Energy transfers in Nd:YAlO₃

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Energy transfer investigations in the solid-state laser material Nd : YAlO₃ have been carried out through the study of the Nd satellite structure (about twenty lines) around the $^4I_{9/2} (1) \rightarrow ^4G_{5/2} (1)$ and the $^4I_{9/2} (1) \rightarrow ^4F_{3/2} (1)$ transitions.

The experiments were achieved using technics of high resolution spectroscopy :

- optical absorption spectroscopy (resolution around 70 000);
- fluorescence spectra and decay measurements induced by selective excitations;
- monochromatic excitation, in the $^4G_{5/2} (1)$ level, of the fluorescence monitored on the 8754.75 Å line ($^4F_{3/2} (1) \rightarrow ^4I_{9/2} (1)$ transition). In this case the satellite structure appears clearly thanks to the reabsorption of the resonant fluorescence transition by the Nd ions outside the exciting laser beam. This reabsorption affects the intense fluorescence lines (i.e. relative to a large number of Nd ions), therefore essentially the main line. Its rate can be fitted by changing the distance between the beam and the exit surface.

In the continuous mode experiments the high resolution was obtained by use of a single mode dye laser, and the laser wavelengths were accurately calibrated (better than 0.1 cm⁻¹).

The investigated samples were 0.1%, 0.5% and 1% Nd concentrated and were helium cooled, the temperature being varied between 4K and 77K.

The investigation of the two spectra (around 5894.2 Å and 8754.75 Å) relative to the transitions between the ground level and the lowest Stark levels of the $^4G_{5/2}$ and $^4F_{3/2}$ multiplets, has proved that the spectral shifts of the satellites

with respect to the main line are due to a modification of the static crystal field. This is ascertained by the following facts :

- the proximity of a satellite from the main line changes according to the transition,

- the intensities of the satellite lines depend linearly on the concentration.

Moreover, no connection has been found between the spectral shifts of the satellite lines and the lifetimes of the corresponding excited Nd ions.

The whole of the study has shown that the Nd ions in the YAlO_3 host were belonging to different classes, and that different types of transfers were connected with the various classes. Nevertheless a common feature exists, which is the absence of any spectral diffusion, since the excitation remains localised on the excited ions.

Four classes of Nd ions have been distinguished :

- Isolated Nd ions in regular sites (relative to the main line). They exhibit an exponential decay with a relatively long lifetime (175 μs), and the fluorescence that they emit may be reabsorbed. The transfer that concerns these ions is a resonant radiative transfer.

- Isolated Nd ions in distorted sites. No quenching of the emitted fluorescence is observed, and the lifetime is of the same order of magnitude (120 μs) than the lifetime of the main line.

- Nd ions in the vicinity of a trap. They exhibit a fast non exponential decay (10 μs) and a quenching of the emitted fluorescence, which means that they are submitted to a fast transfer to the trap.

- Coupled Nd ions. At 4K, a selective excitation in any satellite line induces a one-line fluorescence spectrum. When the temperature is raised, and for two pairs of satellites, a selective excitation in one of the lines of one of the pairs induces a fluorescence spectrum made up of the two lines of the pair involved in the excitation. The phenomenon appears around 10K, and the equilibrium is reached at 35K.

Therefore the coupled ions undergo an intracouple transfer that is selective, fast, temperature dependant and concentration independant.

This paper is a summary of the results presented at the LASER M 2 P conference. The experimental details will be published in Journal of Luminescence.