



Condensed Matter and Materials Physics

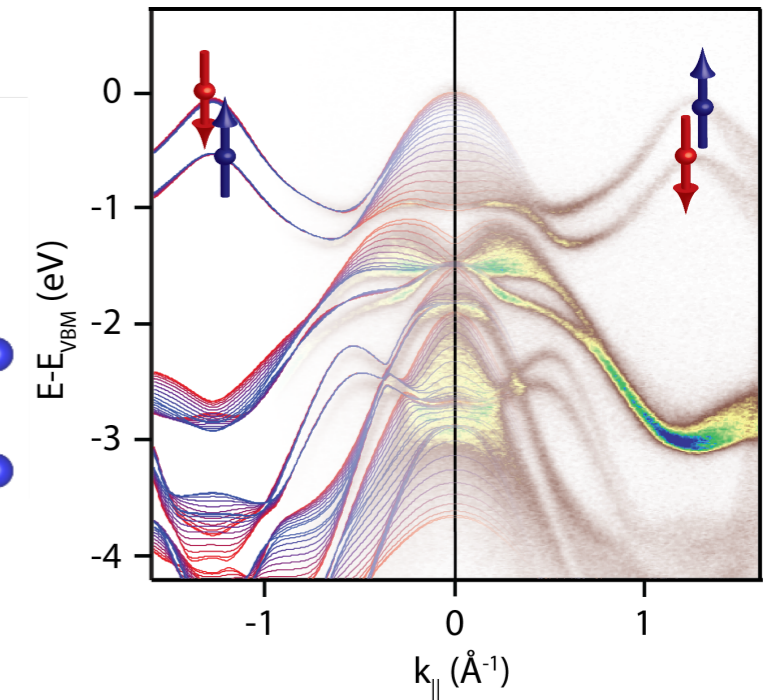
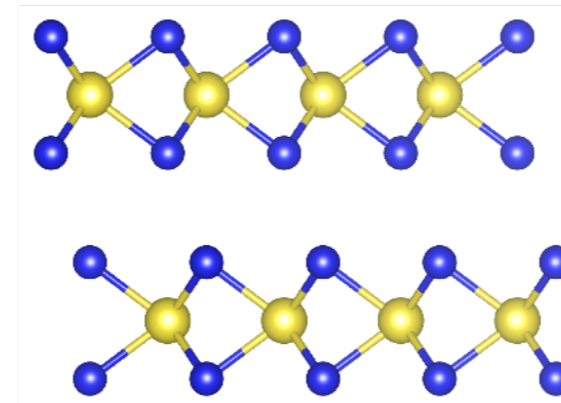
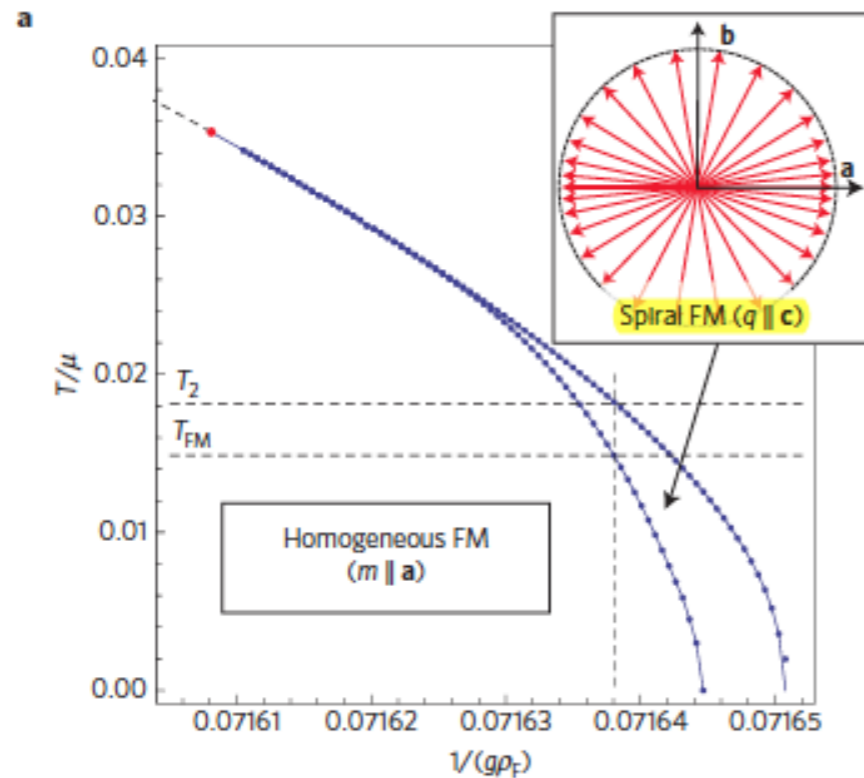
Annual General Meeting, 25th March 2015

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Quantum Matter and Quantum Technology

Probing Quantum Magnetism



- Phase transition at $T=0$ “quantum critical point”
- Singular behaviour avoided by entering complex modulated phases.

