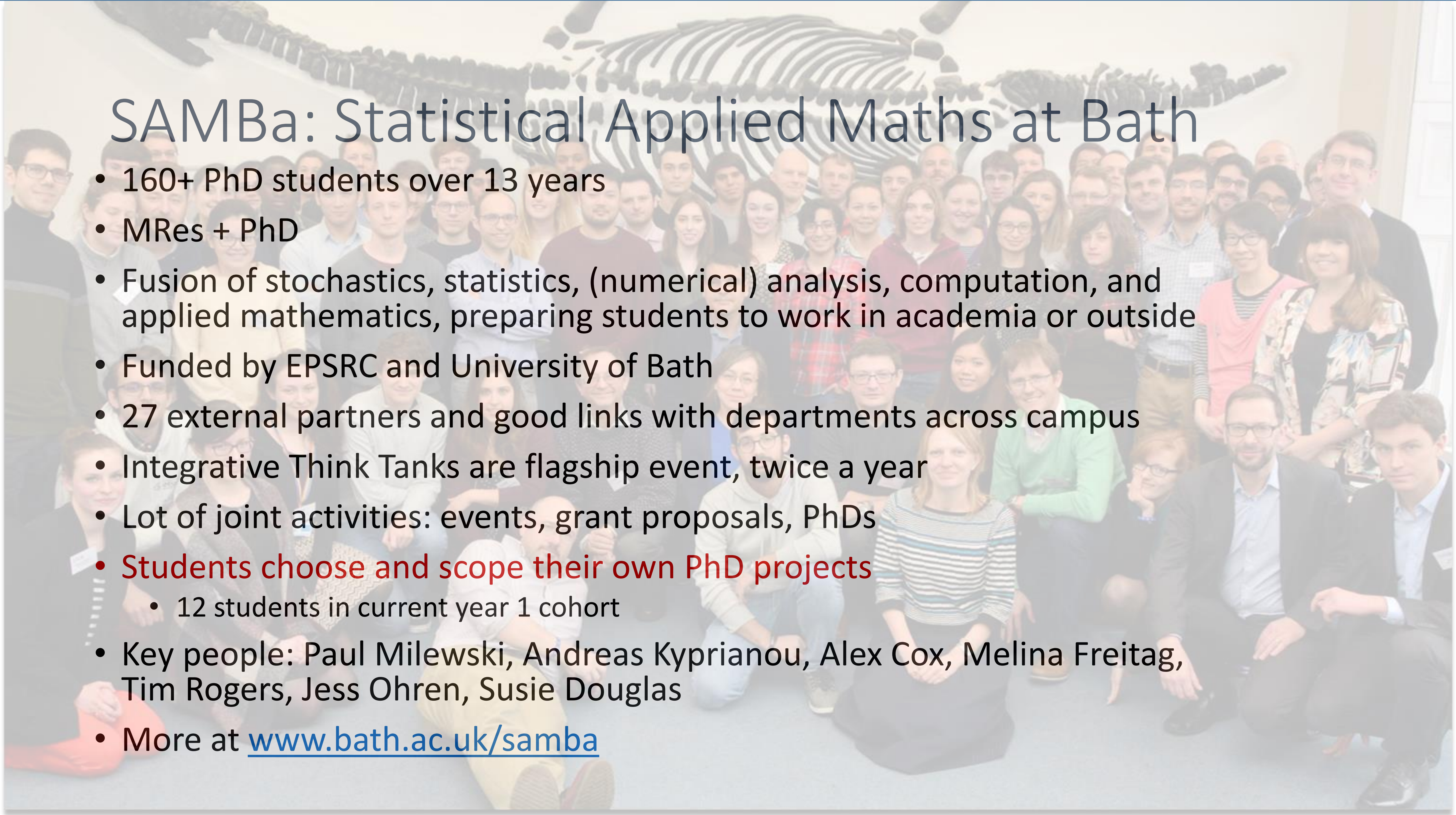
Welcome

From SAMBa



SAMBa: Statistical Applied Maths at Bath

- 160+ PhD students over 13 years
- MRes + PhD
- Fusion of stochastics, statistics, (numerical) analysis, computation, and applied mathematics, preparing students to work in academia or outside
- Funded by EPSRC and University of Bath
- 27 external partners and good links with departments across campus
- Integrative Think Tanks are flagship event, twice a year
- Lot of joint activities: events, grant proposals, PhDs
- Students choose and scope their own PhD projects
    - 12 students in current year 1 cohort
- Key people: Paul Milewski, Andreas Kyprianou, Alex Cox, Melina Freitag, Tim Rogers, Jess Ohren, Susie Douglas
- More at www.bath.ac.uk/samba

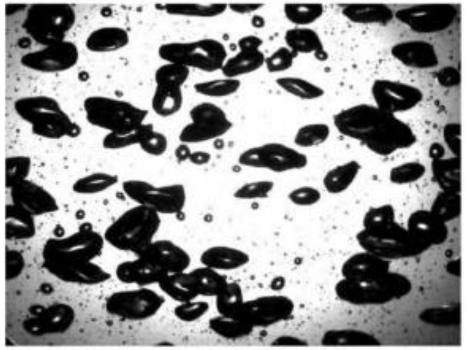
Here's the Maths

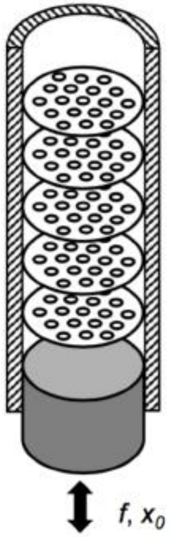
Oscillating Bubble Column Reactors
&
Fragmentation-Coalescence processes

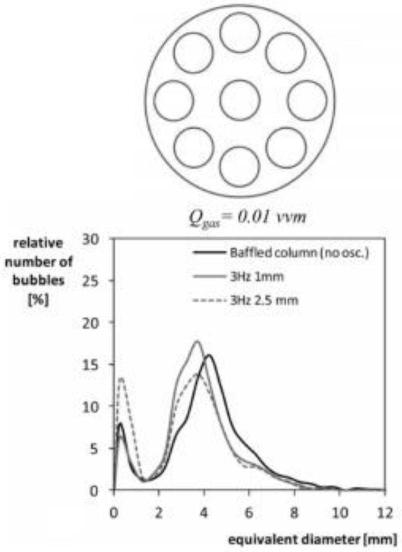
Nuno Reis (Chemical Engineering)
Tim Rogers (Mathematical Sciences)

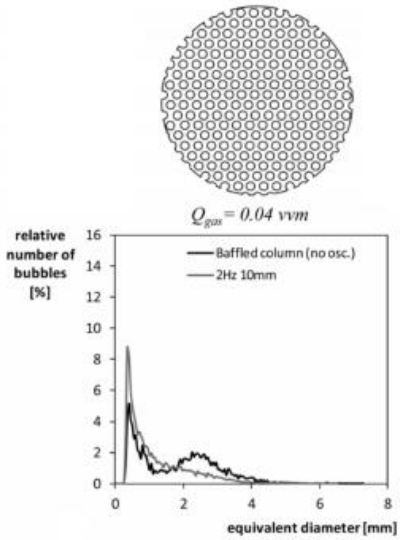
Oscillating Bubble Column Reactors

- Bubble column reactors used for gas-air reactions
- New idea: speed up reactions by oscillating the bubble column
- Efficiency of reactor linked to distribution of bubble sizes
- Need mathematical model to predict bubble sizes and optimise design





