ARTEMIS MULTI-CELL EXPERIMENT.

Wk 1

Monday 7 - August - 2017.

- Completed safety training
- Signed off as TAO.
- Adam got stages to communicate with Control PC.
- Beam not aligned to chamber.
- Gas lines not yet installed.

Tuesday 8 - August - 2017

- Injections
  - Install stages on chamber
  - Install gas cells
  - Observe HHG on single cell

lionsgate
l1on$gete

- Stages working with LabVIEW
- Problem connecting ~~to~~ camera
- Gas inlet still not operational by 4:30 pm

- Adam abandoned Labview implementation for camera.
- Started working on Matlab software in the late evening.

- Able to roughly position jets in chamber and connect all hardware.

- Finished at ~7pm. Still waiting on gas ~~to~~ to be completed; still waiting on software; still waiting ~~for~~ for laser to be sent to chamber & ~~stuff~~ including focal lens.

Wednesday 9-August-2017.

- Cut top plate connected to stages and mounted stage in approx position.
- Question about safety of gas cells. Given all clear by Richard and Emma.

- Beam routed through compressor before lunch.

- TiPA (auto-correlator) was used to measure pulse duration. Some pulse front tilt, as well as multiple pulses.

- Pulse front tilt due to instrument misalignment. Corrected.

- Multiple pulse traced back to laser output. Appears to be slightly elliptical. Wave plate ~~polarizer~~ polarizer combination ~~spectrum~~ showed oscillations in spectrum - strongest when beam attenuated.

- Solution was to keep ~~beam~~ waveplate-polarizer in place and use a 2nd waveplate before compressor 2. Compressor acted as a polarization "cleaner". No observable modulations in spectrum after compressor. No longer done pulses on autocorrelation.

- Sufficient contrast between max and min using waveplate before compressor.
  Max: 2.3 W.
  Min 0.08 W.

- As a check performed measurements of spectrum and TiPA after compressor / waveplate combo. → Double pulse feature still present when 1st waveplate / polarizer combo removed.

⇒ Cre-Ne reinstalled.

→ F = 1000 mm lenses put in approx. place.

Thursday 10 - August - 2017.

Objectives
- Send beam to chamber.
- Arrange targets in position.
- Measure size of input beam.
- Measure power transmission (focal point).
- Generate harmonics in cell.

- How to use MCP?
- Scanning software needed.

Actual
⇒ Set up M2 monitor.
→ Measured power transmission through aperture.

- Measured beam transmission through aperture
- Closing aperture directly after compressor 2.

Diameter / mm		Power after iris / mW	
~~(1)~~	(2)	(1)	(2)
Open.		~~970~~ 970	160.
24	4.	960	
22		950	
20		940.	
18		920	
16		890.	
14		830.	
12.		750.	
10		650	
8		490.	
6		340.	

Beam FWHM: (Before lens).

7.85 ± 0.2 mm

Transducers: ~~(Channel 1 → Needle Valve.~~
~~Channel 2 → Mass flow controller)~~

Channel 1 → Mass flow controller
Channel 2 → Needle valve.

- Adam not satisfied with H2 setup. Had to be redone and equipment repositioned. Took all afternoon including writing/ammending software.
- Chris Thornton available in evening. ~~Entered He-Ne on TMS.~~
- Before dinner spent time getting He-Ne aligned to chamber aperture and last irises. Apparently not correct line.
- Switched to working with Chris Thornton ~~in H2~~ after dinner. Aligned He-Ne through chamber; ~~Mounted~~ gas Aligned 800nm through the chamber; Mounted bought gas jets in chamber, aligned using He-Ne.
  Put Faraday piece on chamber + window
  Pumped down with scroll pump only.

Friday 11th August - 2017

- Problem with laser. No beam on Webcam 1.

Plan of experiments

	800nm	1300nm
Argon - Argon 1 day ± 4 scans (short)		
Long - Short (Search for 1 day) max		

- Problem with laser fixed. Laser switched on at 13:30. Light available approx 15:00.

3)

WK2 experiments.. 2 cells at 800nm.

WK3: 2 cells at 1300nm + switch to OCT.

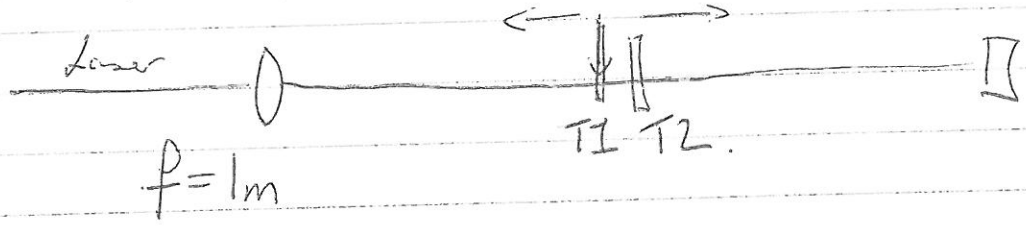
WK4: OCT.