Nature Physics in press (2015)
 [Experiment (Huxley, Edinburgh)
 Theory (Kruger, St Andrews)]

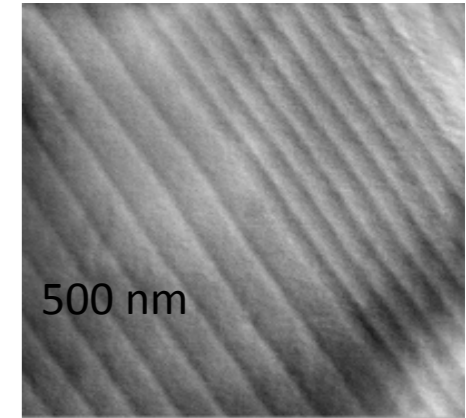
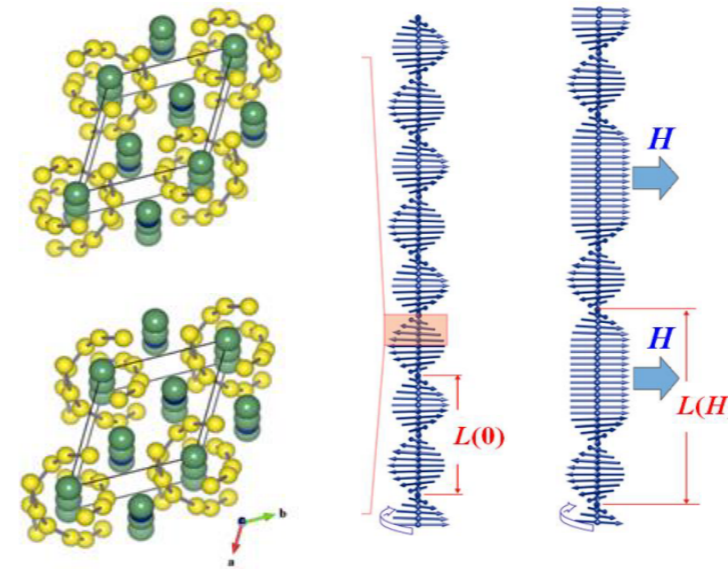
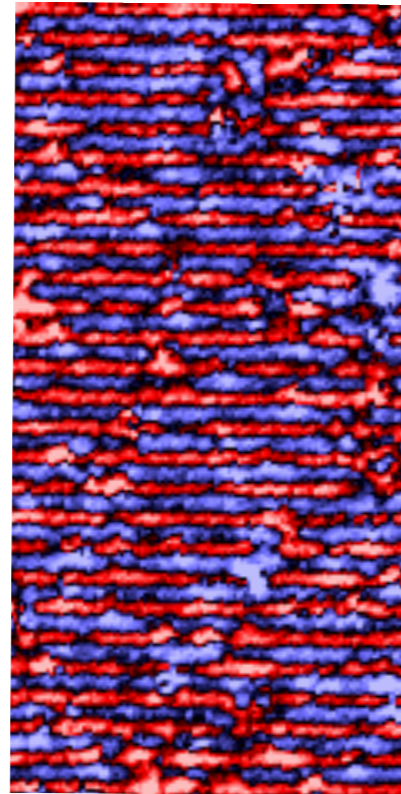
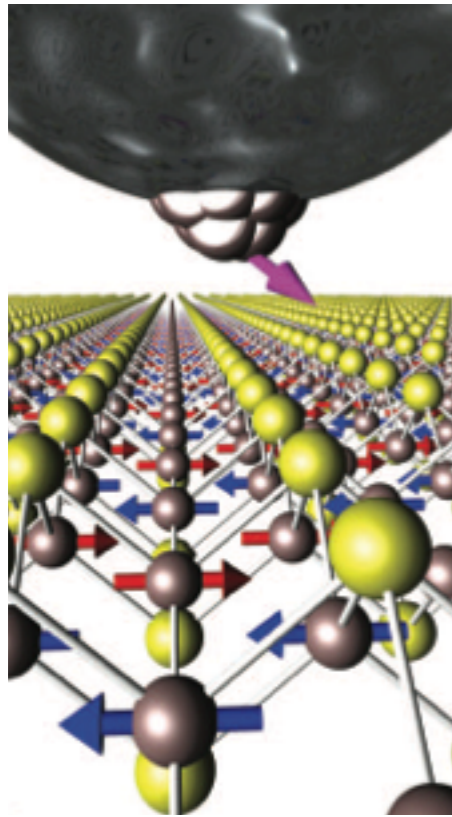
- Dichalcogenides: 2D layered materials beyond graphene
- Spin polarized electronic states in non-magnetic and high symmetry material.
- New kind of electronics “valleytronics”

Nature Physics **10** 835 (2014)
 [King, St Andrews]



Quantum Matter and Quantum Technology

Imaging Magnetism



- Magnetic tip on tunnelling microscope.
- Allows imaging of magnetic order on surface of crystal, on atomic scale.
- Here we see a striped ordering.