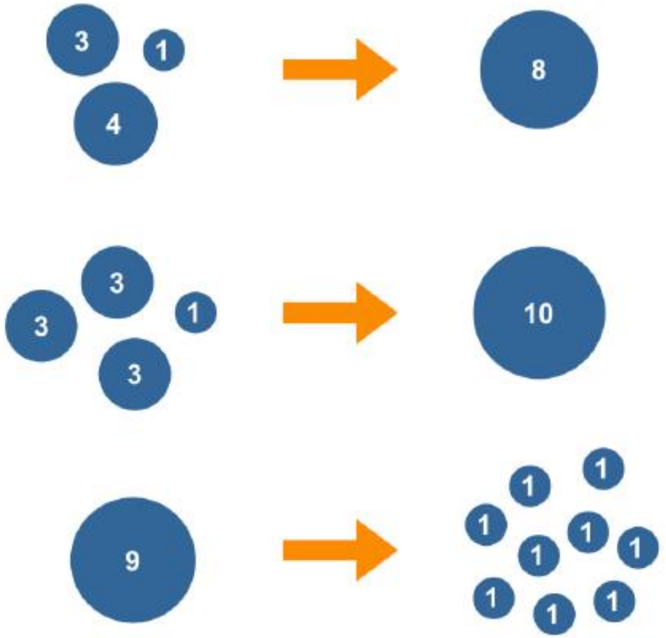




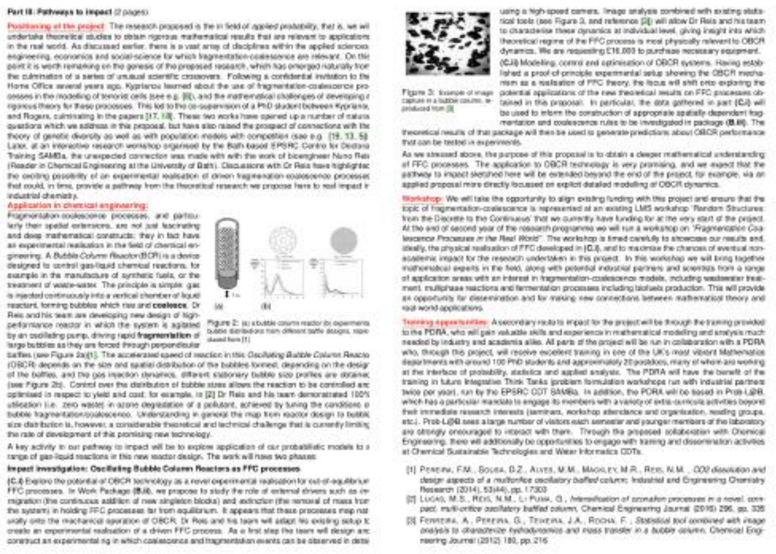
Fragmentation-Coalescence processes

Theorem 2. *If α satisfies (6) and m is the smallest integer such that $\alpha(m) > 0$, then the stationary cluster size distribution exists and is unique. In particular, the limit of this stationary distribution as $\lambda \to 0$ exists and obeys*

$$\lim_{\lambda \searrow 0} p_k = \begin{cases} \frac{1}{k}\left(\frac{m-1}{m}\right)^k \left(\frac{1}{m}\right)^{\frac{k-1}{m-1}} \binom{m\left(\frac{k-1}{m-1}\right)}{\frac{k-1}{m-1}} & \text{if } m-1 \text{ divides } k-1 \\ 0 & \text{otherwise.} \end{cases}$$



EPSRC proposal



Where’s the Maths

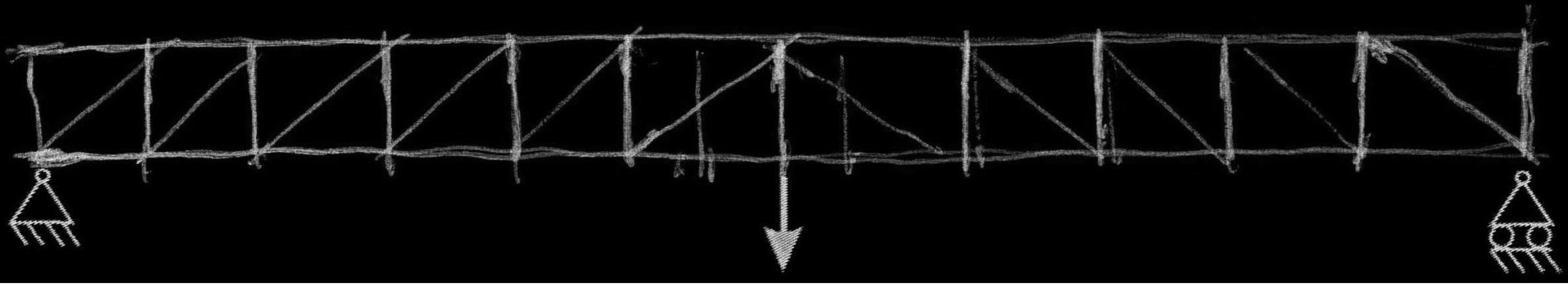
Where’s the Maths

Paul Shepherd

Architecture and Civil Engineering

Clustering of Hand Sketches for Structural Analysis

Paul Shepherd
Architecture & Civil Eng & IMI

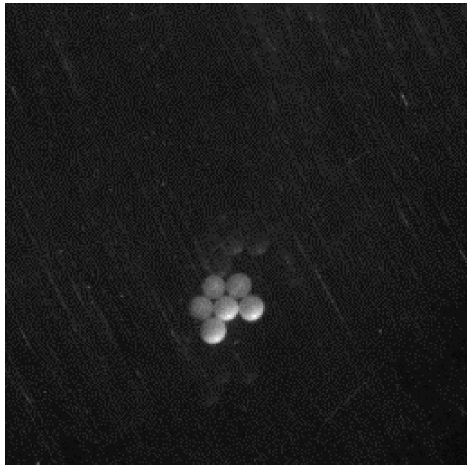


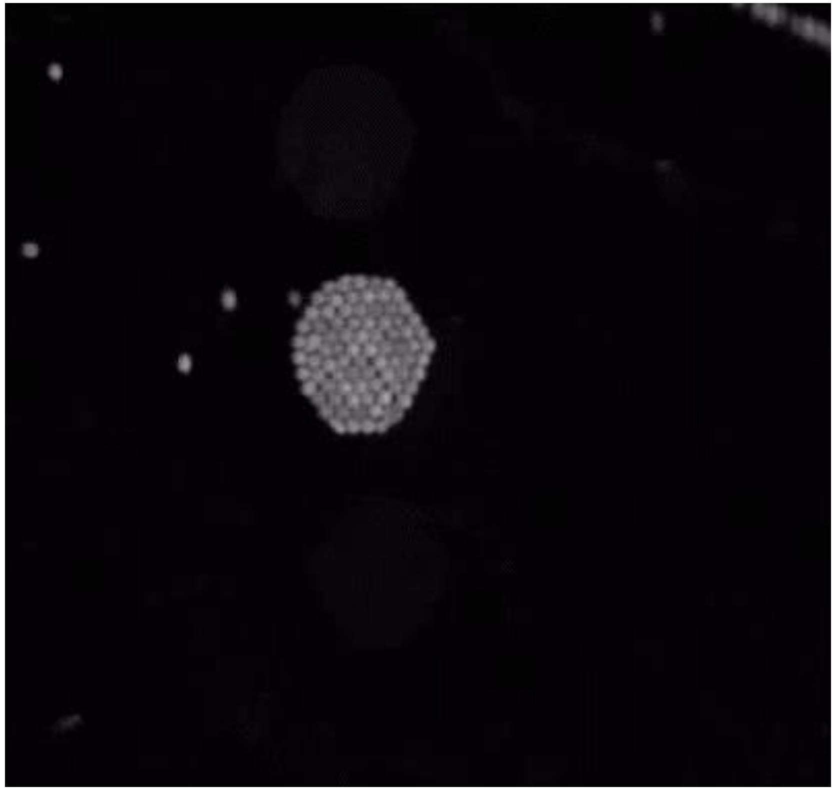
Anton Souslov

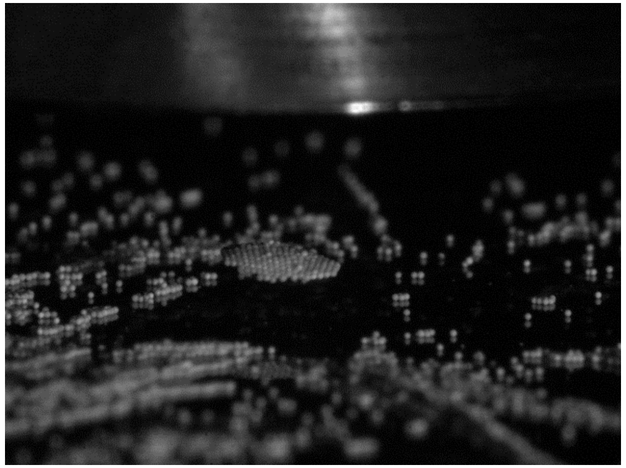
Physics

Why do acoustically levitated clusters spin?

Anton Souslov







Department of
Physics

UNIVERSITY OF
BATH

Cluster formation by acoustic forces and active fluctuations in levitated granular matter
Melody Lim, AS, Vincenzo Vitelli, Heinrich Jaeger. *in press, Nature Physics* (2019) *arXiv:1808.03862*

SAMBa

Where’s the Maths?