800nm 2 Cell.	time	1300nm 2Cell.	Time
-Argon-Argon. See interference ± y scan	1 day 1 day.	Argon-Argon Setup, laser-Interference. ± y scans	1 day. 1 day
Argon-Argon. Search for long trajectories vary ellipticity	½ day ½ day	Argon-Argon. long-short + ellipticity	1 day.
Argon-Krypton repeat above.	1 day.	Argon-Krypton repeat above.	1 day
Argon-Neon. repeat above	1 day.	Argon-Neon repeat above.	1 day
Switch to Argon.		Switch to Argon	

5 days. WK2

5 days WK3

Measuring transmission through Ni tubes to find focal plane.



T1 position: 0 → 25 scanning toward laser.
T2 position: 25 → 0. scanning toward flat field.

Initial position of lens on stage: 12.37 mm.

T1 position at 0 mm.

T2 position/mm	Power/in W
25.0	21.5
24.5	20.3.
24.0	18.7.
23.5	16.4.
23.0	15.5
22.5	11.6.
22.0	9.2.
21.5	7.2.
21.0	6.4.

T2 held at 25 mm (fully forward).

T1	Power/in W.
0.0	21.7.
0.5	21.8
1.0	21.4.
1.5	20.0.
2.0	19.4

(10)

2·5	18·6.
3·0	17·6
3·5	16·7.
4·0	15·5.
4·5	14·2.
5·0	12·7.
5·5	11·5.
6·0	9·9.
6·5	8·4.
7·0.	7·2.

Monday 14 August 2017

ID12B06 : Grating motion.

14579 : Steering mirrors. (h, v)
Motor 1, 2 → closest laser (x, y)

Motor 3, 4 → closest chamber (x, y)
(h, v).

First HHG tests target
Front target Comb 1.9×10^{-4} BG pressure
Rear target unknown 2×10^{-4} BG "
no transducer, but signal x10 less than HHG
set to similar
BG

Power for HHG signal ~300μJ.

Some interference visible when scanning by hand.

- Got to see harmonics from both targets.
- Software not ready yet to correct for scans. However, appears to be modulations on the signal when target 2 moved through focus.
- Transducer on T2 not working. Will repair/replacement tomorrow.

Tuesday 15 August 2017.

- Transducer not working. Need replacement.

Objectives for today:

- Scan ± z using T1 and T2.
- Find optimum position for ~~(Fixed)~~ focusing lens
- ~~Code~~ Get automated scanning up and running.

$w_0 = 70\ \mu m \quad \lambda = 780\ nm = 0.78\ \mu m$

$$\epsilon_r = \frac{\pi 70^2}{0.78} = 19.7\ mm$$

PM

Initial scans vanilla S60.

Aim to see "strong" modulation on on-axis component

540 pJ pulse energy

$P(T_1) = 6.1$ mbar
$P(T_2) = 5.4$ mbar

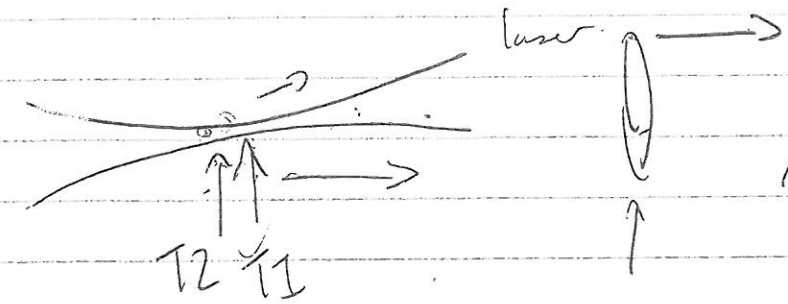
} Bi-Pressure 6.7×10^{-7} Flat-Field
6.4×10^{-4} Chamber

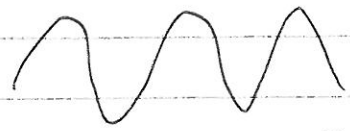
Standard set for one lens position/pulse energy etc

1. $T_2 + T_1$; T_1 Fixed in position
2. T_2 only ; " "
3. T_1 only ; " "
4. $T_2 + T_1$; T_2 Fixed in position
5. T_2 only ; " "
6. T_1 only ; " "

(13)

laser side.





$I_1 + I_2 + 2\cos\phi$

I_1

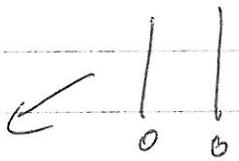
I_2.

$I_1 + I_2$

Moving

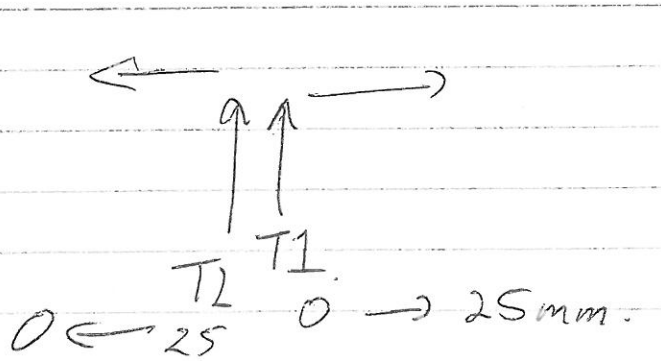
T1.	T1 on	T2 on.
	T1 on	T2 off.
	T1 off	T2 on.
T2	T1 on.	T2 on.
	T1 on	T2 off.
	T1 off	T2 on.

