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Simulaser, a graphical laser simulator based on Matlab Simulink

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Abstract content
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Solid-state laser gain dynamics can be fairly accurately modelled using coupled rate equations for inversion population and cavity photon density. Numerical integration is typically required to simulate dynamics as general analytic solutions don't exist. These simulations are usually programmed in scripted programming languages like C and Java or higher level mathematical engines like Matlab and Mathematica. Customising these scripts for multiple laser systems can be complicated and time-consuming.

Matlab Simulink is a graphical programming environment, providing an additional layer of abstraction for simulating dynamic systems. Its primary interface is a graphical block diagramming tool and a customisable set of block libraries. In the work presented here a set of three (also four) level laser rate equations were derived and simplified with a single element, plane-wave approximation. The differential equations were vectorised and variables logically separated into gain medium and laser cavity terms. When implemented in Simulink, these terms become functional blocks that can be easily linked together with lines representing photon absorption and emission. Functional blocks for Q-switching and laser diagnostics were also developed. As a result, complex laser architectures can be easily simulated using a drag-and-drop interface, including multi-wavelength, multi-crystal designs, and active laser control and stabilisation schemes.

This simulation tool has been used to design and investigate a number of infrared laser systems at the CSIR. In particular, a comparison between simulated and measured results will be presented for an efficient Ho:YLF laser pumped by a Tm:fibre laser. This 2 µm laser consists of a Q-switched oscillator with two birefringent Ho:YLF crystals. The two crystals had their c-axes rotated 90° with respect to each other to optimise the unpolarised pump absorption. This two-crystal design is a good example of the flexibility of the simulation tool and the simplicity through which a relatively complex design can be investigated.

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