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Abstract

Full Text

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ON THE REFINEMENT OF THE SPECTRAL SCHEME OF OIII USED IN CALCULATING ITS RECOMBINATION SPECTRUM IN STARS AND NEBULAE

(Presented by Academician V. G. Fesenkov, 27 III 1963)

The recombination spectrum of OIII was calculated in ⁽¹⁾ on the assumption that all levels of its energy scheme are described by *LS*-coupling. However, the question of how valid this assumption is for all levels without exception is not entirely clear and requires investigation and refinement.

In the present note, some results of the investigation undertaken are briefly set forth.

1. In the laboratory spectrum of OIII a certain number of intercombination lines forbidden in *LS*-coupling are observed, and the intensities of individual lines are comparable with the intensities of allowed lines ⁽²⁾. These lines are for the most part associated with the levels $2p3d^1D_2$, $2p3d^3F_2$, $2p4p^3,1P_1$, $1,3D_1$. Study of the energy scheme of OIII shows that the terms 1D and 3F overlap one another. To a lesser degree this also occurs for the other terms mentioned. The overlap of the terms 1D and 3F indicates that in this case, instead of *LS*-coupling, one must use an intermediate coupling. The parameters of this coupling, as well as the wave functions of the states 1D and 3F , were found by diagonalizing the energy matrix. With the aid of perturbation theory the wave functions of the $2p4p^3,1P$, $1,3D_1$ states were also determined. Knowledge of the wave functions made it possible to estimate approximately the probabilities of intercombination transitions for OIII in the visible and ultraviolet regions of the spectrum. In some cases (for example, the transition $2p3d^3F_2 - 2p^2^1D_2$) these probabilities are appreciable, and their inclusion is necessary in constructing the theoretical recombination spectrum.
2. The lower levels of OIII, belonging to the configurations $2p3s$, $2p3p$, $2p3d$ (with the exception of the terms 1D and 3F), are described rather well by *LS*-coupling. For higher levels, with a large value $l \geq 3$ in the configuration $2pnl$, such a conclusion cannot be drawn. Qualitative considerations on the nature of the coupling in these cases can be obtained by estimating the energy inequalities given in ⁽³⁾, which determine the type of coupling. The estimates made show that for the levels of the configurations $2p4f$, $5f$, $5g$,

etc., apparently a coupling intermediate between LS and LS_0 occurs, while for $2p5g$, LS_0 -coupling is more probable. (We note that lines associated with the levels of these configurations have not been observed at all in the spectrum of OIII.)

In the spectrum of NII, which belongs to the same isoelectronic sequence as OIII, levels of the configuration $2p4f$, etc., are observed, and, according to ⁽⁴⁾, their arrangement is described by one of the nonhomogeneous couplings; it may be assumed that the level schemes of OIII and NII of the configuration $2p4f$ have a number of common characteristics, clearly revealed in NII and less clearly in OIII.

3. As is known, the OIII lines in the spectra of planetary nebulae form incomplete multiplets, having as their origin the anomalously populated level $2p3d^3P_2$. Excitation of this level is at present explained by Bowen's fluorescent mechanism; however, it is of interest to attempt to determine whether the anomalous population of the level 3P_2 is not a consequence of the departure of the OIII level scheme from the LS -scheme, to which attention was drawn earlier in ⁽⁵⁾ with respect to the recombination process.

For this purpose, LS , LS_0 , Jj , and Jl -coupling in two-electron configurations were considered with the aid of work ⁽⁶⁾. Line strengths were determined for transitions to the levels $2p3d^3P_{2,1}$ from the levels $2pnf$, described by different couplings.

Study of such a table shows that the populations of the levels 3P_2 and 3P_1 may differ substantially. Only if there are anomalies in the distribution of O IV ions over the levels of the ground state will this be true for all couplings. On the other hand, the possibility is not excluded that the superposition of cascade and recombination transitions, described by different types of vector couplings in one or another model of the emitting envelope, may also be the cause of a certain anomalous character in the populations of particular levels or terms.

Thus, investigation of the energy scheme of O III shows that the construction of a theoretical recombination spectrum requires detailed knowledge of the energy schemes of the ion and of the atom formed, of the vector coupling describing the grouping of low and highly excited levels, and, in accordance with these data, poses the problem of an appropriate choice of the model of the emitting envelope.

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