Start position of lens : 12.37 mm.



Decreasing stage posn corresponds to moving lens towards laser.

Saving scans in xxxxxx_Z_Scans folders.



Using software.
Start Mallad:
1. CA = + up arrow.
2. obj = + up arrow

CA = EPICS.ChannelAccess('Properties', {'EPICS_CA_ADDR_LIST', '130.246.68.167'})

obj = Artemis.Flatfield('Maximize', true, 'ChannelAcc... CA')

Connect to camera 235-B.

Reset stages:
T1 [ART:IMAG:MOT:SMC100:AXS1].
T2 [, , , , , 2].

To get ROI intensity plot to work:

Go to Flatfield viewer.m
→ Final cell
%% Turn on spectral acquisition
→ Run cell.
Parameter 'idy' sets region over which to scan.

(15)

Window size 196 x 986

~~66~~ 611 296

201. 986.

Not the same as previous scans.
→ Last scan with previous settings: 171235_Z-Scan.

Lens positions 12:37, 10:37, 8:37.
→ Slightly different window size. due to software crash. → No notes saved automatically!
→ All pressures. 4 → 5 mbar.
→ Ordering of scans the same.

Wednesday 16 August 2017.

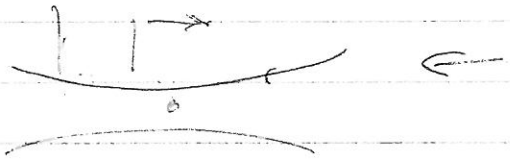
- Optimize modulations.
- Investigate long trajectory interference.

194237.

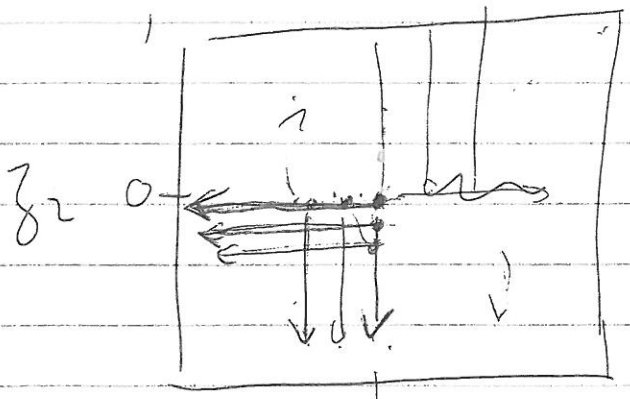
Paying attention to laser energy stability to avoid washing the long trajectory signal out.
Am ⍵ photodiode voltage recorded after second amplification stage ⍵ 3·99 +/- 0·056 V
⍵ ⍵ σ (rms or std dev?)
"jitter" = 1·4 % unknown length of time average. ~1 second

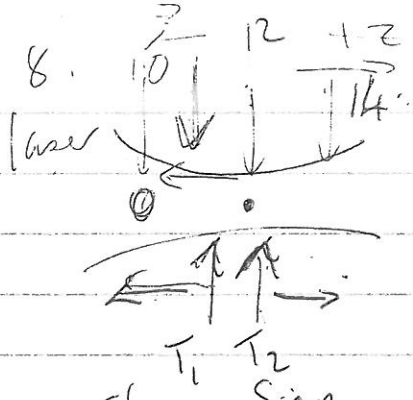
New software:
Scan sideways.
T1 1 . . .
T2 1 . . .
} loop: ~~(T1 then loop T2)~~ T2 in steps. Scan T1 each step

T1 1 . . T2 1 . . → T1 fully. T2 fully.

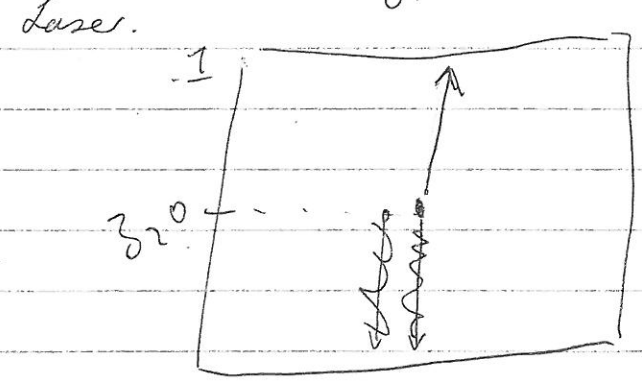


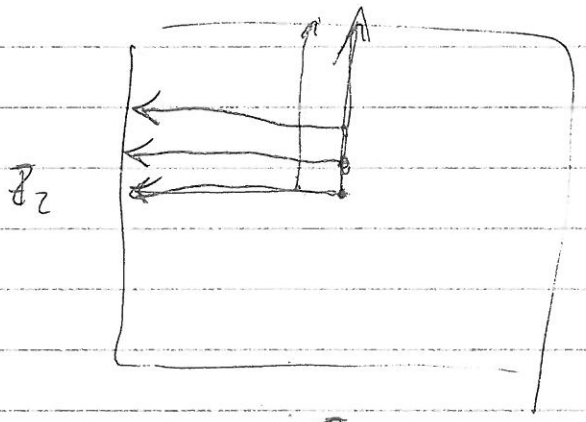
(17)





Laser.





