Research & Education in Gravitational-Wave Astrophysics at the University of Portsmouth

David Keitel, Institute of Cosmology & Gravitation

[visit-hampshire.co.uk]

Portsmouth
the great waterfront city

- ~205k population

- one of the UK's historically most significant harbour cities and "home of the Royal Navy"

- closest airports: Southampton, Heathrow, Gatwick

- University since 1992 (first progenitor: 1908), ~23k students

NO.1
in UK for graduate salary boost
(The Economist, 2017)

TOP 25
university in the UK
(Guardian University Guide, 2019)

97.5%
of graduates working or in further study
(DLHE, 2017)

TEF Gold — Teaching Excellence Framework

Institute of Cosmology and Gravitation

- established 2002

- 60+ researchers

- £1.5M annual research income

- 96% "world-leading" research outputs
  in 2014 REF (89% in physics@UoP overall)

- leading roles in international
  collaborations (e.g. SDSS, DES)

- SCIAMA supercomputer
  (3700 cores, currently upgrading)

- Research topics:
  - Very early Universe
  - Dark energy
  - Testing gravity on cosmological scales
  - Large scale structure
  - Gravitational lensing
  - Supernovae
  - Galaxy evolution
  - Stellar population modelling

GW group @ICG

- established 2018

- 3 faculty:
  - Andrew Lundgren
  - Laura Nuttall
  - Ian Harry

- 1 post-doc: (+1 soon)
  - David Keitel

- 3 PhD students (+more soon)

- several undergrad project students

- members of LIGO Scientific Collaboration (through GEO) and LISA Consortium

- very recently joined GrEAT (just in time for this meeting)

Compact Binaries research @ICG

- LIGO-Virgo GWTC-1:
  10 BBHs + 1 BNS
  from O1+O2

- O3: 5 open alerts,
  and counting.

- local contributions:
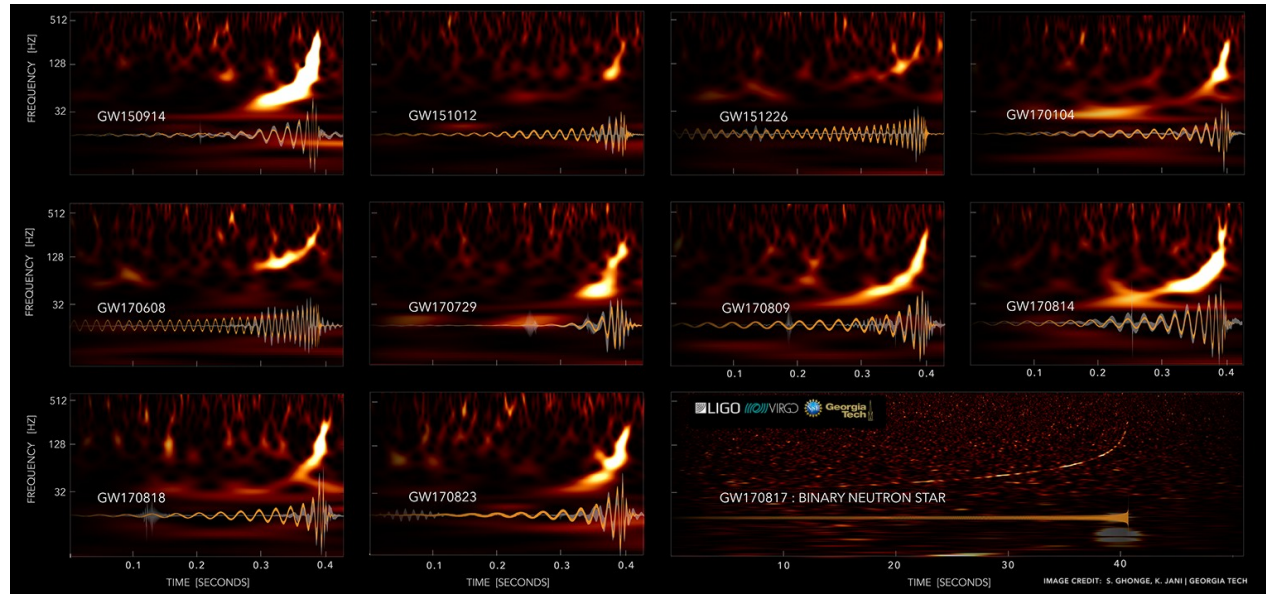
  ◆ I. Harry: one of
    PyCBC senior developers

