Interferometry for Gravitational Wave Detection

Hands-on modelling

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Institute of
Gravitational Wave Astronomy

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Gravitational Wave Astronomy

Founded: 4th October 2016

Web: birmingham.ac.uk/gravitational-waves

Twitter: @UoBigWaves

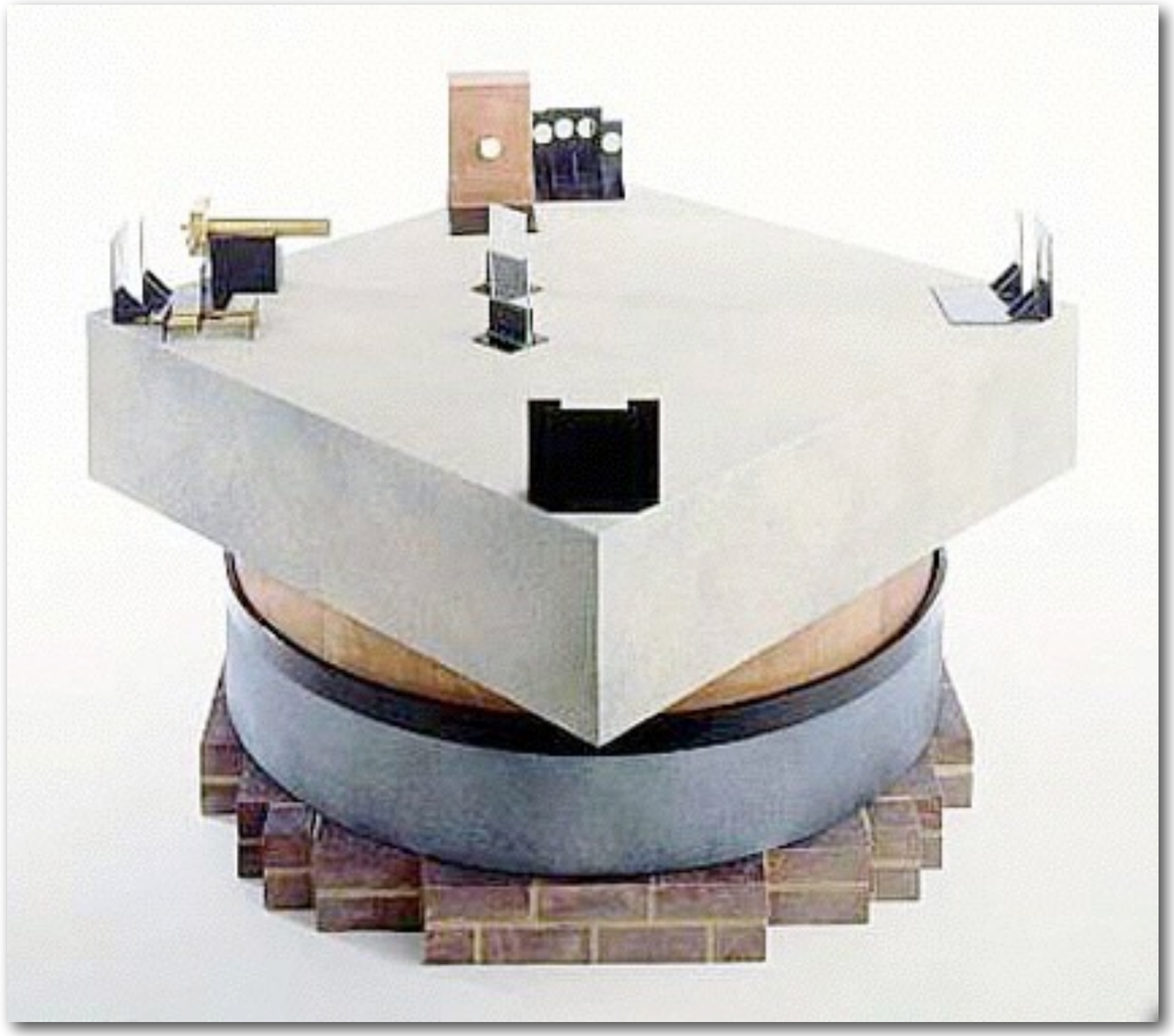
Michelson Interferometer

1887:

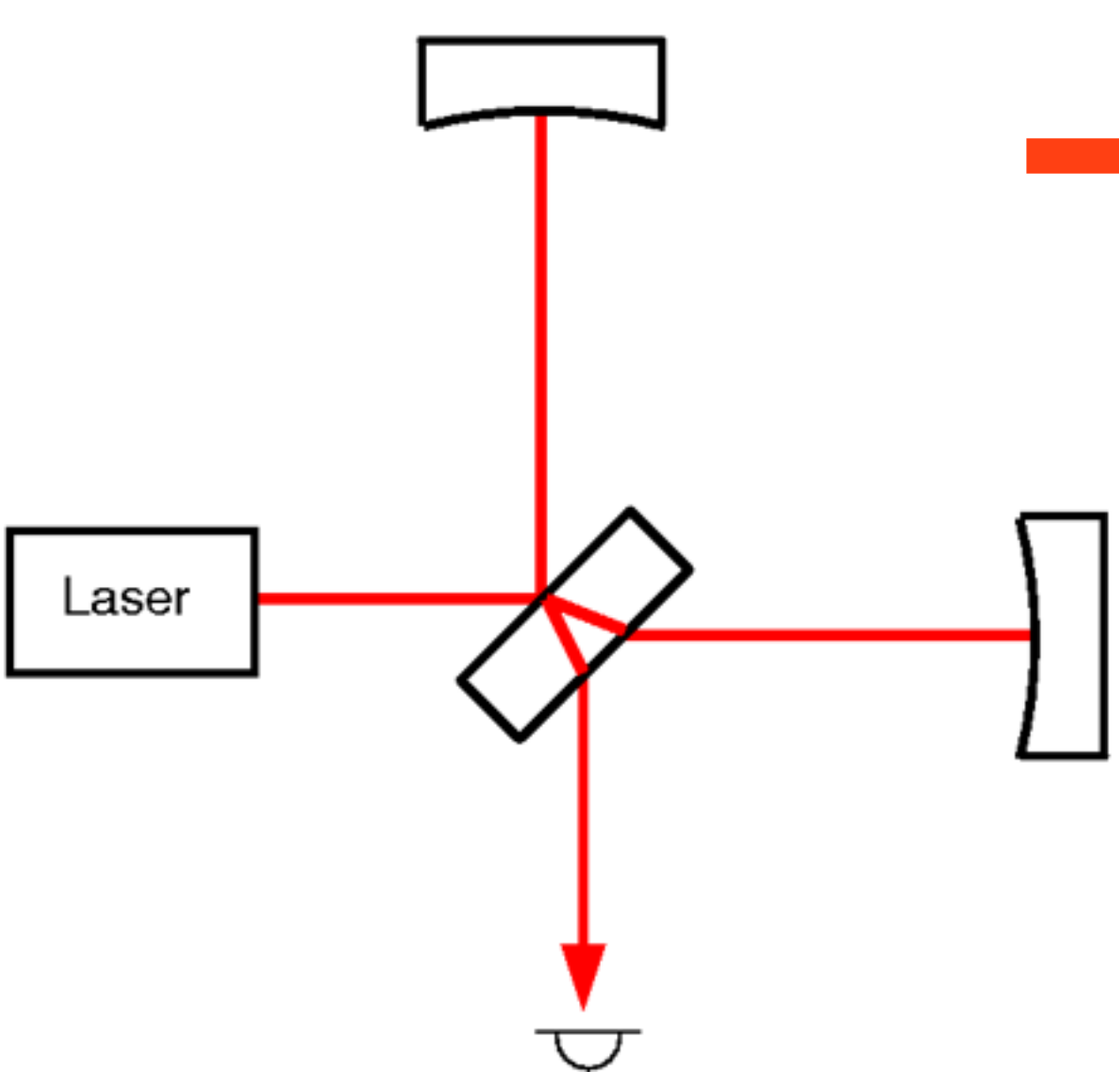
- Michelson Morley Experiment
- Sensitivity: **10^{-2} of a fringe**