Hendrik Van Eerten

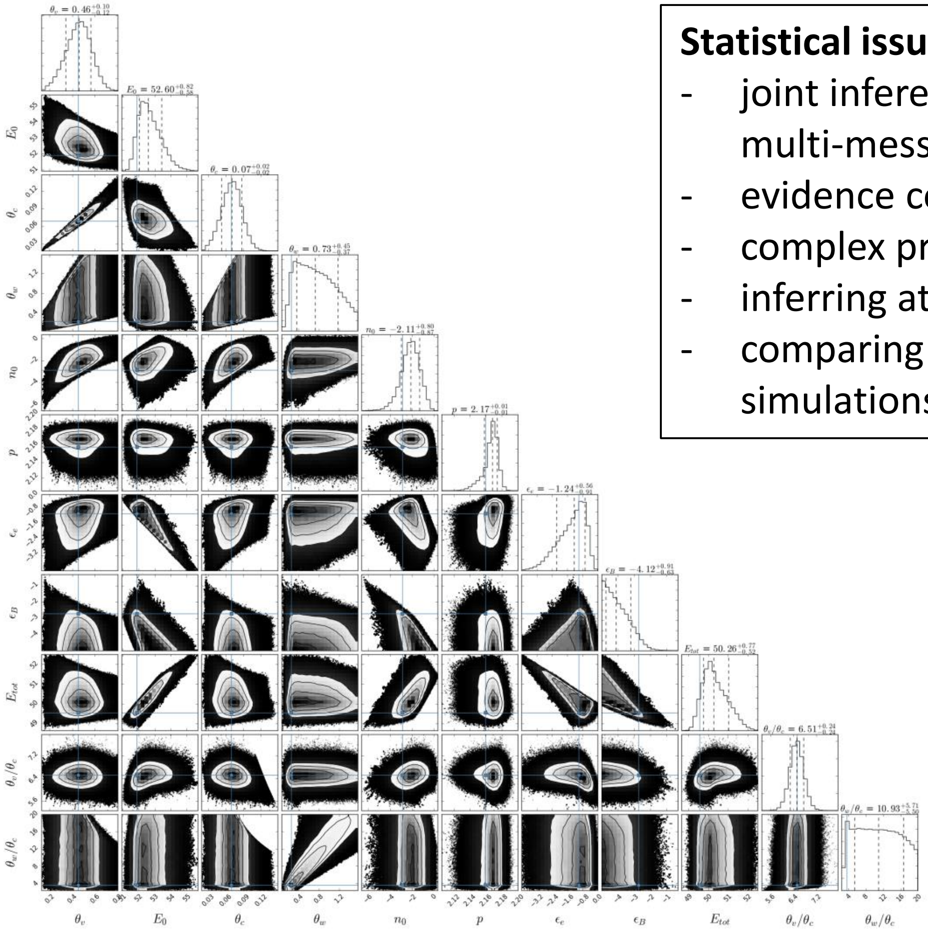
Physics

@SAMBa_CDT

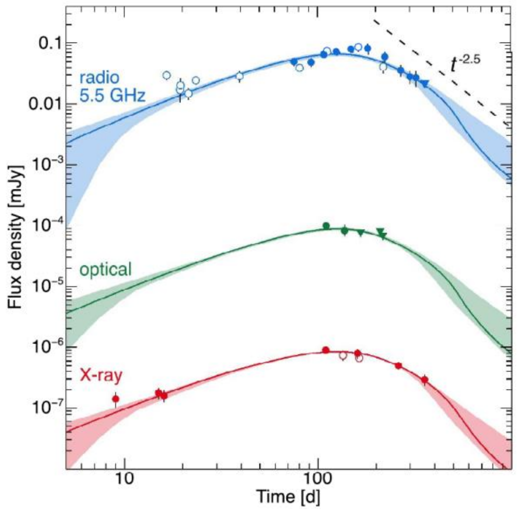
#WherestheMaths

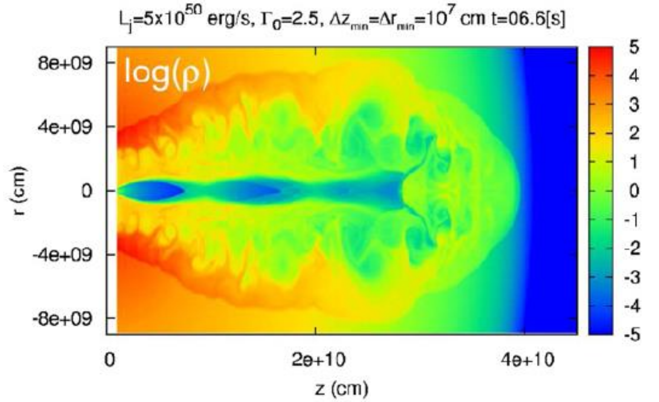
The statistics of inferring the physics underlying cosmic explosions

from comparing computational models to electro-magnetic and gravitational wave observations



Statistical issues:
- joint inferences from multi-messenger data sources
- evidence comparison models
- complex priors
- inferring at larger sample level
- comparing noisy numerical simulations to noisy data





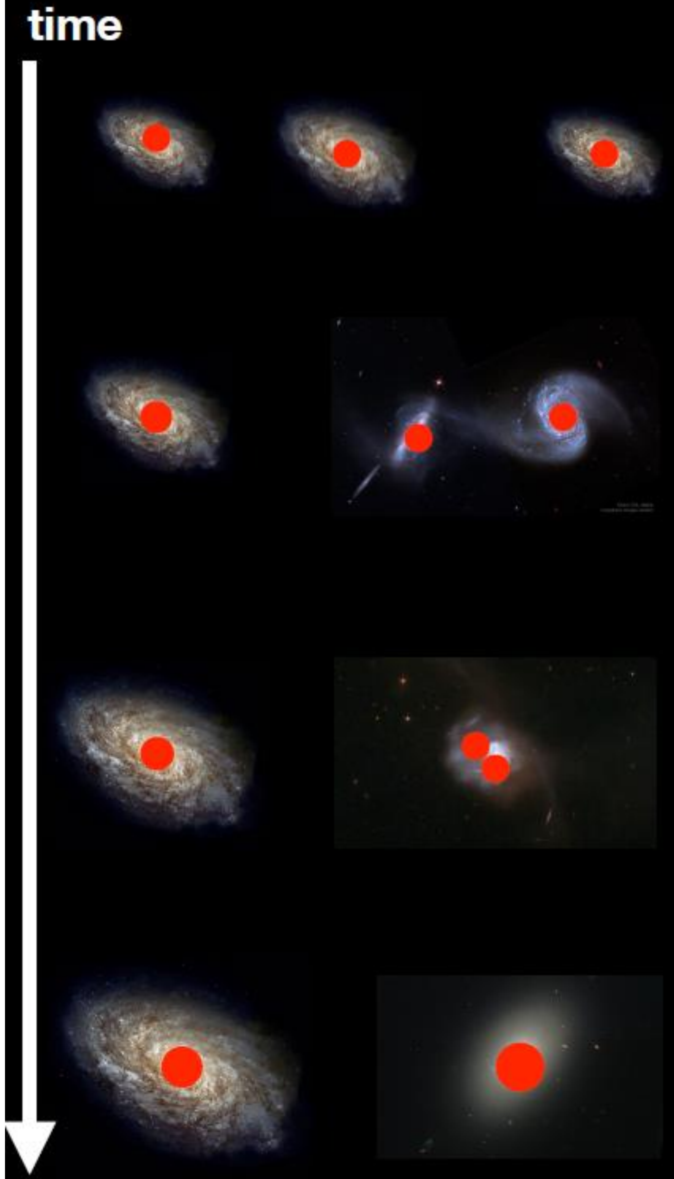
Hendrik van Eerten, lecturer in astrophysics, Physics Dept.

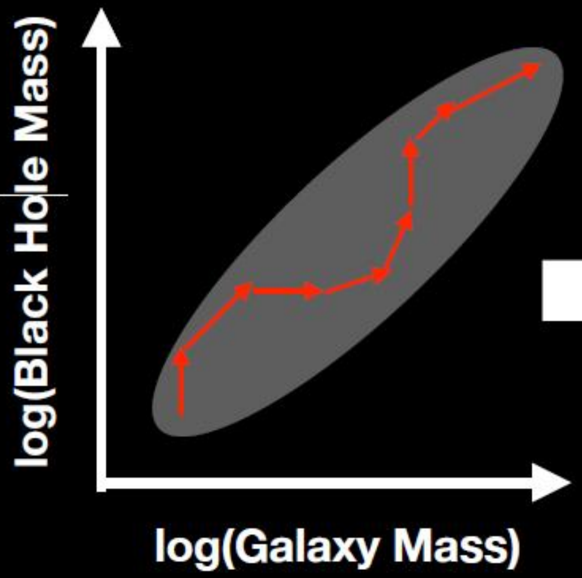
Carolin Villforth

Physics

Connecting the growth of supermassive black holes and galaxies

Carolin Villforth (Physics)





Modelling of observed data

With Beate Erhardt (IMI)

- M1: log(L60) ~ log(M) + log(Lx) + z + Fields
- M2: log(L60) ~ log(M) + z + Fields
- M3: log(L60) ~ z + Fields

Model comparison

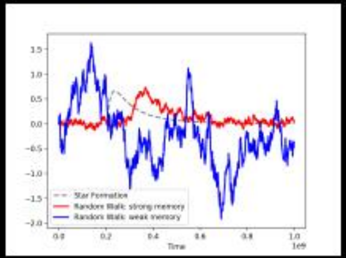
Res.Df	RSS	Df	Sum of Sq	F	Pr(>F)
230	18.29314	NA	NA	NA	NA
231	18.30965	-1	-0.0165099	0.2075798	0.6491008
232	18.70553	-1	-0.3958773	4.9773730	0.0266460

Creating Stochastic Models of BH growth

With Beate Erhardt (IMI)

$$dL(t) = N(\mu(t), \sigma)$$

$$\mu(t) = -\alpha\,(L(t\text{-}1) - \beta(SFR(t\text{-}\delta))$$



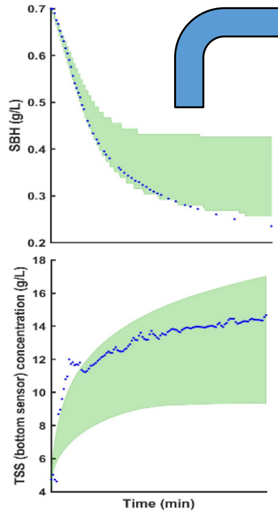
How can we recover the physically interesting coevolution on short timescales?