T_2 →

T_1 ←

1 T_1 T_2

$-z_r$ z_r

T_1 T_2

2

T_2 →

curtains added around laser to improve stability. Laser stable over course of the day.

Evening:

Afternoon:

Performed raster scans of T1 and T2.

- Scan T2 and multiple positions of T1
- Did this for 4 lens positions.
- Laser stable throughout.

Evening:

Looking for interference on long trajectories.

- Performed multiple scans of T2+T1 and T2 only
- David analysed data on the go.
- No clear patterns as before.
- Possible that not as stable as lens laser.
- Noticed some edge on top of spectrum. Tried to tweak beam in to adjust but not very successful.
- Did stability "scans" to observe variation of signal.

Thursday 17 August 2017.

- From yesterday.
  - Adam suggests edge as from chamber aperture. Leave for the moment.

Options for long interferometer.
- Stability of laser → Compare with data from Ian's lab
- Position of lens. → Have already tried several positions
- Intensity → Highest intensity, scan at different values. Good data to have in any case

Morning:
Scan intensity. T1+T2, T2, T1. Moving T2.

T1 on T2 on.
T1 on T2 off.
T1 off T2 on.

David looked through previous data. Oxford a bit more stable. No clear conclusions from yesterday stability measurements.

Some ideas to improve measurements:
- Optimize focussing of flatfield camera. Speckle seems blurred.
- Optimize grating position.
- Remove edge on top of spectrum.
- Monitor laser fluctuations with P.D. to correlate with HHG signal.
- Correct for movement (spatial axis) of harmonics as T2 is scanned.

		T2
closed	141	z = 20
open	130	
open	145	z = 145.25

	fix		
2-20	137	closed	500 post aperture
	110	energy	750 ms (before aperture)

Shifting
Not really energy (intensity) dependent but definitely aperture dependent.

Set aperture to minimize shift in harmonics as it goes through focal region - works well.
Took one scan of T2 to verify.

Aperture used was : 14.3 mm Diameter.

Afternoon:

- Re did pointing into chamber using picomotor controlled mirrors. This centred HHG beam through differential pumping aperture.
- Grating angle and insertion adjusted to maximize signal and ~~#~~ number of harmonic orders. Should be 1 more than previously.
- Aperture beam using iris. This drastically improved interference as the T2 target ~~now~~ no longer exhibits a spatial shift dependent on z-position. Shift the result of laser beam being non-Gaussian.
- Stage ~~pushed~~ for longitudinal positioning of grating not working. However, HHG signal looks good.
- Two target scans now exhibit excellent on-axis interference and clear off-axis, off harmonic interference.
- David has analysed Evelyn's raw scans. Generated plots show good agreement with simple model.

Evening

- Repeat raster scans from yesterday. Apertured beam to yield better interference.

Sequence of 3 scans: Lens at 6.37mm; 8.37mm; 10.37mm; 12.37m

Gas in both cells.

Sequence for each scan: Scan T2. Step T1. repeat.

Friday 18-August-2017

- Objective: Set up $\lambda/2$ + $\lambda/4$ plates & investigate ellipticity dependence of long-term interference.

Calibrate $\lambda/2$ and $\lambda/4$ plate with beam after compressor 2. Using Eksma polarizer.

Angle [°] $\lambda/2$ plate	Power [W]
140°	0.230
136°	0.205
132°	0.178
128°	0.147*
124°	0.118
120°	0.099
116°	0.080
112°	0.065
108°	0.061
104°	0.067
100°	0.080
96°	0.101
92°	0.123
88°	0.152
84°	0.180
80°	0.210
76°	0.252
72°	0.256
68°	0.271
64°	0.280

Angle [°] $\lambda/2$ plate	Power [W]
60	0.270
56	0.263
52	0.249
48	0.225
44	0.199
40	0.168
36	0.140
32	0.111
28	0.092
24	0.078
20	0.064
16	0.065
12	0.074
8	0.084
4	0.110
0	0.132

Angle [°] $\lambda/4$ plate	Power [W]
140	0.208
135	0.227
130	0.243
125	0.253
120	0.260
115	0.258
110	0.245
105	0.228
100	0.208
95	0.190
90	0.172
85	0.162
80	0.153

Angle [°] λ/4 plate	Power [W]
75	0,155
70	0.152
65	0.158
60	0.173
55	0.190
50	0.208
45	0.231
40	0.244
35	0.256
30	0.268
25	0.268
20	0.260
15	0.249
10	0.236
5	0.221
0	0.200

$\lambda/2$ plate: $P_{max} = 280\,mW$ @ $\theta = 64°$; $P_{min} \simeq 60\,mW$ @ $\theta = 108°, 13°$

$\lambda/4$ plate: $P_{max} \simeq 270\,mW$ @ $\theta = 25°, 120°$; $P_{min} \simeq 150\,mW$ @ $\theta = 75°$

