Transverse mode instability in high-power ytterbium doped fiber amplifiers - DTU Orbit
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Transverse mode instability in high-power ytterbium doped fiber amplifiers
The last couple of decades have brought an impressive growth in the output power of rare-earth doped fiber lasers and amplifiers, reaching the kW average power regime in both CW and pulsed systems. As a result, even though fiber lasers have excellent heat dissipation properties, thermal effects due to quantum defect heating have recently begun to negatively impact these systems when operating at high average power. The guiding properties of large-core fiber amplifiers have been observed to change as the operating power is increased, and recently a mode instability phenomenon, which severely degrades the otherwise nearly diffraction-limited beam quality of fiber amplifiers, was discovered. The latter effect has impeded the further power scaling of fiber lasers, since the mode instability sets in when the average power exceeds a certain threshold.

The purpose of the research presented in this thesis is to provide a theoretical understanding of the thermo-optical effects in high-power ytterbium doped fiber amplifiers, with a particular emphasis on understanding the aforementioned mode instability issue. Two main approaches to the problem have been used. The first is the development of a numerical model based on the beam propagation method, and the second is by a formulation of a coupled-mode model of thermally induced mode instability. The former approach is used to study the effect of quantum defect heating on the guiding properties of the fiber, while the latter provides a simplified description of the mode instability. In spite of the approximations made in the formulation of the coupled-mode model, it will be shown that this model is able to explain most of the experimentally observed qualitative features of the mode instability phenomenon.

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