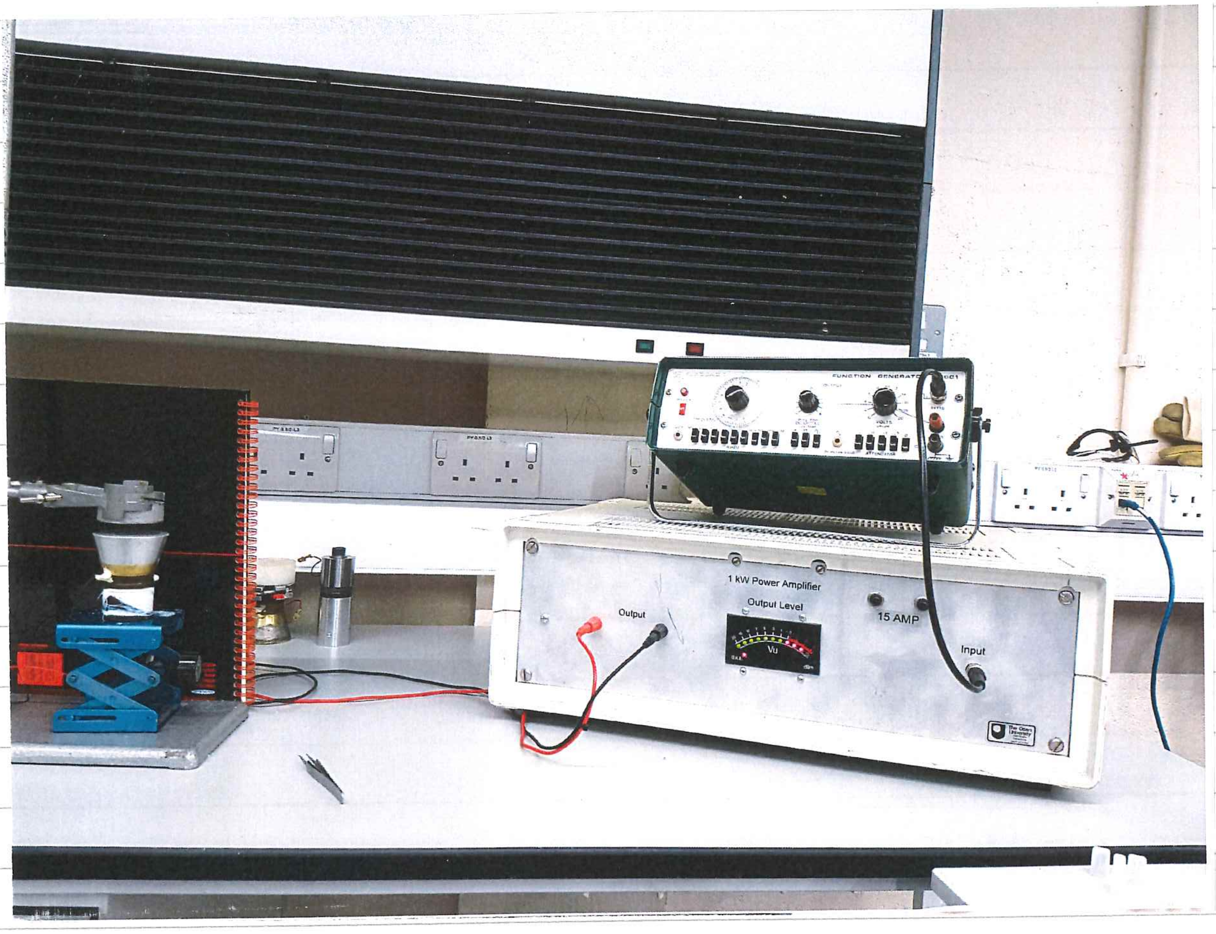
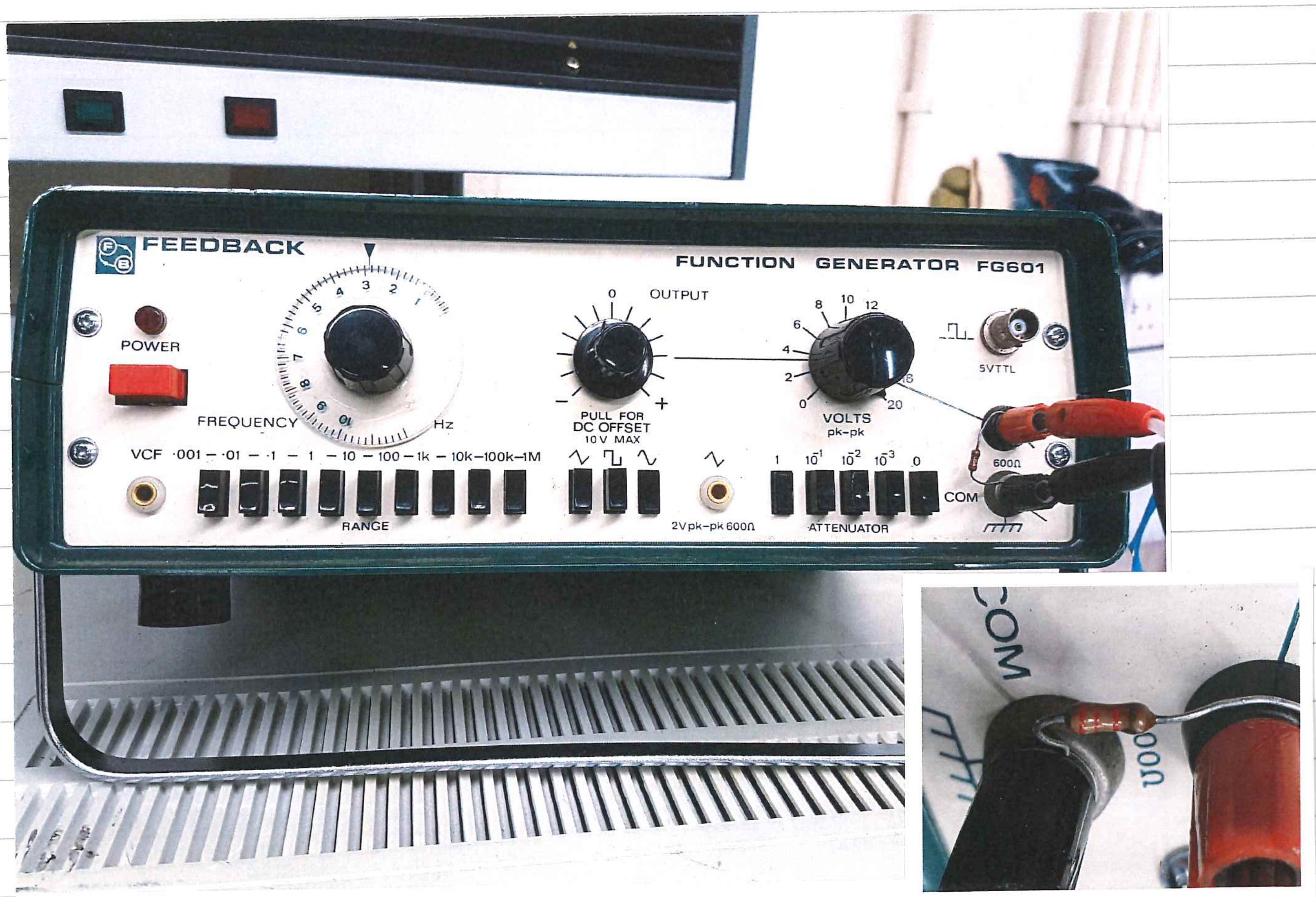
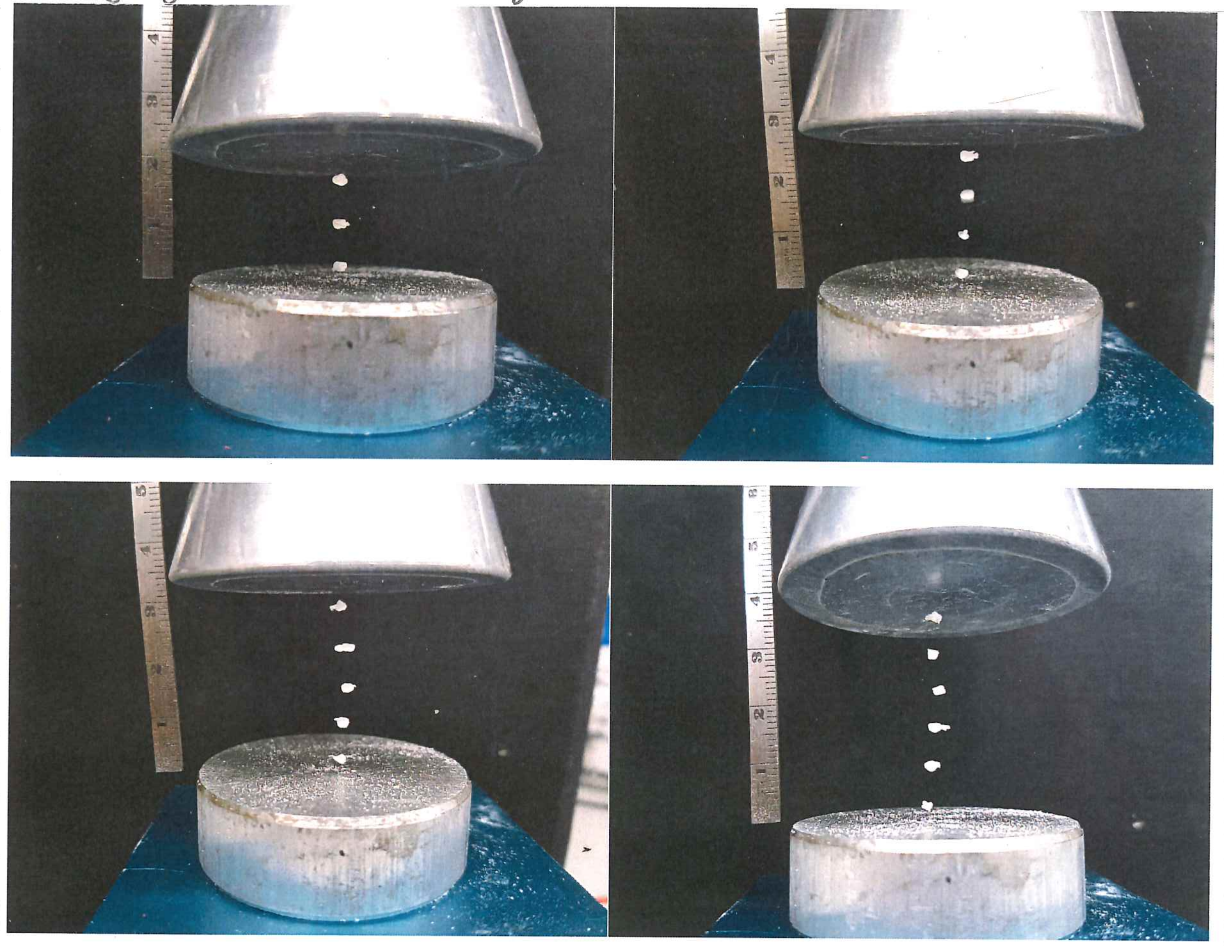




