2} - 2s\ 2p^3(^5S^0)3s^4S_{3/2}$
1bl	937.94	8.03	106616.6	6.8	$2s^22p^2(^1D)3p^2P_{3/2} - 2s^2\ 2p^2\ (^3P)4d\ ^2D_{5/2}$
5bl	944.40	0.39	105887.3	8.35	$2s^22p^2\ (^3P)3p^2D_{5/2} - 2s^2\ 2p^2\ (^3P)4s\ ^2P_{3/2}$
4	968.90	0.86	103209.8	11.62	$2s^2\ 2p^2(^1D)3p^2D_{5/2} - 2s^2\ 2p^2(^1D)4s^2D_{5/2}$
4	969.81	0.83	103113.0	2.6	$2s^2\ 2p^2(^1D)3p^2D_{3/2} - 2s^2\ 2p^2(^1D)4s^2D_{3/2}$
3	982.77	0.72	101753.2	2.9	$2s^22p^2(^3P)3d\ ^4F_{7/2} - 2s^2\ 2p^2(^3P)4f\ 2[3]_{7/2}$
3	985.93	0.91	101427.1	7.4	$2s^22p^2(^3P)3d\ ^4F_{9/2} - 2s^2\ 2p^2(^3P)4f\ 2[4]_{9/2}$
5	986.37	0.39	101381.8	1.61	$2s^2\ 2p^2(^3P)3p^4S_{3/2} - 2s^2\ 2p^2(^3P)4s^4P_{5/2}$

(continued)

Table 2. Continued

Intensity	Wavelengths λ_{obs} (Å)	λ^a (Å)	Wavenumber σ_{obs} (cm^{-1})	σ_{cal} (cm^{-1})	Assignment
4	987.62	0.58	101253.5	2.9	$2s^22p^2(^3P)3d\ ^4F_{7/2} - 2s^2\ 2p^2(^3P)4f\ 2[5]_{9/2}$
4	990.46	0.42	100963.2	3.8	$2s^22p^2(^3P)3d\ ^4F_{5/2} - 2s^2\ 2p^2(^3P)4f\ 1[4]_{7/2}$
5	991.84	0.96	100822.7	2.8	$2s^22p^2(^3P)3d\ ^4F_{3/2} - 2s^2\ 2p^2(^3P)4f\ 1[3]_{5/2}$
8	992.42	0.44	100763.8	3.4	$2s^22p^2(^3P)3d\ ^4F_{9/2} - 2s^2\ 2p^2(^3P)4f\ 2[5]_{11/2}$
5	993.09	0.07	100695.8	4.8	$2s^22p^2(^3P)3d\ ^4F_{5/2} - 2s^2\ 2p^2(^3P)4f\ 1[3]_{7/2}$
7	993.78	0.81	100625.9	5.9	$2s^22p^2(^3P)3d\ ^4F_{7/2} - 2s^2\ 2p^2(^3P)4f\ 1[4]_{9/2}$
4	993.97	4.23	100606.7	7.8	$2s^22p^2(^3P)3d\ ^4F_{3/2} - 2s^2\ 2p^2(^3P)4f\ 0[3]_{5/2}$
4	995.20	0.19	100482.3	2.8	$2s^22p^2(^3P)3d\ ^4F_{5/2} - 2s^2\ 2p^2(^3P)4f\ 0[3]_{7/2}$
4	995.61	0.52	100440.9	40.61	$2s^2\ 2p^2(^3P)3p^4S_{3/2} - 2s^2\ 2p^2(^3P)4s^4P_{1/2}$
5	995.89	0.95	100412.7	2.9	$2s^22p^2(^3P)3d\ ^4F_{7/2} - 2s^2\ 2p^2(^3P)4f\ 1[3]_{7/2}$
5c	998.25	0.28	100175.3	82.5	$2s2p^3(^5S)3d\ ^6D_{9/2} - 2s2p^3(^5S)\ 4f\ ^6F$
5c	998.25	0.28	100175.3	78.8	$2s2p^3(^5S)3d\ ^6D_{7/2} - 2s2p^3(^5S)\ 4f\ ^6F$
3	1002.06	0.15	99794.4	4.9	$2s^2\ 2p^2(^3P)3p^2P_{1/2} - 2s^2\ 2p^2(^3P)4s^2P_{1/2}$
5	1021.91	0.98	97856.0	7.0	$2s^22p^2(^3P)3d\ ^4D_{5/2} - 2s^2\ 2p^2(^3P)4f\ 0[3]_{7/2}$
5	1022.82	0.89	97768.9	8.7	$2s^22p^2(^3P)3d\ ^4D_{3/2} - 2s^2\ 2p^2(^3P)4f\ 2[2]_{5/2}$
7	1023.46	0.48	97707.8	7.4	$2s^22p^2(^3P)3d\ ^4D_{7/2} - 2s^2\ 2p^2(^3P)4f\ 2[4]_{9/2}$
3	1023.94	4.10	97662.0	2.4	$2s^22p^2(^3P)3d\ ^4D_{7/2} - 2s^2\ 2p^2(^3P)4f\ 2[3]_{7/2}$
5	1024.49	0.54	97609.5	9.4	$2s^22p^2(^1D)3d\ ^2F_{7/2} - 2s^2\ 2p^2(^1D)4f\ 2[4]_{7/2}$
4	1025.98	6.03	97467.8	7.2	$2s^22p^2(^1D)3d^2F_{5/2} -2\ s^2\ 2p^2(^1D)4f\ 2[4]_{7/2}$
6	1026.72	0.77	97397.5	6.8	$2s^22p^2(^1D)3d\ ^2G_{9/2} - 2\ s^2\ 2p^2(^1D)4f\ 2[5]$
4	1027.24	0.23	97348.2	6.8	$2s^22p^2(^3P)3d\ ^2D_{3/2} - 2s^2\ 2p^2(^3P)4f\ 1[3]_{5/2}$
4	1029.52	0.64	97132.6	1.8	$2s^22p^2(^3P)3d^2P_{3/2} - 2s^2\ 2p^2(^3P)4f\ 0[3]_{5/2}$

