SENSITIVITY LIMITS OF INTRACAVITY ABSORPTION SPECTROSCOPY

V.M. BAEV, J. SIERKS, T. LATZ, R. BOEHM, J. HUENKEMEIER, P.E. TOSCHEK, *Institut fuer Laser-Physik, Universitaet Hamburg, D-20355 Hamburg, Germany.*

Emission spectra of multimode lasers are very sensitive to selective absorption in the cavity. The sensitivity of measurements grows with the laser pulse duration t. The absorption signal in the laser spectrum is equivalent to the signal obtained by the conventional absorption technique, when the length of the absorption cell is replaced by the velocity of light times t. The ultimate sensitivity obtained with a cw laser is limited by quantum noise, at a small pump rate, and by nonlinear mode coupling at high pump rate. The optimum pump power and the highest sensitivity to absorption are individual features of the actual laser. Reliable identification of the dominant type of nonlinear mode coupling allows one to optimize the laser parameters for the highest sensitivity. Up to now, the highest spectral sensitivity has been obtained with a cw Rh6G dye laser. The nonlinear mode coupling in this laser is determined by four-wave mixing on the saturated laser gain, and by stimulated Brillouin or Rayleigh scattering. Reduction of these interactions by increasing the cavity length to 3 m, and by decreasing the cavity loss to about 2% per round trip, have resulted in spectral sensitivity to absorption which is equivalent to 70.000 km absorption length, at the pump rate being 1% above the laser threshold. Further enhancement of the sensitivity is possible in a strongly dispersive cavity. A Ti:sapphire laser shows stronger limitation of sensitivity due to four-wave mixing, since the gain medium is 100 times longer. The spectral sensitivity reached with this laser is equivalent to 1000 km absorption path length. Rare-earth-doped fiber lasers exhibit strong second-order nonlinearity due to their small cross section and comparatively long fibers. The sensitivity to absorption achieved now with these lasers corresponds to 100 km of absorption path. The emission spectrum of diode lasers is determined mostly by quantum noise due to extremely high loss in their cavities. The equivalent absorption length, achieved with this type of laser is about 10 km. Identification of particular factors that limit the sensitivity in each of these lasers allows one to optimize the laser parameters for most precise, sensitive, and reliable measurements.