Modelling of Nonlinear Amplifier in the Mid-IR Region

B. Dutta Gupta[a,b,c], I. Hendry[a,b,c], S. Tang[a,b,c], M. Erkintalo[a,b] and C. Aguergaray[a,b,c]

[a]*Department of Physics, University of Auckland, New Zealand*

[b]*The Dodd-Walls Centre for Photonic and Quantum Technologies, New Zealand*

[c]*The Photon Factory, University of Auckland, New Zealand*

Broadband generation in the 2.5 - 4 μm region can find use in a host of applications such as molecular spectroscopy, remote sensing and LIDAR. Standard approach of generating a supercontiuum in a passive fibre seeded by an amplified pulse suffers from having low optical powers which makes it difficult for use in certain applications. The technique of nonlinear amplification, on the other hand, uses a piece of pumped active fibre to generate a broadband spectrum while simultaneously increasing the average power contained within that whole spectral range.

Here, we demonstrate a numerical model which can accurately capture the gain characteristics of a Er:ZBLAN fibre using experimental pump power along with absorption and emission cross-sections. The model shows excellent agreement with experimental results from mode-locked lasers and therefore allows us to analyze the features of a nonlinear amplifier. Broadband generation using a passive and pumped active fibre for two different sets of initial conditions are compared. For an input pulse with low energy and peak power, the output from the active fibre demonstrates an increase in bandwidth, as shown in Fig. 1(a), with ~3.2 times higher output power spread across the newly generated spectral components. In Fig. 1(b), it is observed that the advantages in terms of increased spectral broadening and output power are still maintained when the input pulse has higher energy and peak power, and the active fibre is pumped at relatively high power. The numerical model will be further used to guide the design of optimized nonlinear amplifiers by comparing different core diameters and doping concentrations.
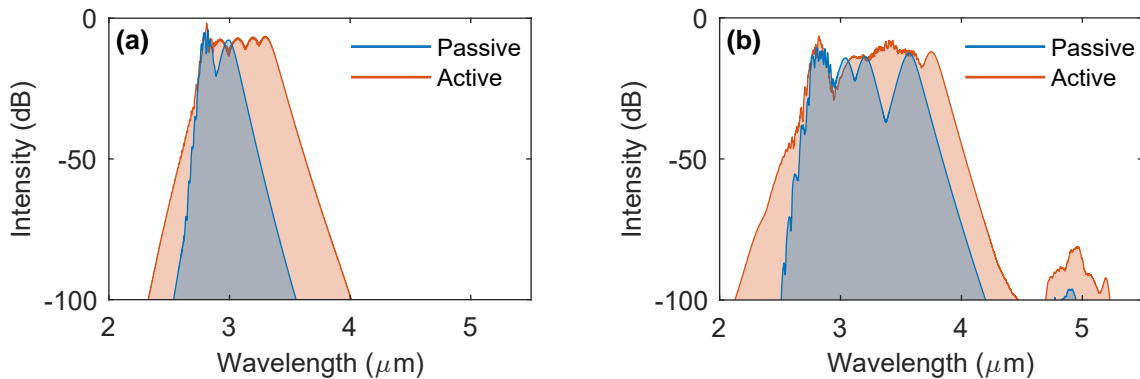

Figure 1: Comparison of output spectra from a passive and pumped active fibre for an input pulse duration of 3.2 ps having (a) peak power: 10 kW, average power: 1 W and (b) peak power: 30 kW, average power: 4.3 W. Pump powers are 6.5 W and 25 W for the active fibre respectively.