

Theory & Models

Observations

Instrumentation

Formation
Bate

Exoplanets made in

UNIVERSITY OF
EXETER

I. Baraffe

Disc
Interferometry
Kraus

PFI

Atmospheres
(1D RT/Chemistry)
Tremblin

Debris discs &
Atmospheres
Direct imaging
Hinkley

ELT

Atmospheric
dynamics (GCM)
Mayne

Atmospheres
Transit
Sing

Interior & evolution
(Planets & Stars)
Browning/Baraffe

THE
(£1M)
Naylor

Planet formation: Disc Interferometry

People: Stefan Kraus

postdocs: A. Kreplin, J. Kluska

PhD: M. Wilson

- Infrared and mm-wave interferometry (VLTI, CHARA, ALMA)

➡ resolve protoplanetary disc structures from sub-AU to few hundred AU

- **Future (ERC Starting Grant):**

(Instrumentation work at CHARA array will enable first 6-telescope interferometry of YSO discs)

➡ Time-resolved imaging of possibly planet-induced structures in the inner AU

- **Planet Formation Imager**

PFI science working group (lead by Stefan Kraus)
(talk by John Young)

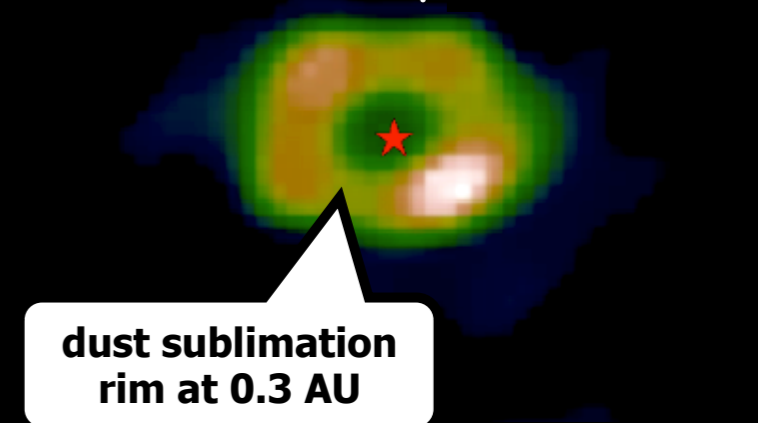
Imaging the inner-most AU

HD100453

5 mas

VLTI image (2 μ)