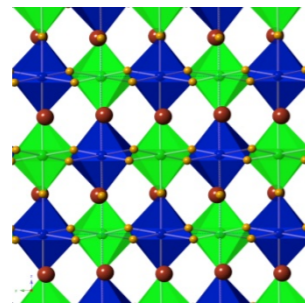
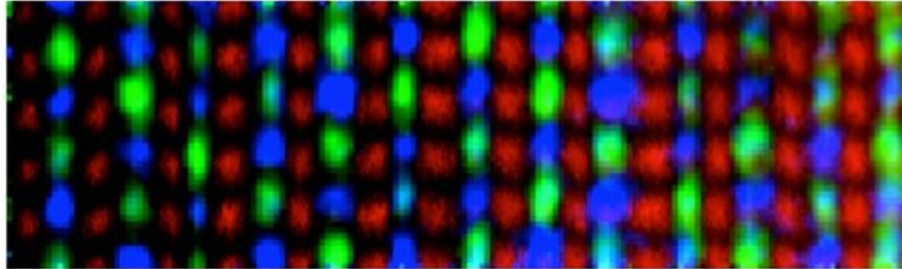
Science **345** 653 (2014)
[Wahl, St Andrews]

- Aberration correction in scanning transmission electron microscopy.
- High resolution imaging of magnetic textures.

Ultramicroscopy **152** 57 (2015)
[McVitie et al., Glasgow]

Imaging and Characterization

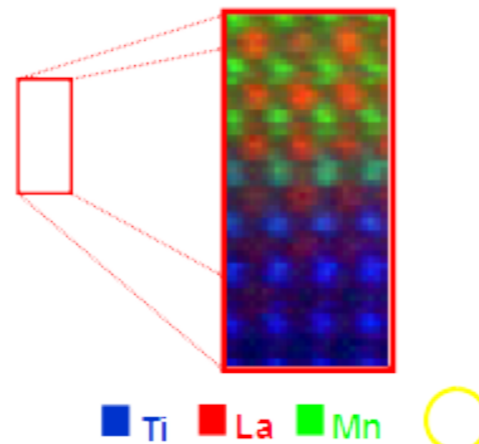
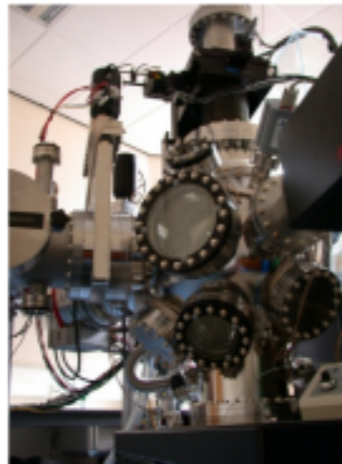
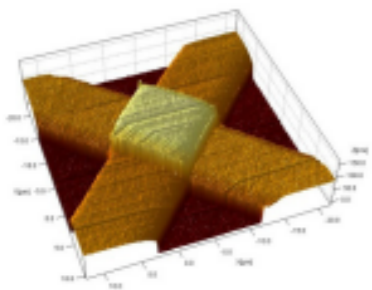
Imaging Developments



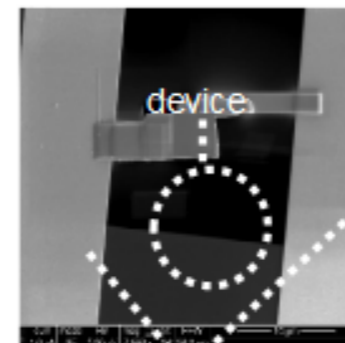
Co: blue
Mn: green
La: red

- Atomic scale imaging and analysis
- Magnetic ordering in multiferroics

Adv. Func. Mater.
[MacLaren, Glasgow]



- Four steps: synthesis, device, nanocharacterisation and in-situ TEM.

