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Wavelength and lifetime measurements on intercombination lines of Ag XVIII, Ag XVII and Ag XVI (Zn I, Ga I, and Ge I-like)

ABSTRACT AND INTRODUCTION

Intercombination lines are frequently used in the diagnosis of solar and terrestrial plasmas. A number of recent review papers have been devoted to the subject (see Träbert et al. 1988, Ellis et al. 1989). Much of the more recent progress in the identification of $\Delta n=0$ intercombination transitions has been achieved by exploiting the time resolution inherent in the observation of foil-excited fast ion beams. The present study gives results of such work on Ag ions of the isoelectronic sequences of Zn, Ga and Ge. The results are compared with predictions from semi-empirically scaled and or ab-initio calculations.

EXPERIMENT

The experiment was done at the Bochum 4 MV Dynamitron tandem accelerator laboratory. Ag ions of energies of 19 MeV and of 25 MeV were excited by being passed through a thin carbon foil. A grazing-incidence spectrometer equipped with a low dark rate channeltron detector analyzed the light emitted by the ion beam at right angles. Further details of the experimental apparatus and procedures are given elsewhere (Träbert et al. 1988, Träbert 1989).

Spectra were recorded in the wavelength range λ = 18 - 70 nm, at various distances downstream of the foil. Decay curves were recorded at the positions of all sufficiently strong intercombination lines and were analyzed by multi-exponential computer fits. The results are listed in table 1.

DISCUSSION

A lifetime study of the Ag XVIII intercombination line (λ=35.1804nm, Churilov et al. 1988) has been reported by Träbert (1989) and corroborated by new decay curve data. The agreement with the results of an ab-initio MCRRPA calculation (Huang et al. 1985) is excellent. The results of a semi-empirically adjusted Hartree-Fock Relativistic calculation (Biémont et al. 1989) deviate considerably from these results, probably because of a non-optimum choice of the scaling parameters (Fig. 1). The low-Z trend of the latter, however, seems to be closer to experiment than that of the MCRRPA calculation.

The intercombination lines in Ga- and Ge-like Ag have been identified in the wavelength range λ = 32 - 40 nm, in rough agreement with various calculations. The lifetime of the Ag XVII 4 $^4P_{1/2}$ level has been established from decay curves recorded at the $^2P^o{}_{1/2}$ - $^4P_{1/2}$ transition at λ = 35.908 nm. The Ag XVII 4 $^4P_{3/2}$ level has two decay branches. The $^2P^o{}_{3/2}$ - $^4P_{3/2}$ line (at λ = 39.695 nm) is the stronger one and yielded a lifetime of 8.6 ns.

The Ga-like $^2P^o{}_{3/2}$ - $^4P_{5/2}$ line at 36.439 nm is blended with the Ge-like $^3P_1$ - $^5S^o{}_2$ at 36.551 nm. The predicted lifetimes of both levels involved (see table 1) differ by only about 60%. This makes it almost impossible to separate the two major decay components in the superimposed experimental decay curves. The observed effective decay time of 1.3 ns is compatible with a range of pairs of lifetimes of the two levels. This "time blend" can be partly disentangled by a lifetime measurement on the other decay branch of the Ge-like quintet level, $^3P_2$ - $^5S^o{}_2$, at 38.66 nm.

These are the first lifetime measurements on intercombination transitions in Ga- and Ge-like ions. The lifetimes of these levels as calculated by different codes scatter and also differ from the experimental findings by 10 to 30%. However, this present mismatch may be expected to decrease when dedicated calculations will be done.

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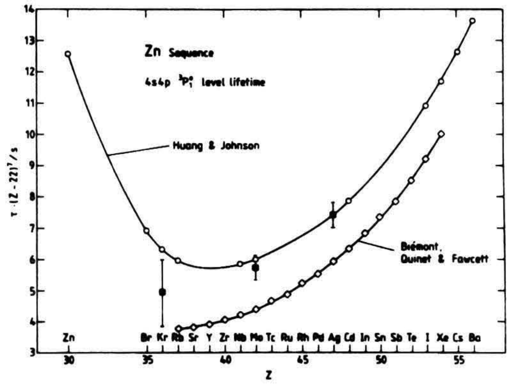

Fig. 1: Scaled transition probability of the intercombination transition in the Zn I sequence. Experimental data: Kr (Pinnington et al. 1984), Mo and Ag (Träbert 1989 and this work), Theoretical predictions: Huang et al. (1985), Biémont et al. (1989)

Table 1: Lifetimes of the lowest levels in the high-multiplicity term systems of Ag XVIII (Ag^{17+}), Ag XVII (Ag^{16+}) and Ag XVI (Ag^{15+}).

Spectrum	Level	Lifetime τ / ns Experiment	Theory
XVIII	$^3P^o_1$	1.20±0.06	$1.224^{a,b}$
		1.18 ± 0.08^c	0.974^d
XVII	$^4P_{1/2}$	1.05±0.10	1.277^b
			0.905^e
XVII	$^4P_{3/2}$	8.60±0.40	6.750^b
			6.047^e
XVII	$^4P_{5/2}$	1.13±0.15	0.999^b
			0.941^e
XVI	$^5S^o_2$	2.10±0.30	1.52^b

a Huang et al. (1985)
b Fawcett (1988)
c Träbert (1989)
d Biémont et al. (1989)
e Kaufman (1988)

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