0.6 AU





European Research Council
Established by the European Commission

Planet formation models and dusty discs

People: Matthew Bate

Postdoc: Pablo Loren

- RHD calculations of protoplanets embedded in discs

➡ **Protoplanet growth; migration; disc structures**

- Dusty-gas simulations of dust and planetesimals in gaseous discs

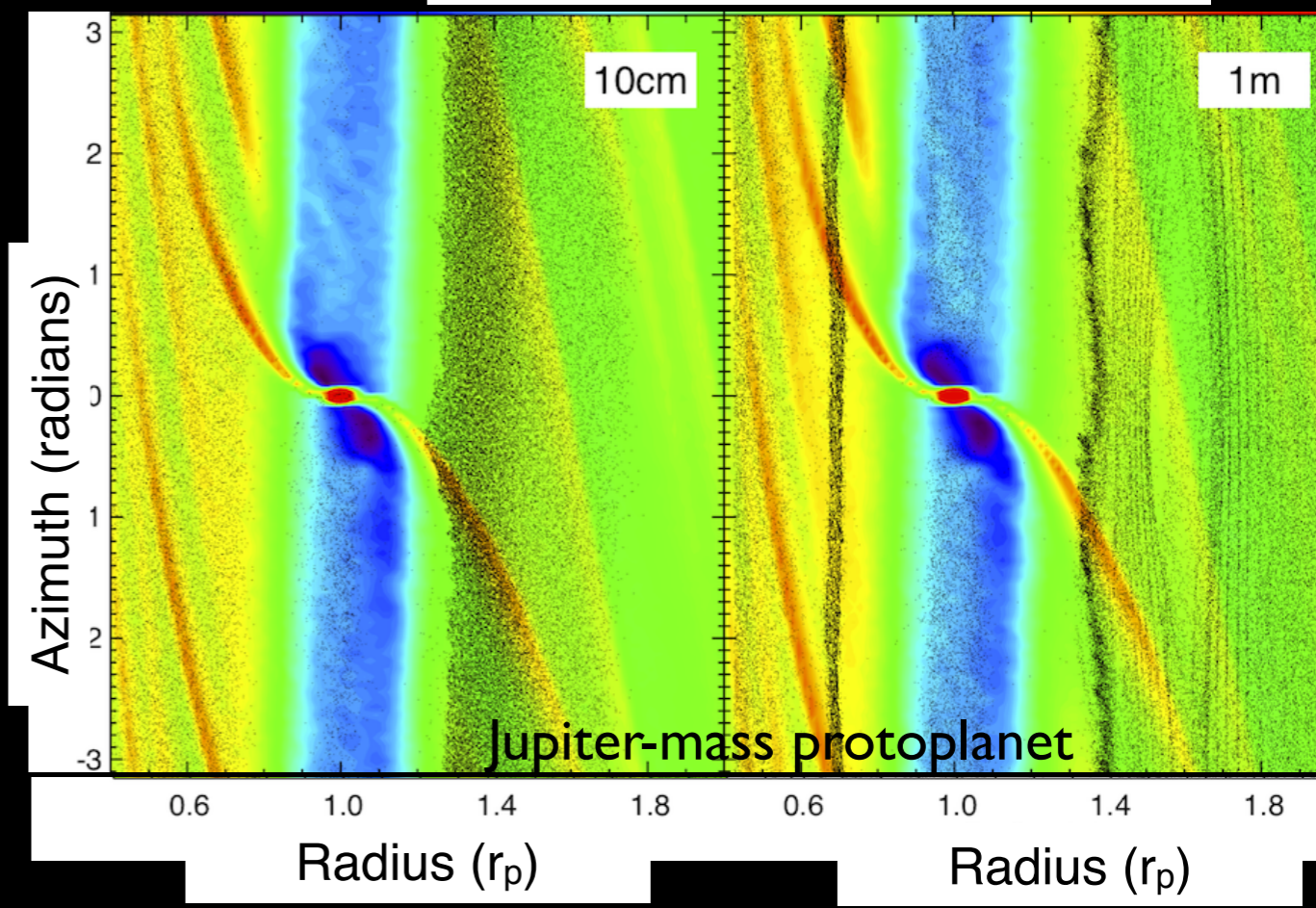
➡ **Dust structures in discs; interaction of planetesimal with protoplanets**

