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Pressure Effects on Spectra of Tunable Laser Crystal GSGG:Cr^{3+} IV: Pressure-Induced Shifts of R_1 Line, R_2 Line, and U Band at 300 K

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Abstract: By means of both a theory for pressure-induced shifts (PS) of energy spectra and a theory for shifts of energy spectra due to electron-phonon interaction (EPI), the `pure electronic' PS and the PS due to EPI of R_1 line, R_2 line, and U band of GSGG:Cr^{3+} at 300 K have been calculated, respectively. The calculated results are in good agreement with all the experimental data. Their physical origins have also been explained. It is found that the mixing-degree of $|t_2^2(^3T_1)e^4T_2\rangle$ and $|t_2^{32}E\rangle$ base-wavefunctions in the wavefunctions of R_1 level of GSGG:Cr^{3+} at 300 K is remarkable under normal pressure, and the mixing-degree rapidly decreases with increasing pressure. The change of the mixing-degree with pressure plays a key role not only for the `pure electronic' PS of $R_1$ line and $R_2$ line but also the PS of $R_1$ line and $R_2$ line due to EPI. The pressure-dependent behaviors of the `pure electronic' PS of R_1 line (or R_2 line) and the PS of R_1 line (or R_2 line) due to EPI are quite different. It is the combined effect of them that gives rise to the total PS of R_1 line (or R_2 line). In the range of about 15 kbar$\sim$45 kbar, the mergence and/or order-reversal between $t_2^2(^3T_1)e^4T_2$ levels and $t_2^{32}T_1$ levels take place, which cause the fluctuation of the rate of PS for $t_2^2(^3T_1)e^4T_2$ (or $t_2^{32}T_1$) with pressure. At 300 K, both the temperature-dependent contribution to R_1 line (or R_2 line or U band) from EPI and the temperature-independent one are important.

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Key words: high-pressure effect, spin-orbit interaction, electron-phonon interaction, d orbital, tunable laser crystal.

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