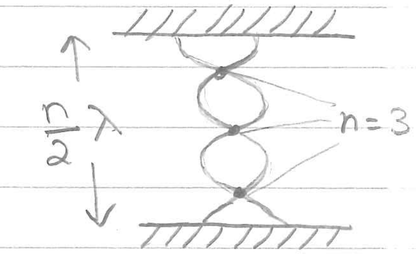
~ 28.5 kHz on frequency generator

20 V p-p

Varying the number of antinodes



3 antinodes = 1.5λ ~ 20 mm
λ ~ 13.3 mm



4 antinodes = 2λ ~ 26.5 mm
λ ~ 13.25 mm

5 antinodes = 2.5λ ~ 33 mm
λ ~ 13.2 mm

6 antinodes = 3λ ~ 40 mm
λ ~ 13.3 mm

← 1.2 or 2.2 kΩ resistor ?

Speed of sound in air
= 343 ms^{-1}

$\lambda = \frac{s}{f}$

$= \frac{343}{28.5 \times 10^3}$

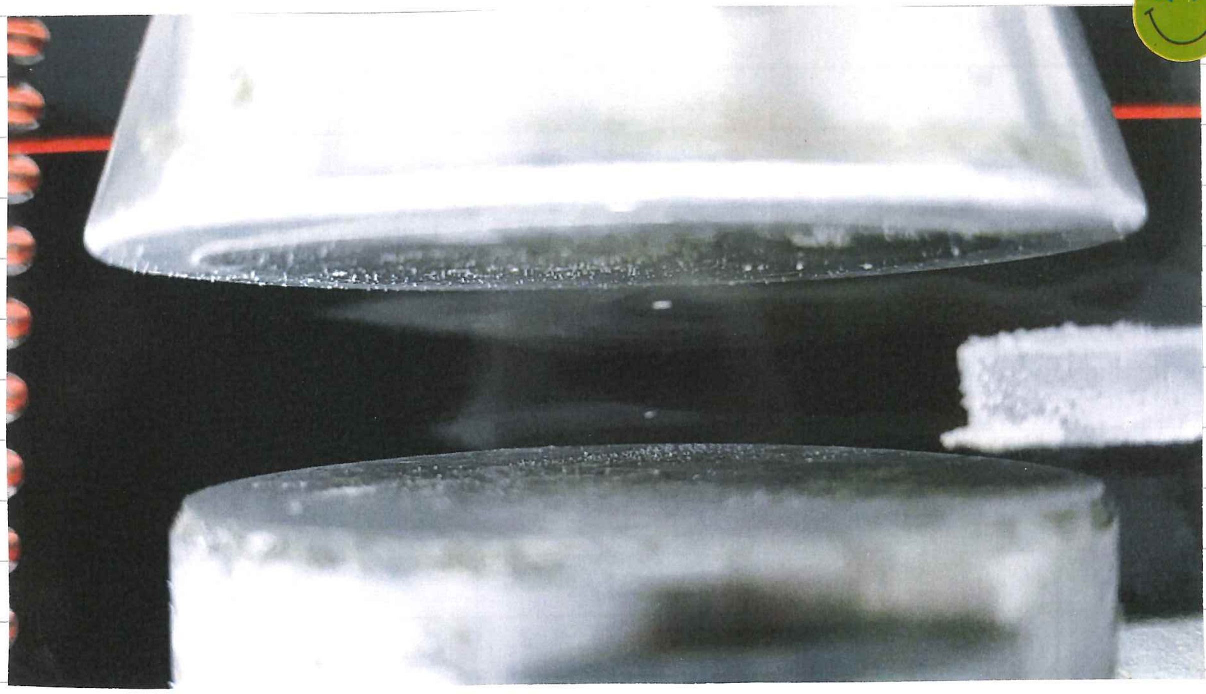
$= 12.03$ mm

NB. Temp & humidity corr.

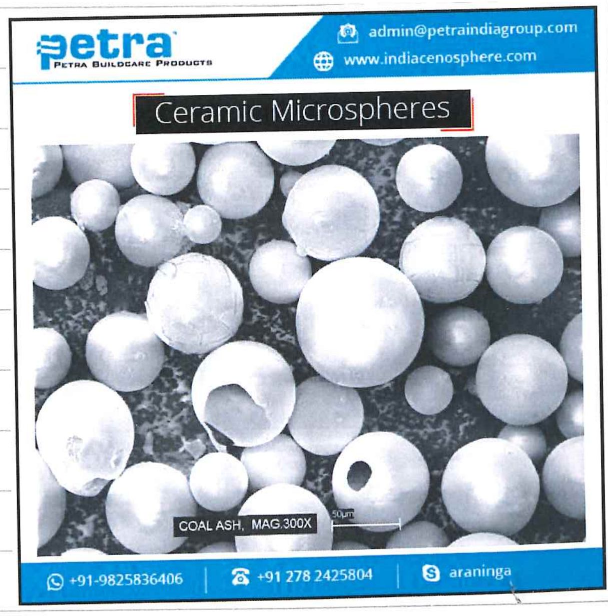
Need a more accurate way of changing/measuring height

Thu 20/07/17

Shabbir found some ceramic microspheres — ideal for levitation & coating in ice?



Snowflakes growing by nucleating on ceramic microspheres.



They look like this!

Sat 05/08/17

Benzene paper submitted!!!

moving on...

Physical Chemistry Chemical Physics

PCCP

Vacuum ultraviolet photoabsorption spectroscopy of crystalline and amorphous benzene

Journal:	*Physical Chemistry Chemical Physics*
Manuscript ID	CP-ART-08-2017-005319
Article Type:	Paper
Date Submitted by the Author:	05-Aug-2017
Complete List of Authors:	Dawes, Anita; The Open University, Department of Physical Sciences Pascual, Natalia; The Open University Hoffmann, Søren; Aarhus University, ISA, Deparment of Physics and Astronomy Jones, Nykola; Aarhus University, ISA, Department of Physics and Astronomy Mason, Nigel; The Open University, Department of Physical Sciences

SCHOLARONE™
Manuscripts

Submitted Manuscripts

Manuscript status explanation:

1. **Checking submission and files** - we are checking to see if your submission is complete and we have all the files we need.
2. **Initial assessment** - manuscript is undergoing initial assessment.
3. **With editor** - manuscript is with the editor, either to select new or additional reviewers, or to make a decision following initial assessment or peer review.
4. **In peer review** - manuscript has been sent to reviewers.
5. **Accepted** - manuscript has been accepted for publication.

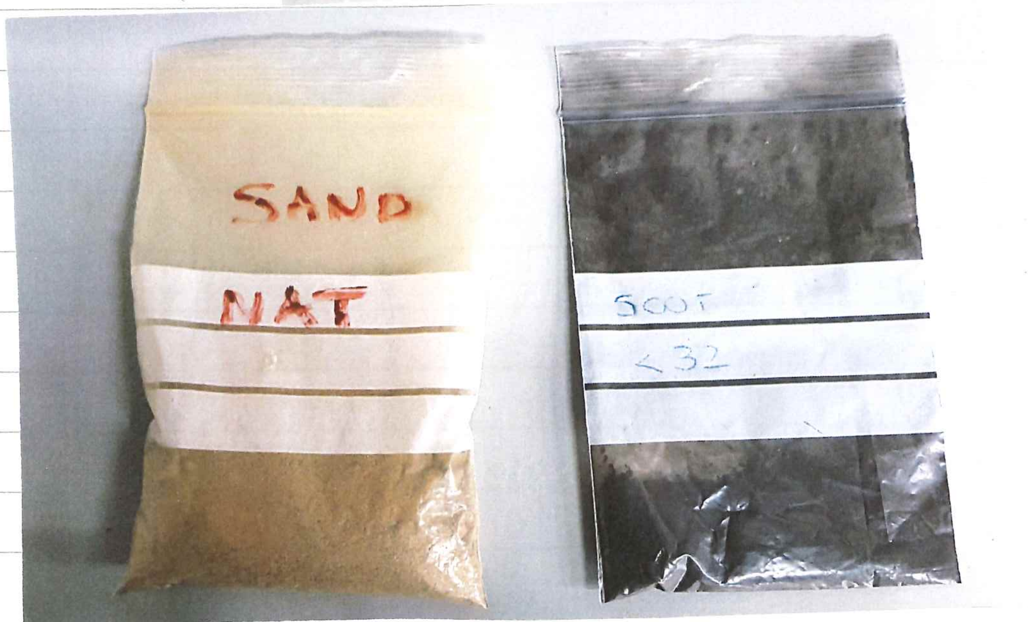
Please note that manuscripts can move back and forth between status 3 and 4.

STATUS	ID	TITLE	CREATED	SUBMITTED
• In peer review Licence to Publish Completion submitted (07-Aug-2017) - view	CP-ART-08-2017-005319	Vacuum ultraviolet photoabsorption spectroscopy of crystalline and amorphous benzene View Submission	05-Aug-2017	05-Aug-2017

08/08/17

Shabbir found a very useful precision height adjuster!
together with a reflector and transducer attached!