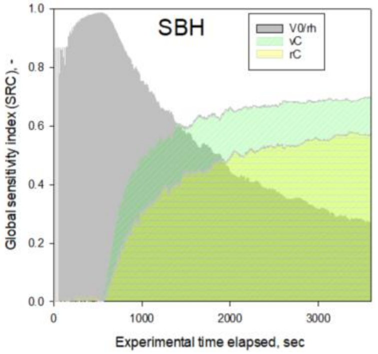
(Given only sample properties and limited sampling in time)

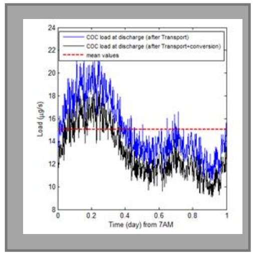
Benedek Plosz

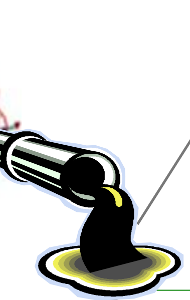
Chemical Engineering

Data handling, model identification and parameter estimation for climate change adaptation in urban water treatment

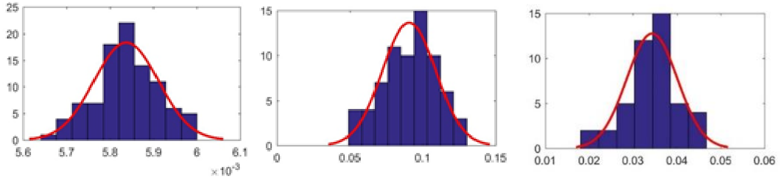


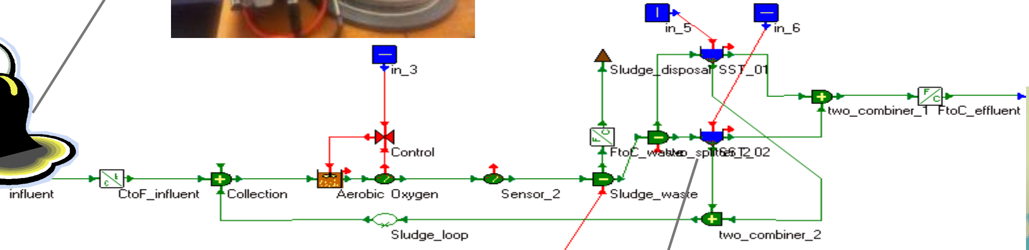


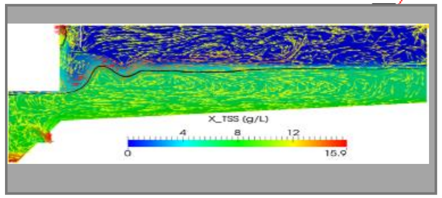




$$v_S = \begin{cases} v_H = v_0 e^{-r_H X_{TSS,i}}, & X_{TSS,i} \leq X_{TSS,C} \\ v_H \left(1 - \dfrac{\rho_S}{(\rho_S - \rho_f) g \cdot X_{TSS,i}} \dfrac{\partial \tau}{\partial X_{TSS,i}} \dfrac{\partial X_{TSS,i}}{\partial z}\right), & X_{TSS,i} > X_{TSS,C} \end{cases}$$







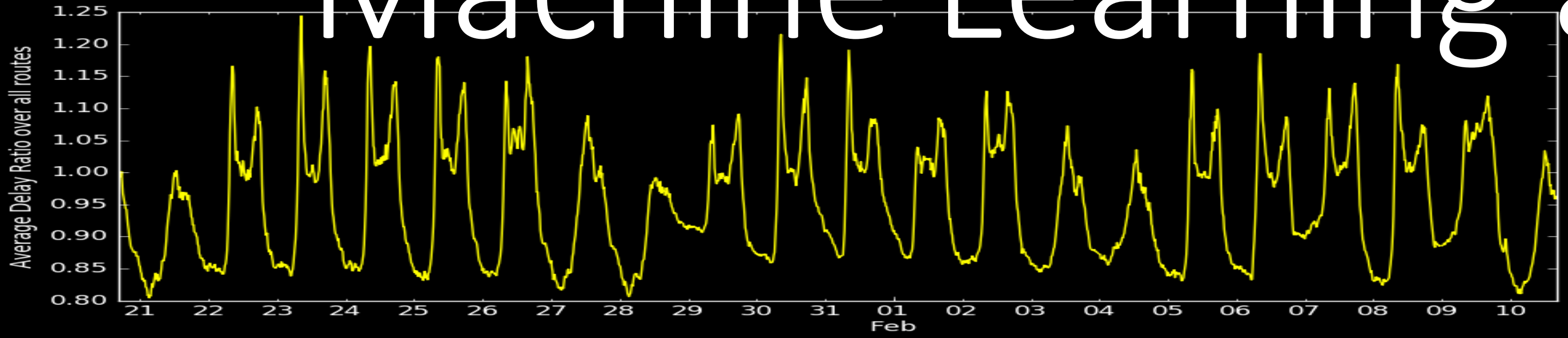
UNIVERSITY OF BATH
Department of Chemical Engineering

