24: Intensity Stability of HeNe Lasers

There are at least three kinds of intensity variations present with HeNe (or other gas) lasers: long term as various longitudinal modes compete for attention, short term due power supply ripple or discharge instability, and beat frequencies between modes that are active.

Common internal mirror HeNe laser tubes include a specification called "Mode Cycling Percent" or something similar. This relates to the amount of intensity variation resulting from changes in longitudinal modes due to thermal expansion. Typical values range from 20 percent for a small (e.g., 6 inch, 1 mW) tube to 2 percent or less for a long (e.g., 15 inch, 10 mW) tube. These take place over the course of a few seconds or minutes and are very obvious using any sort of laser power meter or optical sensor. Even the unaided eyeball may detect a 20 percent change. The more modes that can be active simulataneously, the closer those that are active can be to the same output power on the gain curve. Very short tubes or those with low gain (other wavelengths than 632.8 nm or due to age/use or poor design) may vary widely in output intensity or even cycle on and off due to mode cycling. (Note that since the polarization for each mode may be different, reflecting the beam of one of these HeNe lasers from a non-metallic reflective surface (which acts somewhat as a polarizaer) can result in a large variation in brightness as the dominant polarization changes orientation over time.) Trading off between tube size and mode cycling intensity variations is one reason that HeNe tubes with otherwise similar power output and beam characteristics come in various lengths.

There are also stabilized HeNe lasers which use optical feedback to maintain the output intensity with a less than 1 percent variation. (They usually also have a frequency stabilized mode but can't do both at the same time.) An alternative to doing it in the laser is to have an external AO modulator or other type of variable attenuator in a feedback loop monitoring optical output power. See the next section for more info.

Short term changes in intensity may result from power supply ripple and would thus be at the frequency related to the power line or inverter. These can be minimized with careful power supply design.

Intensity variations at 100s of MHz or GHz rates result from beats between the various longitudinal modes that may be simultaneously active in the cavity. For most common applications, these can be ignored since they will be removed by typical sensor systems unless designed specifically to respond to these high beat frequencies.

Also see the section: Amplitude Noise.