3	1033.76	0.82	96734.3	3.7	$2s^22p^2(^3P)3d\ ^4D_{3/2} - 2s^2\ 2p^2(^3P)4f\ 1[2]_{5/2}$
3	1035.90	0.97	96534.4	5.4	$2s^22p^2(^3P)3d^4D_{7/2} - 2s^2\ 2p^2(^3P)4f\ 1[4]_{9/2}$
3	1038.38	0.37	96303.9	5.0	$2s^22p^2(^3P)3d\ ^4D_{5/2} - 2s^2\ 2p^2(^3P)4f\ 0[3]_{7/2}$
3bl	1039.07	0.16	96239.9	40.8	$2s^22p^2(^1D)3d^2G_{9/2} -2s^2\ 2p^2(^1D)4f\ 2[4]_{7/2}$
3	1059.95	60.02	94344.1	3.8	$2s^22p^2(^3P)3d\ ^4P_{5/2} - 2s^2\ 2p^2(^3P)4f1[3]_{7/2}$
4	1060.86	0.90	94263.1	3.6	$2s^22p^2(^3P)3d\ ^2F_{5/2} - 2s^2\ 2p^2(^3P)4f\ 1[4]_{7/2}$
8	1062.37	0.44	94129.2	31.8	$2s^22p^2(^3P)3d\ ^2F_{7/2} - 2s^2\ 2p^2(^3P)4f\ 2[5]_{9/2}$
5c	1063.89	0.88	93994.7	4.6	$2s^22p^2(^3P)3d\ ^2F_{5/2} - 2s^2\ 2p^2(^3P)4f\ 1[3]_{7/2}$
5c	1063.89	0.88	93994.7	5.5	$2s^22p^2(^1D)3d^2D_{3/2} - 2s^22p^2\ (^1D)4f\ 2[3]_{5/2}$
4	1064.50	0.52	93940.8	39.7	$2s^22p^2(^1D)3d\ ^2D_{5/2} -2s^22p^2\ (^1D)4f\ 2[3]_{5/2}$
2	1066.31	0.29	93781.4	2.6	$2s^22p^2(^3P)3d\ ^2F_{5/2} - 2s^2\ 2p^2(^3P)4f\ 0[3]_{7/2}$
7	1343.57	4.6	74428.6	7.8	$2s^22p^2(^3P)3d\ ^4F_{5/2} - 2s^2\ 2p^2(^3P)4p\ ^4D_{3/2}$
6	1356.24	0.6	73733.3	2.3	$2s^22p^2(^3P)3d\ ^2F_{7/2}\ \_2s^2\ 2p^2(^3P)4p^2D_{5/2}$
4	1421.93	2.0	70326.9	7.9	$2s^22p^2(^3P)3d\ ^4P_{3/2}\ \_2s^2\ 2p^2(^3P)4p^4P_{1/2}$
2	1494.32	3.4	66920.1	19.1	$2s^22p^2(^3P)3d\ ^2D_{5/2}\ \_2s^2\ 2p^2(^3P)4p^2D_{5/2}$
3	1617.47	0.9	61824.9	2.2	$2s^2\ 2p^2(^3P)3p^2S_{1/2} - 2s^2\ 2p^2(^3P)3d^4D_{1/2}$
2a	1787.61	0.65	55940.6	39.6	$2s^2\ 2p^2(^3P)3p^4D_{3/2} - 2s^2\ 2p^2(^3P)3d^4D_{5/2}$
1	1787.96	0.93	55299.7	9.9	$2s^2\ 2p^2(^3P)3p^4D_{3/2} - 2s^2\ 2p^2(^3P)3d^4D_{3/2}$
2	1799.25	0.23	55578.7	8.84	$2s^2\ 2p^2(^3P)3p^4D_{5/2} - 2s^2\ 2p^2(^3P)3d^4D_{3/2}$
2	1814.57	0.62	55109.5	8.71	$2s^2\ 2p^2(^3P)3p^4D_{7/2} - 2s^2\ 2p^2(^3P)3d^4D_{5/2}$
1d	1814.72	0.69	55104.9	5.3	$2s^2\ 2p^2(^3P)3p^4P_{1/2} - 2s^2\ 2p^2(^3P)3d^4P_{3/2}$
4	1841.04	0.06	54317.1	7.06	$2s^2\ 2p^2(^3P)3p^4P_{5/2} - 2s^2\ 2p^2(^3P)3d^4P_{5/2}$
4	1841.78	0.78	54295.3	5.68	$2s^2\ 2p^2(^3P)3s^4P_{1/2} - 2s^2\ 2p^2(^3P)3p^4S_{3/2}$
8	1931.37	0.36	51776.7	7.6	$2s^2\ 2p^2(^3P)3p^4D_{1/2} - 2s^2\ 2p^2(^3P)3d^4F_{3/2}$
3	1939.30	0.29	51565.0	4.8	$2s^2\ 2p^2(^3P)3p^4D_{3/2} - 2s^2\ 2p^2(^3P)3d^4F_{3/2}$
2	1985.25	0.25	50371.5	1.4	$2s\ 2p^3(^5S)3p^6P_{3/2} - 2s\ 2p^3(^5S)3d^6D_{1/2}$