Mounted Focussing lens on a motorised stage
Stage = 0 is closest to chamber
27 mm range of motion ~ 1.5 Zr

- Set scans of lens and T1-T2 going at 6 μm

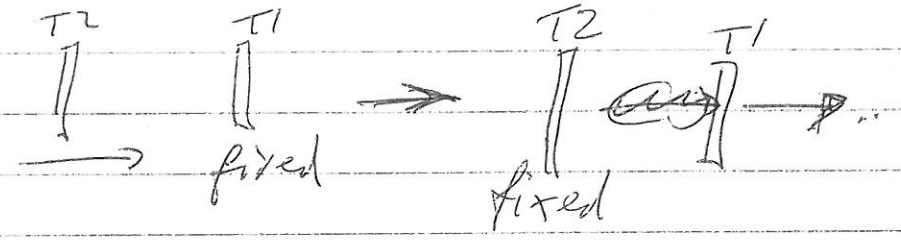
Monday 21 August 2017

Afternoon

- Measure interference as a fn of drive ellipticity.

Arrangement of beams:

T2: 25 → 0, then T1: 0 → 25

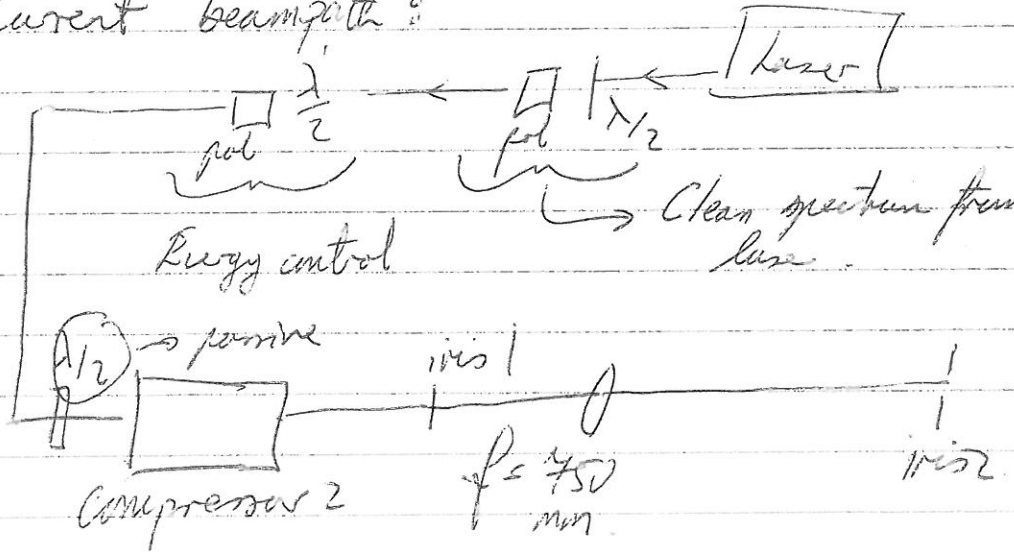


The structure of off-harmonic alignment seems to show the same structure regardless of ellipticity.

Evening

- Set up 750mm lens. (Achromat)
- Included additional waveplate/polarizer combination to give better energy control.

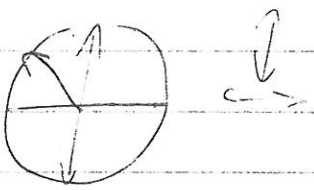
Current beampath:



- Obvious spatial chirp on beam.
- Aperturing input definitely improves spatial chirp.
- Ran Scanned lens positions overnight.

- Ellipticity data shows no variation of structure with ellipticity.
- Also, on and off axis components decrease at same rate.
- Clear ~~side~~ fringes in spatial direction. Converge and diverge. → Possibly just interference of circular wavefronts.

Paper data ~~from~~ 2408-2015 Scan 003 T7 cm



Tuesday 22 - August - 2017

Morning

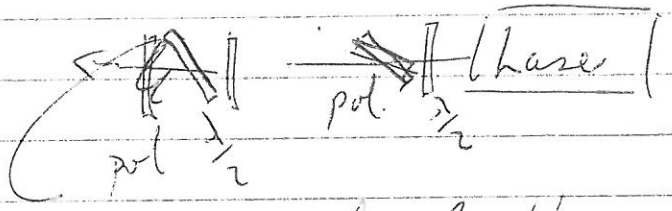
- Scan which was set off overnight was still running. Only ~ 50% done by 5 o'clock. Killed scan.

- Realigned beam.

Afternoon

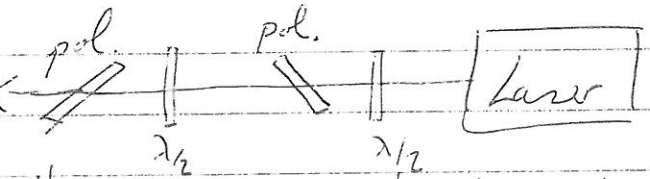
- Rotated polarizer to opposite direction to 1st polarizer.

or Previously:



Both polarizers at same angles (possible cause of spatial chirp on beam.

Changed to



Made a noticeable improvement to spatial chirp. No shifting of harmonics with changing beam position.