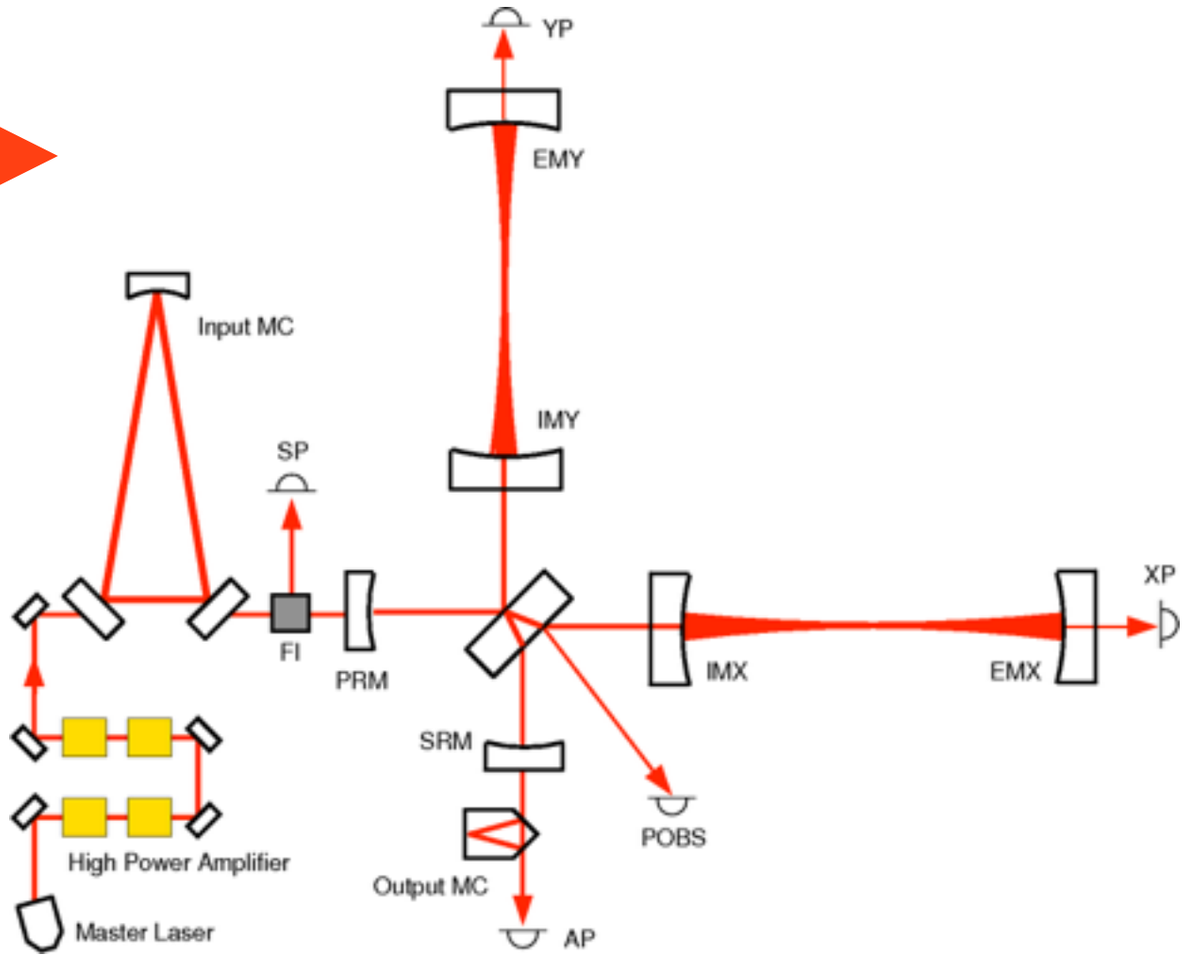
Today:

- Advanced LIGO
- Modified Michelson interferometer
- Sensitivity: **10^{-13} of a fringe**

