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VUV SPECTROSCOPY OF Ar^{9+} AND Kr^{9+} LOW ENERGY COLLISION WITH H_2

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Photon spectroscopy of low energy collisions between multicharged ions and neutrals has opened new possibilities of wavelength and energy level determination since recent multicharged ion sources like the E.C.R. source, giving μA electric current of highly multicharged ions, are available.

The experimental set-up has been already described (1,2). The ion beam is produced by an E.C.R. ion source. Light emitted as a result of the collision is observed at 25° to the beam axis with a 3m grazing incidence (82°) spectrometer equipped with a 300 or 600 lines/mm grating blazed at 55.2 or 27.6 nm respectively. The detection is realised by micro-channel plates (MCP). Typical beam currents are 0.45 and 0.40 μA for Kr^{9+} and Ar^{9+} respectively, through the 8 mm diameter entrance hole of the gas cell. The gas pressure was kept at 5×10^{-5} mbar. The emission cross sections of all the new observed lines have been measured. Taking into account the statistics; the error on the beam intensity due to double collisions; the errors on the pressure, on the relative efficiency curve of the spectrometer and on the absolute calibration, we may estimate the error bar to $\pm 30\%$.

This spectroscopic source bring together the properties of beam sources (mass and charge purity of the ions) with the properties tied up with the physic of electron exchange.

Lines come mainly from ions having one known charge obtained by one electron capture (true with H target ; spectra are a little more complicated with He and H_2 due to two electron exchange and double collisions which is minimised with low pressure target).

The electron capture is selective on a given principal quantum number n , which means that we know the maximum n from which we may observe transitions to lower n' first directly and secondly by cascading process. The identification of lines is then facilitated.

In addition to these spectroscopic results, charge exchange collision study leads also to the determination of capture cross sections which are interesting in the fusion problems. The great quantity of results obtained in these recent years gives an opportunity to test the computation codes of charge exchange processes.

We present here our preliminary results on the collisions of Ar^{9+} and Kr^{9+} with H_2 at 90 KeV energy.

Typical spectra obtained at 1.07 and 2.25 kev/amu for KrIX and ArIX are displayed in figure 1 and 2 respectively. All KrIX lines of figure 1 are observed for the first time and are tentatively identified to transitions from $n=4$ levels following calculations of Wyart and Ryabtsev (3). Some

Figure 1. Partial spectrum from $\text{Kr}^{9+} \cdot \text{H}_2$ collisions at 1.07 Kev/amu

Figure 2. Partial spectrum from $\text{Ar}^{9+} \cdot \text{H}_2$ collisions at 2.25 Kev/amu

weak KrVIII lines appear also in this spectrum. They may be due to double collisions process as we have previously observed for other ions in collision with H_2 . The spectrum of figure 2, between 100 Å and 200 Å, shows only new lines of ArIX. Identification are based on Fawcett calculation (4). Upper levels are $n=4$ and $n=5$.

The emission cross sections of newly observed KrIX and ArIX lines are reported in tables 1 and 2

Complete results on spectroscopy and electron capture cross sections will be published later with more details and for much more observed transitions and levels, in both KrIX and ArIX.

This experiment was carried out at the GIS-AGRIPPA-CEA-CNRS, Grenoble.

TABLE I

New lines observed in Kr IX during the collision $Kr^{9+} + H_2$ at 1.07 Kev/amu.
Emission cross sections σ_{em} ($10^{-17} cm^2$) within $\pm 30\%$ accuracy.

$\lambda(\text{\AA})$ our work	Identification (Wyart and Ryabtsev) (JN) ^a	λ théorique	σ_{em}
402.6 ± 0.5	$3d^9 4p(3,1) - 3d^9 4d(4,1)$	402.0	66
418.2 ± 0.5	(JN) - (JN)	415.2-419	106
585.0 ± 1	$3d^9 4s(3,1) - 3d^9 4p(3,2)$	583.6	43
600.0 ± 1	(2,1) - (2,3)	599.3	45
618.9 ± 0.5	(3,1) - (4,1)	617.8	86
	(2,2) - (3,3)	617.8	
641.4 ± 0.5	(2,1) - (1,1)	640.5	20
662.1 ± 0.5	(1,1) - (2,2)	661.1	48
	(2,1) - (3,1)	663.0	
674.5 ± 0.5	(3,1) - (2,1)	674.2	38

a/Reference 3

TABLE II

New lines observed in ArIX during the collision $Ar^{9+} + H_2$ at 2.25 Kev/amu.
Emission cross sections σ_{em} ($10^{-17} cm^2$) within $\pm 30\%$ accuracy.

$\lambda(\text{\AA})$ our work	Identification (Fawcett)	λ théorique	σ_{em}
115.2 ± 0.5	$2p^5 3p^3 D - 2p^5 5d^3 F$	115.2	29
138.0 ± 0.5	$3s^3 P - 4p^3 S$	137.2	12
153.4 ± 0.5	$3p^1 P - 4d^3 F$	152.7	10

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