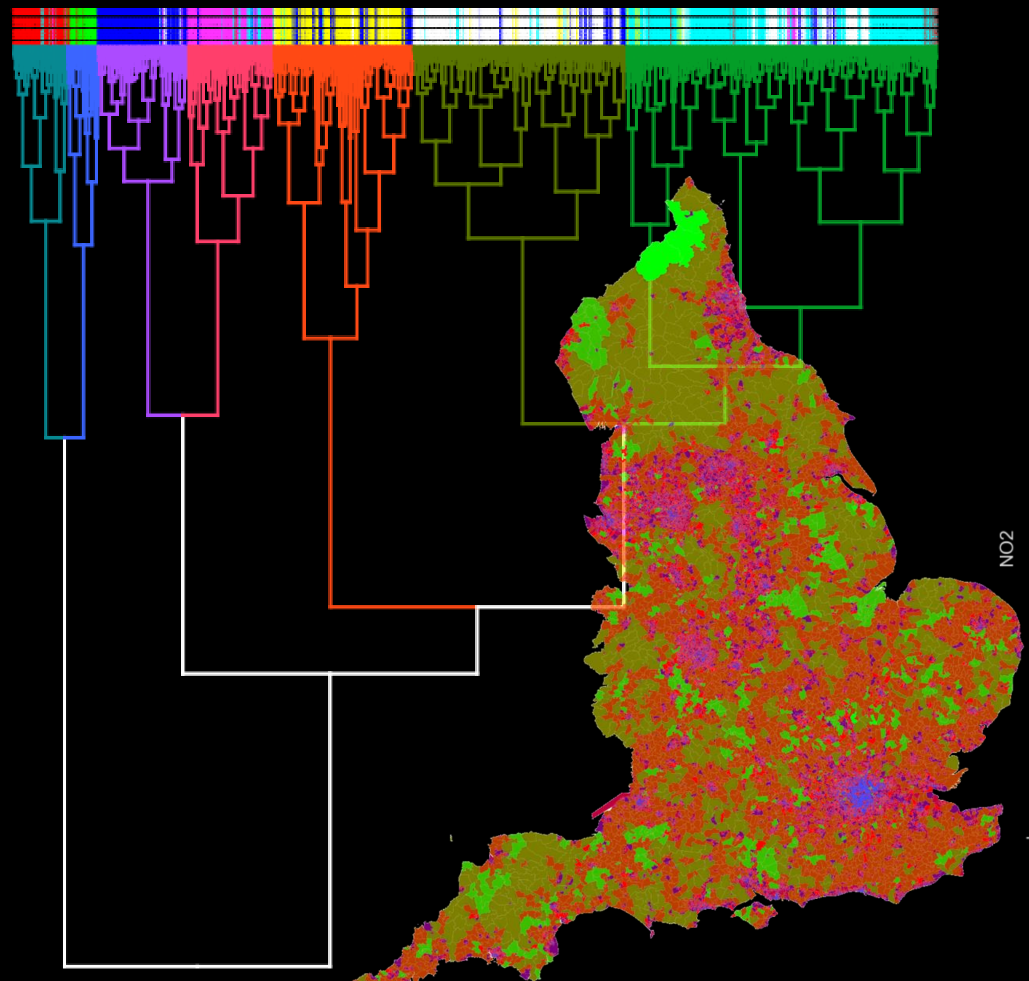
Benedek G. Plosz – bgp24@bath.ac.uk

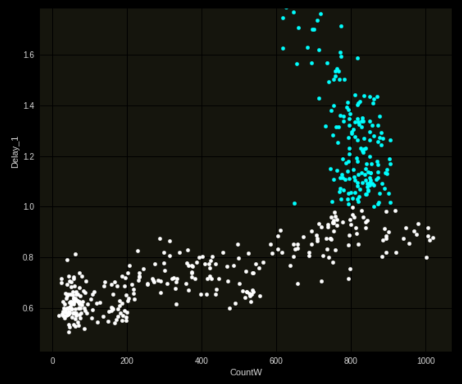
Nick McCullen

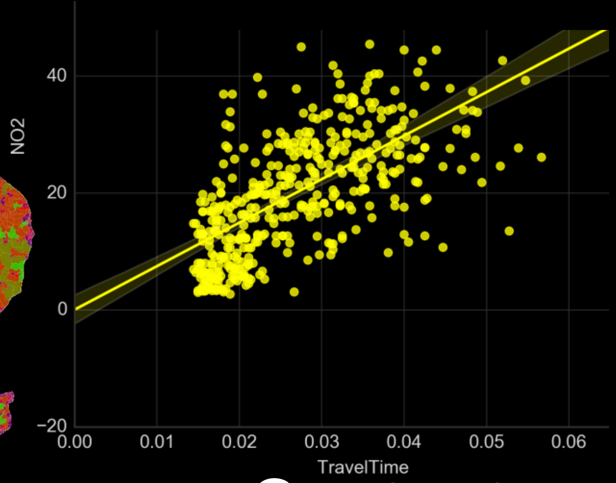
Architecture and Civil Engineering

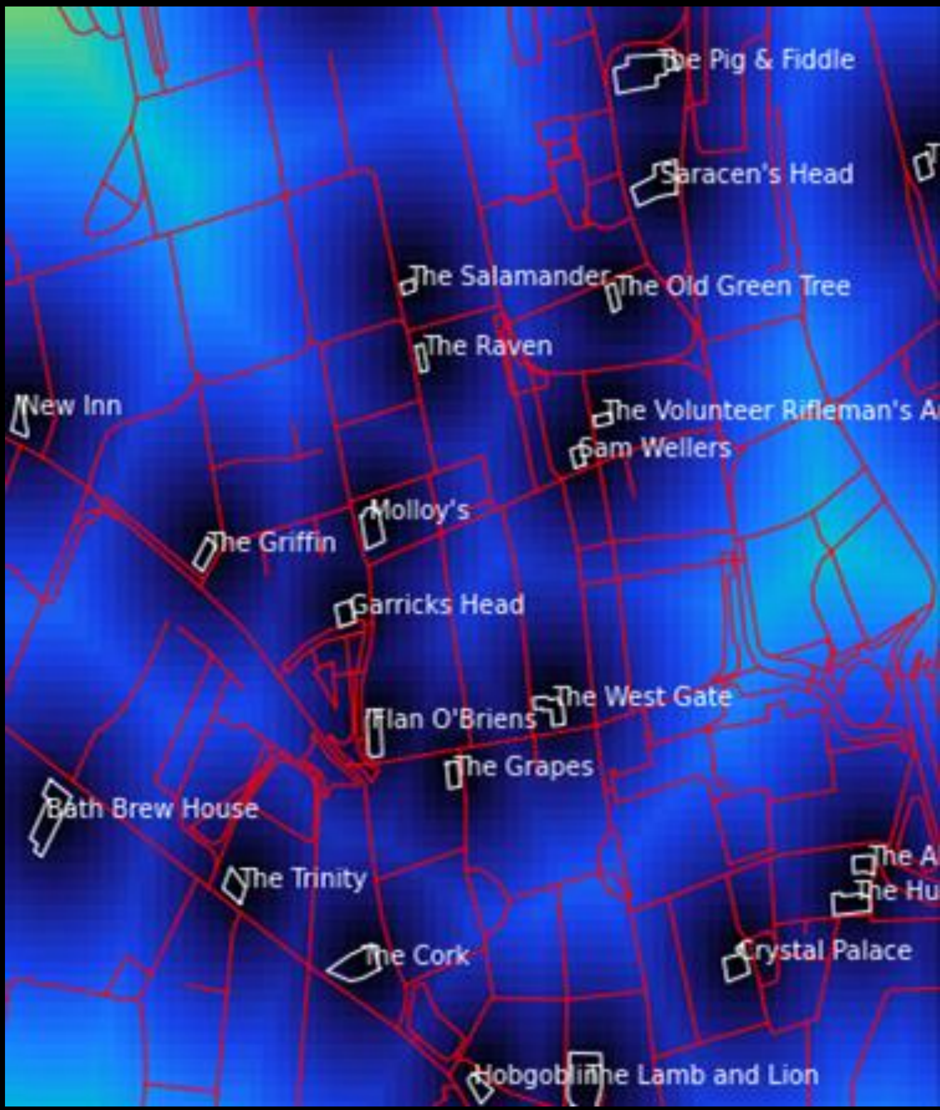
Machine Learning and Cities











Contact: n.j.mccullen@bath.ac.uk

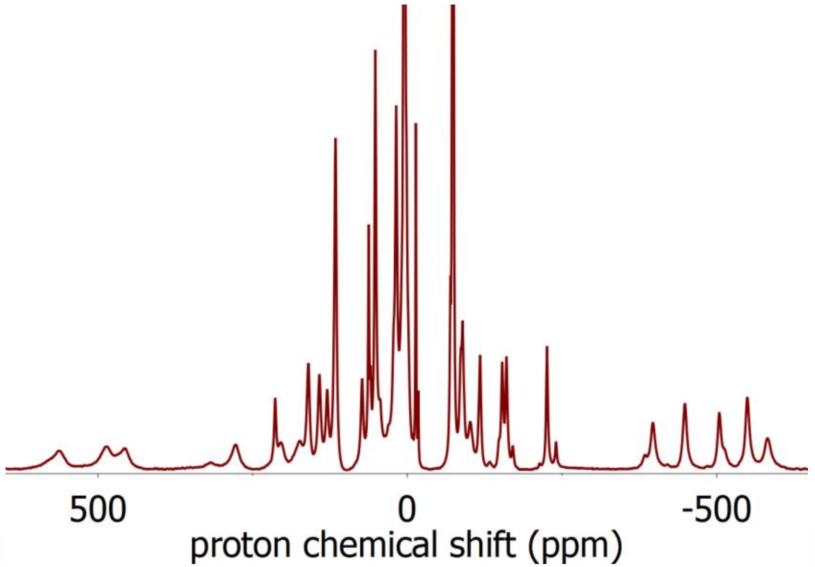
Elizaveta Suturina

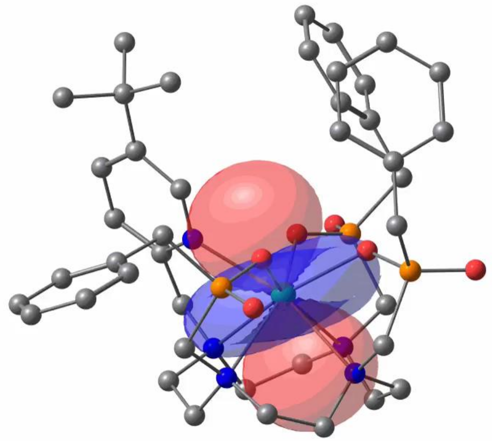
Chemistry

Paramagnetic NMR assignment

- Position of the NMR signal depends on the structure of the molecule and magnetic properties of the paramagnetic center
- Lanthanide induced shift can be written as a linear combination of second rank spherical harmonics

$$\sigma^{\text{point}} = \frac{1}{4\pi r^3} \sum_{m=-2}^{2} \chi_m Y_2^m(\hat{\mathbf{r}})$$





- For which arrangement of atoms (protons) we can uniquely define 5 parameters (χ) of magnetic susceptibility ?
- Is it possible to make an inambiguous linear scaling assignment protocol?

For more information contact
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SAMBa

Where's the Maths?