  ◆ A. Lundgren and L. Nuttall also CBC experts
    since initial LIGO era

  ◆ D. Keitel: contributions to numerical relativity
    and parameter estimation since first detection

  ◆ often overlooked, but extremely crucial:
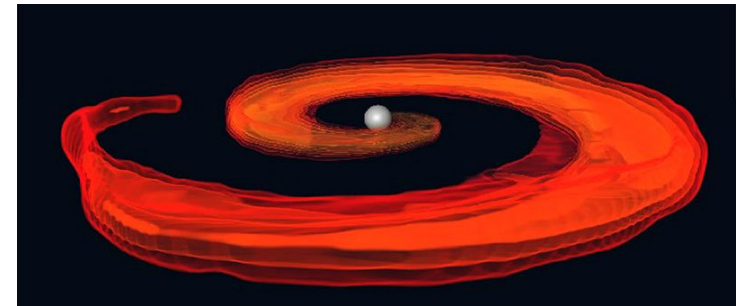   detector characterization (more later)
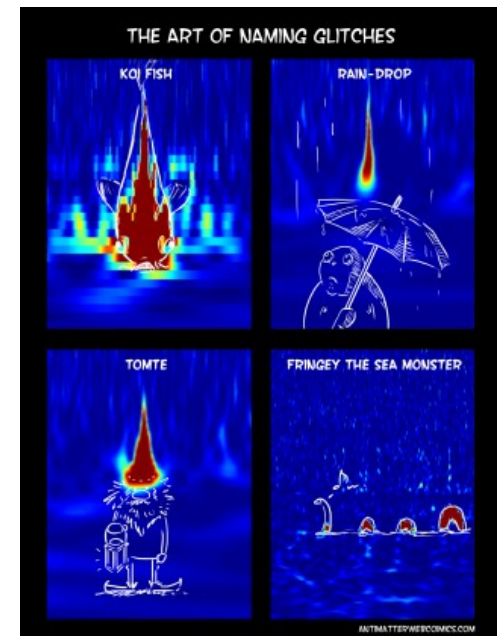
# Compact Binaries research @ICG

- PyCBC ongoing developments:
  - 3-detector online search
  - robust analysis of single-detector times
  - inference module as alternative to LALInference & Bilby
  - productive open-source collaboration with non-LSC research groups

- the latest frontier: NS-BH mergers
  - how to find them, how to characterise them
  - Possibly got one last week…?
    (S190426c, though only 13% NSBH, high FAR...)

- EM counterparts: joining GOTO consortium
  - ➜ 20-40 sq.deg. dedicated follow-up telescope

- gravitational lensing of GWs (more later)

- For the future: what can we do with 2.5 and 3rd gen ground-based detectors, and from space? (more later)

PyCBC

Free and open software to study gravitational waves.

[Tonita, Rezzolla & Pannarale]
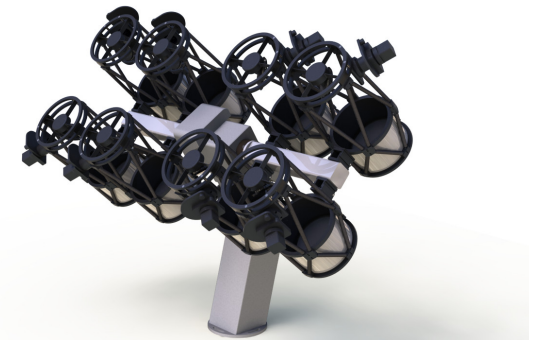
[University of Warwick]

Detector Characterization

- A. Lundgren & L. Nuttall leaders of LIGO "detchar"

- We couldn't claim any confident GW detections without understanding the noise behaviour.

- non-stationary noise curve, spectral lines, glitches!

- Each nominally significant candidate needs to pass data quality and detchar checklist.

- Over 200k auxiliary channels!

- Crucial part of "Rapid Response Team" for O3 open alerts
  → e.g. S190425z, our candidate 2nd BNS merger!