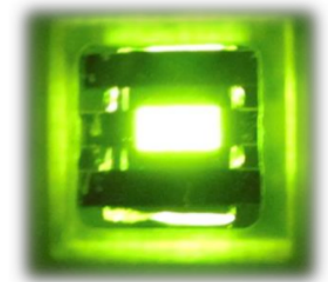
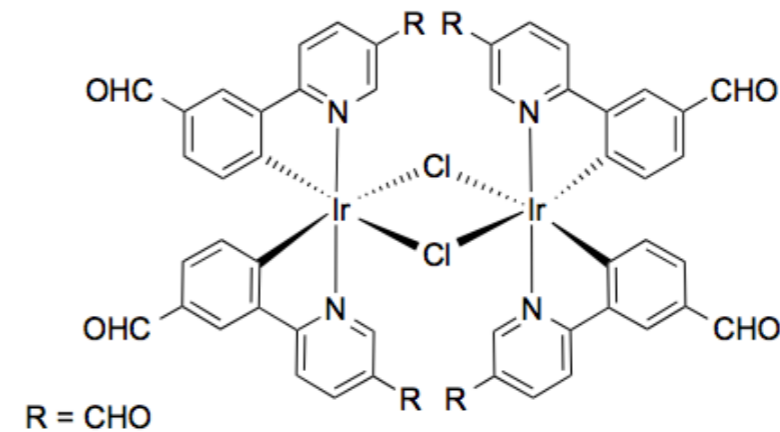
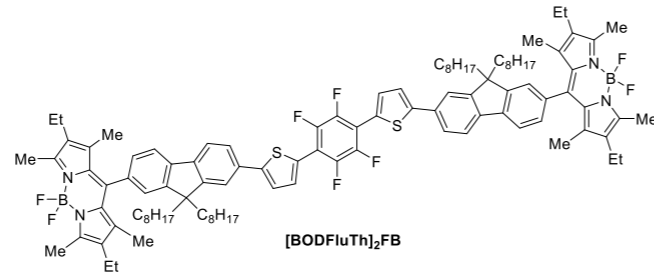


Nano Lett. **14** 6056 (2014)
[Paul, MacLaren,
MacIntyre Glasgow]

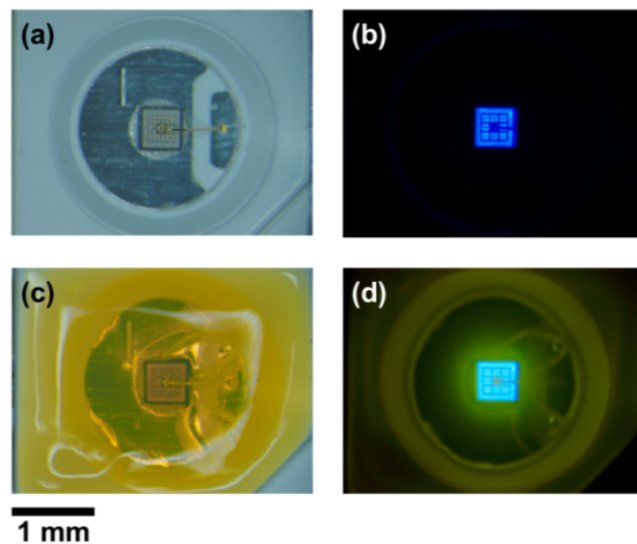
Light Matter Interface

Organic Lighting

- Blue inorganic LED with this downconverting organic material.



- Results efficient conversion into a white hybrid LED



- Chloro-bridged iridium dimers - tunable emitters
- Green emitter

Dalton Trans. DOI: 10.1039/c4dt03127j (2015)