David Tsang

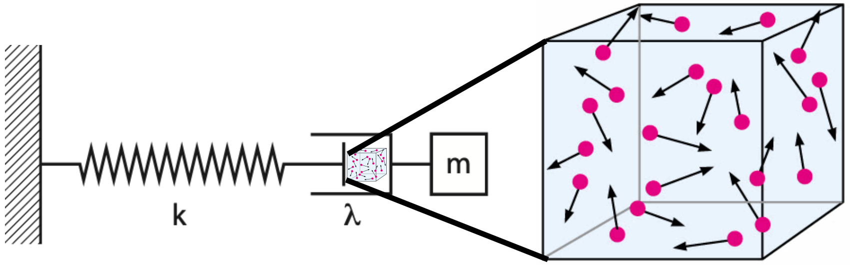
Physics

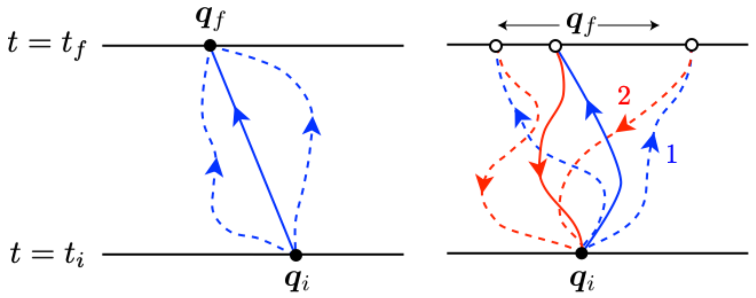
@SAMBa_CDT

#WherestheMaths

Non-Hamiltonian Action Principles: Numerical and Physical Applications

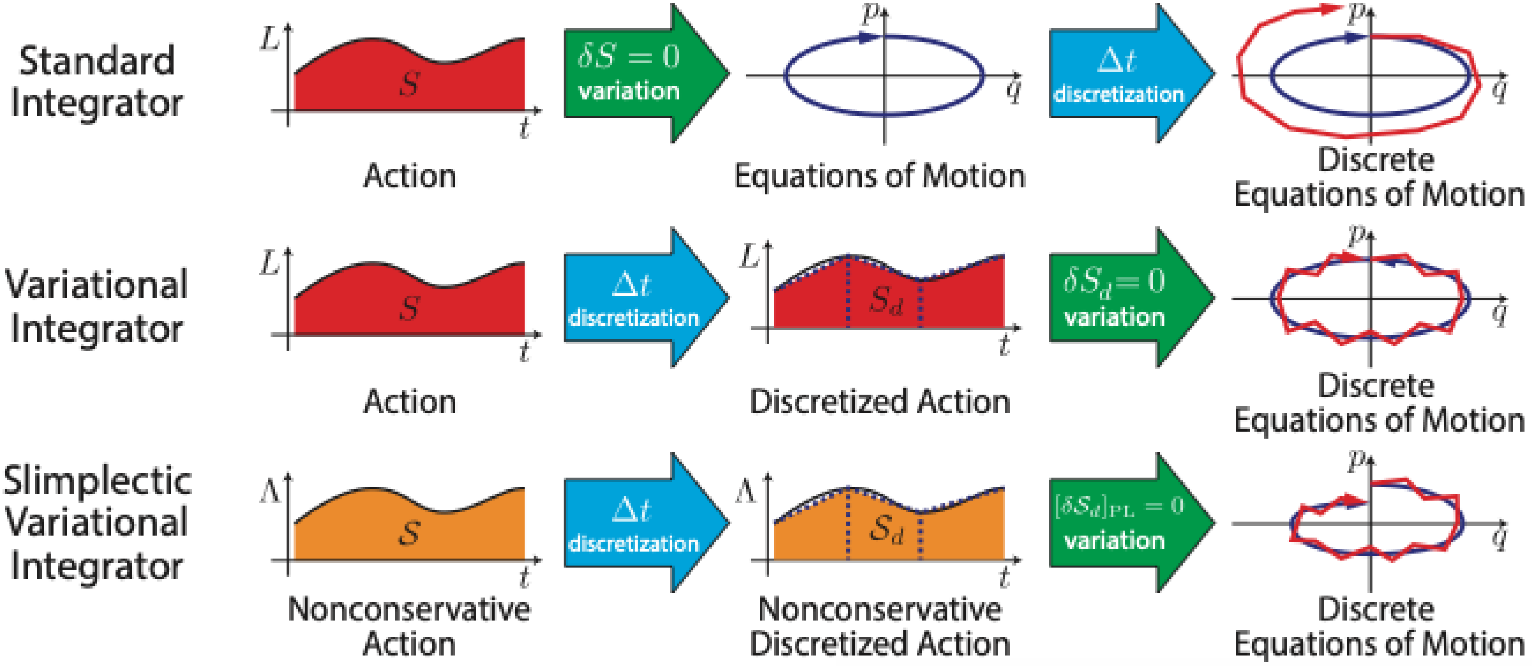
David Tsang
Dept of Physics
D.Tsang@bath.ac.uk

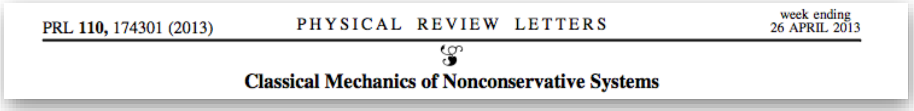




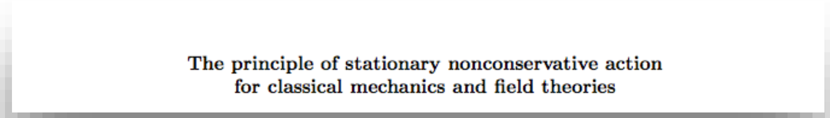
Boundary Value Problem

Initial Value Problem




PRL 110, 174301 (2013) PHYSICAL REVIEW LETTERS week ending 26 APRIL 2013

Classical Mechanics of Nonconservative Systems


The principle of stationary nonconservative action for classical mechanics and field theories

Where's the Maths?

Richard Bowman & Neill Campbell

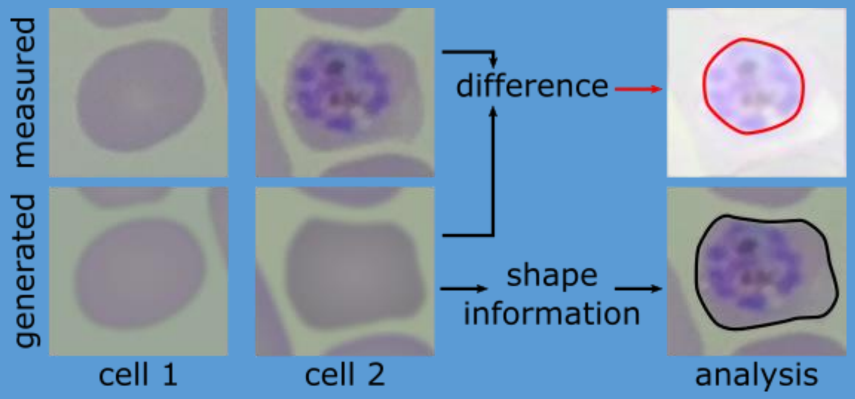
Physics & Computer Science

@SAMBa_CDT

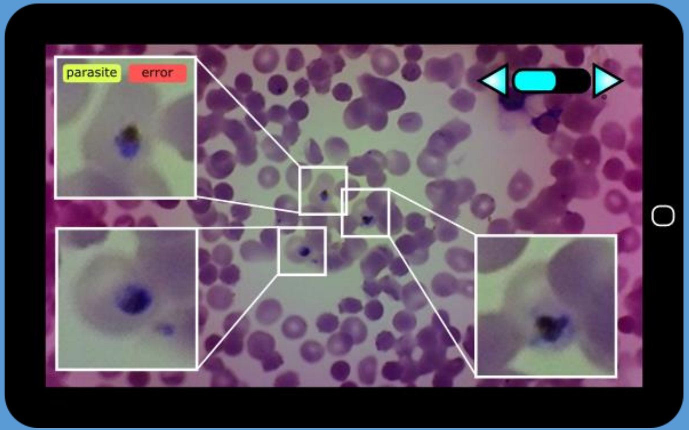
#WherestheMaths

Spotting malaria with smart microscopy

Generative models of blood & parasites



- Locally made hardware
- Open source designs
- Computer vision to spot parasites
- Trials with users in Tanzania and Kenya
- Clinical work in Bagamoyo & Cambridge



WaterScope | ihi IFAKARA HEALTH INSTITUTE research | training | services | UNIVERSITY OF CAMBRIDGE | NHS National Institute for Health Research | EPSRC Engineering and Physical Sciences Research Council

SAMBa

Where's the Maths?

Mauro Carnevale

Mechanical Engineering

@SAMBa_CDT

#WherestheMaths

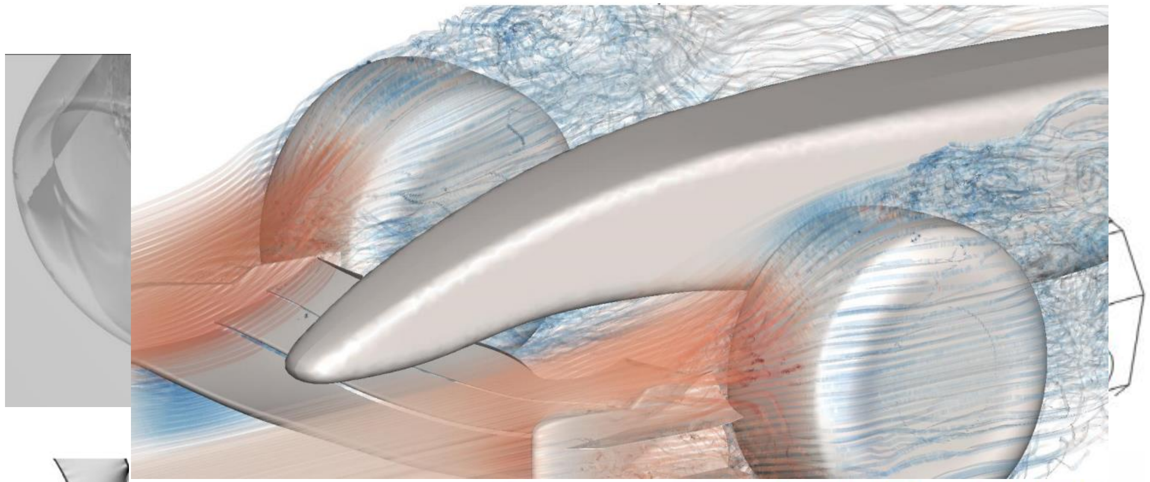
T. R. C.