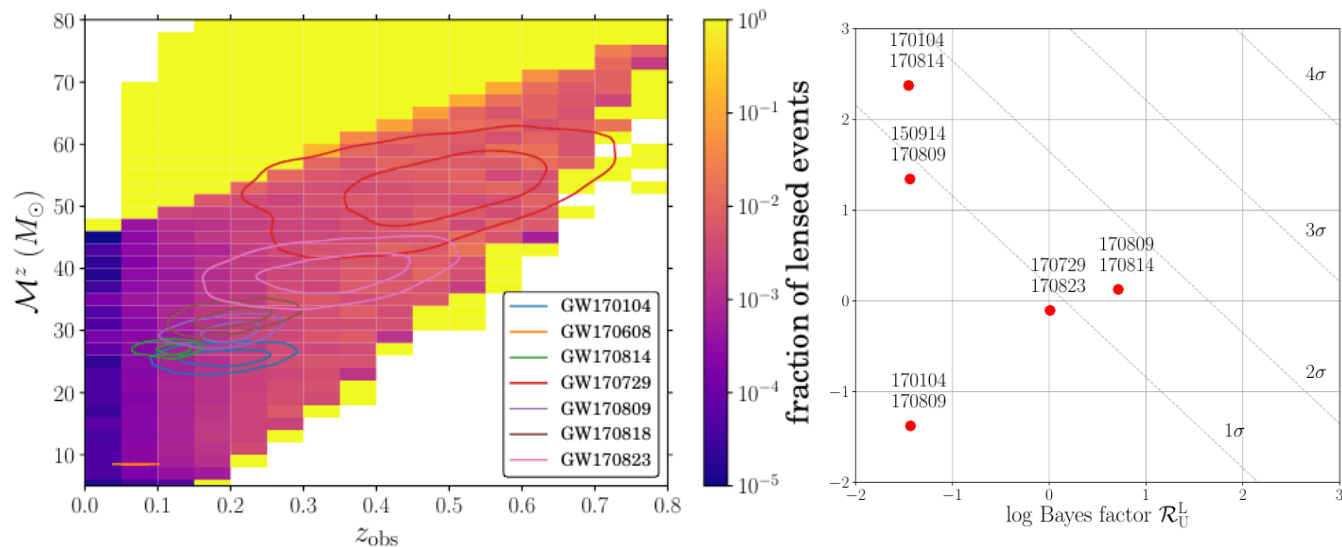- also sending PhD students to LIGO sites (fellows program)
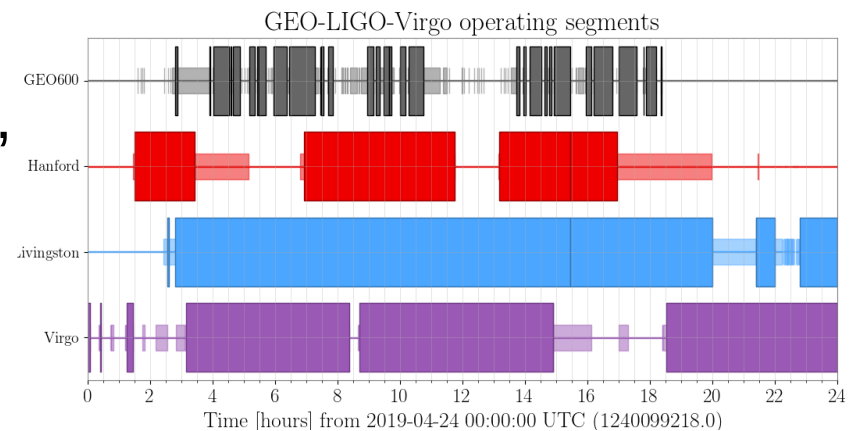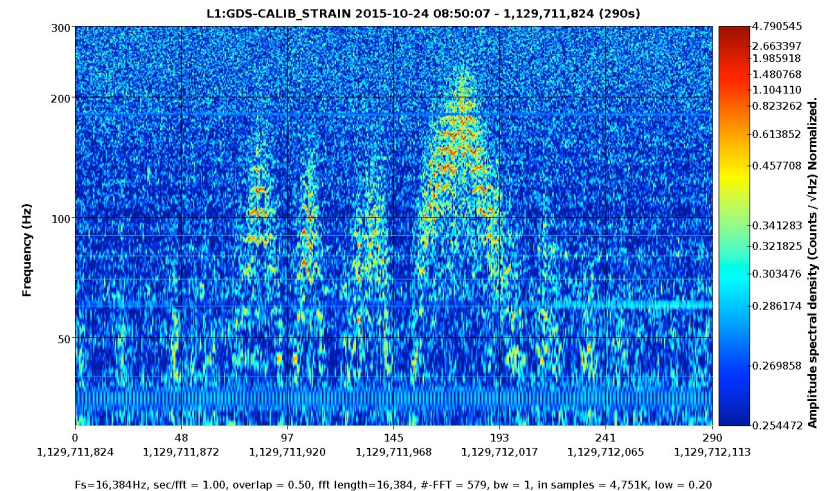
Lensing of GWs

- collaboration of D. Keitel with groups in Hong Kong
  (lead by T.G.F. Li) and India (lead by P. Ajith):
  signatures of gravitational lensing on O1+O2 BBH events?