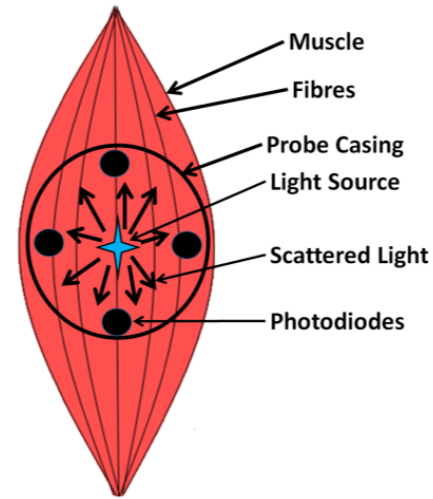
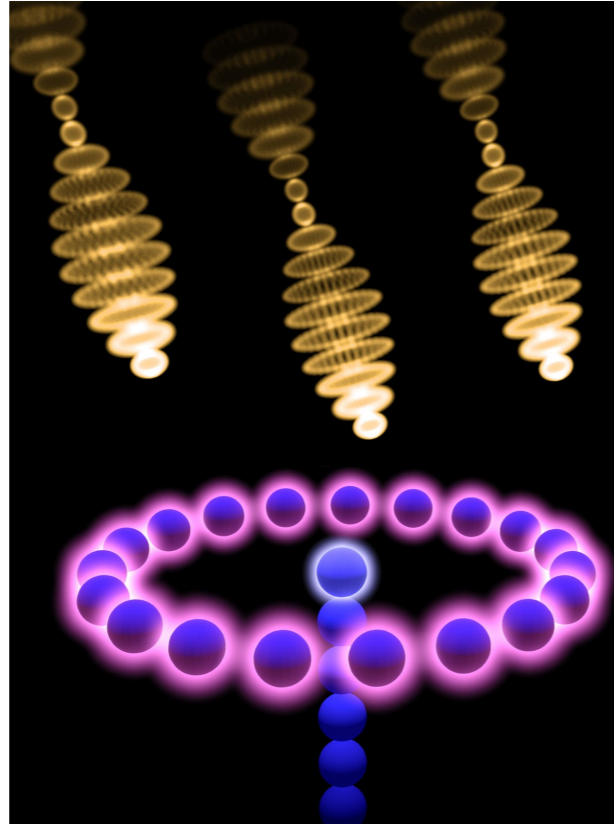
[EastChem/SUPA collaboration
Samuel, Zysman-Colman, St Andrews]

Advanced Materials **43** 7290 (2014)
[Martin, Skabara, Strathclyde -
collaboration with Plessey]

Light Matter Interface

Detectors and Sensors

- Ring shaped structures can allow for more efficient absorption of light.



- Light emission and detection in muscle depends on contraction.
- Can be used as a wearable sensor.

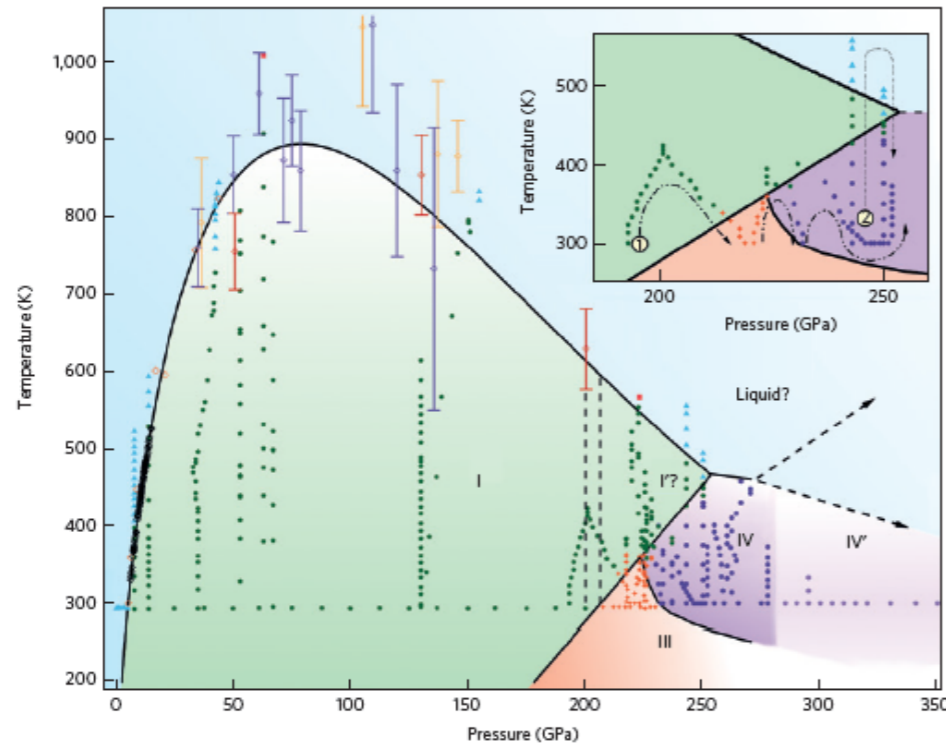
Advanced Materials DOI: 10.1002/adma.201403560 (2014)
[Samuel, St Andrews]

Nature Communications **5** 4705 (2014)
[Theory, Lovett, St Andrews, Gauger now at Heriot Watt]