Tools: SPH code

Facilities: DiRAC HPC facilities

University of Exeter's supercomputer

Planetesimal/dust interactions with protoplanets

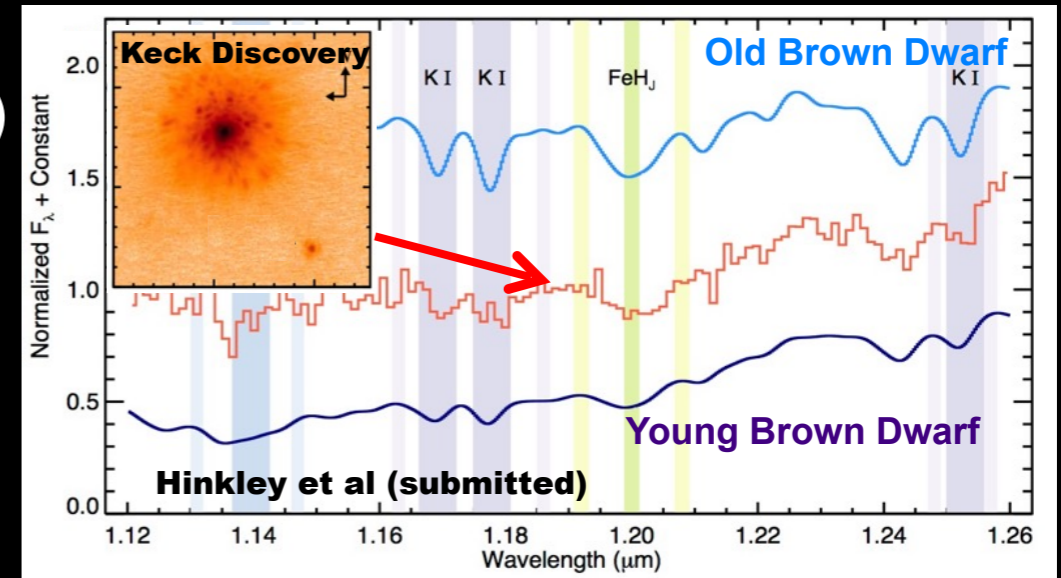


Exoplanet direct imaging and debris disks

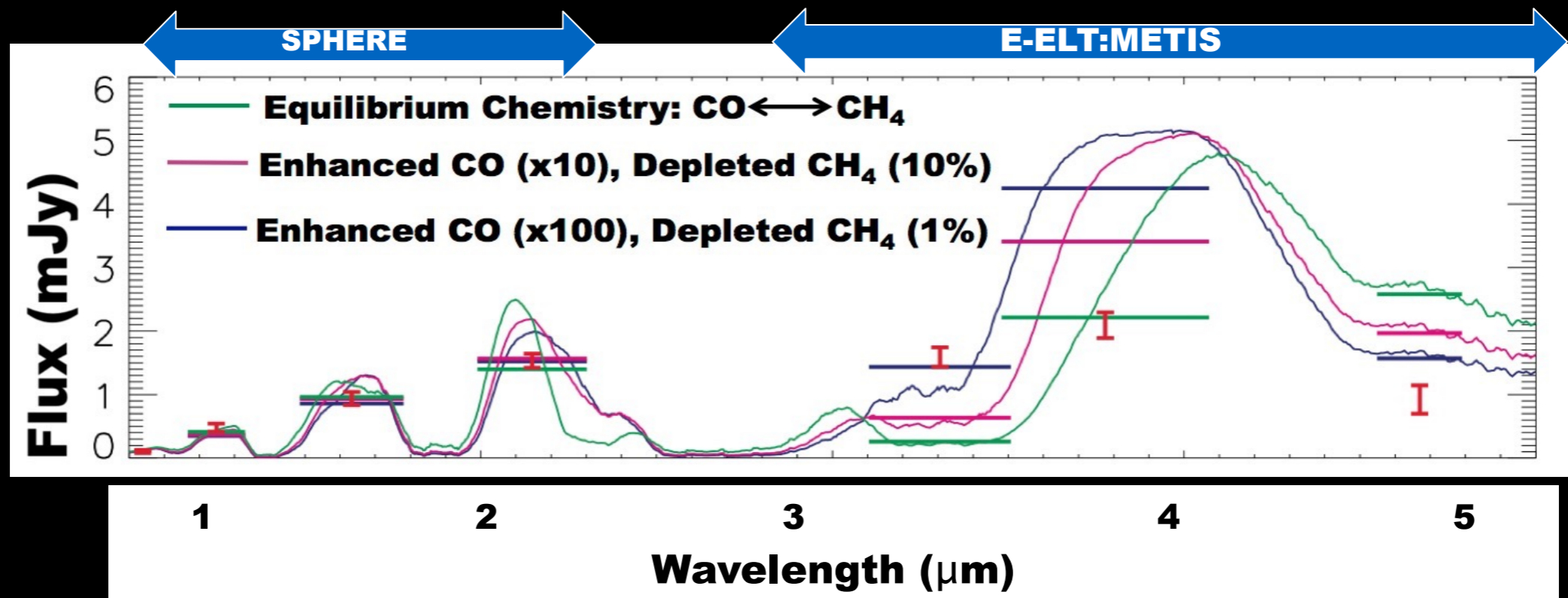
People: **Sasha Hinkley**

PhD: Elisabeth Matthews

- High resolution spectroscopy (SPHERE)
 - ➔ Characterisation of young exoplanets & brown dwarfs
- Exoplanet & debris disk (Keck)
 - ➔ Explore the relation between debris disks and presence of a planet



