School of Physics
OPTICS GROUP
Atom Optics
THE UNIVERSITY OF MELBOURNE

External cavity diode lasers

See Azmoun-Metz for comprehensive information on locking external cavity diode lasers to a vapour cell.

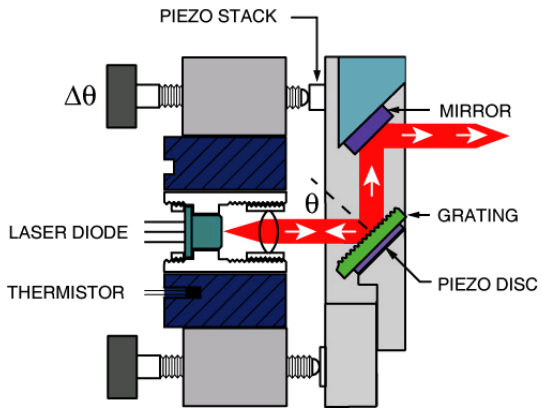
We have experimented with various external cavity diode lasers. Before continuing, we have *not* tried the Hänsch design. Compared to ours, it requires substantially more workshop time and is trickier to set up initially, but is possibly the most stable of the three mentioned here, so you might want to investigate. Look at:

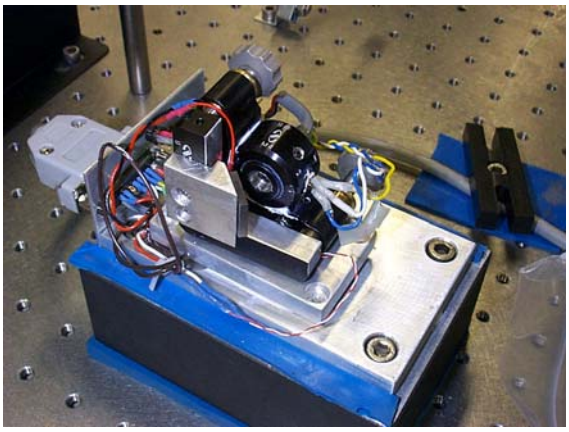
- Ricci L, Weidemüller M, Esslinger T, Hemmerich A, Zimmermann C, Vuletic V, König W, Hänsch TW. A compact grating-stabilized diode laser system for atomic physics. *Optics Communications* **117**, no.5-6, pp.541-549 (1995).

Sussex / Melbourne design

We have had good results with the design of Arnold et al., including 25GHz tuning range and a linewidth of less than 500kHz (and that's integrated over several minutes, not just a quick sweep).

- Frequency noise characterisation of narrow linewidth diode lasers, *Opt. Commun.* **201** 391 (2002)
- Littrow configuration tunable external cavity diode laser with fixed direction output beam, *Rev.Sci.Instrum.* **72** 4477 (2001)
- A.S.Arnold, J.S.Wilson and M.G.Boshier:"A simple extended-cavity diode laser", **69** *Rev.Sci.Instrum* 1236 (1998).



Gratings

Using a holographic grating with poor diffraction efficiency, most of the light (85%) is coupled out of the cavity, and we are able to extract about 60mW of useable output, single frequency, at 780nm. Our gratings are gold coated, with 1800 lines/mm on a 15 x 15 x 3mm substrate, Richardson Grating Laboratory 3301FL-330H (formerly a 35-33-01-330H), which is a specific size of the 53-*-330H. The diode polarisation is parallel to the lines of the grating, perpendicular to the plane defined by incident and reflected light (call this the p-plane). The grating specs (look at right hand column of table) suggest a relative efficiency of anywhere from 20 to 30% at 780nm, depending on which master they used.

You might also like to try Optometrics. They have 3-4181 or 3-4182 gratings at US$55.00 each. These are Al coated, 1800l/mm, blazed for UV or visible. They will do a gold coating run for US$150, up to 5 gratings per run.

Diodes

April 2005: we are now using mainly the GH0781JA2C diodes from Digikey (see below), and a new very cheap diode, the ADL-78901TX from Roither Lasertechnik ($10 each).