Matter at Extreme Conditions

High Pressure Hydrogen



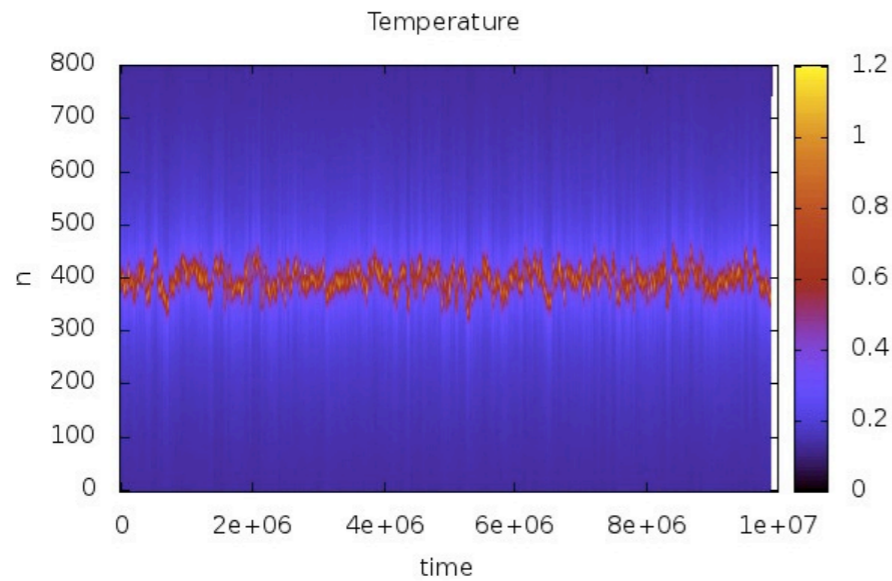
- Theory suggests hydrogen could be a metallic liquid at very high pressure (owing to zero point motion).
- The recent advance is to extend the measured melting curve and phase diagram to $P > 250$ GPa (i.e. 2.5 million atmospheres pressure. For comparison the pressure at the centre of Earth is 3.6 million atmospheres!).
- Hydrogen has the lowest melting point of any material measured at this enormous pressure.

Nature Materials doi:10.1038/nmat4213
[Gregoryanz, Edinburgh]

Driven Quantum Systems

New Theory and Phases

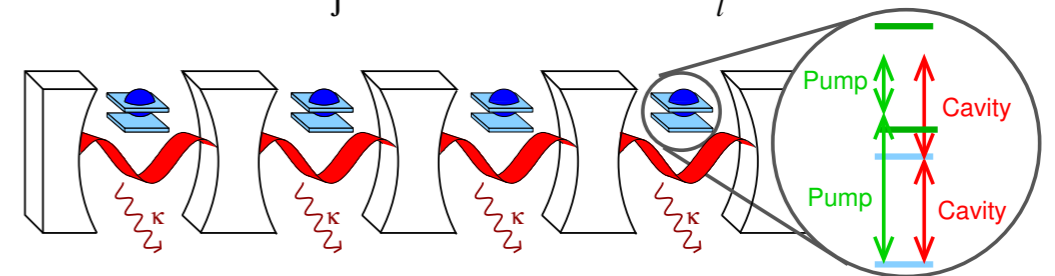
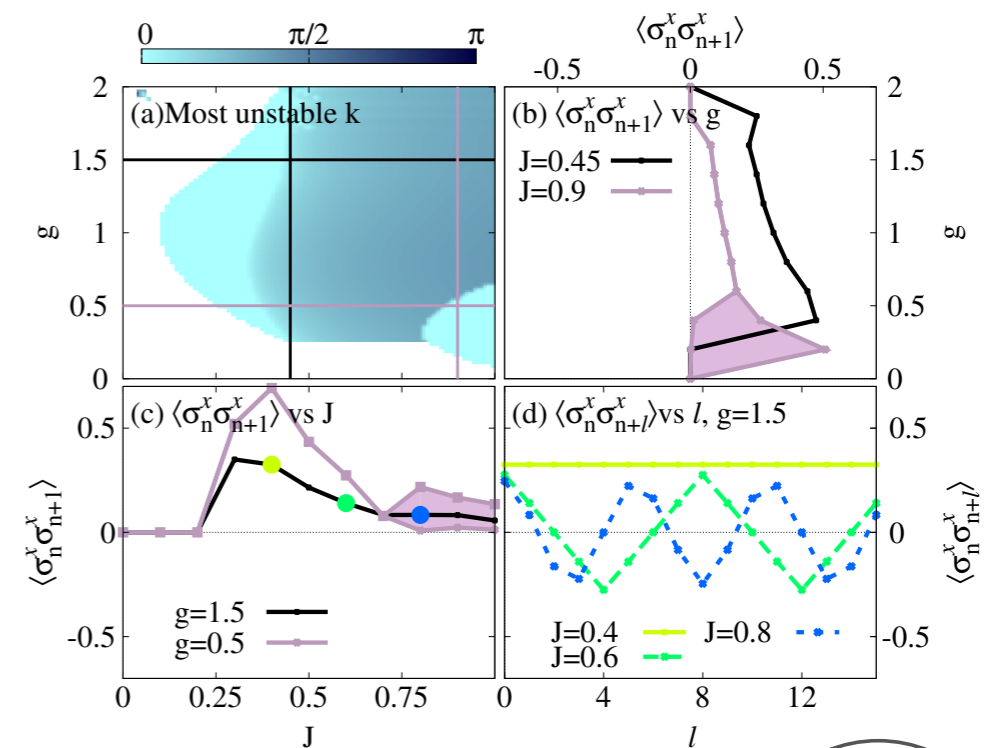
- Coupled driven cavity arrays.
- New phases!
- Sometimes limit cycles.



