9:30am

JWA5 Kerr lens mode-locking of diode-pumped lasers

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The Kerr nonlinearity has been used extensively for self-mode-locking or Kerr lens mode locking (KLM) of Ti:sapphire lasers[1] but only recently has it been exploited for mode locking of diode-pumped solid-state lasers.[2,3] Common diode-pumped media such as Nd:YAG have narrower gain bandwidths and lower gain saturation levels than Ti:sapphire, restricting the available peak intensities and precluding the use of effective gain apertures. In addition, the characteristics of high power diode lasers make efficient, tightly focused pump geometries difficult to attain, limiting self-focusing within the gain medium.

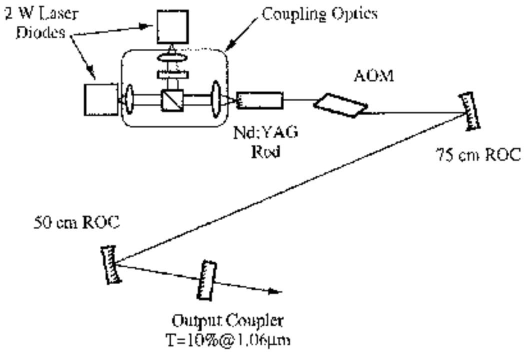
The first diode-pumped KLM laser, based on Nd:YLF, included a separate Kerr medium and a hard aperture in the cavity.[2] We have developed a diode-pumped KLM Nd:YAG laser,[3] without additional Kerr media or intracavity apertures, which produced stable trains of 8.5 ps FWHM pulses with 1 W of average power. A schematic diagram of this laser is shown in Fig. 1. Self-focusing in the Nd:YAG rod and the aperturing effect of thermal lens aberration (TLA) induced by the pump beam create the fast saturable absorber-like action. Optimizing the trade-offs between pumping efficiency, TLA, and self-focusing has been fundamental to achieving KLM operation. Here we discuss the mode size in relation to TLA, mode size changes due to the Kerr lens and the modulation of the roundtrip transmission by both the aberration aperture and the gain aperture. We have calculated changes in roundtrip transmission on the order of 10^{-3} for cw as compared to mode-locked operation.

Based on our detailed analysis of the Nd:YAG system, we have investigated KLM of diode-pumped Nd:LNA and Nd:glass lasers using doubly-folded cavities similar to that in Fig. 1. These media were chosen for their different bandwidths, gain saturation intensities, and thermal properties which permit us to verify different aspects of our modelling. Results for the different gain media are compared.

Finally, the reactive Kerr nonlinearity used in KLM does not, in general, lead to self-starting; however, KLM lasers have been made self-starting by means of a saturable absorber placed in an external cavity.[4] We have self-started the diode-pumped KLM Nd:YAG laser in this manner using an InGaAsP/InP MQW saturable absorber and subsequently examined resonant passive mode locking (RPM) of the diode-pumped Nd:YAG, Nd:LNA, and Nd:glass lasers using the same MQW sample. This investigation was driven by considerations of self-focusing effects in RPM and the similarities between successful cavity designs for KLM and for RPM. We discuss the role of self-focusing and cavity design in both systems.

1. See, e.g., Digest of Conference on Lasers and Electro-Optics (Optical Society of America, Washington, D.C., 1992).
2. G. P. A. Malcolm, A. I. Ferguson, Opt. Lett. **16**, 1967 (1991).
3. K. X. Liu, C. J. Flood, D. R. Walker, H. M. van Driel, Opt. Lett. **17** (1992).
4. U. Keller, G. W. 'tHooft, W. H. Knox, J. E. Cunningham, Opt. Lett. **16**, 1022 (1991).

JWA5 .pdf



JWA5 Fig. 1. Schematic diagram of the diode-pumped KLM Nd:YAG laser. The acoustooptic modulator (AOM) is used only during cavity alignment.