(*continued*)

Table 2. Continued

	Wavelengths		Wavenumber		
Intensity	λ_{obs} (Å)	λ^a (Å)	σ_{obs} (cm^{-1})	σ_{cal} (cm^{-1})	Assignment
3	1985.41	0.41	50367.4	7.1	$2s\ 2p^3(^5S)3p\,^6P_{3/2} - 2s\ 2p^3(^5S)3d\,^6D_{3/2}$
2	1985.68	0.68	50360.6	60.7	$2s\ 2p^3(^5S)3p\,^6P_{3/2} - 2s\ 2p^3(^5S)3d\,^6D_{5/2}$
1	1987.33	0.33	50318.8	9.0	$2s\ 2p^3(^5S)3p\,^6P_{5/2} - 2s\ 2p^3(^5S)3d\,^6D_{3/2}$

[a]Reported wavelength values from Ref. [7].
bl, blended line; d, diffuse line; a, asymmetric line;
c, double classification.

Table 3. New and adjusted energy level values in Ne IV

Designation	New energy levels (cm^{-1})	Adjusted energy level (cm^{-1})	Energy levels from Ref. [7] (cm^{-1})
$2s2p^3(^5S)3s\ ^4S_{1/2}$		588019	588023
$2s^22p^2(^3P)4s\ ^4P_{1/2}$		633427	633434
$2s^22p^2(^3P)4s\ ^4P_{3/2}$		633793	633795
$2s^22p^2(^3P)4s\ ^4P_{5/2}$		634368	634371
$2s^22p^2(^3P)4s\ ^2P_{1/2}$		636502	636497
$2s^22p^2(^3P)4s\ ^2P_{3/2}$		637222	637225
$2s^22p^2(^3P)4p\ ^4D_{1/2}$		647284	647290
$2s^22p^2(^3P)4p\ ^4D_{3/2}$		647405	647410
$2s^22p^2(^3P)4p\ ^4D_{5/2}$		647664	647660
$2s^22p^2(^3P)4p\ ^4D_{7/2}$		648033	648020
$2s^22p^2(^3P)4p\ ^4P_{3/2}$		650061	650040
$2s^22p^2(^3P)4p\ ^2D_{5/2}$		654119	654110
$2s^22p^2(^3P)4p\ ^4S_{3/2}$	655665		
$2s^22p^2(^3P)4p\ ^2P_{3/2}$	656446		
$2s^22p^2(^1D)4s\ ^2D_{3/2}$		664369	664371
$2s^22p^2(^1D)4s\ ^2D_{5/2}$		664368	664374
$2s2p^3(^3D)3s\ ^2D_{3/2}$		667682	667690
$2s^22p^2(^3P)4d\ ^4D_{5/2}$		669036	669040
$2s^22p^2(^3P)4d\ ^4D_{7/2}$		669280	669270
$2s^22p^2(^3P)4d\ ^2F_{5/2}$		670901	670910
$2s^22p^2(^3P)4d\ ^2F_{7/2}$		671545	671560
$2s^2\ 2p^2(^3P)4f\ 0[3]_{5/2}$		673388	673369
$2s^2\ 2p^2(^3P)4f\ 1[3]_{5/2}$		673603	673599
$2s^2\ 2p^2(^3P)4f\ 1[2]_{3/2}$	673845		
$2s^2\ 2p^2(^3P)4f\ 1[2]_{5/2}$		673879	673874
$2s^22p^2(^3P)4d\ ^2D_{5/2}$		673879	673869
$2s^2\ 2p^2(^3P)4f\ 1[4]_{9/2}$		673885	673880
$2s^22p^2(^3P)4f\ 2[1]_{3/2}$	674204		
$2s^22p^2(^3P)4f\ 2[1]_{1/2}$	674216		
$2s^2\ 2p^2(^3P)4f\ 2[2]_{5/2}$		674914	674912
$2s^2\ 2p^2(^3P)4f\ 2[3]_{7/2}$		675012	675004
$2s^2\ 2p^2(^3P)4f\ 2[3]_{5/2}$	675101		