 ➔ Hannuksela et al., ApJL 874:L2 [arXiv:1901.02674]
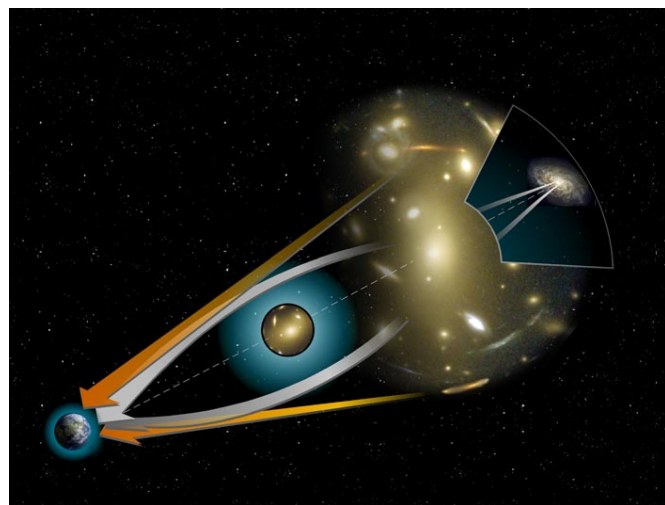
[NASA/STScI]

- Ongoing work at ICG:

  ◆ pyCBC search for sub-threshold lensed counterparts

  ◆ collaborating with lensing experts (David Bacon, Thomas Collett)

  ◆ lead by PhD student Connor McIsaac

other GW topics

- it's not all about binaries

- GWs from individual spinning NSs (my own main topic):

  - ◆ LSC code development & review for Continuous Wave searches

  - ◆ open-data search for long-duration transient GWs from glitching pulsar

  - ◆ work on emission mechanisms in collaboration with Ik Siong Heng (Glasgow) and Ian Jones (Southampton)

  - ◆ searches for a (hypothetical) NS remnant of GW170817 [Abbott et al. ApJL 851:L16, ApJ 875:160]
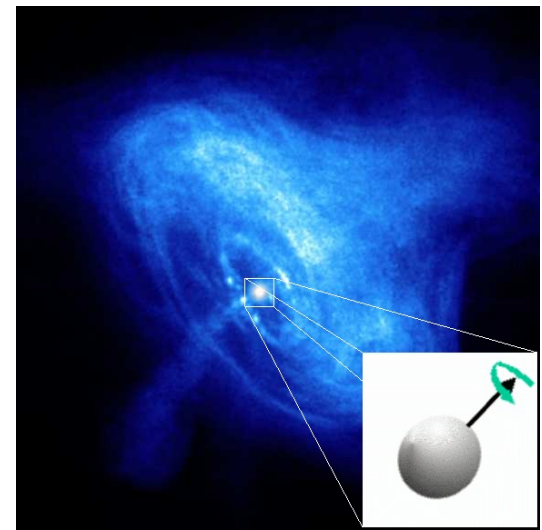

