The life of a condensed matter theorist

Gareth Conduit
Condensed matter physics

Talk outline:

What is condensed matter physics?

Research in Theory of Condensed Matter

Career progression of a physicist:

`A' level → Undergrad → PhD Student → Where I am now

GCSE

Researcher
What is condensed matter physics?

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- We study the objects that surround us in our everyday lives.

Sand is used to make computers!

Steel is used to make bridges.
Constituent particles

- A condensed matter physicist assumes everything is made up of electrons and atoms

![Electron and Atom Diagram]

- and takes for granted that they interact according to the well-established laws of electromagnetism

![Electrostatic and Magnetic Diagram]
The effects of simple interactions can be seen in a magnet.

A magnet can be thought of as many small magnetic domains – each one is like a small bar magnet.

An external magnetic field makes the domains align and the material as a whole magnetic.
Thermal fluctuations

• If the magnet is hot the thermal energy allows some of the domains to flip, so a very hot magnet would prefer the domains to be randomly N or S

• At an intermediate temperature there is a transition from aligned to randomly distributed domains, as the computer simulation shows
Tennis balls fired through slits travel in straight lines.

However, quantum mechanics tells us that electrons behave like waves and interfere.
What is condensed matter?

- Condensed matter physics is when interactions are strong and quantum mechanics is important.
- Leads to new interesting many-body effects that have practical applications in modern day life e.g.
  - Elastic bands used in hospitals and the same technology is relevant to making quieter car tyres.
  - Hi-tech magnets used in computer hard drives.
  - Superconductors used in MRI scanners in hospitals.
Research in condensed matter

- TCM is also involved with computational research:
- CASTEP models electrons in solid and molecules
- Used by drug and chemical companies, and researchers
In my PhD I study atoms that have been cooled to $10^{-9}$K.

Experimentalists have an unprecedented degree of control over cold atomic gases, making them ideal to study many-body systems.
What does a theorist do?

Design a model to explain some aspect of the world's behavior

Use this to make some predictions and suggest how these might be tested experimentally

Back to the drawing board

Does your model agree with reality?

No

Get *someone else* to do the experiment

Yes

You have learnt something new about the way the world works