Pulsed Coherent Light: Cavity Dumping a Helium Neon Laser

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Overview
Lasers can operate in continuous wave (cw) or pulsed regimes. Pulsed lasers have high repetition rates, short pulse durations, and peak powers orders of magnitude greater than average power.

Continuous wave
- Laser pointers
- Optical drives (CD/DVD)
- Laser pointers
- Barcode scanners
- Traditional laboratory lasers
- Metal machining

Techniques for creating a pulsed laser include cavity dumping, modelocking, Q-switching, and pulsed pumping. In this project, an open cavity helium neon laser is cavity dumped.

Laser basics
A laser cavity is a resonator for light. Spontaneous emission occurs when a gain medium is pumped, emitting photons in random directions. Some of these photons hit one of the mirrors and bounce back in the gain medium, causing stimulated emission. More photons bounce off the other mirror and back into the gain medium, causing more stimulated emission. The output coupler is less than 100% reflective, so a fraction of these resonating photons are emitted as the laser output beam.

Cavity dumping
We replaced the output coupler with a high reflector to allow high intracavity power. When intracavity power peaks, an optical switch is gated on to extract the circulating power within a few round trips, creating a pulsed output. After extraction, the optical switch is gated off to allow intracavity power to build up again.

Cavity dumped pulses
An acousto-optic modulator (AOM) is placed inside an open cavity helium neon laser near the beam waist as a high speed optical switch. When intracavity power is built up to a high level, the AOM is gated on to extract the power out of the cavity. After the power is extracted, the AOM is gated off to allow power to build up again.

Intracavity power over time
Intracavity power as AOM is turned on at t=0:

\[ P_c = P_b \exp (-\frac{2t}{2L/c}) \]

We have not yet developed a method to measure circulating power, so we use arbitrary units for \( P_b \). We assume cavity power has built up to a maximum by \( t = 0 \).

Cavity dumped pulses

The extracted beam is monitored with a high speed photodetector. Intracavity power is monitored via the reflection off of the Brewster window of the helium neon tube.

Peak power characteristics
Peak power per pulse is related to VHF signal duration and repetition rate. Output pulse duration stays constant at about 100 ns.

References