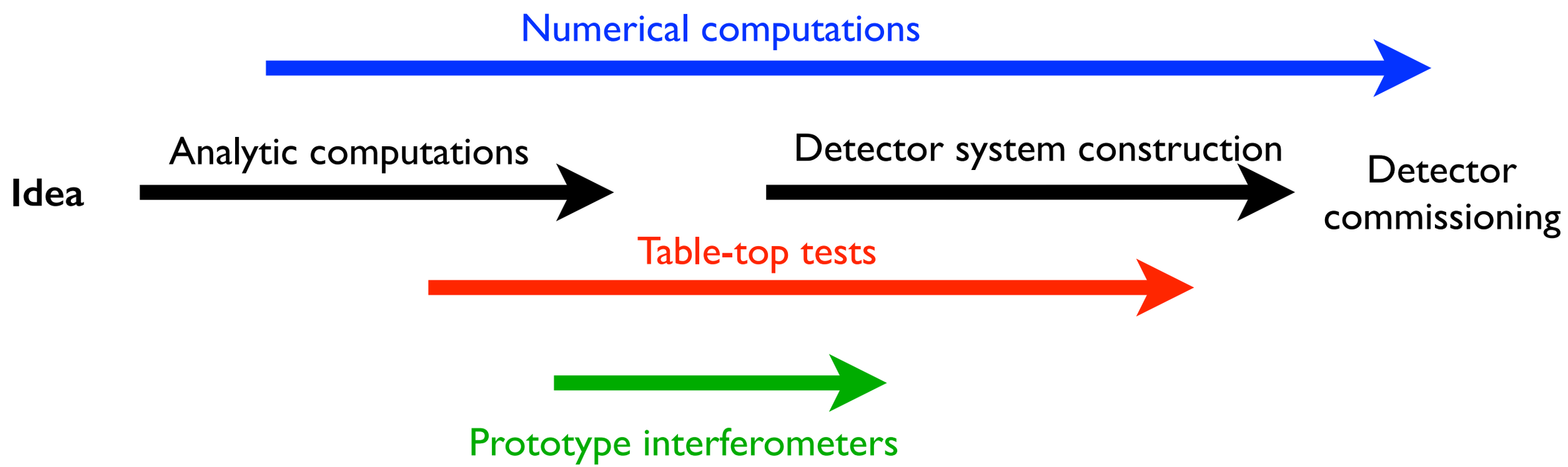


Advanced Interferometry





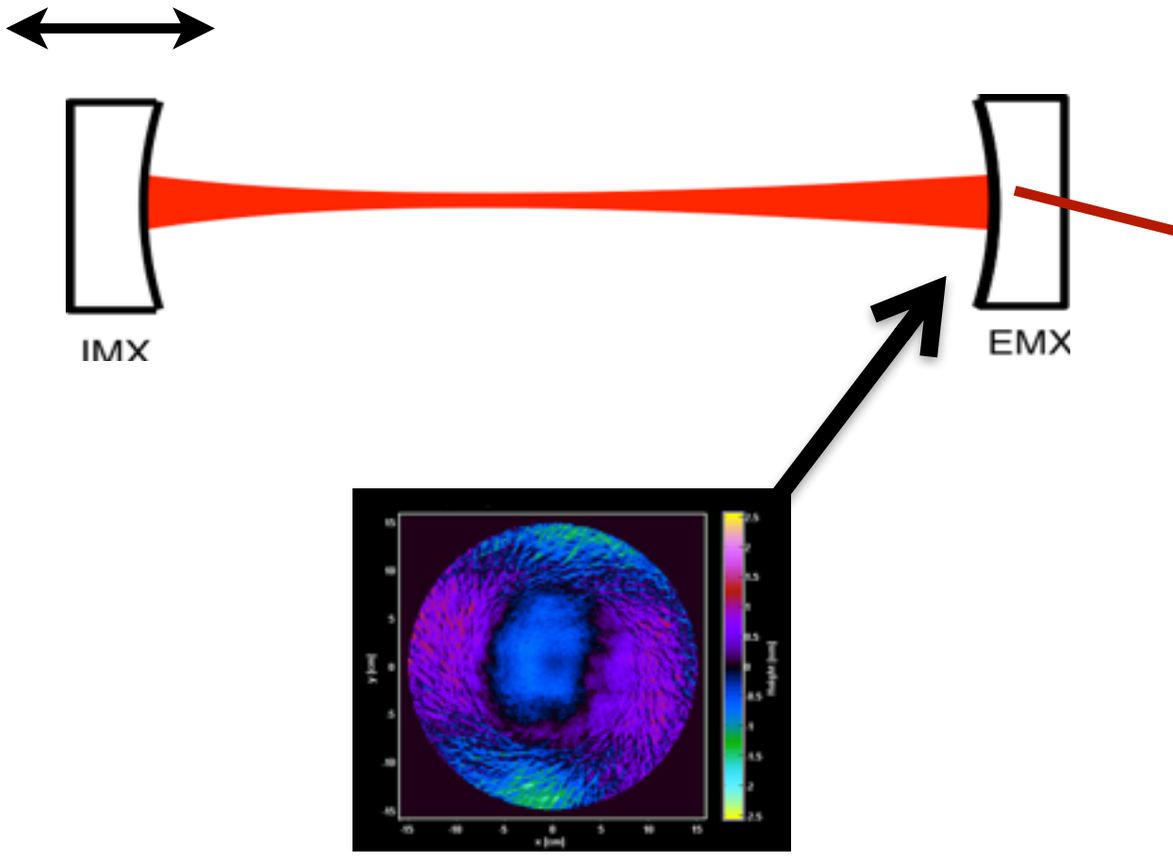
From Idea to Implementation

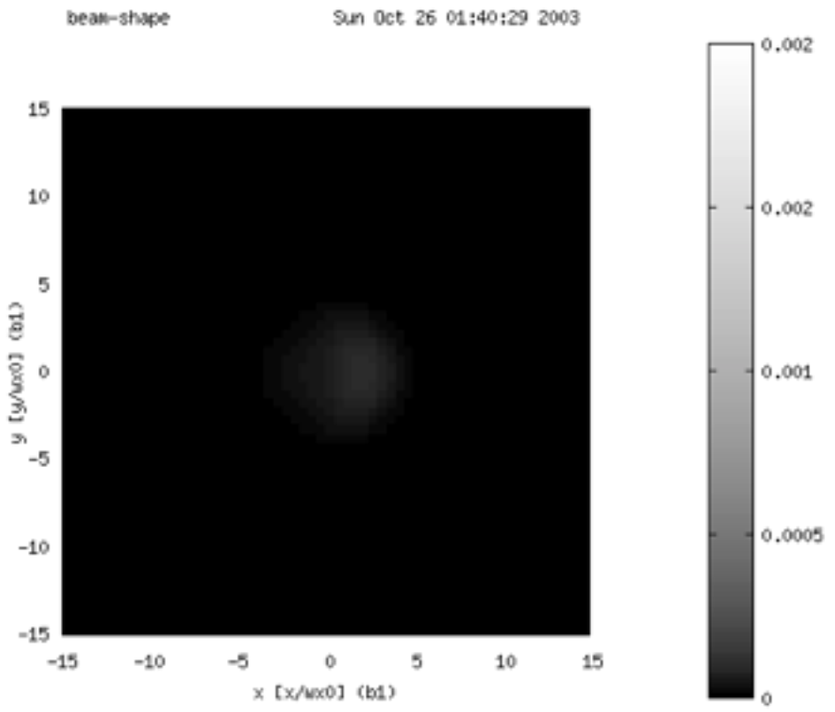


10 to 30 years is a good time scale to go from idea to an implementation/application of a new concept or technology

Beam Shape Distortions

Acceptance of mirrors from manufacturer: Computer model is used to estimate the optical distortions due to the measured mirror distortions.





Beam shape inside arm cavity

Interferometer simulation: FINESSE

- Started1997, PhD side project
- Used extensively worldwide
- Open sourced in 2012
- Continuously used and developed

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Learn Laser Interferometry

gw optics » Tools for detecting gravitational waves

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Course: Learn Laser Interferometry

Learn Laser Interferometry

A self-study course on interferometry for precision measurements, using IPython notebooks.

This page provides resources and self-study material on laser interferometry. In particular we cover the topics related to the use of optical systems for gravitational wave detectors such as LIGO. At the same time this is a collection of reference examples for using PyKat.

Daniel Töyrä
Daniel Brown
Andreas Freise
and others
since 2016



Table of Contents

Modelling is not Theory

- Numerical simulations are different from other theoretical work:
  - Write your own software? Probably not.
  - Do it alone? Definitely not!
  - Solving elegant problems? Not very often.

Collaborative Work

- Our code is modern, open source and under continuous development
- We use the right tools for collaboration with people around the world:
  - git repositories for simulations files
  - chat channels for quick questions
  - joint papers and LIGO DCC notes to document our work

Open Tasks

- Modelling in support of detector commissioning
  - mode-matching, parametric instabilities, …
- Modelling designs for future detectors
  - LIGO upgrades, Einstein Telescope, …
- Code development of current software
  - implement/test advanced features
  - improve user interface

Resources

- Interferometer techniques for gravitational wave detection, Living Rev. Relativity (2017) https://link.springer.com/article/10.1007/s41114-016-0002-8
- FINESSE, numerical modelling software for interferometers http://www.gwoptics.org/finesse/
- Learn Laser Interferometry, a self-study course on interferometry for precision measurements http://www.gwoptics.org/learn/
- **Installation instructions and example files:** www.gwoptics.org/learn/schools/St_Andrews_2017

Apps for iOS, Android (or PC and Mac):

www.laserlabs.org