Future: Exoplanet atmospheric compositions with E-ELT 3-5 μm



Transiting Exoplanet Atmospheres

People: David Sing

Postdocs: T. Evans, T. Kataria, N. Nikolov

PhD: H. Wakeford, J. Spake

Detection Highlights

- Observations**

HST, GTC, NTT, WHT, VLT

- Observations meet modelling**

1D analytic

3D Sparc/MIT + UK Met Office UM

Planet	Species Detected	Referece
WASP-12b	Haze	Sing, <i>et al.</i> 2013
WASP-31b	K, Haze & Clouds	Sing, <i>et al.</i> 2015
XO-2b	Na & K	Sing, <i>et al.</i> 2011, 2013
HD189733b	Haze, Na Blue colour	Sing, <i>et al.</i> 2011 Evans, <i>et al.</i> 2013
Hat-P-1b	Na, H ₂ O	Wakeford, <i>et al.</i> 2013, Nikolov, <i>et al.</i> 2014
WASP-6b	Haze, K	Nikolov, <i>et al.</i> 2015
WASP-19b	H ₂ O	Huitson, <i>et al.</i> 2013

Future: ExoMOS development

much more soon...

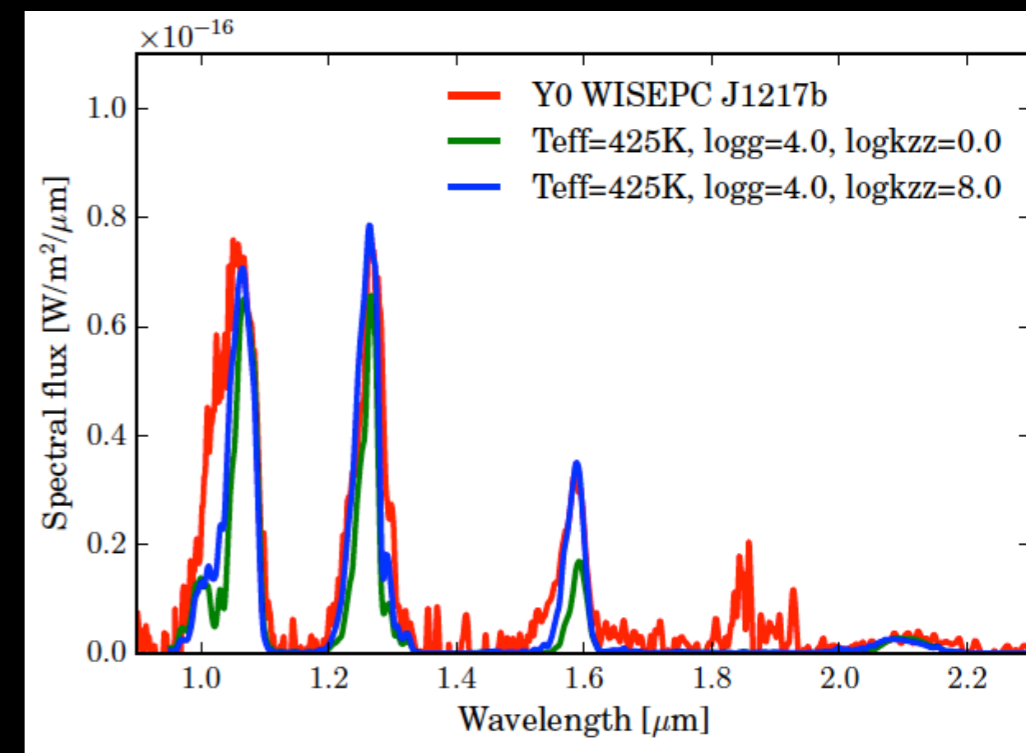
People: N. Mayne, I. Baraffe

Postdocs: P. Tremblin

PhD: B. Drummond, D. Amundsen

Met Off: J. Manners, C. Smith

- 1D RT + Convection + Chemistry
(photochemistry, mixing) → **B. Drummond**
 ↳ Structure/spectra for exoplanets (irradiated or not) and brown dwarfs



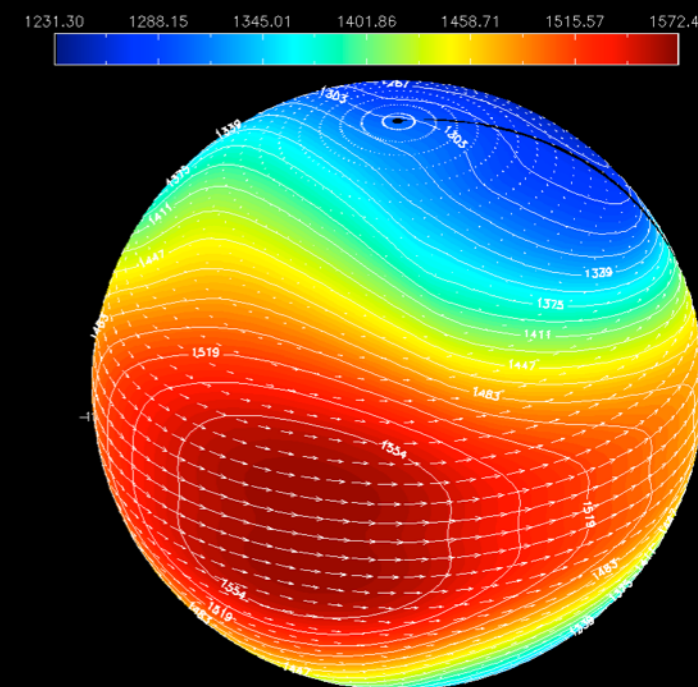
Tremblin et al. 2015, ApJ Letter

- Atmospheric dynamics (N. Mayne)
 ↳ Hot Jupiter circulation and link with observations
Future: → Coupling with chemistry/cloud schemes
 → Solar system and Earth-like planets

Tools: ATMO (1D RT)

UK Met Office GCM (3D deep non HSE + RT)

Facilities: DiRAC HPC facilities; University of Exeter and Met Office supercomputers



