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ENERGY LEVELS IN NEUTRAL ERBIUM

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JANUARY 1965

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GREENBELT, MARYLAND

[redacted]

ENERGY LEVELS IN NEUTRAL ERBIUM

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The recent advances[1] in the analysis of the $4f^{12}\ 6s^2$ configuration of ErI were brought about, in part, by a study of those emission lines which become self-reversed when excited in a very hot electrodeless discharge tube. Such lines are likely to correspond to transitions to the lowest energy levels[2] and hence afford a useful starting place in the analysis of such a complex spectrum as is exhibited by erbium. However, after an extensive analysis of the $4f^{12}\ 6s^2$ ground configuration, we found that 76% of these reversed lines remained unclassified. Apparently a second low-lying configuration, of odd parity, is overlapping the ground configuration.

The unclassified reversed lines were searched for any repeated intervals of significance, yielding four new levels. Upper and lower levels were then successively generated using the entire wavenumber catalogue of about 8000 lines[3]. The success of this search rested heavily upon the high precision of the wavenumbers ($\pm 0.015\ cm^{-1}$). Calculations were carried out with a searching program using an IBM-7094 computer. The 28 most reliable lower levels are listed in Table I. About 150 even upper levels were found, but only one even level was found lying below the new system. For reasons discussed below we suspect this to be the ground term, $^3H_6$, of $4f^{12}\ 6s^2$. Accordingly, the values listed in Table I are based upon an energy of 0.000 cm^{-1} for this level. Thus far over 900 lines have been classified as transitions to this system, including 94 out of the 210 remaining reversed lines.

Although the Zeeman data necessary for a determination of the g- and J-values of these new levels are not yet available, it is highly probable that the new odd terms do belong to the $4f^{11}\ 5d\ 6s^2$ (and possibly the $4f^{11}\ 5d^2 6s$) configurations. Similar configurations have been observed to be low-lying in other rare earth spectra[4,5,6]. One would expect transitions to $4f^{11}\ 5d\ 6s^2$ to show large positive isotope shifts[7], and 22 lines classified as transitions to the new system do show such shifts[8]. Three of the lines from the system to the lower even level mentioned above have large negative isotope shifts, as expected for a $4f^{11}\ 5d\ 6s^2 \rightarrow 4f^{12}\ 6s^2$ transition. Inasmuch as the low terms of $4f^{11}\ 5d\ 6s^2$ are likely to have high J-values (since the lowest term of $4f^{11}$ is $^4I_{15/2}$), it is probable that this low even level is the term in $4f^{12}\ 6s^2$ with the highest J-value This is the ground term, $^3H_6$. Moreover, it is worth noting that the 14 transitions to this level include the most intense lines in the red-yellow portion of the spectrum. Of course, final verification of these assignments must await additional Zeeman analysis.

TABLE I

Observed low-lying odd energy levels in ErI. Energies are given in cm^{-1}, with an estimated precision of ±0.005 cm^{-1}.

7176.508	16321.180
7696.959	16501.420
8620.570	17029.058
9350.109	17073.798
9655.854	17157.311
10557.920	17297.675
11401.197	17347.856
11557.674	17456.379
11799.783	17796.141
11887.509	18335.497
15083.117	18774.129
15185.349	19125.249
15846.553	19201.336
16070.100	19326.595

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