SPECTRAL STUDY OF HIGHLY IONIZED NOBLE GASES USED FOR DIAGNOSTIC PURPOSES IN HIGH TEMPERATURE PLASMAS.

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Abstract

We have studied the spectra of highly charged ions of argon, krypton and xenon with few valence electrons, in the 300-2100 Å range using a pulsed-discharge tube. In the spectral analysis we used isoelectronic comparisons and atomic calculations. We found new energy levels and classified lines and, in the existing level values, the uncertainty has been considerably decreased.

1. Introduction

In the thermonuclear-fusion experiments plasmas produced by inert gases like argon, krypton and xenon are studied because they are present as impurities in the fusion machines.

The spectroscopic data of these highly ionized noble gases, are employed in fusion devices for plasma diagnosis as well as for estimating the effect of impurity ions in high temperature plasmas.

In particular, the spectra of highly ionized atoms isoelectric with neutral Na, Mg, Al, Cu, Zn, Ga, Ge and Ag have attracted much interest in recent years, and a great number of theoretical and experimental data were published[1].

We report here results about spectra of highly charged ions of argon, krypton and xenon.

2. Experiment

The light source employed is a device adapted to the low VUV region[2]. It was made from a pyrex tube with one end of the tube connected to a vacuum spectrograph through a nylon flange adaptor. The other end has a glass window for observing the discharge and alignment of the tube. The electrodes, 20 cm apart, were made of tungsten covered with indium. At one side of the tube there is an inlet connected via a pressure reduction system to the bottles of noble gases. A continuous flow of gas was achieved this way during the exposures. The gas pressure was measured by a thermocouple vacuum gauge before and after the exposures. The pressure range was varied between 20 and 300 mTorr.

Gas excitation was produced by discharging through the tube a bank of low inductance capacitors varying between 2.5 and 100 nF and charged up to 19 kV.

The current was observed by using a Rogowski coil. It was a damped sinusoidal with a period of 2 μs having peak values between 1 and 1.5 kA.

Light radiation emitted axially was analyzed using a 3-m normal incidence vacuum spectrograph with a concave diffraction grating of 1200 lines/mm. The plate factor in the first order is 2.77 Å/mm. Ilford Q-2 plates were used to record the spectra. C, N, O, and known lines of argon, krypton and Xe spectra were also recorded as internal wavelength standards.

To distinguish among different states of ionization, a number of experimental parameters, e.g., gas pressure, discharge voltage, and capacitance, were varied.

3. Result

Isoelectronic sequences and theoretical predictions of the energy levels of the studied configurations have been used in the analysis of the different spectra of Xe, Kr, and Ar obtained between [illegible] and 2100 Å with the described spectral source.

The theoretical predictions were obtained by diagonalizing the energy matrices with appropriate Hartree-Fock[3] values for the energy parameters, and using multiconfigurational Dirac-Fock calculations[4].

We obtained and studied spectra related with diagnostic purposes in high temperature plasmas of Xe, from Xe V to Xe VIII, Kr, from Kr V to Kr VIII, and Ar, from Ar V to Ar VIII. New level values were determined for Kr VII [ref 5] and Kr VIII [ref 6]. In Xe V and Xe VIII the determination of new level values and classiffied lines is in progress.

In Ar VI, lines observed are given in Table 1 where all of them are classiffied in accordance with the theoretical predictions of Fawcett[7], and in the rest, the uncertainty of the wavelength value has been decreased with respect to previous experimental results using other kind of sources[8,9].

TABLE 1 Wavelengths of Ar VI emission lines

λ(Å) theory [ref 7]	λ(Å) Experimental	
	This Work	Other Experiments
455.62	455.48	455.4 (a)
460.69	460.77	460.9 (a)
463.78	463.489	463.4 (a) 477.7 ± 0,15 (b)
470.92	470.94	470.7 (a)
502.52	502.38 502.49	502.1 (a)
505.56	505.496	505.5 (a) 502.2 ± 0,2 (b)
545.7	545.53(*)	
545.91	545.82(*)	
553.83	553.86	553.6 (a) 574.05 ± 0,3 (b)
583.10	582.91 583.002	582.3 (a)
584.77	584.87	583.4 (a)

TABLE 1 (cont.)

603.72	603.63(*)	
603.87	603.82(*)	
	603.9 (*)	
614.22	613.87(*)	
614.48	614.3 (*)	
634.1	633.85	633.4 (a)
759.99	759.4	758.1 (a)
760.05	759.90(*)	

(*) New transitions

(a) Ref. 6

(b) Ref. 9

Aknowledgements

The financial support of the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), the Comisión de Investigaciones Científicas de la Provincia de Buenos Aires (CIC), Argentina, and the Conselho Nacional de Desenvolvimento Científico e Technologico (CNPq), Brasil, is gratefully aknowledged.

M. Gallardo is CONICET researcher, M. Raineri is CIC fellow, and J. Reyna Almandos and F. Bredice are CIC researchers.

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