Background

- Numerical techniques such as ***Computational Fluid Dynamics (CFD)*** simulations are essential to develop new technologies for aero-engines and aerospace applications. (not only)

PhD: High order CFD of secondary air systems

- Development of the state of the art in CFD techniques (LES-DES) to investigate cavity flows: **unsteady flows**

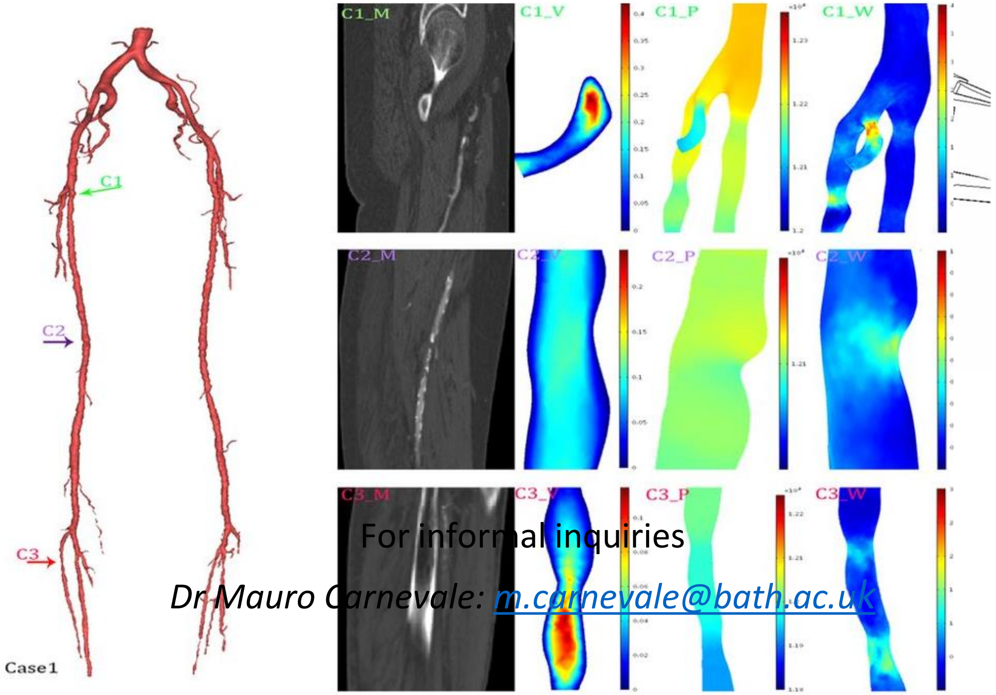


Challenge in Math

- High order CFD is characterised by the capability in catching stochastic phenomena such as turbulence $\boldsymbol{u}(\boldsymbol{t}) = \overline{\boldsymbol{u}} + \boldsymbol{u}'$
- Turbulence is identified by Reynolds Stresses = $\overline{u'_i u'_j} = \sum_k \phi^k_{u_i} \phi^k_{u_j}$
- ***Proper Orthogonal Decomposition POD:***
  Any instantaneous flow property h'_{tn} can be evaluated by projecting on a suitable orthogonal basis

$$\phi^k_{u_t} = \sum_{n=1}^{N} \chi_n^{(k)} h'_{tn}$$

- This new procedure will allow to identify the nature and the source of the unsteady effects.



For informal inquiries

Dr Mauro Carnevale: m.carnevale@bath.ac.uk

Impact

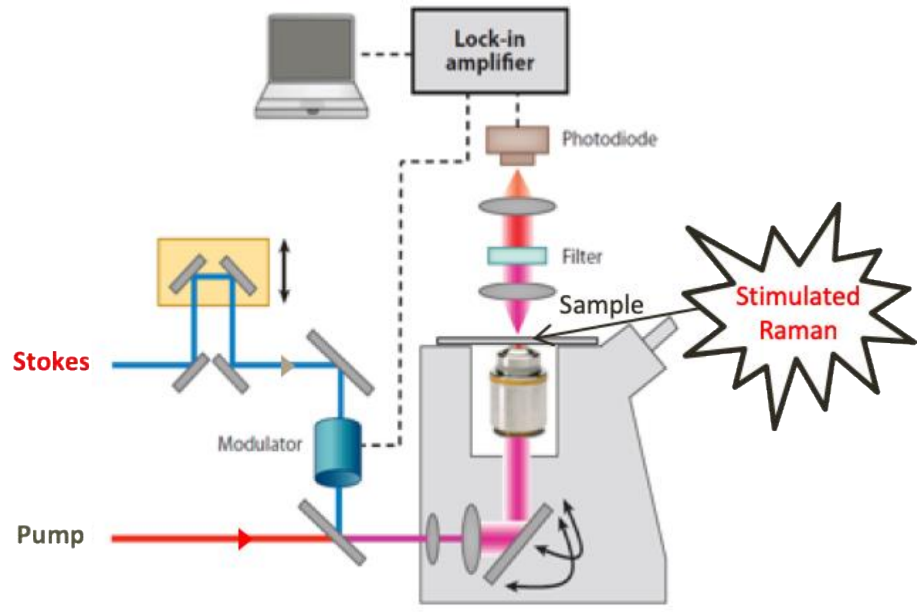
- The aim is to investigate flow structures in turbine cavities and their interaction with the main flow in turbine stage.
- Results will be disseminated in international journals and conferences.

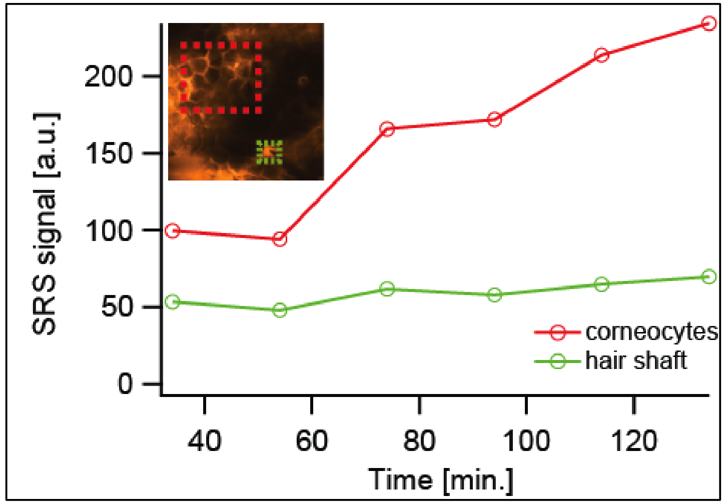
Richard Guy

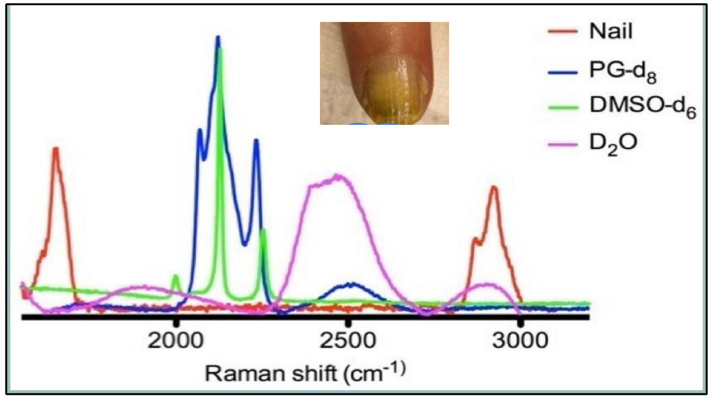
Pharmacy and Pharmacology

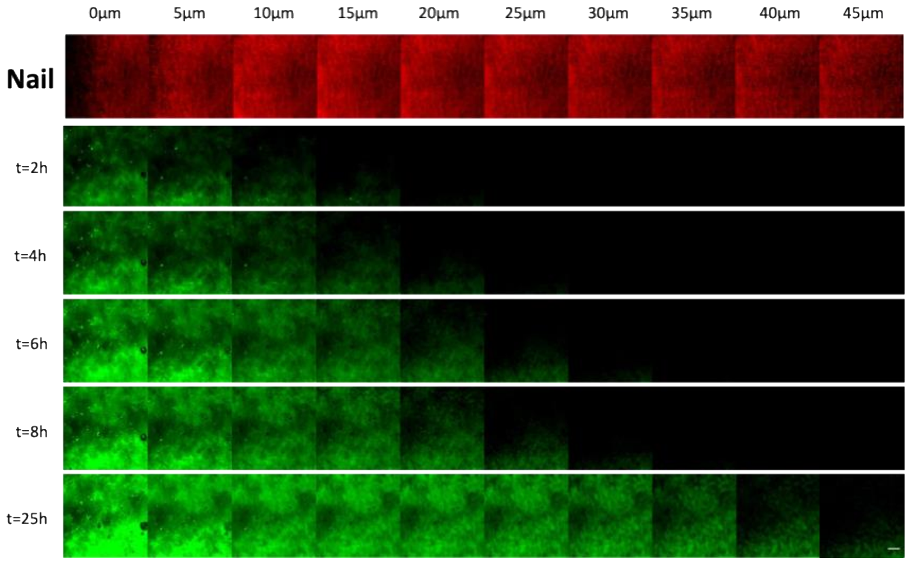
Mathematical modelling of chemical permeation across biological barriers

