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REGULARITIES IN THE DISTRIBUTION OF OSCILLATOR STRENGTHS OF LINES IN SPECTRA OF ALKALI METAL ATOMS AND THEIR ISOELECTRONIC IONS

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Abstract—Regularities in the distribution of oscillator strengths of lines in spectra of alkali metal atoms and their isoelectronic ions are established. It is established that the linear dependence described the oscillator strengths of transitions, for which the principal quantum numbers of the upper and lower states are simultaneously changed by unity.

INTRODUCTION

At present abundant literature data[1,2] exist on oscillator strengths (f_{ik}) and transition probabilities (A_{ik}). These data need generalization, critical analysis and establishing regularities in their distribution. For example, in Ref. 3 the following interesting regularity was found: the stability of oscillator strengths for identical transitions n_ip–n_ks in the homologous series NaI–CsI, AlI–TlI and NeI–XeI. In Ref. 4 analogous regularities for ions isoelectronic to alkali metal atoms and for other homologous series were demonstrated. The behavior of the oscillator strength of a transition through an isoelectronic sequence is an important feature in evaluating the reliability of various theoretical predictions as well as experimental determinations[5–7].

In Ref. 8 a regularity in the dependence of oscillator strengths of spectral lines on the change in principal quantum numbers of the lower (n_i) and upper (n_k) levels in spectra of homologous series NaI and AlI was established. It was shown that when transitions e.g. n_is–n_kp for sodium are written in the form $(n_i+j)s$–$(n_i+j+m)p$, where $n_i=3$ is the principal quantum number of the normal state NaI, $j=0, 1, 2, 3\ldots$ and $m=0, 1, 2, 3\ldots$, a linear dependence of the f_{ik} values on j at given m value is observed, i.e. the linear dependence describes the oscillator strengths of transitions with n_i and n_k simultaneously changed by unity. These dependencies were approximated by

$$f_{ik}^{\text{app}} = A(m)^*j + B(m). \tag{1}$$

The aim of this paper is to analyze analogous regularities for alkali metal atoms (LiI, NaI, KI, RbI, CsI, FrI) and their isoelectronic ions. The analysis is based on data of Ref. 9 where for these atoms and ions the f_{ik} values have been calculated in the Coulomb approximation.

It should be noted that previously established regularities mainly hold for considering atomic systems as well. However, some transitions of a number of ions have their own features. Let us consider regularities for transition of each type.

TRANSITION $(n_i+j)s$–$(n_i+j+m)p$

For the isoelectronic series NaI the dependencies are described by expression (1) with the correlation coefficient $R > 0.999$ for all ions up to TiXII. The dependencies for KI, RbI, CsI and their isoelectronic ions are described using nearly the same R value. However, for higher levels the accuracy in calculating the f_{ik} values lowers and therefore the correlation coefficient has smaller values. For some transitions, e.g. at $m=1$ for AlIII lines the oscillator strengths change by several