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Renormalization of oscillator strengths in aluminum

ABSTRACT

Renormalization of the lifetime values and oscillator strengths of aluminum levels is necessary. The data available are not sufficiently reliable. Accurate values obtained until now are given; plans for future experiments are described.

DESCRIPTION

Aluminum is an important element in astronomical spectra. A large number of AlI lines are present in the solar spectrum. Moreover, the element is of physical interest: it demonstrates strong configuration interaction effects, especially the $3s^2nd\ ^2D$ series, which is perturbed by the $3s3p^2(^1D)\ ^2D$ term. The perturbing term without interaction is situated between the states n=4 and n=5. The interaction affects the whole series and its influence on lifetimes, level positions etc. can be observed up to the high n values (Buurman, 1989a).

For astronomical applications the oscillator strengths in the lowest part of the spectrum are of special interest. Penkin and Shabanova (1965) published experimental values of oscillator strengths of the sharp and diffuse series for n<12. The experimental values show a discontinuity between n=4 and n=5, which is in accordance with calculations of Weiss (1974) and others. Penkin and Shabanova's values for the oscillator strengths have been normalized by Wiese using one accurate lifetime value obtained by Buddick for the 3p-3d transition (Wiese, 1969 and references therein). As far as we know these are upto now, except for measurements by Buurman et al (1986,1989b), the only experimental data for the oscillator strengths of this series.

Jönsson et al (1984) have measured the lifetimes along the series upto n=12. The claimed accuracy is 10%. These lifetime values may be compared with the normalised values from Wiese. However, with the exception of n=4, the deviations are between +25 and +30 %.

A renormalization of the experimental data from Penkin and Shabanova based on new accurate lifetime measurements is therefore required. We are undertaking such a systematic study of the lifetime values of the lowest part of the nd ^2D and ns ^2S series together with a study of other observables for the higher members of these Rydberg series.

In the experiment aluminum atoms in an atomic beam are excited by a short pulse of dye laser radiation (pulse duration 6ns). Population of the levels of the ^2P series is achieved by non-resonant two step excitation. The levels of the ^2S and ^2D series are excited directly by frequency-doubled radiation from the dye laser.

The fluorescent light from the excited atoms is detected by a fast photomultiplier (risetime ~ 1 ns). By optical filtering corrections for cascades are made. The signals are recorded by a fast multichannel system coupled to a personal computer. Averaging over a large number of laserpulses increases the signal/noise ratio to an acceptable level.

Normal precautions are taken to prevent influence of multiple scattering, collisions, flight out of view and saturation of the photomultiplier tube and electronic devices.

Table 1. Lifetimes in AlI (in ns). Error limits are given in parentheses

	Buurman et al. (1986,1989b) experiment	theory	Jönsson (1984) experiment	Wiese (1969)
$4s^2S_{1/2}$	6.92 (7)	5.54		6.8
$5s^2S_{1/2}$	19.8 (5)	16.1	24 (4)	25
$4p^2P_{1/2}$	65 (2)	52.9		
$4p^2P_{3/2}$	60.5 (9)	52.9		
$5p^2P_{1/2,3/2}$	275 (8)	200		
$3d^2D_{3/2,5/2}$	14.0 (2)	12.0	16 (3)	13.7
$4d^2D_{3/2,5/2}$	29.5 (7)	26.4	29 (4)	37.9

Experimental and calculated values for the lifetimes of the lowest part of the spectrum obtained till now, are given in table 1.

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