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Development of Frequency Domain Multidimensional Spectroscopy with Applications in Semiconductor Photophysics

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Abstract

The explanatory stories that people find compelling are simple; are concrete rather than abstract; assign a larger role to talent, stupidity and intentions than to luck; and focus on a few striking events that happened rather than on the countless events that failed to happen.

The ultimate test of an explanation is whether it would have made the event predictable in advance.

Paradoxically, it is easier to construct a coherent story when you know little, when there are fewer pieces to fit into the puzzle. Our comforting conviction that the world makes sense rests on a secure foundation: our almost unlimited ability to ignore our ignorance.

– Daniel Kahneman [1]

Part I

Background

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Chapter 1

Software

Cutting-edge science increasingly relies on custom software. In their 2008 survey, Hannay et al. [2] demonstrated just how important software is to the modern scientist.

- → 84.3% of surveyed scientists state that developing scientific software is important or very important for their own research.
- → 91.2% of surveyed scientists state that using scientific software is important or very important for their own research.
- → On average, scientists spend approximately 40% of their work time using scientific software.
- → On average, scientists spend approximately 30% of their work time developing scientific software.

Despite the importance of software to science and scientists, most scientists are not familiar with basic software engineering concepts. This is in part due to the their general lack of formal training in programming and software development. Hannay et al. [2] found that over 90% of scientists learn software development through 'informal self study'. Indeed, I myself have never been formally trained in software development.

Software development in a scientific context poses unique challenges. Many traditional software development paradigms demand an upfront articulation of goals and requirements. This allows the developers to carefully design their software, even before a single line of code is written. In her seminal 2005

case study Segal [3] describes a collaboration between a team of researchers and a contracted team of software engineers. Ultimately

Part II

Development

Part III

Applications

Part IV

Appendix

Appendix A

Procedures

A.1 Calibrating the 407A

Calibrating the 407A

You may sometimes notice that the zero position changes dramatically from sensitivity to sensitivity with the 407A. If this happens, iterate through the following until zero stays consistent:

Use the fine adjust (knob on side) to zero the 407A on the highest sensitivity

Use the front adjust (flathead screwdriver needed) to zero on the lowest sensitivity

A.2 Lytron Kodiak RC006

We have one Lytron Kodiak RC006: Model Number RC006G03BB1C002 Serial Number 739383-02

Regular Chiller Maintenance:

1. Gather supplies.
   (a) 1 gallon distilled water (do not use deionized)
   (b) 1 gallon Nalco 460-PCCL104 (the pink stuff)
2. Drain system completely.
   (a) Turn off chiller.
   (b) Break tubing at push-to-connect, plugging return.
   (c) Allow chiller to run until liquid stops flowing. You will get a pressure error, ignore (silence) it.
   (d) Use tube to mouth-syphon remaining liquid from within chiller
   (e) Reconnect at push-to-connect
3. Fill chiller with distilled water (should require ¡1 gallon), let run for 30 minutes.
4. Drain system again.
5. Replace filter.
6. Fill system with one gallon Nalco 460-PCCL104 (the pink stuff).
7. Turn chiller on, top-off with distilled water.
8. Record maintenance, order new supplies for next time if necessary.

In the past we have had trouble with low flow errors upon system startup. These seem to have been fixed by adding a "high" flow loop connecting the outlet and inlet of the chiller. Ideally the pressure drop across this loop is sufficient to still drive fluid through the laser.

A.3 PolyScience 6000 Series

We own two PolyScience chillers—different models but functionally equivalent.

Grey: Serial Number 3E1161245

White and Blue: Serial Number 4K1050550

Regular Chiller Maintenance:

1. Gather supplies

maintenance directions Gather supplies Filter - sold in the stockroom 1 gallon of Nalco 460-PCCL104 (the pink stuff) Drain system completely Disconnect red water line and allow chiller to pump water out. Push nipple of male end with flat object so check valve is released Take off of filter Push down to allow water out Check filters If air filter dirty, wash with water (let dry after washing) If water filter is dirty, replace Reassemble, fill with Nalco 460-PCCL104 (the pink stuff) Turn chiller on and top-off.

A.4 NesLab Merlin M33

A.5 Aligining TOPAS-C

A.6 Aligning Spitfire PRO

A.7 Air Handling

A.8 Six Month Maintenance

A.9 Tuning MicroHR Monochromator

Visible Grating.

Align the HeNe as perpendicular as possible to the monochromator entrance slit.

Move the grating angle until the HeNe falls on the exit slit.

Shine a flashlight through the entrance slit and observe the colour on the exit slit: if white, then you are at 0-order (0 nm), if red, then you are at 1st order (632.8 nm).

Go to 0-order, narrow the slits, and slowly adjust the angle until the HeNe is going through the exit slit.

Go to Jovin Yvon/utilities and find the motor configuration program.

In the Gratings tab, select the 1st grating (1200 line density) and hit Calibrate.

In theoretical wavelength, enter 0 nm.

In experimental wavelength, enter the wavelength you observe from the control program.

Hit set.

Bibliography

[1] Daniel Kahneman. *Thinking, Fast and Slow*. Farrar, Straus and Giroux, 2013.

[2] Jo Erskine Hannay, Carolyn MacLeod, Janice Singer, Hans Petter Langtangen, Dietmar Pfahl, and Greg Wilson. "How do scientists develop and use scientific software?" In: *2009 ICSE Workshop on Software Engineering for Computational Science and Engineering*. Institute of Electrical and Electronics Engineers (IEEE), May 2009. DOI: 10.1109/secse.2009.5069155.

[3] Judith Segal. "When Software Engineers Met Research Scientists: A Case Study". In: *Empirical Software Engineering* 10.4 (Oct. 2005), pp. 517–536. DOI: 10.1007/s10664-005-3865-y.