Single-Frequency Light Amplification by Injection into a Broad Area, High Power Diode Laser

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Motivation

We wish to construct a low cost source of high power (hundreds of mW), single-frequency light using diode lasers for excitation of the He 3^3P_2 state to Rydberg states in the wavelength range 793-795nm. Previous studies (see ref. 1. - 4.) show that injection of light from a low power diode laser (“Master”) into a high power, broad area diode laser (“Slave”) can produce the desired effect. We show that by anti-reflection (AR) coating the slave laser, injection can be achieved for very high slave currents, giving high output power while retaining desirable spectral properties. We have demonstrated a single-frequency slave output power of 460mW for a slave current of 1020mA.

Diode Laser Characteristics

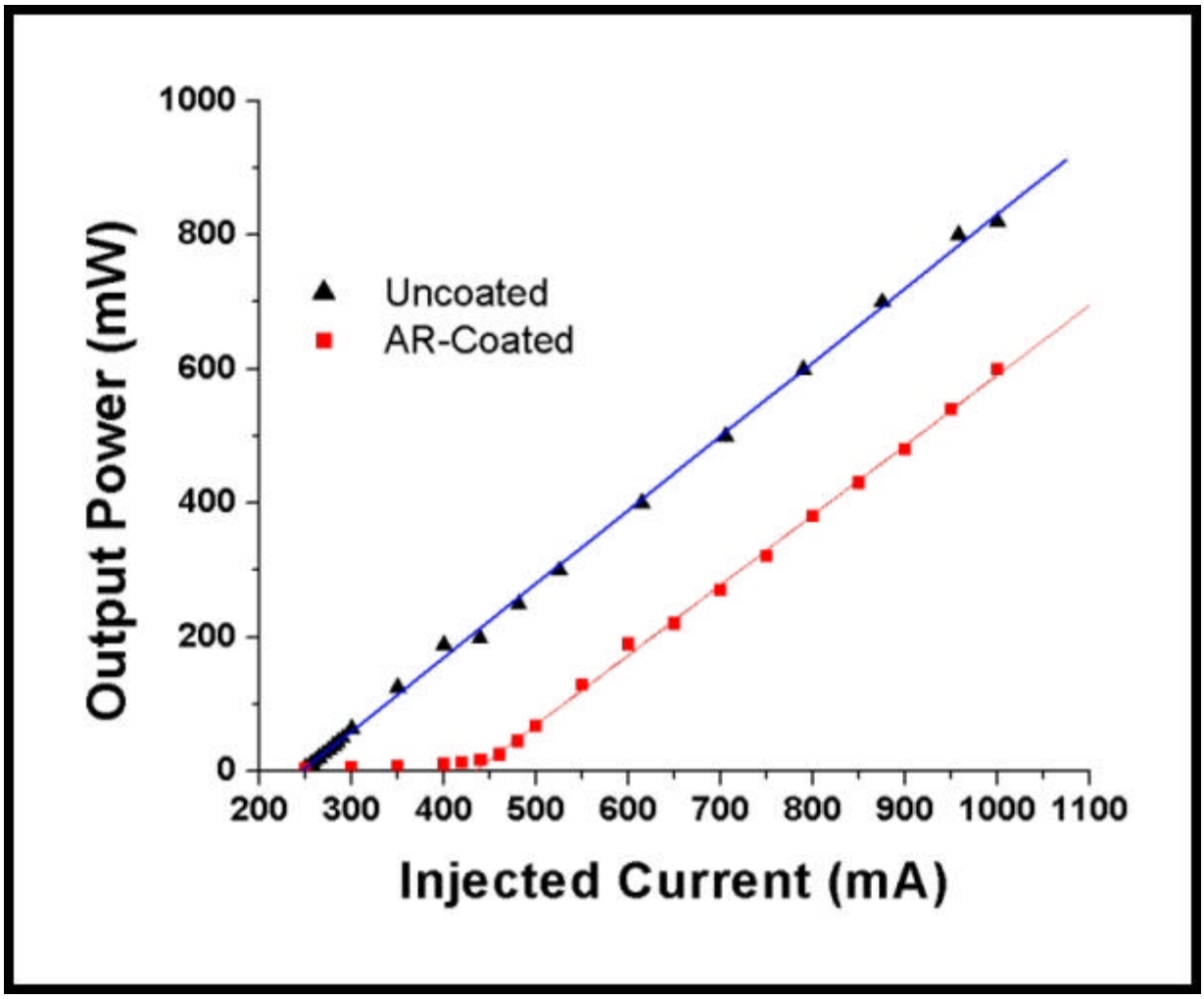
Master

- *Sacher Lasertechnik* Model TEC 100, Tunable External Cavity diode laser.
- Littrow configuration.
- Commercial diode laser system.