$2s^2\ 2p^2(^3P)4f\ 2[4]_{7/2}$	675201		
$2s^2\ 2p^2(^1D)4d\ ^2F_{7/2}$		698096	698090
$2s^2\ 2p^2(^1D)4d\ ^2G_{7/2}$		698853	698844
$2s^2\ 2p^2(^1D)4d\ ^2G_{9/2}$		698865	698844
$2s^2\ 2p^2(^1D)4d\ ^2D_{5/2}$		699930	699905
$2s^2\ 2p^2(^1D)4f\ 2[4]_{7/2}$		703251	703247
$2s2p^3(^5S)4s\ ^6S_{5/2}$		722809	722811

Ab initio relativistic Hartree-Fock calculations were used to interpret the structure of the energy level values. The new energy level values are presented in Table 3. For the $2s^2\ 2p^2(^1D)4f\ 2[4]_{7/2}$ energy level with value in 703251 cm^{-1}, it was possible to determine the J value. The same was made for the $2s^2\ 2p^2(^1D)4f\ 2[3]_{5/2}$ energy level with value in 703360 cm^{-1}, taken from Ref. [7] and not included in Table 3. The adjusted energy level values included in the same table were obtained in an iterative procedure where the wavenumbers of the observed lines are weighted according to their estimated uncertainties, considering not less than three of our improved transitions for each adjusted level value, except for the energy level values in 698853 and 698865 cm^{-1} determined by only one line, where it was also possible to determine the J value.

In our case, the relative uncertainty of separation between the given values is generally less than 2 cm^{-1}. With this procedure, we improve the values for 32 energy levels reported in Ref. [7]. All level designations are taken from the same reference.

We observed two lines at 589.78 and 590.31 Å (590.29 Å in Ref. [7]), with intensities 2 and 2d respectively, that could be classified as $2s^2 2p^2(^1D)3p\ ^2F_{5/2} - 2s^2\ 2p^2(^1D)5s\ ^2D_{3/2}$ and $2s^2 2p^2(^1D)3p\ ^2F_{7/2} - 2s^2\ 2p^2(^1D)5s\ ^2D_{5/2}$, respectively. These transitions would permit determination of the J value for the $2s^2\ 2p^2(^1D)5s\ ^2D$ energy levels, in 724860 cm^{-1} for $J = 5/2$ and 724872 cm^{-1} for $J = 3/2$, although they have a small discrepancy with the uncertainty for the 724910 cm^{-1} value reported in Ref. [7].

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