

## AOM selection for the aLIGO squeezer

Following the approach used in the VOPO set-up at MIT<sup>1</sup>, in the aLIGO squeezer the coherent locking field (CLF) is generated by passing a beam at the fundamental frequency through two single pass acousto-optic modulators (AOMs).

This scheme is different from what has been historically used in squeezing experiments, where an additional laser is used to produce the CLF beam. The main reason why an additional laser is typically used is so as to reduce the amount of light at the carrier frequency leaking in the CLF beam. If light at the main carrier frequency reaches the OPO, it degrades the amount of squeezing produced (this is referred to as “seeding” the OPO).

Even if during the H1 squeezing test the CLF was produced by an additional control laser, “seeding” to the OPO was observed<sup>2</sup>. This was caused by accidentally driving the EOM in the control laser path at the CLF frequency, thus down-converting the frequency shifted CLF beam to the carrier frequency. Extrapolation from the H1 squeezing test, it can be quantified that 10 pW of “seeding” light is enough to deteriorate the squeezing spectrum<sup>3</sup>.

For the double AOM set-up to be compatible with high levels of squeezing, it is important that the amount of 0<sup>th</sup> order seeding (light passing through the AOM at the carrier frequency) is as small as possible.

To minimize the amount of 0<sup>th</sup> order seeding, high frequency drives are preferred. The bigger the AOM driving frequency is, the bigger will be the separation angle between the 1st order and the 0th order beams through the AOM. Also, a highly focused beam deteriorates the contrast ratio; therefore, large crystals are preferred.

On the other hand, a larger beam sizes requires more time for the acoustic wave to cross it, resulting in longer rise times. For this reason, a smaller and faster AOM is used for applying the CLF feedback control signal.

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<sup>1</sup> <https://dcc.ligo.org/LIGO-P1600074>

<sup>2</sup> [http://ilog.ligo-wa.caltech.edu/ilog/pub/ilog.cgi?group=detector&date\\_to\\_view=11/19/2011&anchor\\_to\\_scroll\\_to=2011:11:20:00:59:18-sheilad](http://ilog.ligo-wa.caltech.edu/ilog/pub/ilog.cgi?group=detector&date_to_view=11/19/2011&anchor_to_scroll_to=2011:11:20:00:59:18-sheilad)

<sup>3</sup> [http://emvogil-3.mit.edu/ilog/pub/ilog.cgi?group=lasti&date\\_to\\_view=10/02/2015&anchor\\_to\\_scroll\\_to=2016:05:20:12:49:07-eoelker](http://emvogil-3.mit.edu/ilog/pub/ilog.cgi?group=lasti&date_to_view=10/02/2015&anchor_to_scroll_to=2016:05:20:12:49:07-eoelker)

For these reasons, the aLIGO squeezer uses two different AOMs:

- **AOM1** is the small AOM that shifts the beam up by 203.1 MHz (and has the CLF feedback applied)
- **AOM2** is the large AOM that shifts the beam down by 200 MHz at a fixed frequency.

The resulting CLF beam is shifted by 3.1 MHz.

After discussions with several vendors, we have selected the following AOMs<sup>4</sup>:

**AOM1** is from **Quanta Tech** (<http://www.quanta-tech.com/3en.aspx>) – specs TBC.

The 203.1 MHz drive is produced by a VCXO, and it is controlled by the CLF loop feedback.

**AOM2** is driven at a fixed frequency, and it is a large crystal from **Intraaction AOM ATM-2002DA6** CENTER FREQUENCY, 200 MHz; FREQUENCY SHIFT RANGE, +/- (150 TO 250 MHz); BEAM SEPARATION, 50 MRAD (1064 NM, 200 MHz); ACTIVE APERTURE HEIGHT, 2 MM; DIFFRACTION EFFICIENCY, 85 PERCEN.

The amount of seeding observed with these AOMs in the VOPO experiment set-up is negligible<sup>5</sup>.

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<sup>4</sup> [http://emvogil-3.mit.edu/ilog/pub/ilog.cgi?group=lasti&date\\_to\\_view=04/28/2015&anchor\\_to\\_scroll\\_to=2015:04:28:18:46:54-eoelker](http://emvogil-3.mit.edu/ilog/pub/ilog.cgi?group=lasti&date_to_view=04/28/2015&anchor_to_scroll_to=2015:04:28:18:46:54-eoelker)

<sup>5</sup> [http://emvogil-3.mit.edu/ilog/pub/ilog.cgi?group=lasti&date\\_to\\_view=10/02/2015&anchor\\_to\\_scroll\\_to=2016:05:20:12:49:07-eoelker](http://emvogil-3.mit.edu/ilog/pub/ilog.cgi?group=lasti&date_to_view=10/02/2015&anchor_to_scroll_to=2016:05:20:12:49:07-eoelker)