Was it Sarah or Liz's?



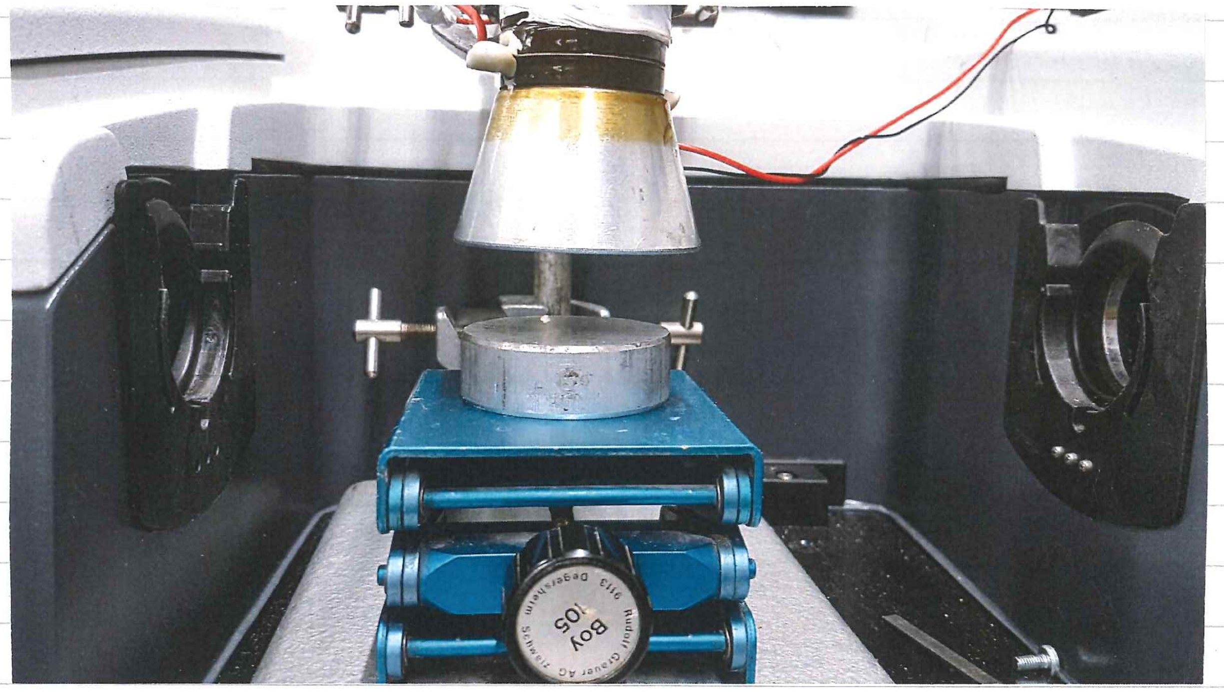
Found this on my desk on 30/08/17

From Nigel?

Original soot from Sarah's grandma's chimney!

31/08/17

Today I set up the trap in the FTIR spectrometer compartment.



The set up used to acquire the spectra today

Transducer frequency ~ 28.5 kHz
p-p voltage ~ 20 V

16:42 Background spectrum through empty trap (in atmosphere)
Soot_20170831_BG.spa
16 scans $1\ cm^{-1}$ res ~~4.2 peak signal.~~ ? not recorded

16:45 Scan through empty trap 4.2 peak value
Soot_20170831_0001.spa

16:50 Soot levitated in the trap 4.1 peak value
Room temp.
Soot_20170831_0002.spa

17:26 Soot and ice levitated in the trap.
Reflector LN_2 cooled
vapour admitted with LN_2 cooled screwdriver
16 scans ; $1 cm^{-1}$ res ; 3.4 peak value.
17:31 Soot_20170831_0003
17:34 Repeat Soot_20170831_0004 , _0005
17:43 Levitated thermalite + ice peak value 3.3
LN_2 cooled
Soot_20170831_0006

17:45 Repeat above peak value 3.2
Soot_20170831_0007
N.B. Spectrum very noisy!

17:51 Levitated thermalite + ice ~~soot~~
16 scans ; $1 cm^{-1}$ res ; peak value 2.3
Soot_20170831_0008

17:55 Repeat above peak value 2.9
Soot_20170831_0009

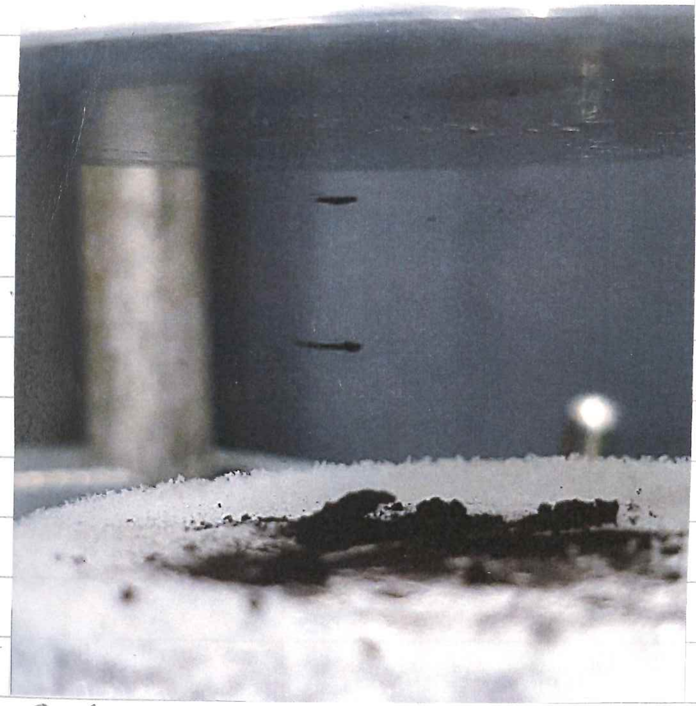
18:13 Just levitated ice (+snow flakes)
No soot or thermalite (reflector cleaned)
16 scans ; $1 cm^{-1}$ res ; peak value 3.1
Soot_20170831_0010

18:16 Repeat above peak value 2.9
Soot_20170831_0011

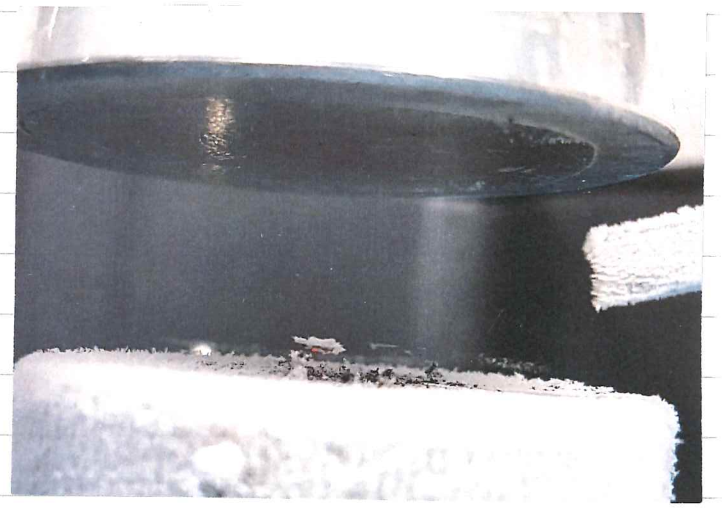
18:19 Repeat above peak value 3.1
Soot_20170831_0012

18:25 Soot and ice again
LN2 cooled
16 scans ; $1 cm^{-1}$ res ; peak value 2.8
Soot_20170831_0013

18:30 Repeat above (soot & ice flakes collapsed and stuck to the reflector)
Soot_20170831_0014 peak value 3.0