- Chains of oscillators
- Torque applied at ends at zero temperature
- Induces a temperature spike in middle of chain!

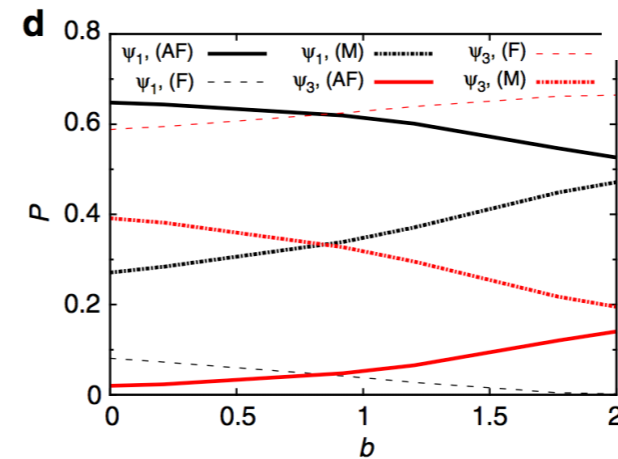
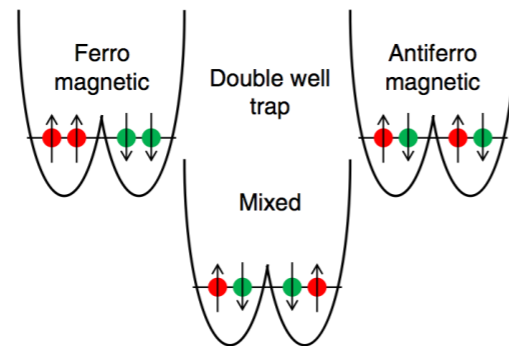
Phys. Rev. Lett. **112** 134101 (2014)
[Politi, Aberdeen]

[Keeling St Andrews]



More Theory Highlights

Confined Quantum Systems

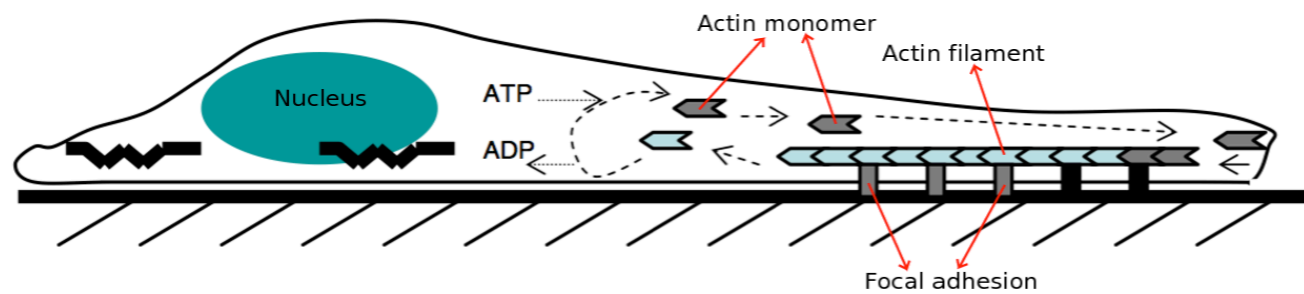


- Exact solutions
- Strongly interacting confined fermions or bosons in 1D

Nature Communications **5** 5300 (2014)
[Valiente, Heriot Watt]