- Simulations SFA vs ~~can~~ analytical give reasonable agreement

Evening

- Raster scans for increasing intensity (lens fixed at 13mm). Objective is to extend cutoff such that observed harmonics are in the plateau. Question as will additional (long) features emerge in the q_z raster scans at higher intensities?

- Raster scans for changing ellipticity. Keeping input energy (after iris) at 400 μJ, where there was some long trajectory structure. Changing integration time for each scan.

Finished at 03:30 am

Wednesday 23 - August - 2017.

Morning

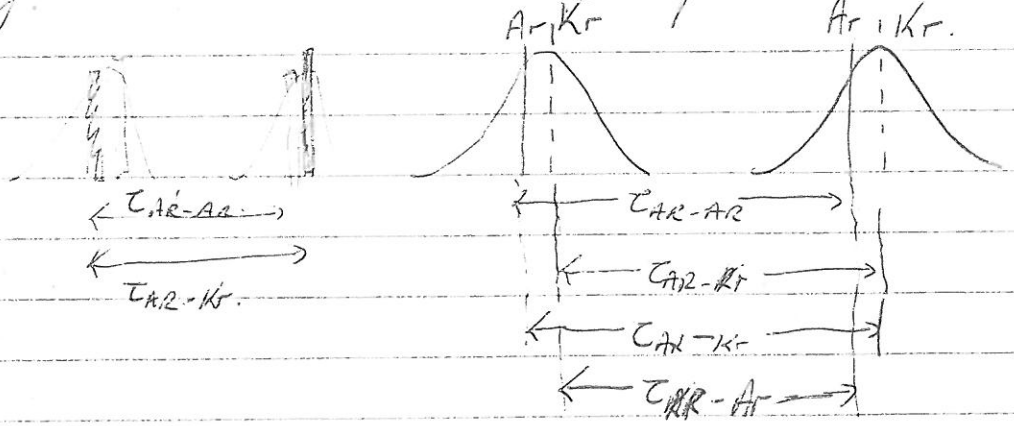
- Gas change. Can now switch between Argon and Krypton easily in first cell.

Afternoon:

Krypton in 1st cell. HHG immediately. Clear oscillations between Ar and Kr sources.

Scan intensity. Faster scans as yesterday.

Idea: Compare scan from Krypton-Argon to a scan from Argon-Argon under identical conditions. Would expect a phase shift between the two scans due to difference in emission time from cell 2.
Diff. ent ionization potentials should result in different generation windows within the pulse.



Calibrating flow meter and pressure gauge for Krypton.

Flow / SCCM	Pressure / mbar.
4	-2.4
14	1.1
24	4.4
34	7.1
44	10.1
54	12.9
64	15.9
71	18.

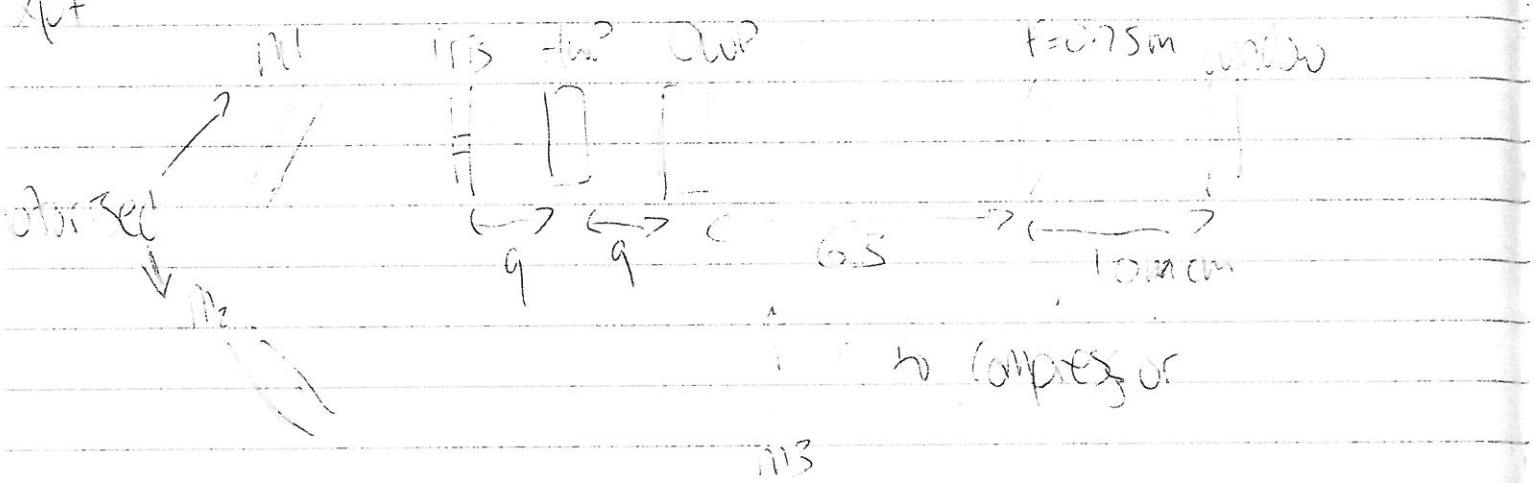
Thursday 24-Aug-2017.