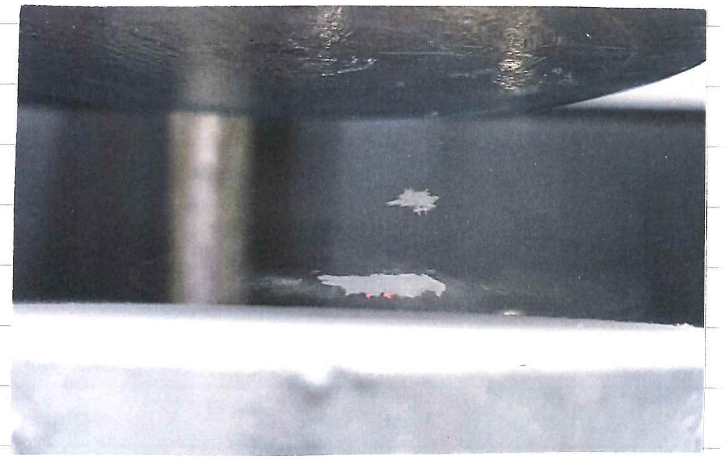


Soot

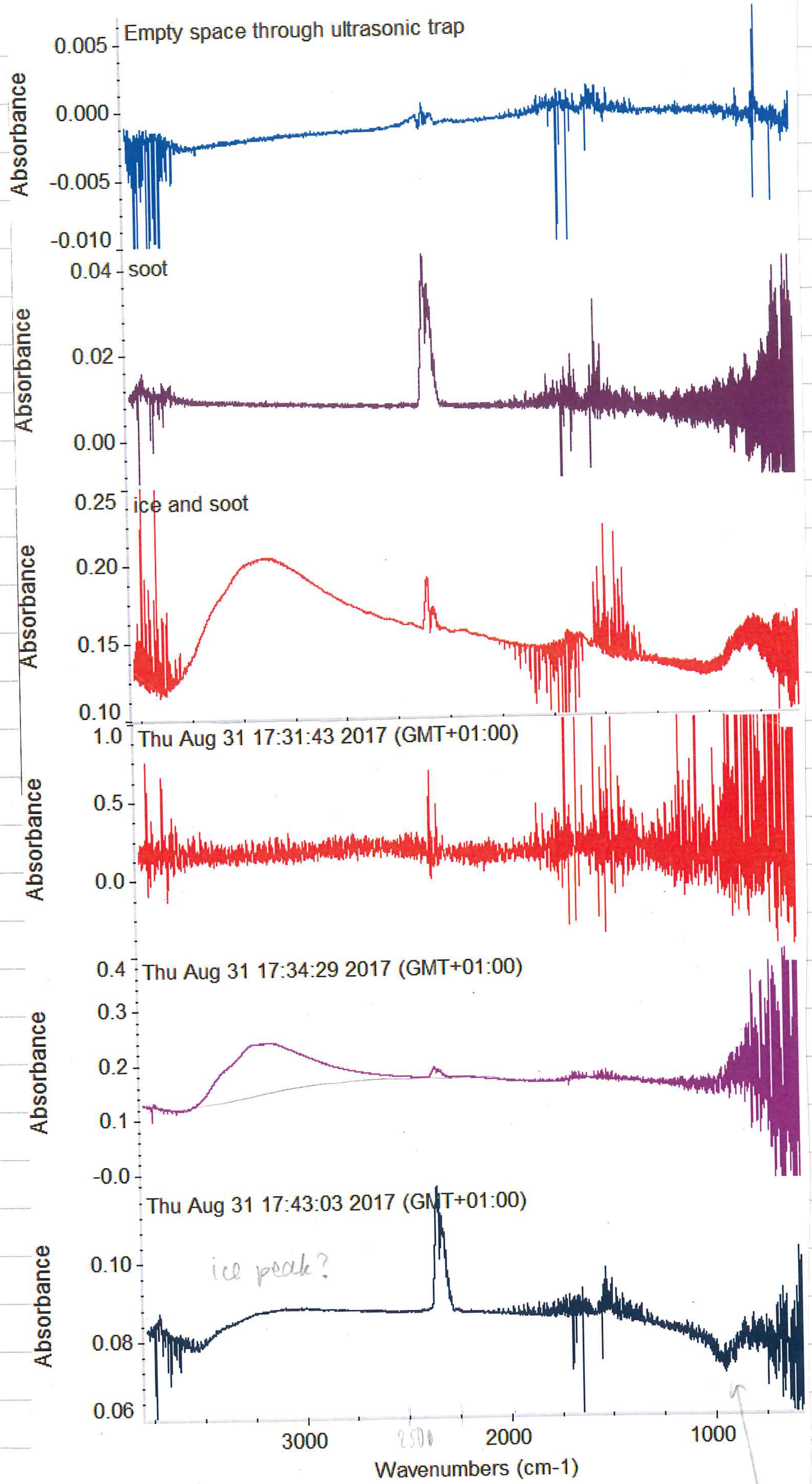


Soot + ice

Soot + ice



ice / snow flakes



-0001 Empty trap

-0002 Soot (room temp)

-0003 Soot & ice (LN2)

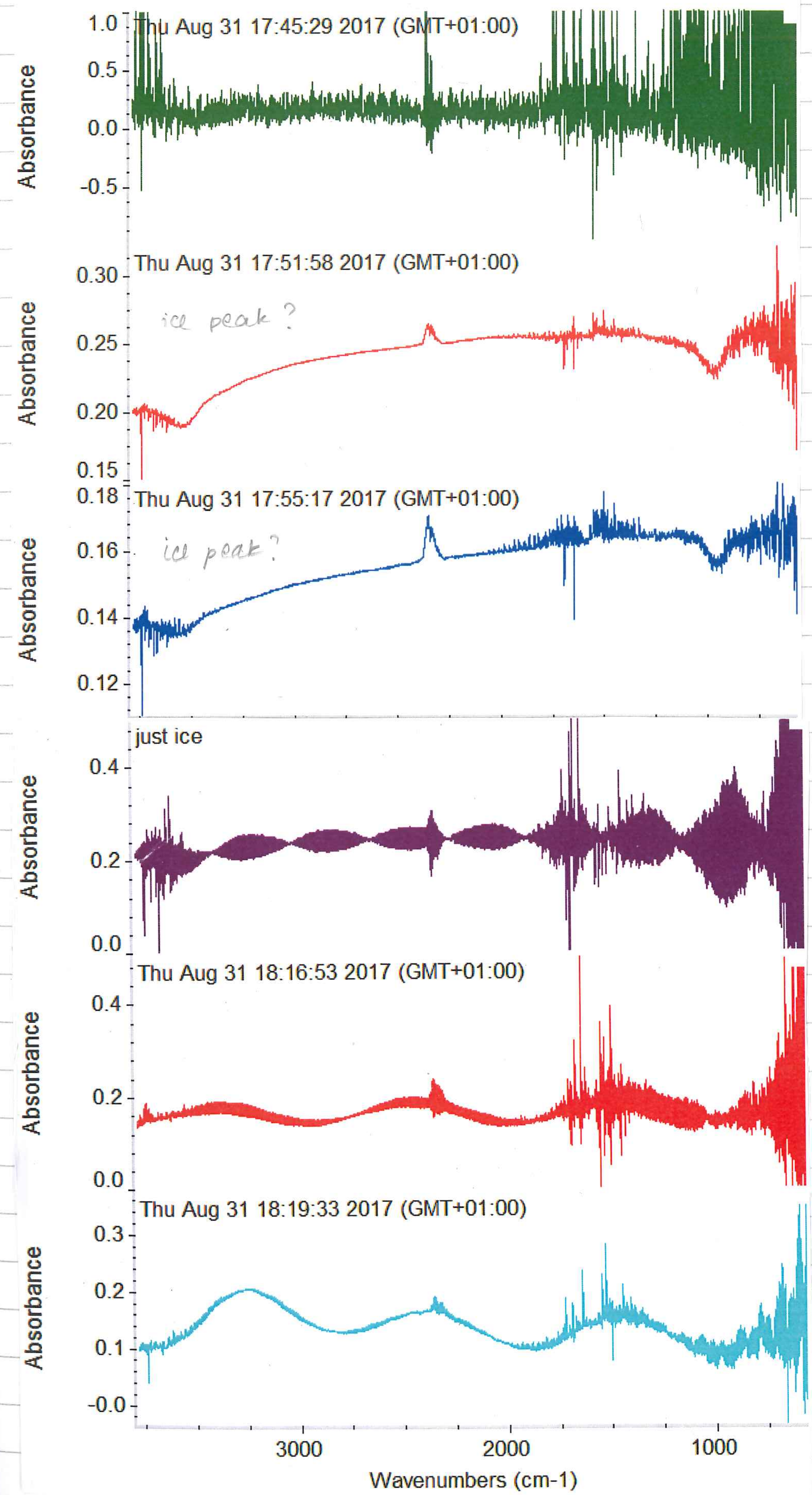
-0004 Soot & ice repeat

-0005 Soot & ice repeat

-0006 thermolite + ice (LN2)

"Silicate peak"

No can't be - wrong way!



-0007 Thermolite + ice repeat

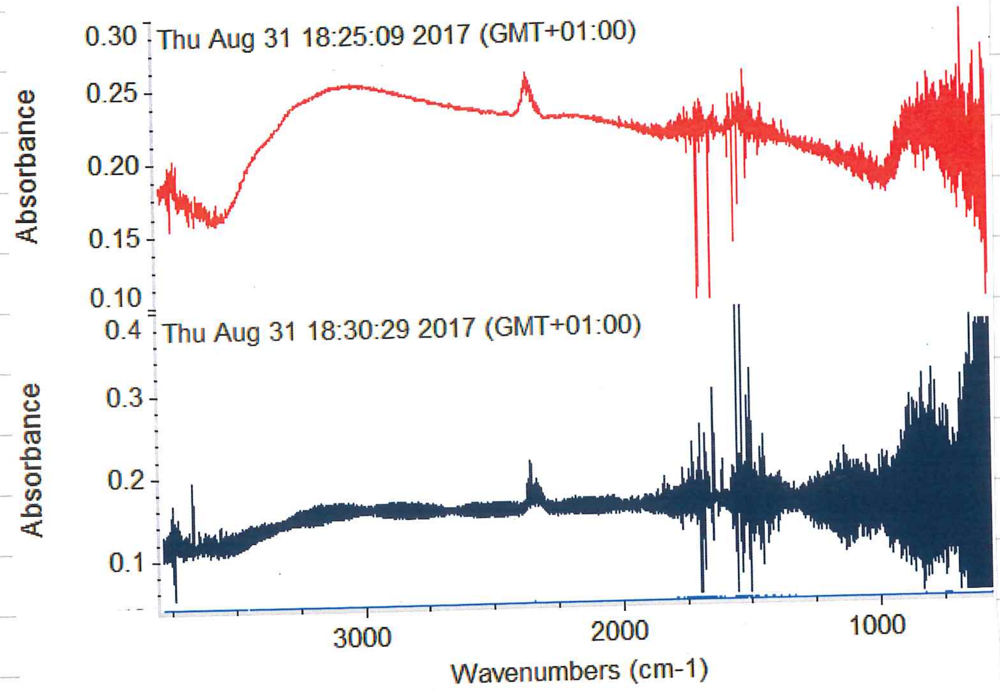
-0008 Thermolite + ice rep

-0009 Thermolite + ice rep.