Theory at Biology Interface

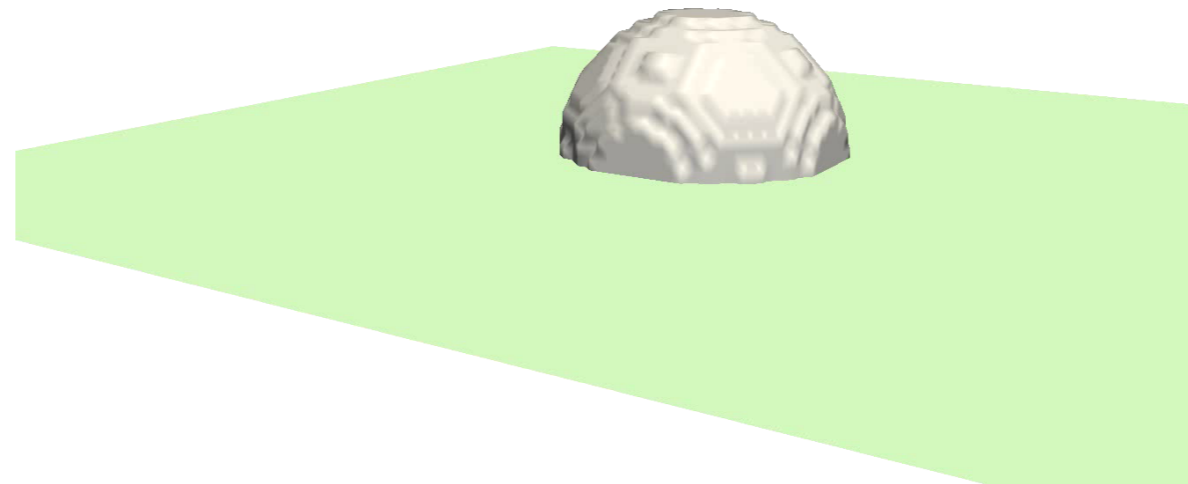
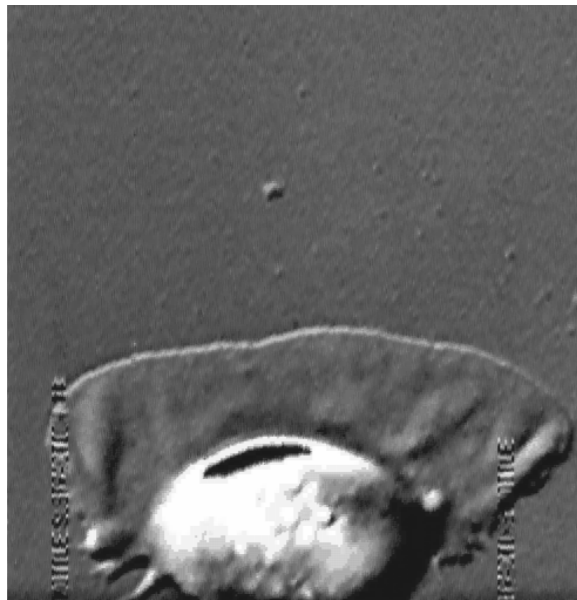
Cell Crawling



- How do cells crawl?
- Active liquid crystal layer
- Focal adhesions
- Reversible polymerisation

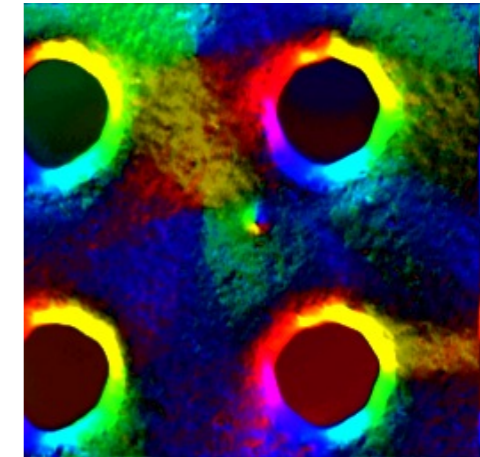
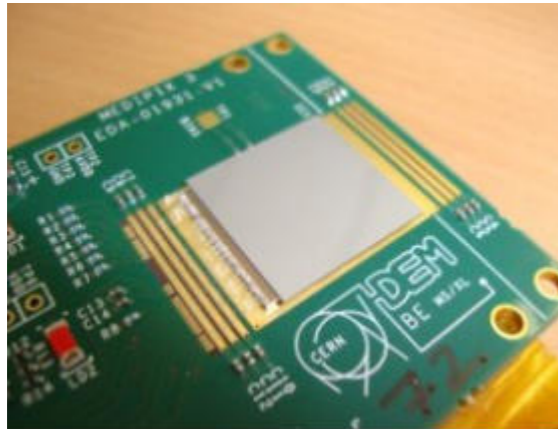
Nature Communications 6 5420 (2014)

[Tjhung (former Prize Student),
Tiribocchi, Marenduzzo, Cates,
Edinburgh]



Particle Physics Interface

Imaging Condensed Phases with Particle Physics Detectors



- Medipix Project, through CERN.
- Electron microscopy - with high energy physics detectors.
- Pixellated images of crystallographic and magnetic structure.

[Glasgow Particle and Condensed Matter groups, Strathclyde]