Slave

- Coherent S-79-1200C-100-Q (new part #1024308*143918).
- Nominal center wavelength 795nm, threshold 250 mA, output power 1.2W @ 1305 mA.
- Wavelength spread in output of 1-2nm, depending on temperature and current.
- AR coating the front facet increases susceptibility to injection, while increasing the free-running threshold and lowering the output power for a given current (see output power graph).

Free Running Slave Output Power



Conditions for Injection

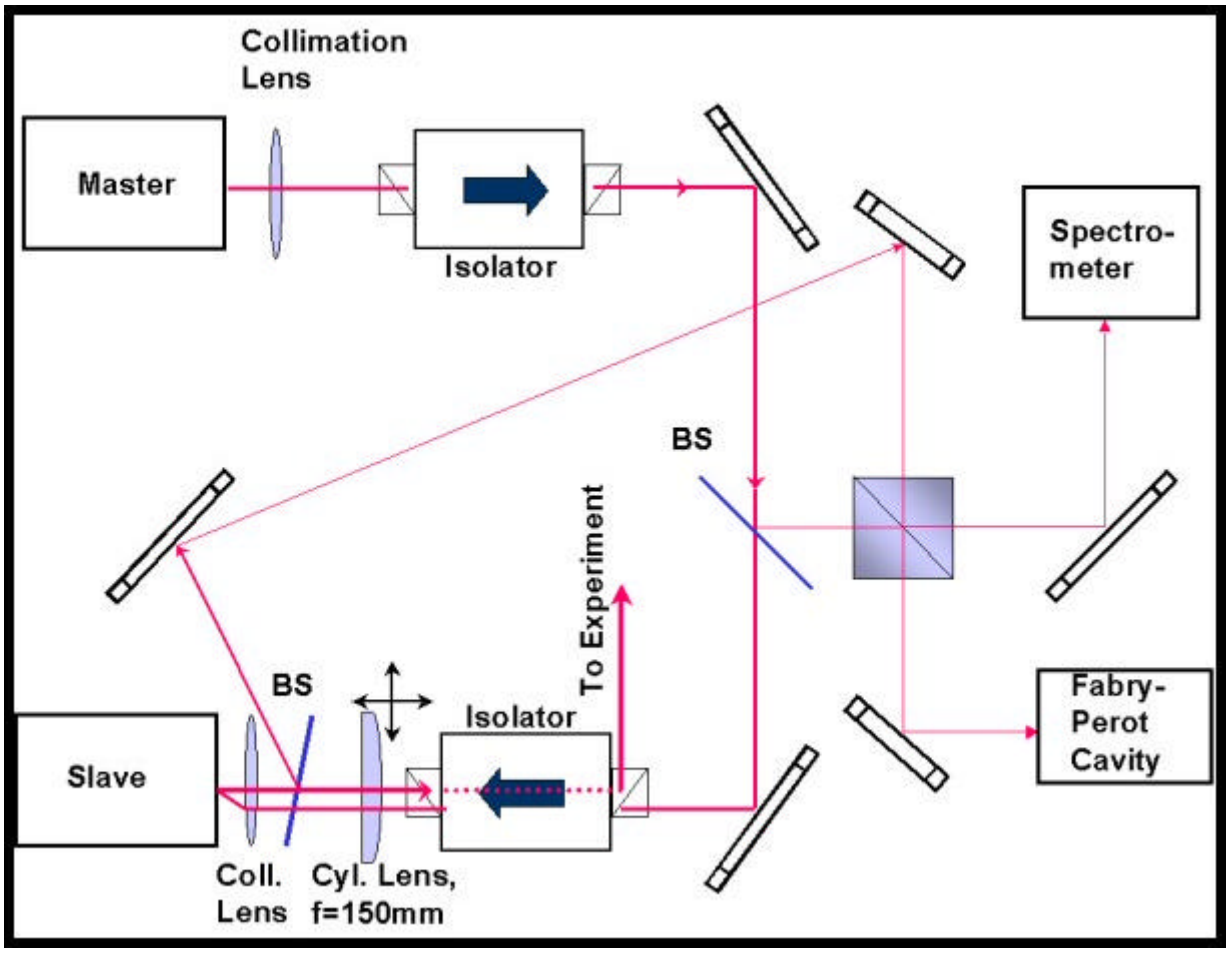
Polarization Match:
: the polarization of the master beam must match the polarization of the slave output beam.

