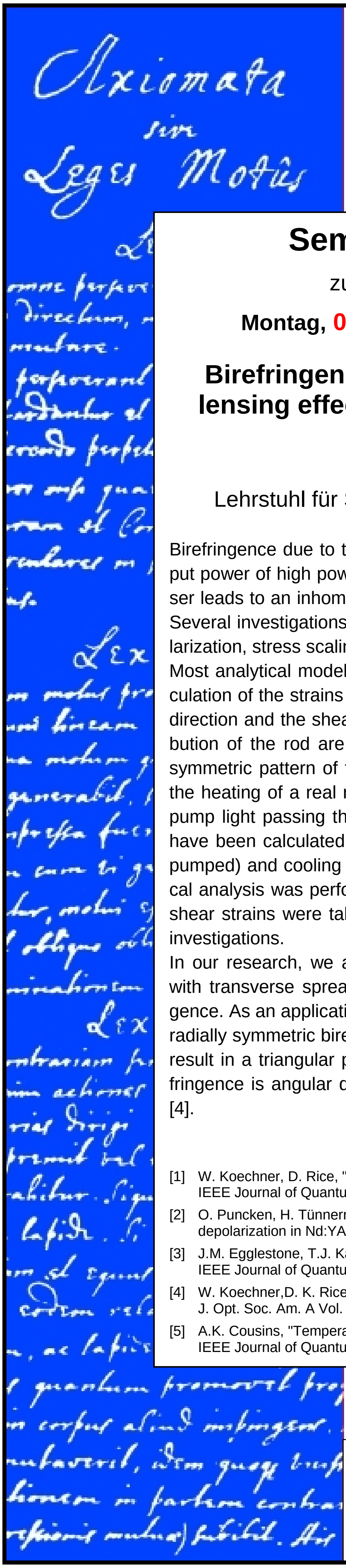

Friedrich-Alexander-Universität Erlangen-Nürnberg

Seminar über Fragen der Mechanik

zu folgendem Vortrag wird herzlich eingeladen

Montag, 08.07.2013, 14:15 Uhr, Egerlandstr. 5, Raum 0.044

Birefringence in solid-state laser rods due to the thermal lensing effect regarding shear strains in axial-radial plane

Thomas Graupeter

Lehrstuhl für Systemsimulation, Department Informatik, FAU Erlangen

Birefringence due to thermal induced stresses has a strong influence on beam quality and output power of high power lasers. It is well-known, that the pumping of laser rods of solid-state laser leads to an inhomogeneous temperature field and causes thermal strains and birefringence. Several investigations have been made to calculate this effect and resulting phase shifts, depolarization, stress scaling, etc.
Most analytical models, presented in literature, applied the plane strain assumption for the calculation of the strains and stresses inside a laser rod [1,2,3]. This means, that the strain in axial direction and the shear strain in the radial-axial plane are neglected. Additionally, heating distribution of the rod are often supposed to be homogenous. With these assumptions, a radially symmetric pattern of the birefringence of a [111]-cut crystal has been calculated [4]. However, the heating of a real rod is not homogenous due to the nonuniform pumping and the diverging pump light passing the crystal. In [5], strain, stress and temperature distribution in a laser rod have been calculated. Thereby, geometric dimensions, the type of pumping (one or both ends pumped) and cooling (edge or face cooled) have been varied. Furthermore, in [5] the mechanical analysis was performed using a full three-dimensional finite element method (FEM) and the shear strains were taken into account. But transverse spreading of the pump light limits these investigations.
In our research, we apply a three-dimensional finite element method and a realistic pumping with transverse spreading of the pump light. This leads to an accurate calculation of birefringence. As an application, birefringence pattern was analyzed for a [111]-cut Nd:YAG, and a non-radially symmetric birefringence pattern was obtained. The shear strains in the radial-axial plane result in a triangular pattern of birefringence in the cross section of the laser crystal. The birefringence is angular dependent opposite to results obtained using the plane strain assumption [4].

[1] W. Koechner, D. Rice, "Effect of Birefringence on the Performance of Linearly Polarized YAG:Nd Lasers", IEEE Journal of Quantum Electronics Vol. QE-6, page 557-566 (1970).

[2] O. Puncken, H. Tünnermann, J.J. Morehead, P. Weßels, M. Frede, J. Neumann, D. Kracht, "Intrinsic reduction of the depolarization in Nd:YAG crystals", Optics Express Vol. 18, 20461-20474 (2010).

[3] J.M. Egglestone, T.J. Kane, K. Kuhn, J. Unternahrer, R.L. Byer, "The Slab Geometry Laser-Part I: Theory", IEEE Journal of Quantum Electronics Vol. QE-20, page 289-301 (1984).

[4] W. Koechner,D. K. Rice, "Birefringence of YAG:Nd Laser Rods as a Function of Growth Direction", J. Opt. Soc. Am. A Vol. 61, 758--766 (1971).

[5] A.K. Cousins, "Temperature and Thermal Stress Scaling In Finite-Length End-Pumped Laser Rods", IEEE Journal of Quantum Electronics, Vol. 28, No. 4, April 1992.

Prof. Dr.-Ing. P. Steinmann
Prof. Dr.-Ing. K. Willner

Lehrstuhl für Technische Mechanik
Egerlandstraße 5, 91058 Erlangen

Prof. Dr.-Ing. S. Leyendecker

Lehrstuhl für Technische Dynamik
Konrad-Zuse-Straße 3-5, 91052 Erlangen