We have successfully used Sanyo DL7140-201 diodes for many years, and Geltech CM230B lenses; both can be purchased from ThorLabs (www.thorlabs.com). Tony Pope at www.photonics.uk.com has been very helpful in providing wavelength-selected Sanyo diode lasers.

Note that high-power 780nm lasers are becoming available, including Sanyo -201M, -201K, -201P, which are sporadically available, and some from Sharp which are more easily obtained. Neil Claussen at NIST Boulder pointed us to the GH0781JA2C, 120mW cw and 180mW pulsed, available from Digikey for just US$20. We have found these to be slightly temperamental (short tuning range, mode hopping, etc.). Sharp also have the nominally higher power GH0781RA2C, 120mW cw and 225mW pulsed. or the GH07P26A2C (120mW cw, 260mW pulsed). The 95mW cw Sharp GH07895A6C diode can be ordered now from Manuco electronics at A$73 each (that's about US$40).

Sony make the SLD253VL 100mW cw and 240mW pulsed. SLI have 150mW single mode lasers at 780nm but unfortunately have been purchased by Boston Laser Inc and now want US$1000 per diode. Toptica and Sacher have very nice AR-coated high power lasers, for a price.

Or you can pull a high-power diode out of a fast cd burner. 32x burners will have approx 100mW diodes, 48x will have 120mW cw and >200mW pulsed.

Modifications to Sussex design

We have made some modifications to the original Sussex design, including addition of a NEC-Tokin AE0203D04 piezo stack and NEC-Tokin datasheet (available from ThorLabs)

to control the grating angle. This is extremely useful, allowing us to scan 20GHz with 100V on the stack. However, that implies 1MHz of laser frequency noise for just 5mV of noise on the high voltage amplifier driving the stack — or 0.5mV of noise on the input to the 10X amplifier. See our electronics pages for more discussion of this point, and our paper:

- Frequency noise characterisation of narrow linewidth diode lasers, *Opt. Commun.* **201** 391 (2002)

We have also added a mirror attached to the grating arm. This compensates for changes in the output beam direction as the laser wavelength is adjusted via the grating angle. We have been able to measure the laser wavelength as it is tuned by more than 10nm using our wavemeter, without any other adjustments to beam direction. A paper describing our laser has been published:

- Littrow configuration tunable external cavity diode laser with fixed direction output beam, *Rev.Sci.Instrum.* **72** 4477 (2001)

Piezo disc

Our piezo discs were provided by Dr. Lutz Pickelmann, of Piezomechanik. They were 16mm diameter x 0.6mm thick, silvered. They were originally provided as samples and unfortunately we don't have any specifications. We have found an excellent alternative at Morgan Electro Ceramics. Some of the Morgan discs have wrap-around electrodes so that you can attach both wires from one side.

Any of the standard lead zirconate titanate (PZT) transducer materials should be fine (e.g. PZT-4, -5A, -5H, -5J). It might be useful to choose one with a large non-linear d33 constant such as PZT-5H or -5J, or Morgan PXE5 or PI Ceramic PIC-151, but other factors such as mechanical Q and polarization resistance could be important.

PI Ceramic have a well-organised assortment of similar discs, including 16mm x 0.25mm or 16mm x 0.5mm. Some links:

- Piezomechanik
- Morgan Electro Ceramics (NL)
- Morgan Electro Ceramics (UK)
- PI Ceramic
- Polytec PI Ceramics
- American Piezo Ceramics
- Piezo systems
- Staveley Sensors

Drawings

Engineering drawing of all necessary parts are available in .pdf (Acrobat) form:

- Drawing 1 of 8 (bottom baseplate)
- Drawing 2 of 8 (top baseplate)
- Drawing 3 of 8 (grating mount)
- Drawing 4 of 8 (Ultima mount)
- Extended version for long cavity (narrow linewidth)
- Drawing 5 of 8 (box front, top, back, D-connector plate)
- Drawing 6 of 8 (box sides)
- Drawing 7 of 8 (piezo stack support cup)
- Drawing 8 of 8 (heavy base)

Other variations (AutoCAD drawings, DXF, etc.) are available, just email us.

Electronics

Click here for circuits, PCB layouts, instructions etc. on our diode laser electronics.

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