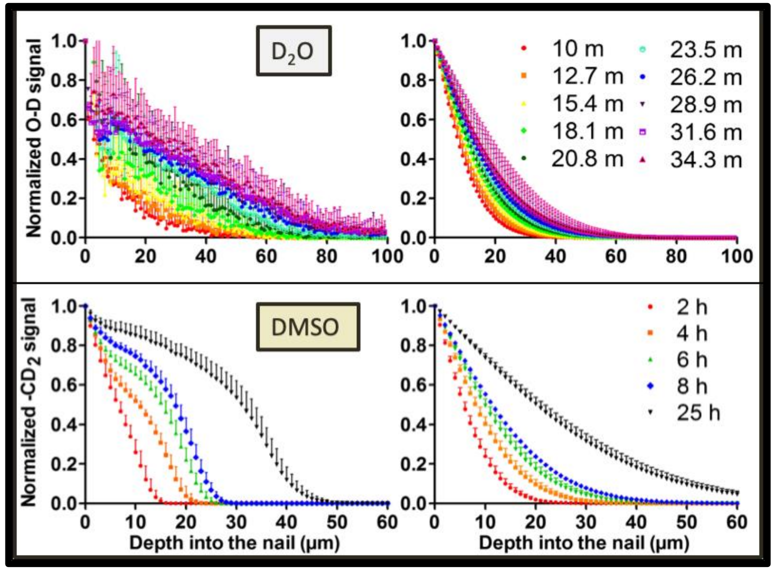
Richard Guy (P&P) r.h.guy@bath.ac.uk











Stimulated Raman scattering

Chemical penetration through skin/nail

Non-Fickian diffusion profiles

Signal attenuation as f(depth)

Mathematical modelling…

Prediction of drug uptake as f(time)…

W.S. Chiu et al., P.N.A.S., USA, 112, 7725-7730, 2015

Where’s the Maths?

Neil McHugh

Pharmacy and Pharmacology

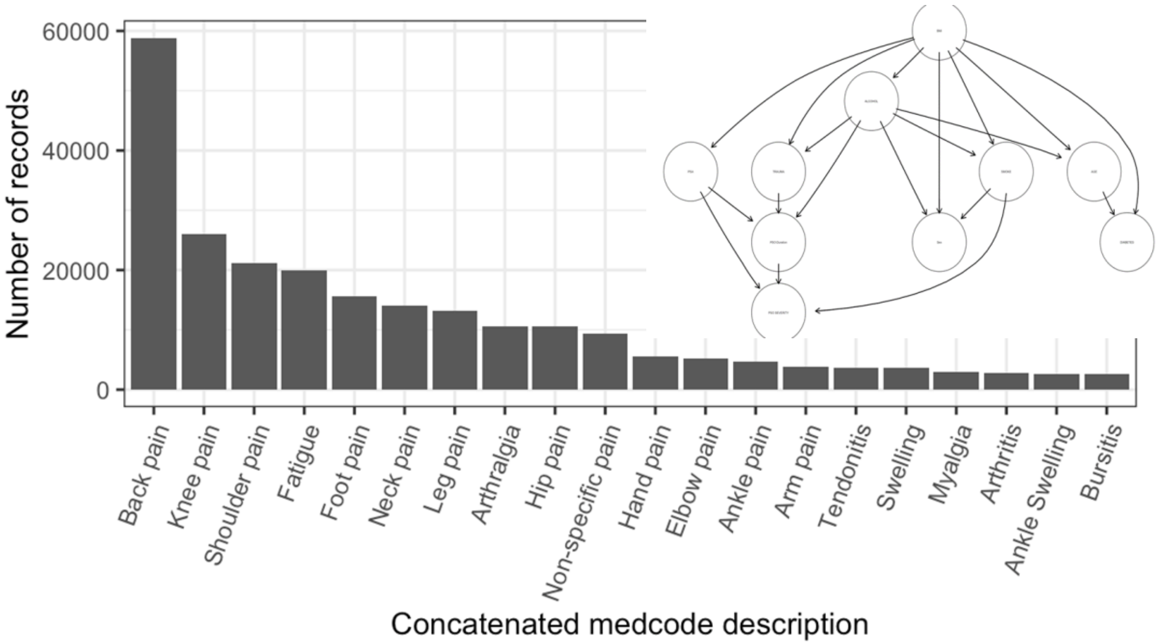
@SAMBa_CDT

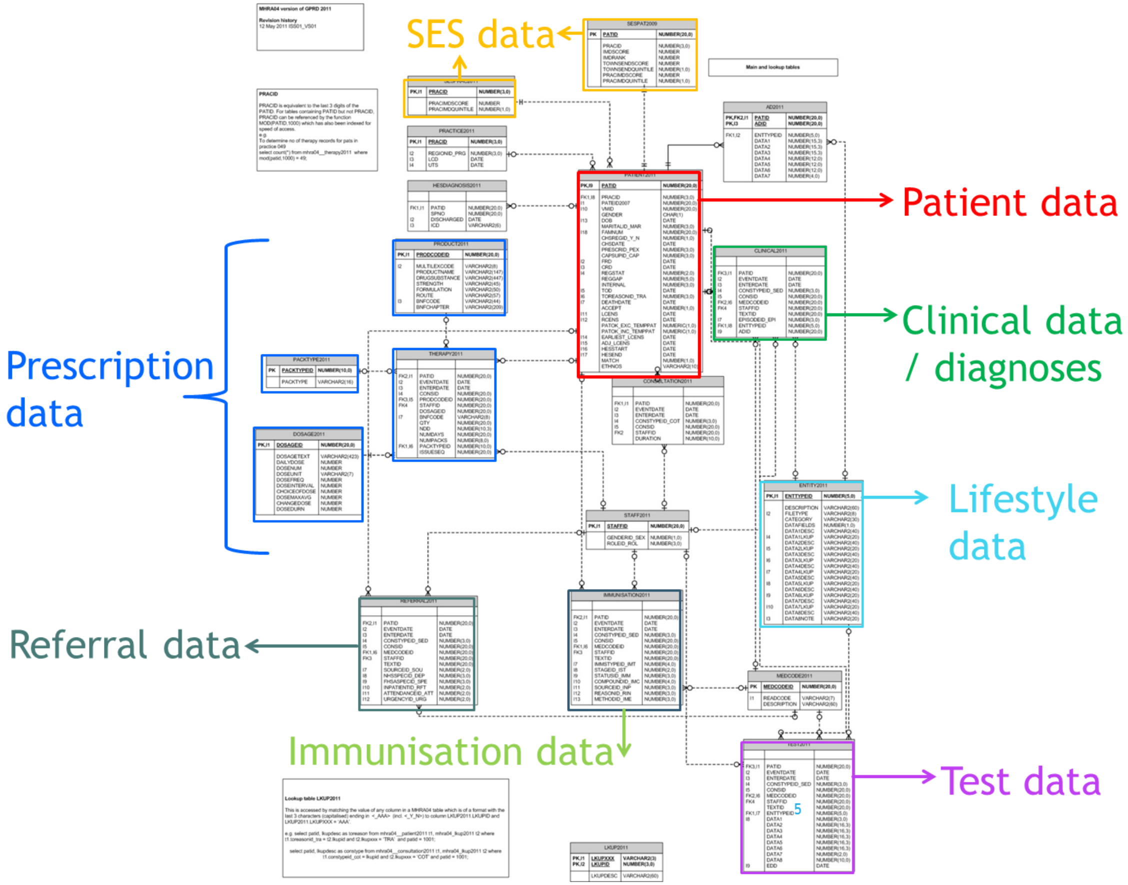
#WherestheMaths

The Clinical Practice Research Datalink

Anonymised primary care data for ~15 million people in the UK
‘Modelling primary care health codes to enable early diagnosis’

- One third of individuals with psoriasis develop arthritis
- Delay in diagnosis leads to worse outcome





James Grant

High Performance Computing

1.0 2.0 3.0	<real> <real> <real>
vector: 1.0 2.0 3.0	<key: vector> <real> <real> <real>
vector_follows	<key: vector_follows>
1.0 2.0 3.0	<real> <real> <real>
vectors_follow	<key: vectors_follow>
1.0	<real>
2.0	<real>
3.0	<real>

```
'$content':
  - '!key':
      '$value': 'vector'
      '$type': '!split'
      '$unit': 'angstrom'
      '$label': 'data'
      '$types': [float]
      '$number': [3]
```

data: [1.0, 2.0, 3.0]

vectors_start	<loop>
1.0 2.0 3.0	- <start_key: vectors_start>
4.0 5.0 6.0	- <real> <real> <real>
7.0 8.0 9.0	- <stop_key: vectors_end>
vectors_end	

data: [[1.0, 2.0, 3.0],
[4.0, 5.0, 6.0],
[7.0, 8.0, 9.0]]

The End

Thank you for listening