-0010 Ice (no soot or thermolite)

-0011 Ice repeat

-0012 Ice repeat

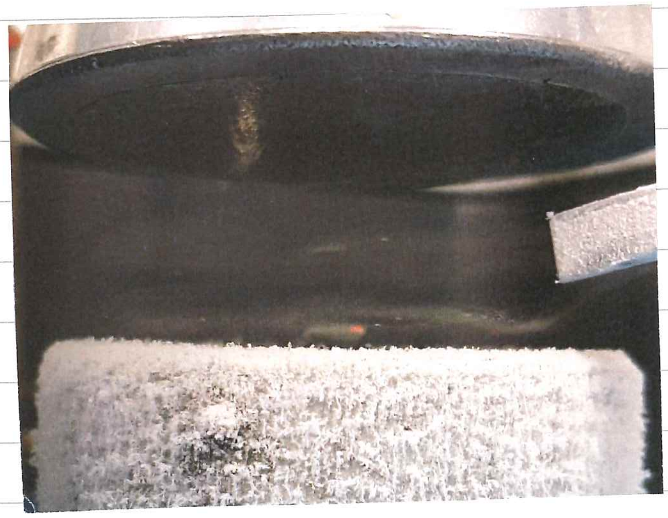


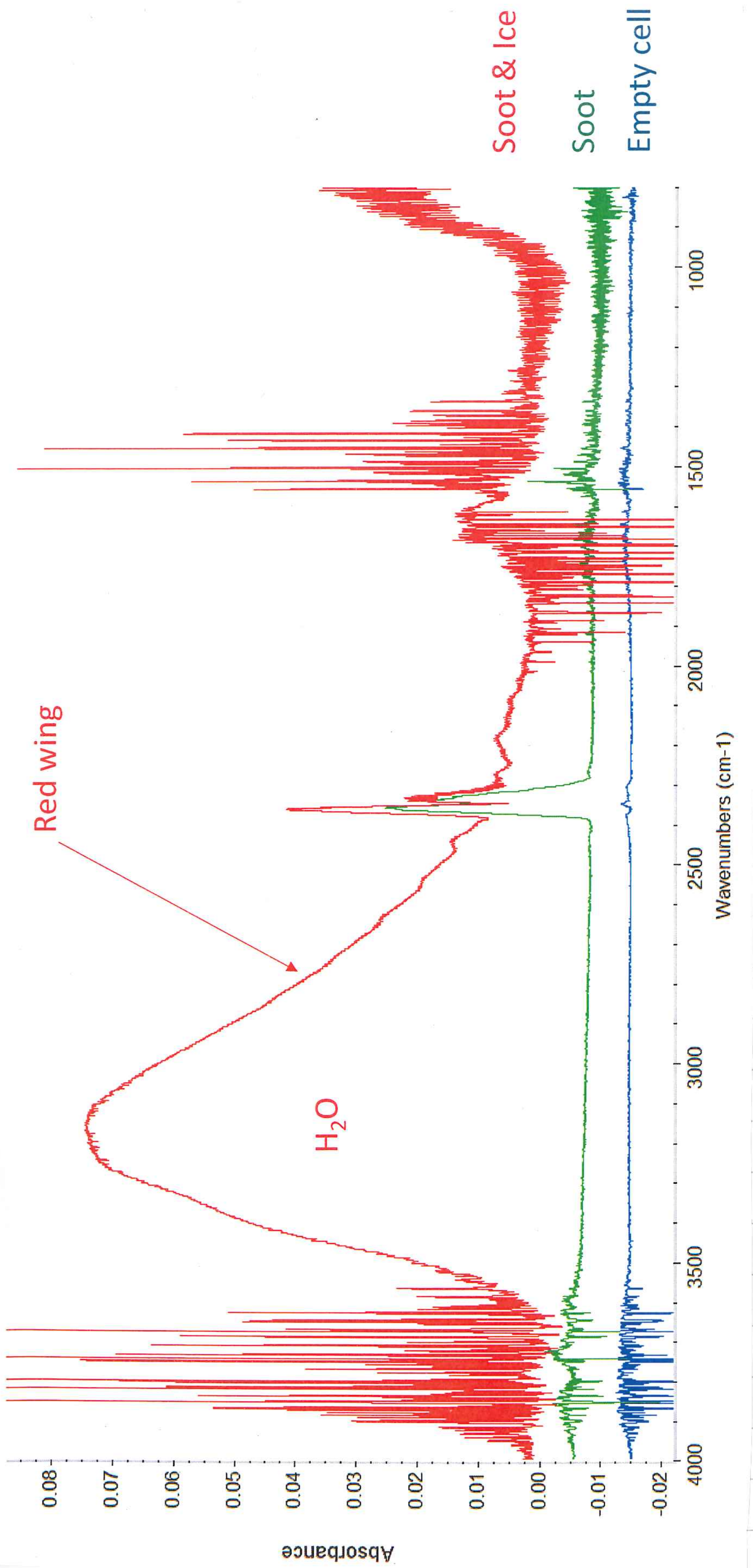
-0013
Soot + ice (LN_2)

-0014
Soot + ice repeat.

Observations from this data set:

- H_2O peak prominent in "ice + soot" spectra with an extensive red wing! — Reproducing data from ~2006
- Silicate feature is clearly visible in "thermalite + ice" spectra — BUT not H_2O band observed. No!
- Pure ice / snowflake spectra show sine wave baseline due to thin film interference — Size dependence?





The "red wing" observed again after 10+ years!

11/09/17 ⟶ 19/09/17 ASTRID 2 Run

$C_6H_6 + CO_2$ and $C_6H_6 + NH_3$ annealing & irradiation

See eLog Book.

28/09/17

Benzene paper accepted & published online!

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Vacuum ultraviolet photoabsorption spectroscopy of crystalline and amorphous benzene

Check for updates

Anita Dawes, Natalia Pascual, Søren Vronning Hoffmann, Nykola C. Jones and Nigel J. Mason

Abstract

We present the first high resolution vacuum ultraviolet photoabsorption study of amorphous benzene with comparisons to annealed crystalline benzene and the gas phase. Vapour deposited benzene layers were grown at 25 K and annealed to 90 K under conditions pertinent to interstellar icy dust grains and icy planetary bodies in our Solar System. Three singlet-singlet electronic transitions in solid benzene correspond to the $^1B_{2u}$, $^1B_{1u}$ and $^1E_{1u}$ states, redshifted by 0.05, 0.25 and 0.51 eV respectively with respect to the gas phase. The symmetry forbidden $^1B_{2u}\leftarrow{}^1A_{1g}$ and $^1B_{1u}\leftarrow{}^1A_{1g}$ transitions exhibit vibronic structure due to vibronic coupling and intensity borrowing from the allowed $^1E_{1u}\leftarrow{}^1A_{1g}$ transition. Additionally the $^1B_{2u}\leftarrow{}^1A_{1g}$ structure shows evidence of coupling between intramolecular vibrational and intermolecular lattice modes in crystalline benzene with Davydov crystal field splitting observed. The optically forbidden 0–0 electronic origin is clearly visible as a doublet at 4.69/4.70 eV in the crystalline solid and as a weak broadened feature at 4.67 eV in amorphous benzene. In the case of the $^1B_{1u}\leftarrow{}^1A_{1g}$ transition the forbidden 0–0 electronic origin is only observed in crystalline benzene as an exciton peak at 5.77 eV. Thicker amorphous benzene samples show diffuse bands around 4.3, 5.0 and 5.4 eV that we tentatively assign to spin forbidden singlet-triplet $^3B_{1u}\leftarrow{}^1A_{1g}$, $^3E_{1u}\leftarrow{}^1A_{1g}$ and $^3B_{2u}\leftarrow{}^1A_{1g}$ transitions respectively, not previously reported in photoabsorption spectra of amorphous benzene. Furthermore, our results show clear evidence of non-wetting or 'islanding' of amorphous benzene, characterised by thickness-dependent Rayleigh scattering tails at wavelengths greater than 220 nm. These results have significant implications for our understanding of the physical and chemical properties and processes in astrochemical ices and highlight the importance of VUV spectroscopy.

Publication details

Altmetric

The article was received on 05 Aug 2017, accepted on 28 Sep 2017 and first published on 28 Sep 2017

Article type: Paper

DOI: 10.1039/C7CP05319C

Citation: *Phys. Chem. Chem. Phys.*, 2017, Accepted Manuscript

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Physical Chemistry Chemical Physics c7cp05319c

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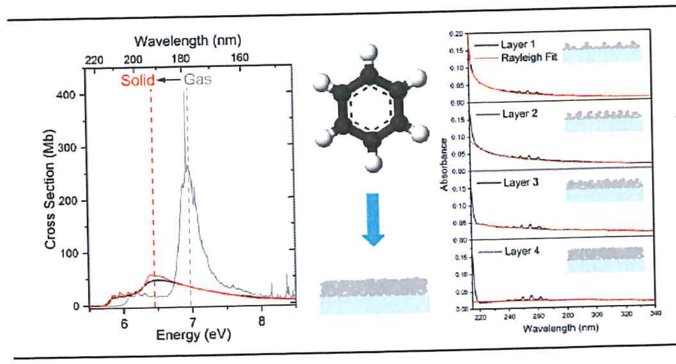


Vacuum ultraviolet photoabsorption spectroscopy of crystalline and amorphous benzene

Anita Dawes,* Natalia Pascual, Søren V. Hoffmann, Nykola C. Jones and Nigel J. Mason

Vacuum ultraviolet spectra of amorphous benzene reveal significant shifts in electronic transitions and thickness dependent scattering during film growth.

02/10/17

Acoustic levitation article from Nigel in the Times!

THE TIMES | Monday August 21 2017 1GM

It's lift-off for DIY levitation thanks to £60 breakthrough

Oliver Moody
Science Correspondent

Long before Sir Andre Geim won the Nobel prize in physics for his work on graphene he gave us the hovering frog.

Suspended in mid-air by a magnetic field, the amphibian became one of the most famous and disconcerting experiments of the past two decades. It won Sir Andre the Ig Nobel prize, which celebrates unusual research, making him the only scientist with both accolades.

Scientists at Bristol University have now published a simple set of instructions that anyone can use to build a levitation machine of their own for less than £60.

The device, which is strung together from parking sensors and a handful of circuit boards, uses soundwaves to raise anything from glass beads to beetles.

Although it involves a slightly less powerful and sophisticated technology than Sir Andre's frog magnet, its inventors hope that it will become a mainstay of school science demonstrations. It can also be used to germinate seeds or even to foster human embryos in nearly weightless conditions such as those found in space.

Doctors could also float drops of their patients' blood with the kit, doing away with the hassle of preparing slides for examination.

"We tried to minimise the difficulty of assembling the levitator, operating it and sourcing the components," Asier Marzo, the mechanical engineer in charge of the project, said.

"All the components are available on the internet. We think the price is affordable not only for most research labs but also for schools and science clubs."

The parts for the device, which is described in the *Review of Scientific Instruments*, include a box of tiny transducers, a microcontroller called an Arduino Nano, and a 3D-printed frame, which can be commissioned online.

The acoustic device is not quite up to levitating frogs, but it is highly resilient to air currents and changes in temperature. Dr Marzo and his colleagues found that they could keep drops of liquid hovering for at least two hours.