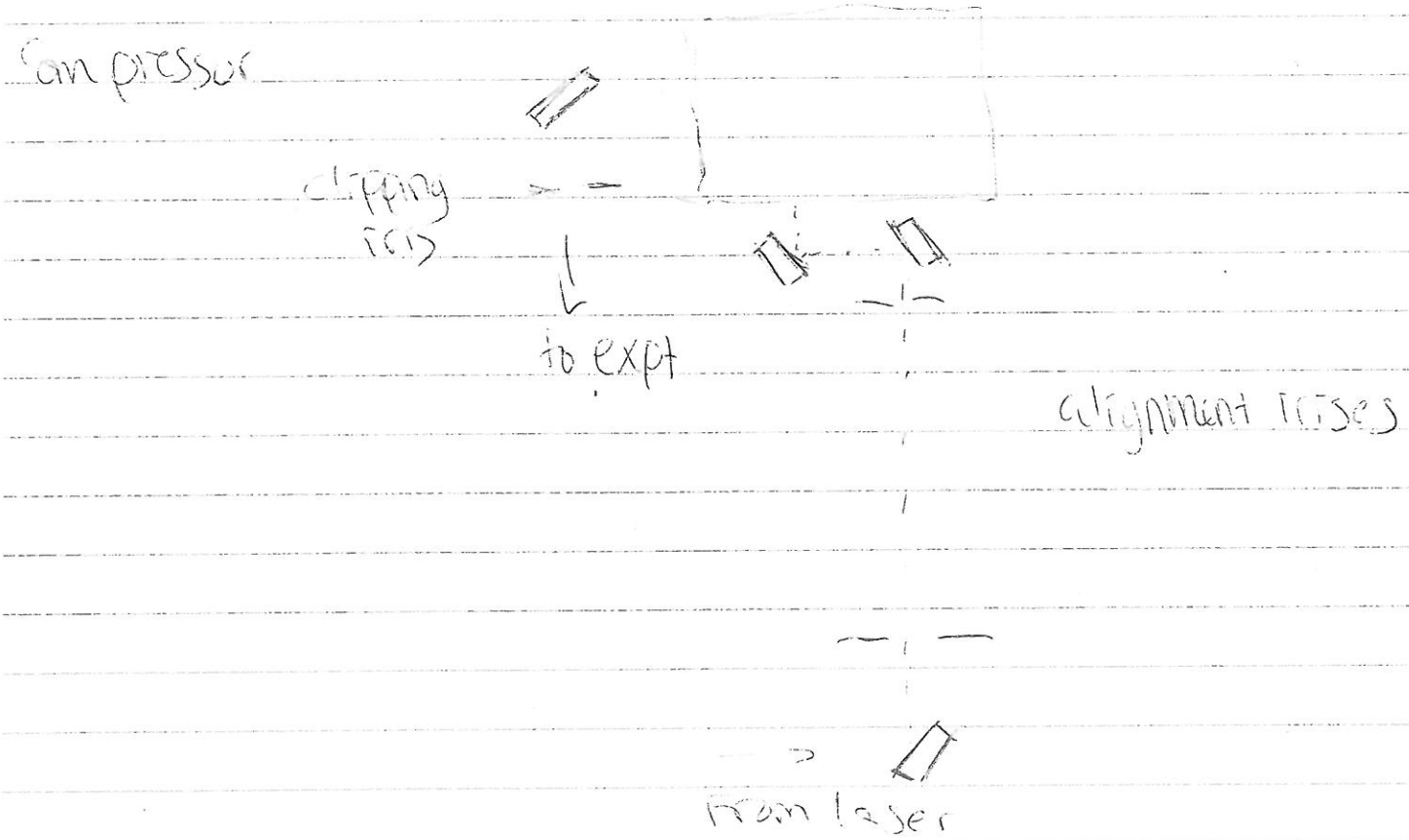
Calibrating flow meter and pressure gauge for Xenon.

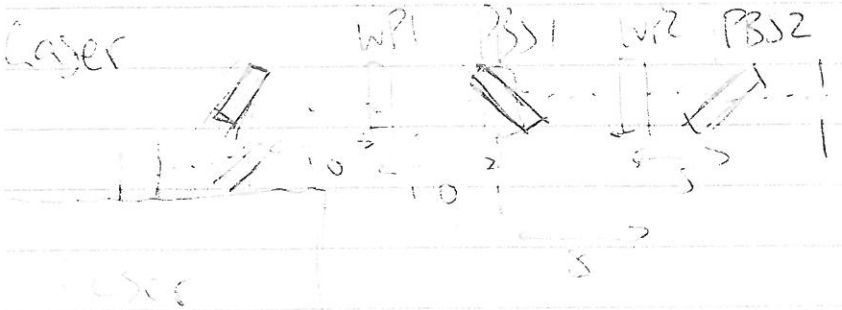
Flow [sccm]	Pressure [mbar] CH1
1	-5.5
2	-3.4
3	-2.5
4	-2.4
10	+0.1
20	3.9
30	7.3
40	10.8

(32)

Sketch of 800 nm set-up





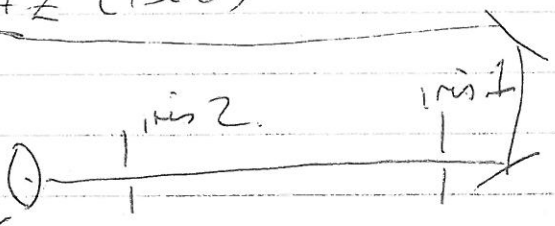


Friday 25th August 2017.

