Study of lasing threshold and efficiency in laser crystal powders

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Random lasers are the simplest sources of stimulated emission without cavity, with the feedback provided by a highly scattering disordered medium [1, 2]. This can be achieved, for example, compacting laser crystal powders (LCP). This type of laser has no spatial coherence, it is not stable in phase and its photon statistics are strongly different from that of a conventional laser. The potential applications of LCP as compact and mirrorless lasers where the coherence is not necessary motivate the study of their laser properties. As in conventional lasers, the most important properties of a random laser are the lasing threshold and the efficiency. The aim of this work is to analyze theoretically the dependence of lasing threshold and efficiency of LCP on the sample thickness, the volume fraction occupied by the particles and the mean particle size.

In LCP photon transport mean-free-path is usually much larger than wavelength and, therefore, the approximation for the light diffusion is satisfied. We have performed theoretical calculations by using three differential coupled equations: two diffusion equations for the pump and the emitted light and a rate equation for the active ion in the excited state. The photon mean-free-paths have been calculated using the Mie theory for spheres in the independent-scatterer approximation [3].

The study has been done in Neodymium borate laser crystal powders. A good agreement between our theoretical results and the experimental data has been obtained. Finally, an analytical expression for the efficiency in terms of the sample parameters has been worked out.

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