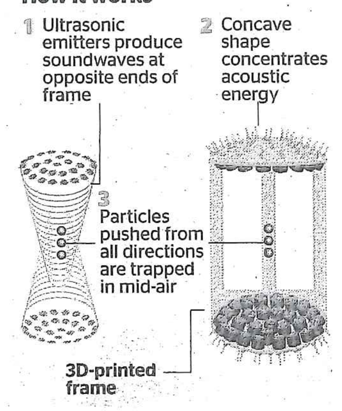
Its wavelength is only 8.6mm (0.27 inches), meaning the largest objects it can handle are about 4mm in diameter. "The maximum supported density is 2.2g per cubic centimetre, allowing researchers to levitate water, insects or glass," Dr Marzo said. "Magnetic levitation can generate stronger forces and does not have constraints in size.

"However, the levitated materials need to be magnetic, ferromagnetic or diamagnetic. In acoustic levitation, liquids and small living things can easily be levitated."

One classroom experiment that would be suited to the machine is teaching pupils how viscosity, the stickiness of liquids, works. If you levitate drops of honey, water and a smelly alcoholic compound called isopropyl, you will see that while the honey keeps its shape the less viscous water will become squashed and the isopropyl will be squeezed into a disk-like form. The gadget could also be shrouded in dry ice to make its waves visible.

Dr Marzo said it would also be a boon for professional scientists as a cheap and simple way of replicating the weightlessness experienced in orbit. "These experiments will study the viability of cultivating plants or human reproduction in microgravity," he said.

How it works



Nigel is doing a viva for Christian Phang on Tue 7th Nov

↳ visit reading to see their trap.

Look at Sarah's thesis for info on Mie theory.

03/10/17. Lit search & brainstorm of trap data for paper

Looking at analysis of trap data — require knowledge of Mie Scattering data.

Resources

→ Sarah's Thesis — Chapter 2 (mie Theory)
- Chapter 3 (Ultrasonic fields)
- Chapter 5 (Trap design).

→ Aleksi's Thesis — A2 (OMNIFIT)

↳ Require this to process lab data & obtain real and imaginary refractive index components. These can then be used as raw data to model mie scattering as a function of varying grain size, composition & shape.

→ Key papers —

1. "Absorption features in the 3 micron spectra of protostars
Smith et. al, ApJ 344, pp 413-426 (1989)

2. "Spectroscopic evidence of grain mantle growth in YSO's. I. CO ice modelling and limiting cases."
Dartois, A&A 445, pp 959-970 (2006)

3. "Water ice nanoparticles: size and temperature effects on the mid-infrared spectrum."
medcraft et.al., PCCP 15, pp 3630-3639 (2013)

4. A study of the H_2O ice in the 3 micron spectrum of OH 231.8+4.2 (OH 0739-14)
Smith et al. ApJ 334 pp 209-219 (1988)

5. "A survey of H_2O, CO_2 and CO ice features towards background stars and low mass YSOs using AKARI"
Noble et. al.

6. "Intrinsic particle properties from vibrational spectra of Aerosols."
Sigurbjörnsson et. al. Ann. Rev. Phys. Chem 60, pp 127-146 (2009)

etc...

→ FTIR spectrometer software packages

↳ Look for K-K (Kramers-Kronig) analysis to transform Abs or Transmittance to n & k.

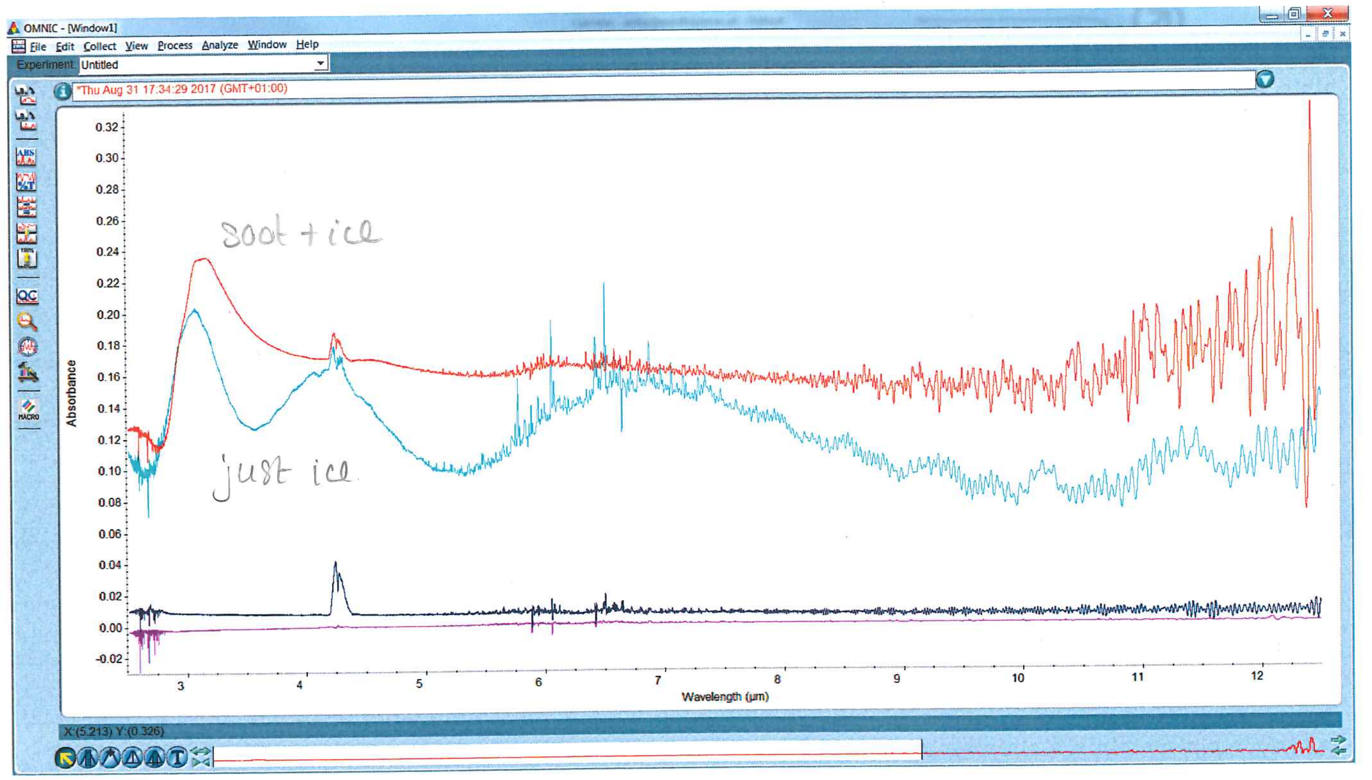
→ Online software

↳ MiePlot www.philiplaven.com/mieplot.htm

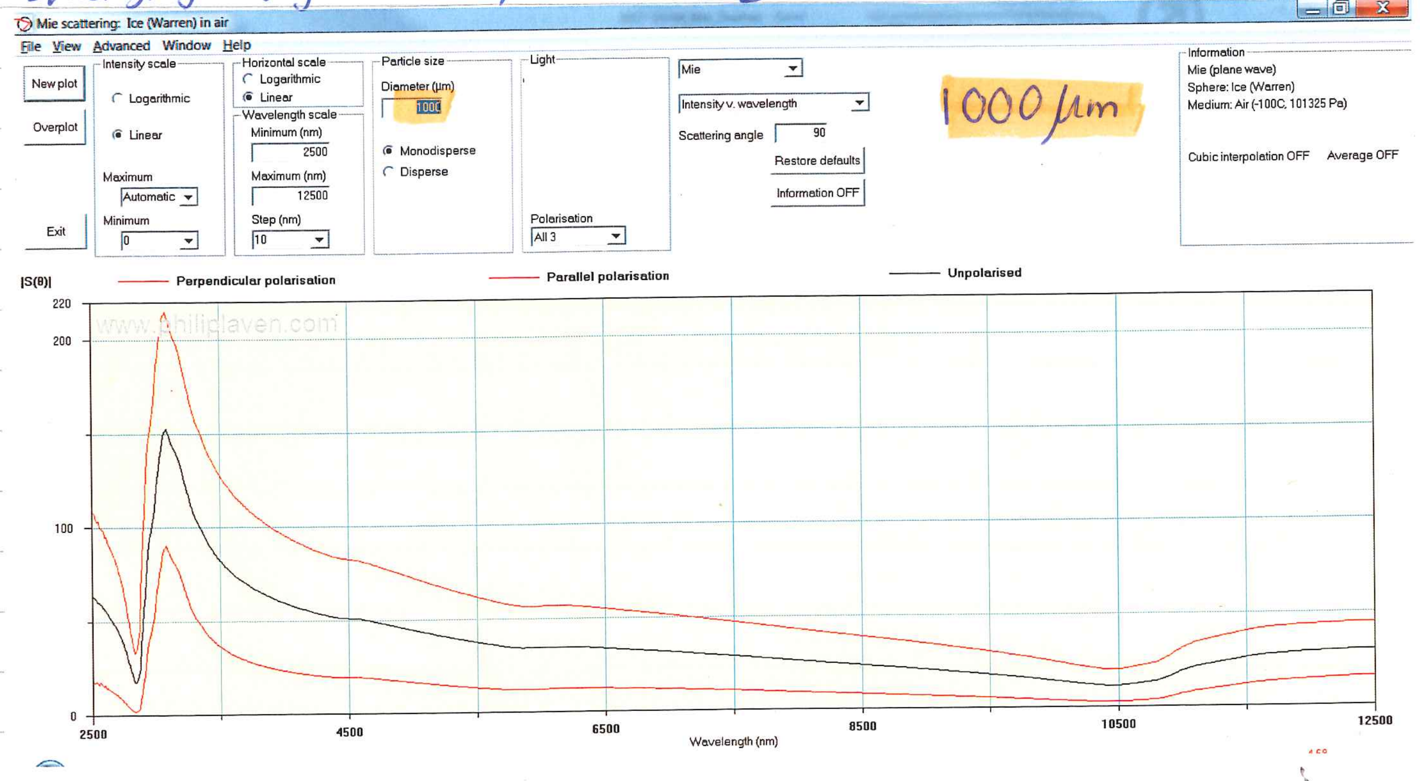
"A computer program for scattering of light from a sphere using Mie theory & the Debye series.