Using TOPAZ. (1300nm)

Setup

TOPAZ (1300)



↳ 500mm singlet.
Not coated.

Aligned He-Ne to holes in gas jet ~~at~~ and iris 1.
Reset iris 2

Energy Control using delay in OPA

Delay 3 / mm	Power after Iris 1. / mW
~~On~~ 1.527	920
1.529	1050 ~~1090~~
1.530	1050
1.532	1020
1.552	0.0825
1.541	0.061
1.540	0.120
1.538	0.255
1.537	0.505
1.535	0.762
1.533	0.946

Monday 28th August 2017

- Optimizing TOPAS output.

Measured caustic from TOPAS at 1300 nm.
Power output 1.05 W before focusing lens

Measured caustic from TOPAS at 1150nm.
Power output ~0.850 W before focusing lens.

Beam profile at 1150 looked better than that at 1300nm.

Can switch easily between 1150nm and 1300nm use TOPAS software

re(al)ate timing/delay power control

Delay	Power
1.529	1.13
1.532	1.00
1.535	0.67
1.537	0.36
1.538	0.19
1.540	0.09
1.543	0.03
1.546	0.027

Switching to shorter wavelength (1150 nm) Focus moves away from OPA

i.e wavelength dependent Focal shift

Tuesday 29th August 2017.

Ar - Ar @ 1300nm ✓
Ar - CO_2 @ 1300nm. ✓
Pressure scan Ar - Ar @ 1300nm ✓

Mirror spectrum from OPA as fn of delay for pulse energy control ✓

Ar - Ar @ 1300nm varying intens. ✓ 53 23 35

Ar - Ar @ 1250nm. ✓
Ar - CO_2 @ 1250nm. ✓

Ar - Ar @ 1200nm. ✓
Ar - CO_2 @ 1200nm ✓

Ar - Ar @ 1300nm ✓
change change grating angle to view higher orders.

Pixel position of brightest harmonic. (2nd from left.)
= ~~224~~ 225
↙ Brightest

0	0	0	0	
	225	329	421	

At large grating angles (74.5°) start seeing bright spots on MCP. Didn't go further.

Restored software grating angle: −0.4.

spectrometer image affected by placing hand or Flat Field Chamber.

Long trajectories visible on higher energies.

Wednesday 30th August 2017

- Optimize grating position to minimise glint/scatter.
- Observe beam trajectories again.
- Scan targets.

Start pos. of grating motor : -5750 steps

Moved to grating position : -48250 steps

Perhaps slight improvement but difficult to say.

Grating angle now -4.5 degs.

Grating angle already quite well aligned.

Observation of fringes on off harmonic component (divergence dim

Breathing of harmonics means not stable enough to scan.
- Solutions - Use beam tubes
  - Log intensity of pulses and ~~discard~~ sort acquisitions accordingly.

In meantime decided to switch to using different gases.
Best use of time while other solutions are being implemented.

(54)

Order of gas scans: All at 1300nm.

Ar - Ar ✓
CO_2 - Ar ✓
Xe - Ar. ✓
N_2 - Ar ✓
Kr - Ar ✓

~~74362~~

- Perform some stability scans (repeat scans) of Ar-Kr to verify the noise levels / stability conditions of data.

Inserted beam tubes over as much of path as feasible

Moved grating to -4.3 degs to see if there is any improvement in stability.

Original grating position at -0.6 degs.

q1 q2 q3 q4 q5 . . . .

After moving to grating -4.3 degs harmonic signal on Hatfield:

q5.

q1 → q4 shifted off MCP.

Grating motor position: ~~-20470 steps~~ 150 step
-- 5750 steps.

1166 signal at 1300nm did not exhibit off harmonic interferences as earlier in the day.

Switched to 1200nm driver. Clearer ringing visible plus off axis interference.

Could optimize the off-axis interference by varying OPA delay 3 (changes intensity). Very clear changes in ring patterns.

Did raster scans at high gain and low camera gain.

Delay 3 Tick	OPA Power (mW)
4910	1030
4911	1020
4912	1000
4913	1000
4914	990
4915	960
4916	940
4917	900
4918	890

→ Tick positions used to change long trajectory structures using 1200nm beam.

Thursday 31st - August - 2017.

- Repeat intensity scans at 2 beam harmonic orders.
- Ellipticity at fixed position + 2part scans.
- Single target 3-scans.
- Mode measurements [1100, 1250]

- Backup all data to harddrive.

Calibrating power from OPA

- Ticks	Power / in W.
4910	1020
4912	1000.
4914	990.
4916	970.
4918	930.
4920	880.
4922	820.
4924	760.
4926	680
4928	590.