[Chandra/NASA/R.Prix]
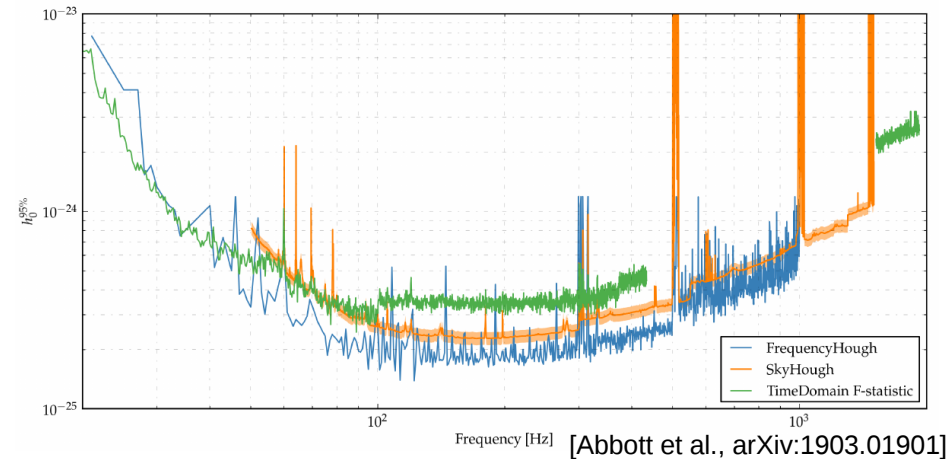
[Abbott et al., arXiv:1903.01901]
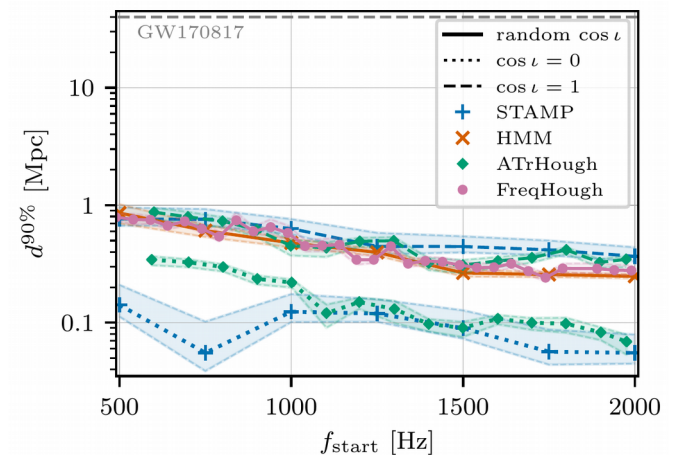
work for LISA and 3G detectors

- participating in Einstein Telescope and GWIC studies for 3rd generation ground-based detectors

- I. Harry: co-chair LISA Science Group's WP2 (data analysis pipelines)

- main topics: super-massive binary black holes, EMRIs, white-dwarf binaries

- L. Nuttall: how do LISA noise properties affect our ability to extract science?
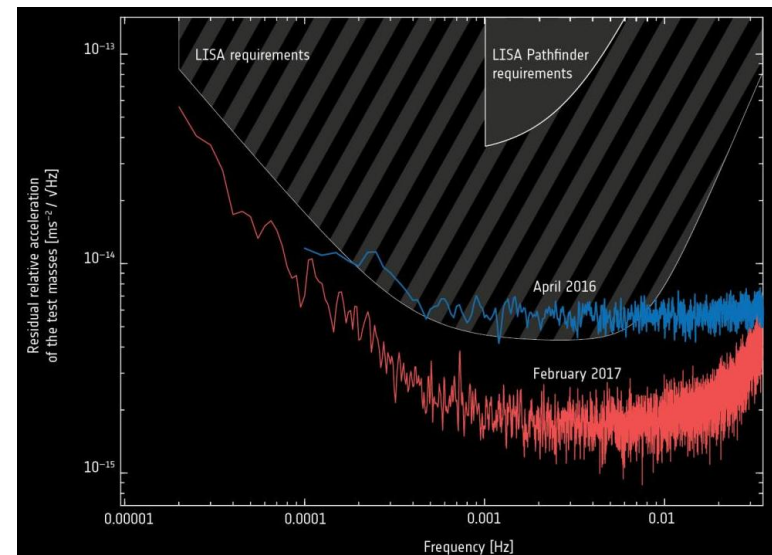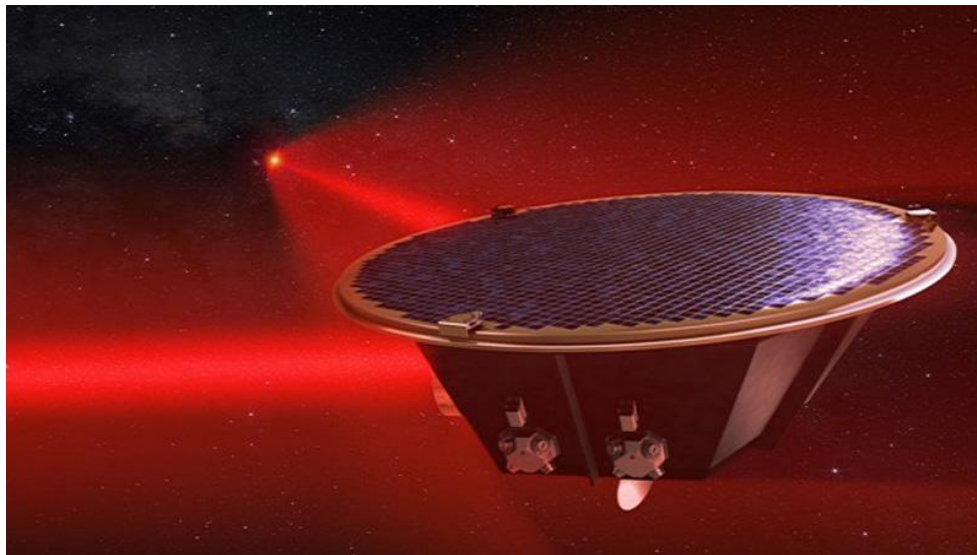
GWs in teaching & outreach

- Gravitational Waves are now a key player in modern observational astrophysics, and have earned their place in the under- and graduate level curricula.