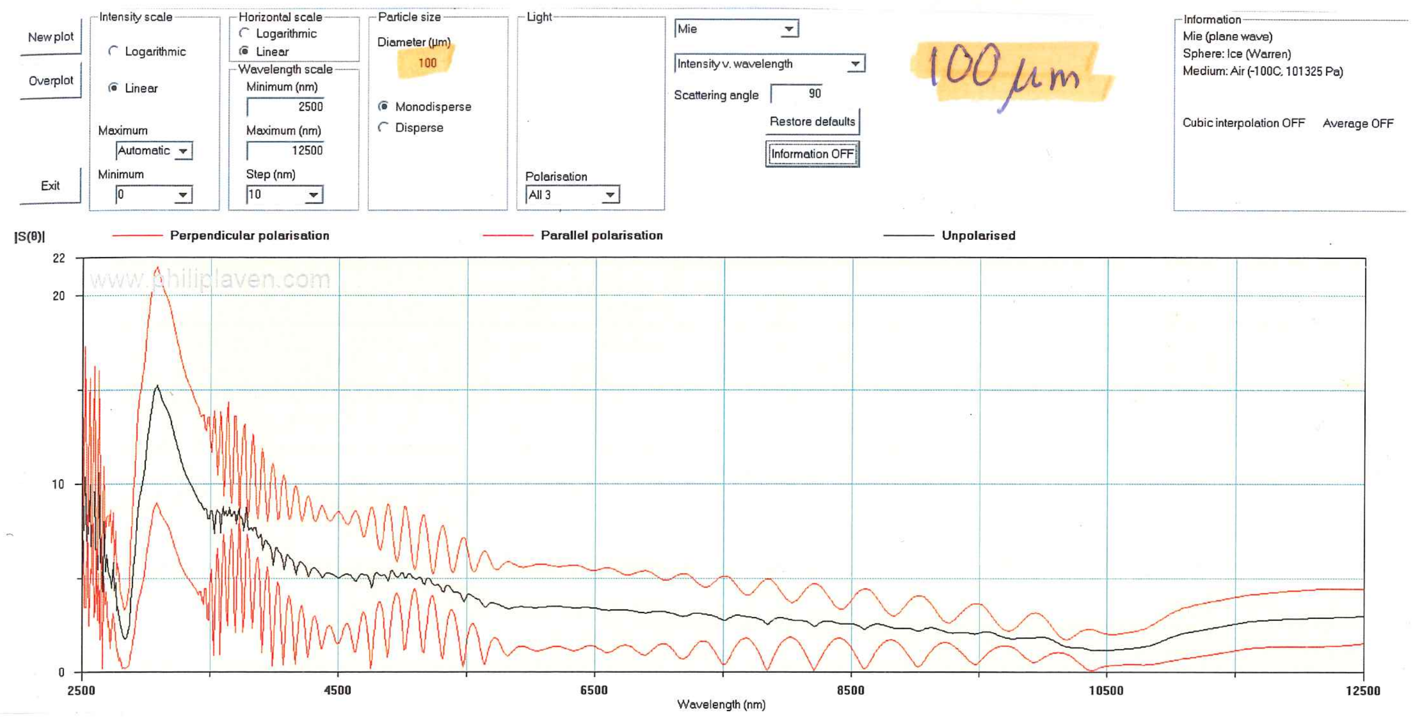
04/10/17 Playing around with Mie Plot.

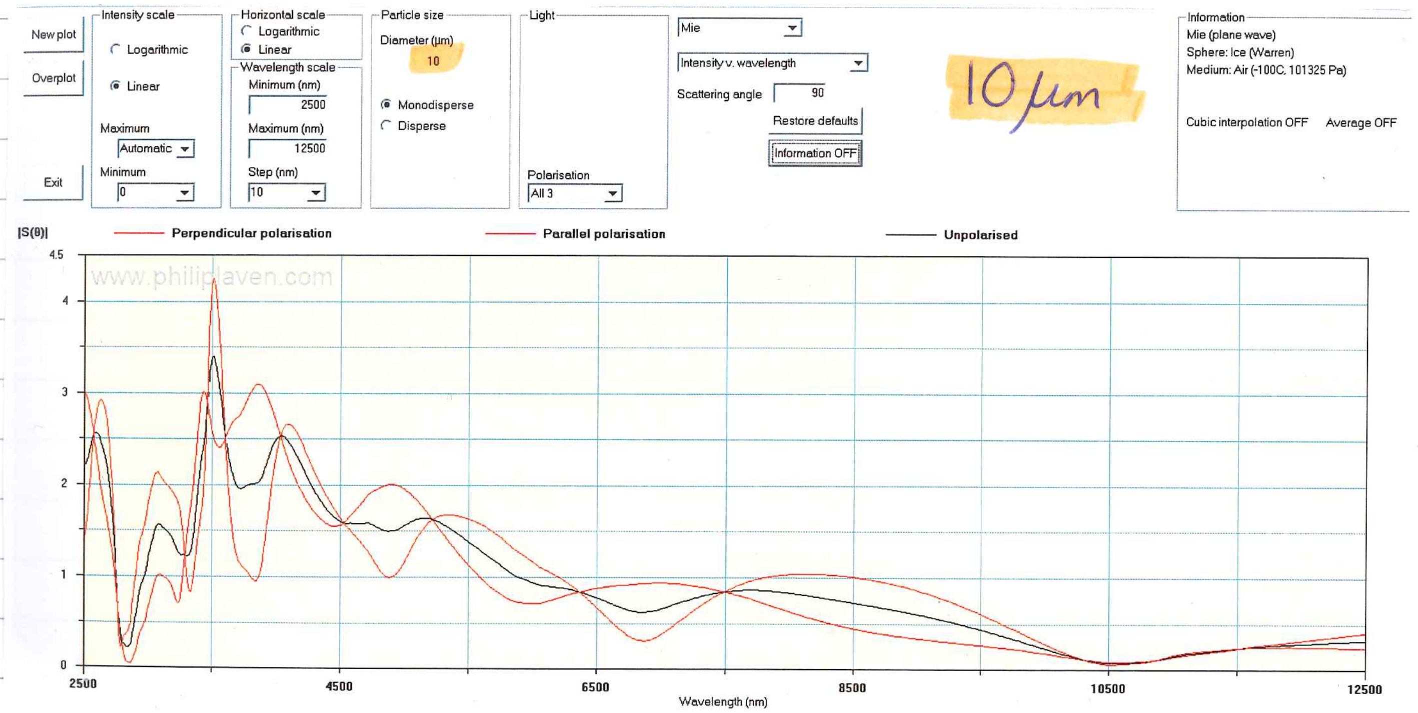
Mie Plot philiplaven.com/mieplot.htm
Downloaded MiePlot 4608 (ver. 4.6)

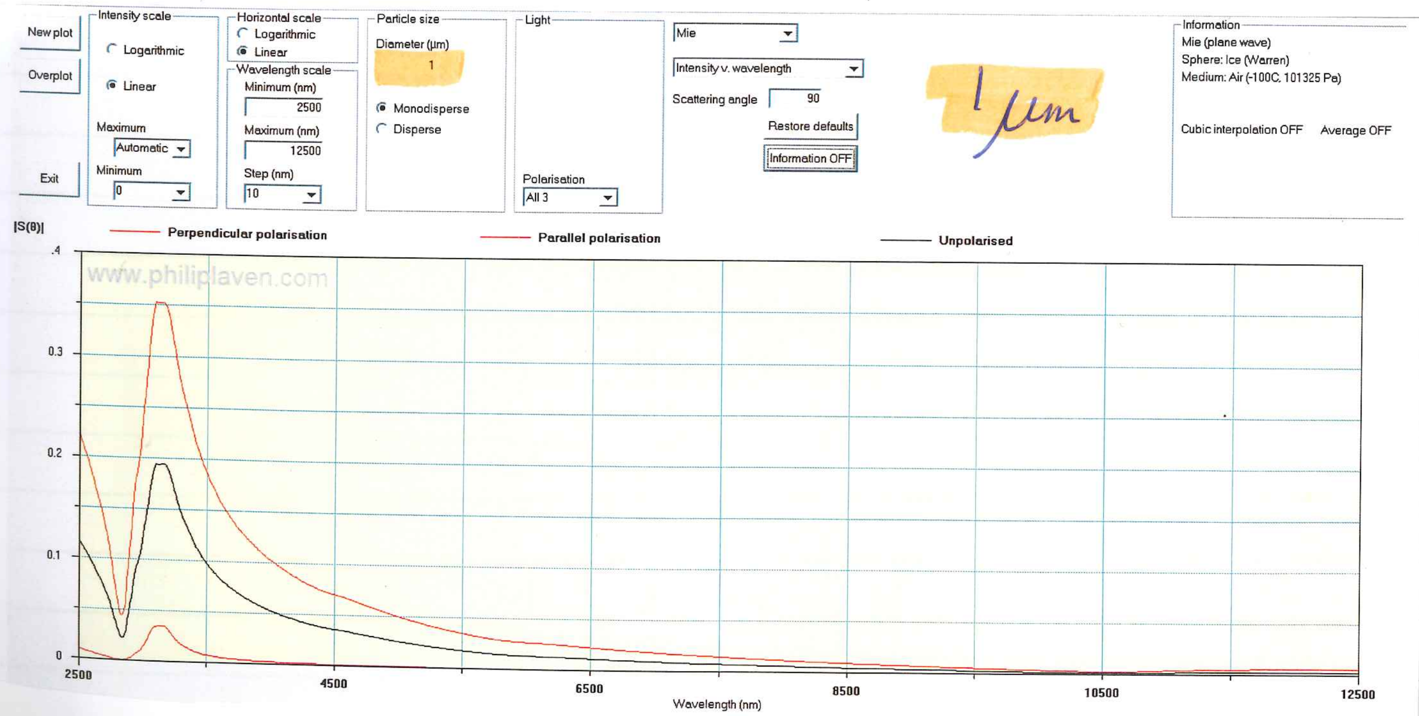


changing only the particle size: model – water ice only.

