

Challenges of a Theoretician / Experimentalist

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Happy International Talk-Like-A-
Pirate Day!
Arrrrrrrrrrrrr!!!

Two Sides of the Coin



Theory and Experiment are the two necessary sides of research, both in science and in engineering.

Without experiment, theory is either philosophy or mathematics at best--at worst, it is just unfounded speculation. Experiment confronts theory with the real world, tests its assumptions, and ultimately falsifies or validates it.

Without theory, experiment is stumbling in the dark. Blind experimenting will produce a handful of data points in the vast sea of possible results. Theory incorporates these points into an overarching structure, and leads to new experiments.

What Theory Isn't



- **Theory isn't plugging numbers into formulas and getting answers.**
- **Theory isn't running a software package and plotting the result.**
- **Theory isn't looking at data and fitting it to a curve.**
- **Theory isn't (just) handwaving.**
- **Theory isn't (just) modeling.**
- **Theory provides a framework. It says not only what, but also how and (sometimes) why. Theories are concrete and unambiguous. Theories can be tested; they can be disproven.**

What Experiment Isn't



Experiment isn't sweeping the lab and polishing the glassware (though this has to be done).

Experiment isn't plugging in an apparatus and writing down data.

Experiment isn't choosing a handful of quantities and measuring them for a new system.

Experiment isn't (just) isolating variables and measuring their effects.

Experiment is the ultimate proving ground of science, and the starting point of new technology. It separates what may be conceivable from what is true, and what is true from what is practical.

Theorists are from Mars, Experimenters are from Venus

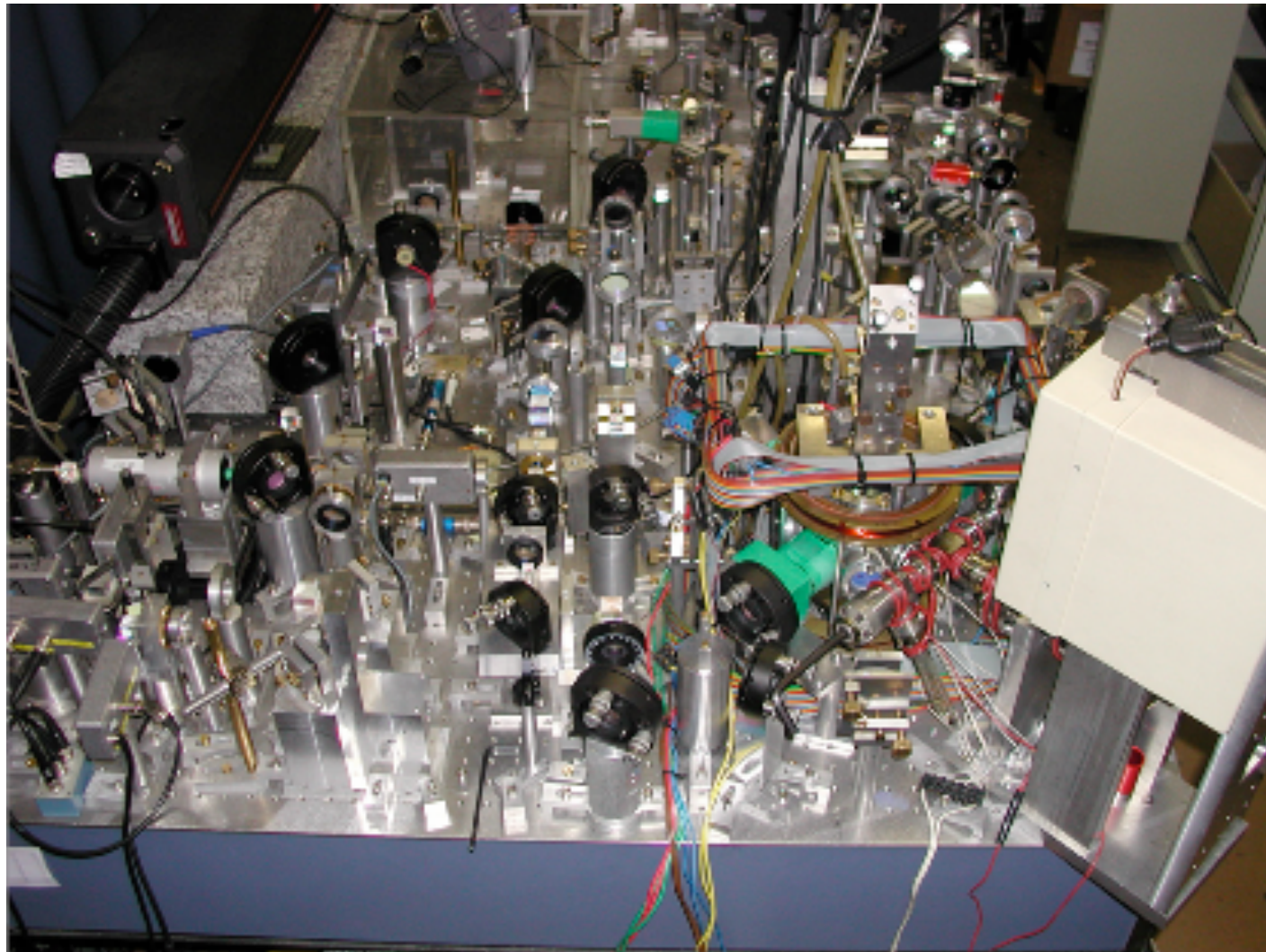


Theory and Experiment are mutually dependent; but most theorists and experimenters don't speak the same language. This barrier weakens the research enterprise, and can also be a barrier in your own research career.

But this is also an opportunity: a theorist with a good understanding of experiment, or an experimenter with a good understanding of theory, will find opportunities that others will miss.

Still...there are many differences.

How experimenters think about experiments



Maxims for theorists



- **Until you have immersed yourself in a problem, it is hard or impossible to make progress.**
- **To gain insight, simplify your problem repeatedly until it becomes completely trivial. Then back up one step.**
- **Before you believe a computer, compare the result to common sense.**
- **If a particular approach keeps getting more and more complicated, try a different approach. If every approach you try seems very hard, solve a different problem.**
- **Remember that numbers have units--and quantities have magnitudes.**
- **Pay attention to what is easy to do, hard to do, and impossible.**

Maxims for experimenters



- **Until you have immersed yourself in a problem, it is hard or impossible to make progress.**
- **95% of what you do is completely unknown to theorists. (Eliminating vibration, stabilizing frequencies, testing connections, etc., etc.)**
- **Nevertheless, it's the other 5% that is important.**
- **You can make progress both by inventing new methods and by refining old methods.**
- **Everything is always harder and takes longer than you think it will. So think very carefully before you start.**
- **Theorists are cheap. Experiments are expensive. Buy a theorist a drink! (It may pay off in the long run.)**

Final Joke

Q: How was the quantum pirate punished for violating Hooke's Law?

A: They made him walk the Planck.