Wavelength range match:
: the wavelength of the master must be within the wavelength range of the free-running slave output, especially at high slave currents.

Spot size match:
: hard to quantify, but we make the waist of the master beam smaller than the size of the slave's front facet. The cylindrical lens is mounted on a translator to optimize the spot size and position on the front facet (see Equipment Layout).

Correct angle:
: the mirror angles are adjusted so the master beam enters at the proper angle for optimal injection.

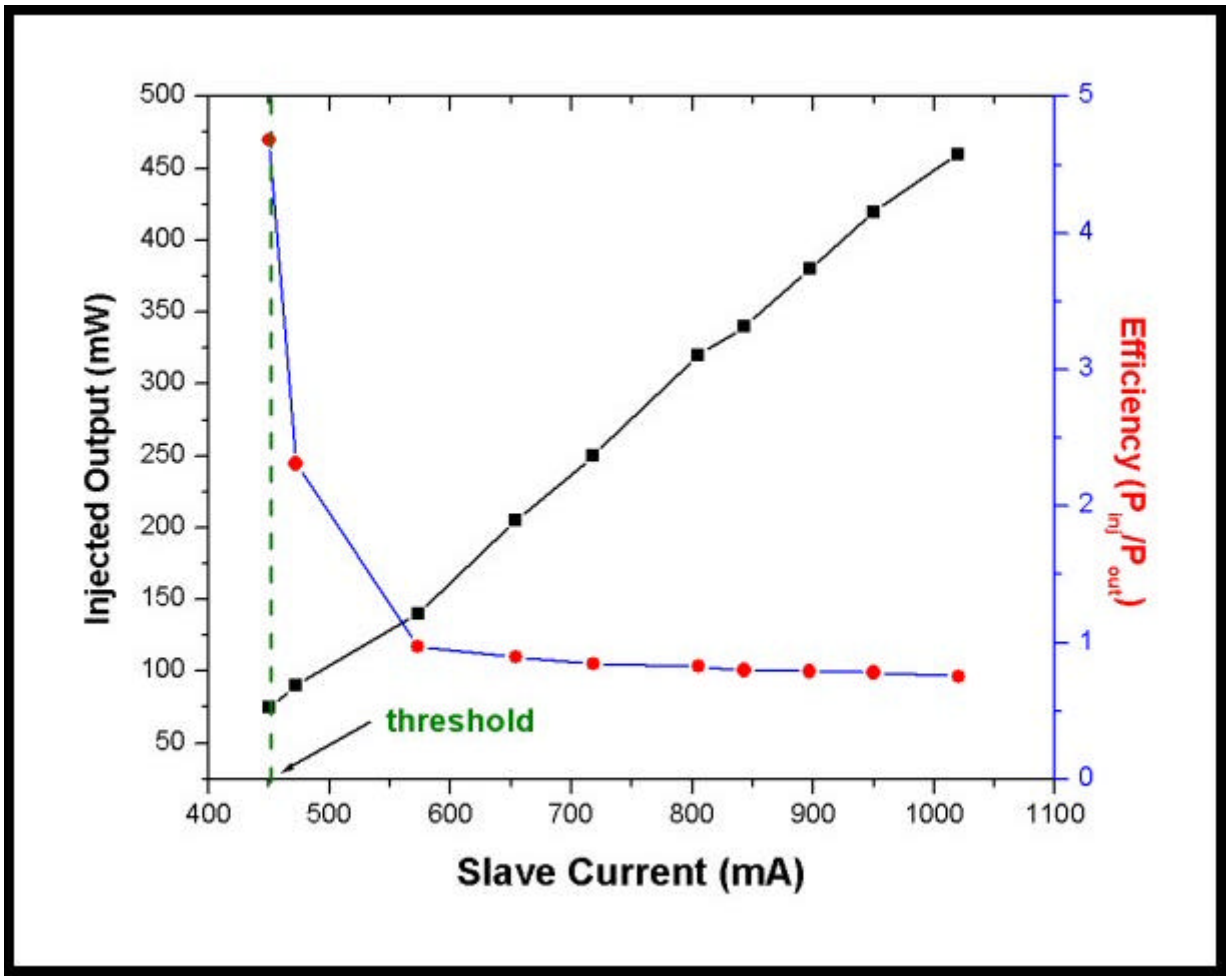
Equipment Layout



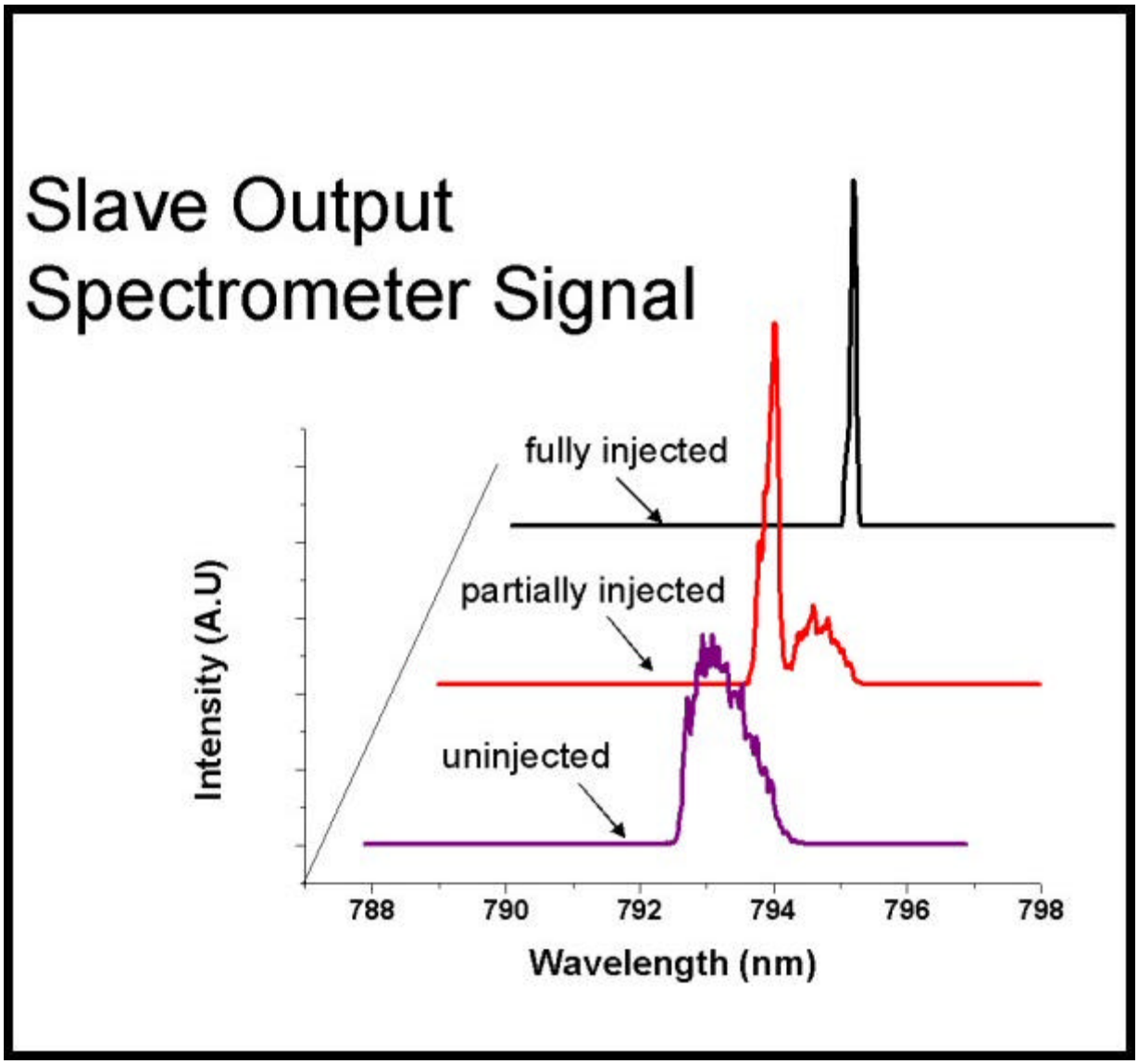
Results

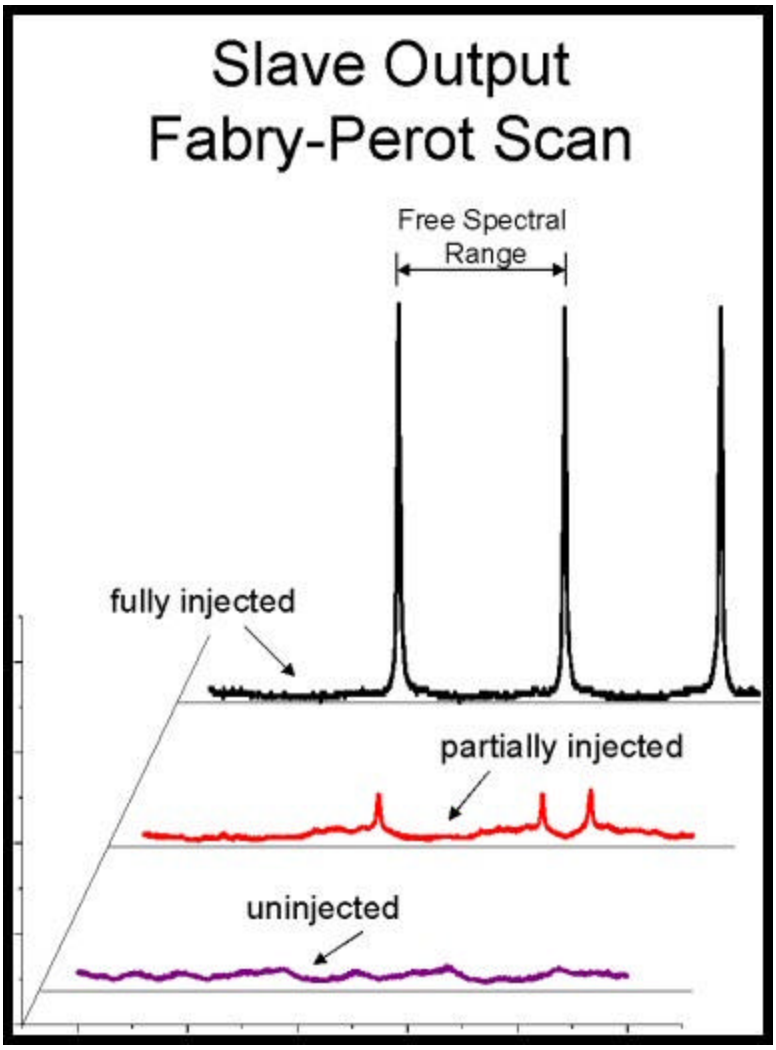
We have observed injection for up to 1020 mA of slave current, resulting in a total power of 460 mW useable for the experiment. The slave follows the master's frequency and spectral structure. Previous injection attempts with uncoated slaves were limited by the slave's natural frequencies lasing at higher currents (depending on the amount of master power). The AR coated slave injects well up to the maximum current of the slave power supply.

Injected Output Power



Injected Output Spectral Properties


Slave Output
Spectrometer Signal
fully injected
partially injected
uninjected
Intensity (A.U)
788
790
792
794
796
798
Wavelength (nm)



Conclusion and Further Work

We have successfully constructed a low cost source of high power, single-frequency light using diode lasers.

The slave follows the master's frequency and mode structure, as long as the master wavelength falls within the slave frequency range (which depends on the slave current and temperature).

AR coating of the slave dramatically improves the susceptibility of the slave to injection.

Further Work:

- Increase the wavelength range to include 795nm by increasing the temperature of the slave, or by acquiring a new slave with a different wavelength selection.
- Beam cleaning; shape the spatial properties of the slave with more optics.

References

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3. M. Praeger et al., Appl. Phys. B, 67, 163, (1998).
4. I. Svarchuck et al., Appl. Phys. B, 71 Appl. Phys. B, 71, 475 (2000).