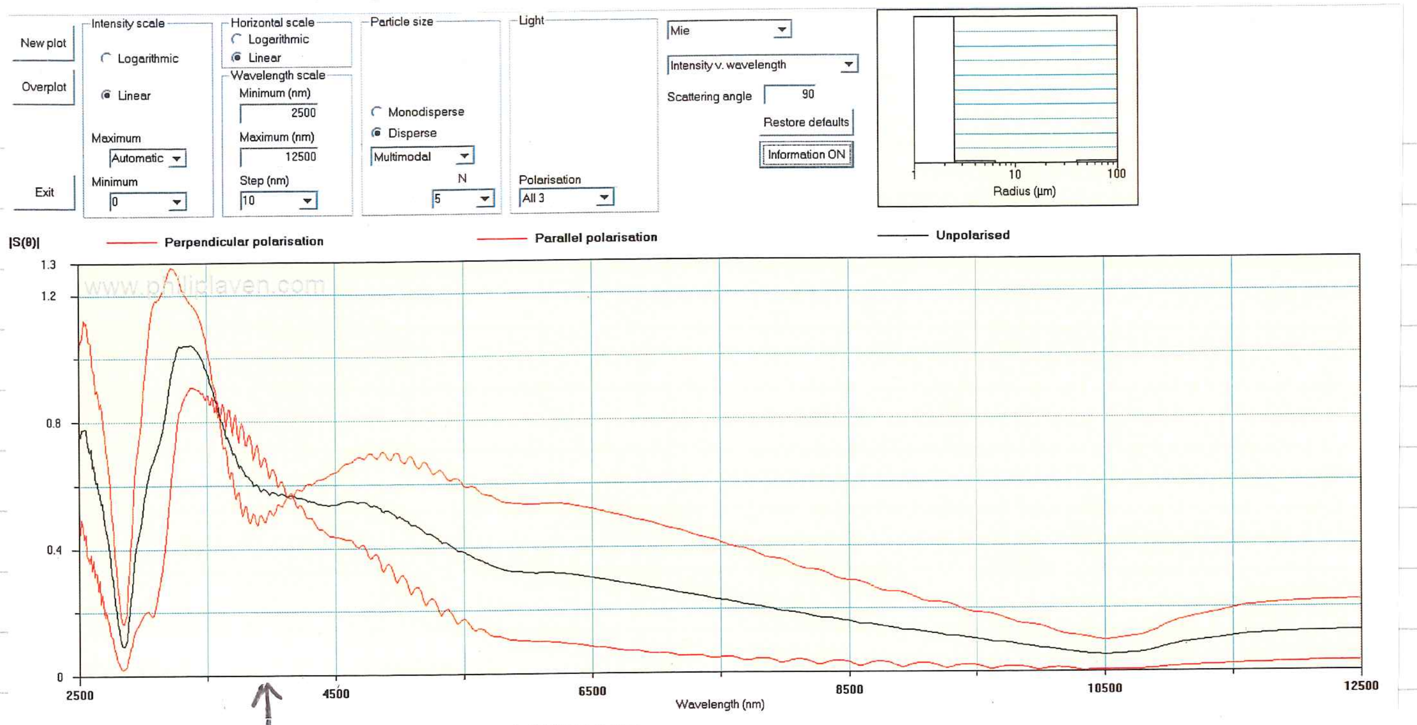


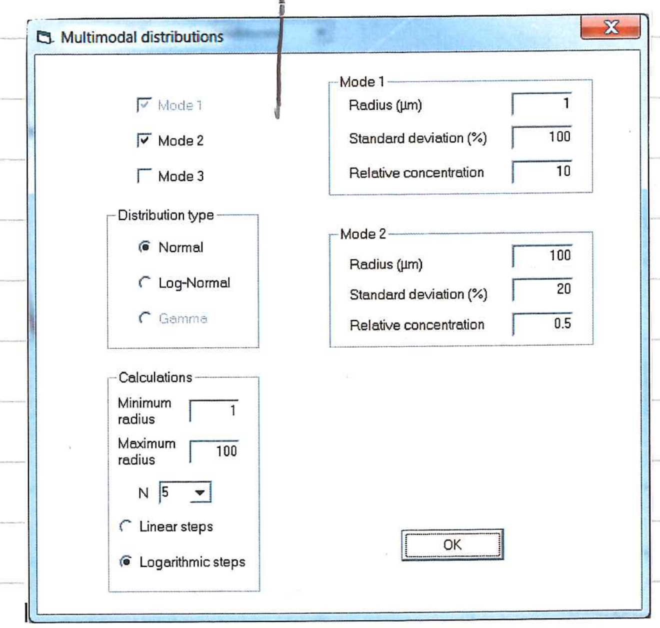


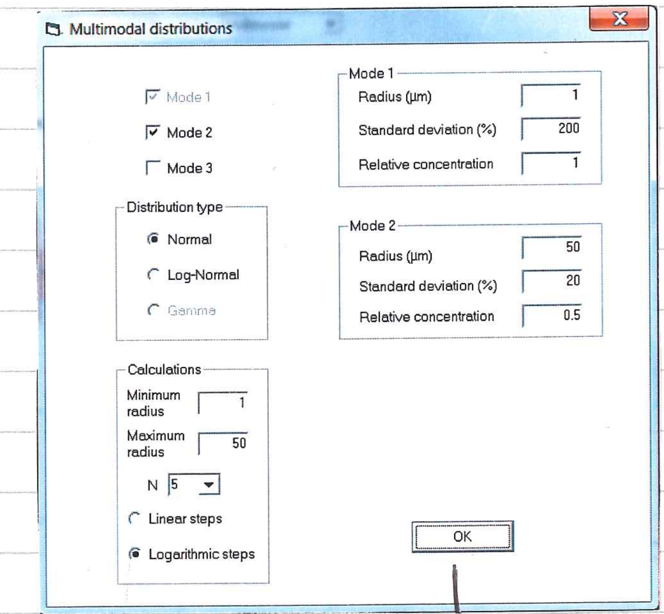


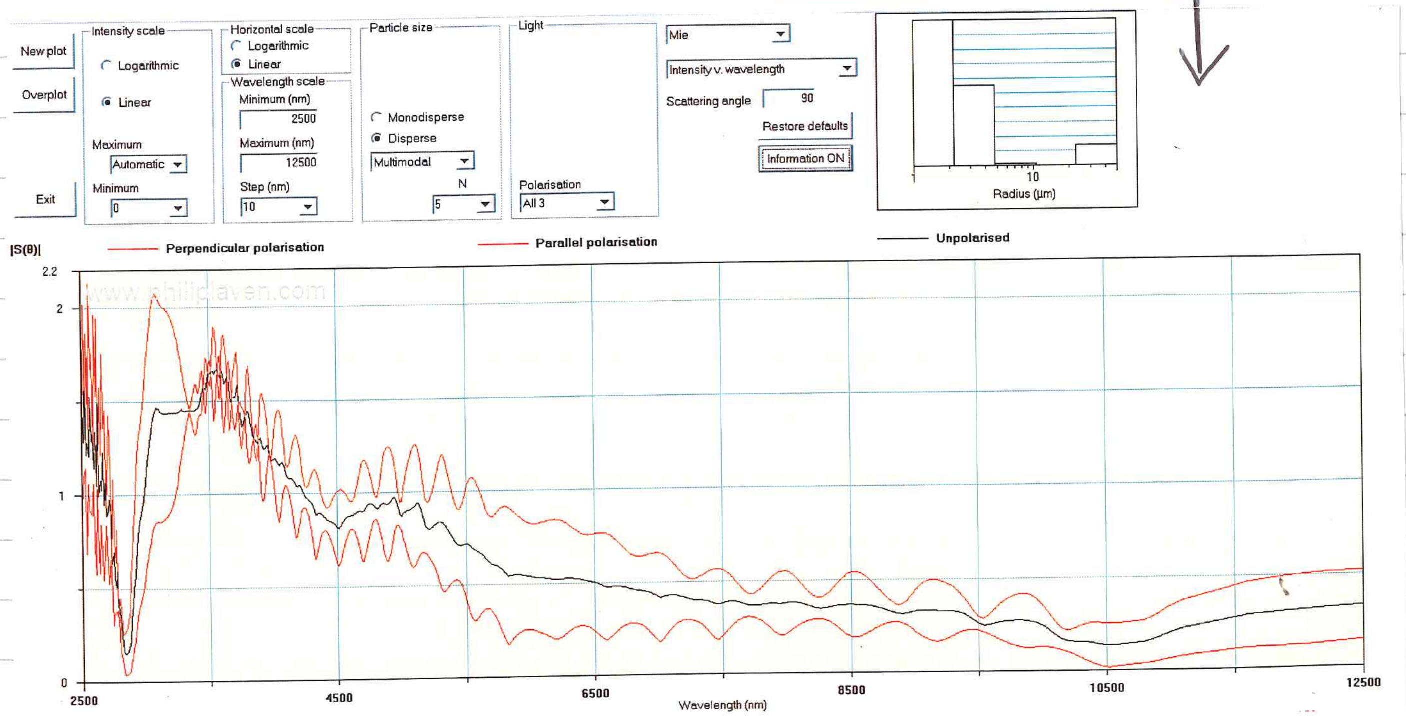


Multimodal (2) distributions:









From initially very basically playing around with the data it looks like that with some tweaking we could use MiePlot to model scattering of particles in the trap.

The plots were produced based on a model of

- Spherical particles
- pure water ice – which is ok for snowflake data
- multimodal → 2 particle size distributions.

I think the multimodal plots fit better.

- Need to get info on coated particles.
- Look at absorbing vs. non-absorbing spheres

NB. REFRACTIVE INDEX

non-absorbing materials have real values of refractive index

$$\boxed{m = n + ik}$$

Absorbing materials have complex values of refractive index

eg. water @λ=650nm $m = 1.33257 + i\,0.0000000164$