- At Portsmouth, we're delivering GW lectures in "Modern Astrophysics" module, and use GW examples for signal processing in computational physics.

- also dedicated PhD-level lectures at ICG

- vivid ICG outreach program to local schools and general public

- We involve undergrads in public outreach at an early stage to stoke their enthusiasm.

  → (e.g. hugely successful yearly "Stargazing Live" event at Portsmouth Historical Dockyards)

[A.Papadoupolous]

industry applicability

- "data science" trend in industry gives a great opportunity to train our students (under- and post-grad) for the real-life job market

- machine learning methods of parti-cular interest; we're actively pursuing these for CBC detection, detector characterization and other applications

arXiv.org > astro-ph > arXiv:1904.08693

Astrophysics > Instrumentation and Methods for Astrophysics

Convolutional neural networks: a magic bullet for gravitational-wave detection?

Timothy D. Gebhard, Niki Kilbertus, Ian Harry, Bernhard Schölkopf

(Submitted on 18 Apr 2019)

- traditional physics skillset ("PhD in problem solving") and formal+applied statistics also still highly marketable

- DISCNet placement scheme (see next slide) for PhD students in in companies

- ICG pursuing many industry and interdisciplinary projects from medical imaging to coastal erosion

- ICG recently awarded "Impact Accelerator Account" from STFC

DISCNet / SEPNET
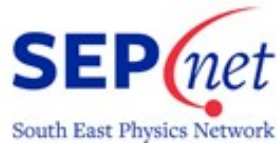
- SEPNET - alliance of South-East England physics

  - universities of Hertfordshire, Kent, Open University, Portsmouth, Queen Mary, Royal Holloway, Southampton, Sussex

  - funding many outreach activities

  - training schools, GRADnet student-lead conferences

- DISCNet: Data Intensive Science Centre

  - CDT (centre for doctoral training, ~50 students)

  - focus on interdisciplinary, externally relevant skills

  - industry placement scheme

    - first of our GW PhD students to work with Madgex in Brighton this summer

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We're happy to collaborate!

- NS-BHs, lensing, eccentric binaries, EMRIs and other frontiers

- What can be transferred from LISA to TianQin?

- Joint outreach activities?

- We can host visitors!

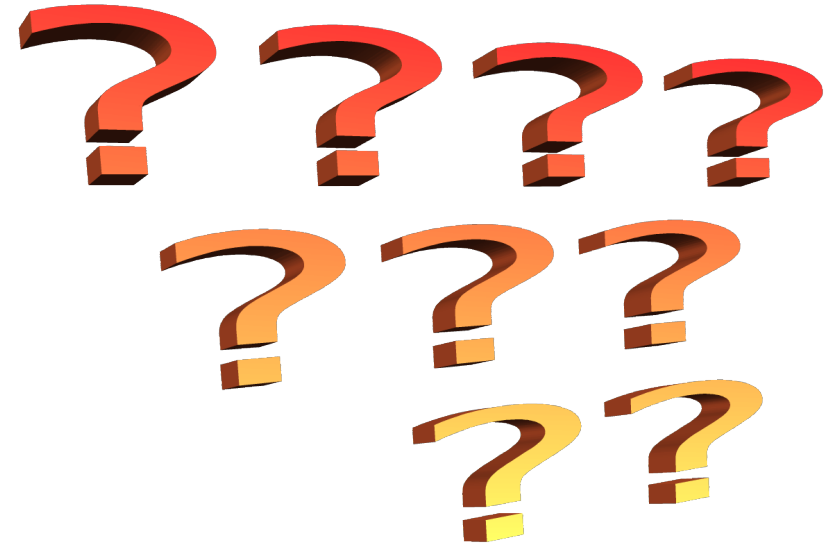- Always looking for qualified PhD and postdoc applicants!

"Portsmouth trade trip to China could boost prospects for Pompey and university", portsmouth.co.uk, 2018-11-30

(note the G-wavy carpet...)

Thanks for your attention!

Time for questions...

...and we're all looking forward to GrEAT collaboration opportunities!