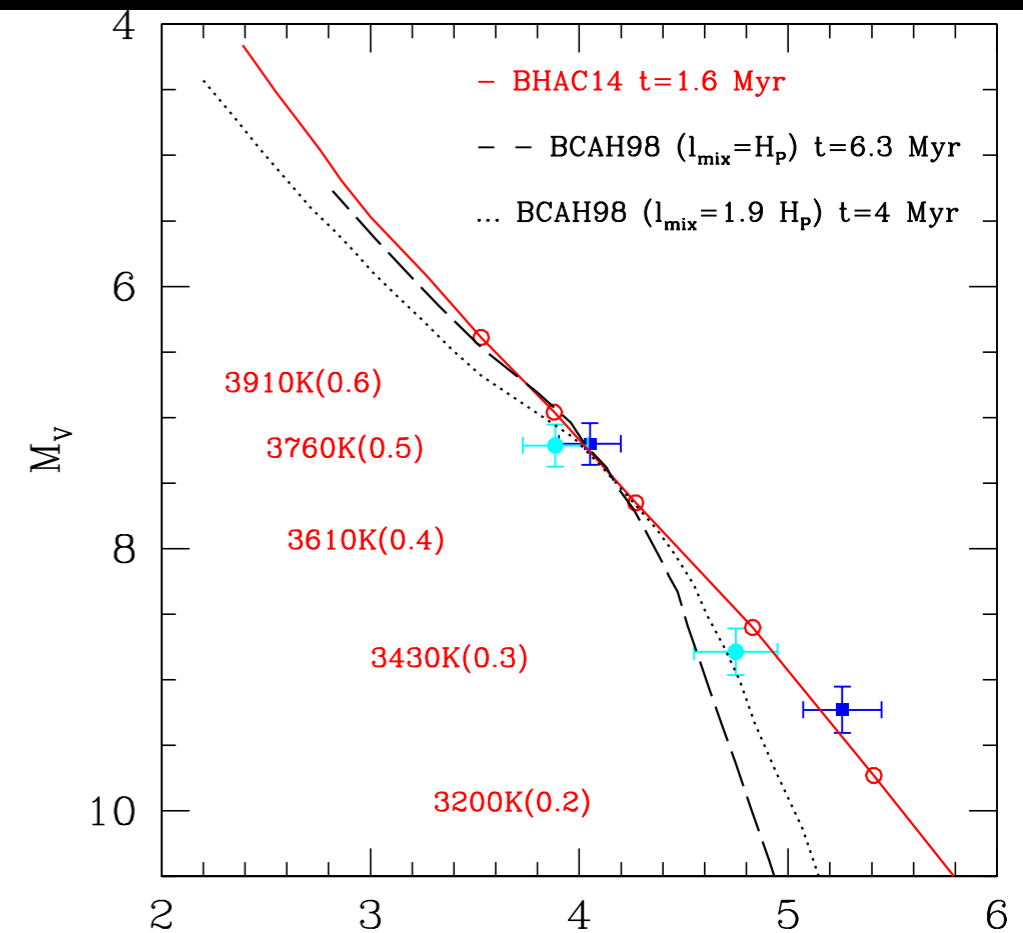
Evolutionary models for planets & stars

People: I. Baraffe. G. Chabrier

- 1D models for irradiated (transit) and non-irradiated (Dir. Imag.) planets
 - ➔ Transit data (Mass-Radius from NGTS, CHEOPS, PLATO, TESS) and DI data (L, colors, Teff) from SPHERE
 - ➔ Development of first principle EOS: New generation of planetary models are coming

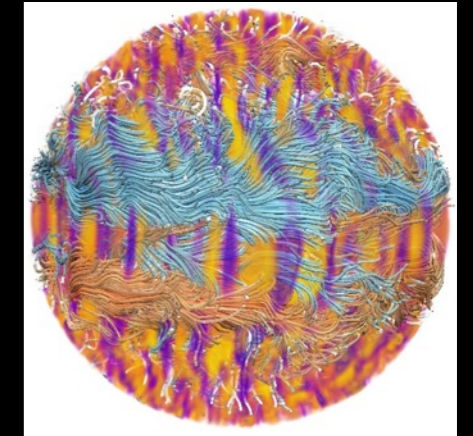
⚠ Who sees a planet sees a star...

- 1D models for planet host stars: MKG
 - ➔ Continued effort to improve the models *Baraffe et al. 2015*



Quadruple young system LkCa
(Torres et al. 2013)

Convection, magnetism and rotation in stellar and planetary interiors



People: Matt Browning

Postdocs: Laura Currie, Lucia Duarte, Maria Weber

PhDs: Lewis Ireland, Felix Sainsbury-Martinez

- Global simulations of convection and magnetism
- More localised studies of heat and angular momentum transport
 - Relating simulations to MLT, incorporating into 1-D models
 - Misc. topics: instabilities, near-surface shear, magnet. buoyancy

Tools: Anelastic spherical harmonic (ASH, Rayleigh)
Compressible spherical segments (CSS), f-plane (Dedalus)

Facilities: DiRAC HPC facilities and the University of Exeter's supercomputer

2D/3D stellar models: fully compressible time implicit simulations

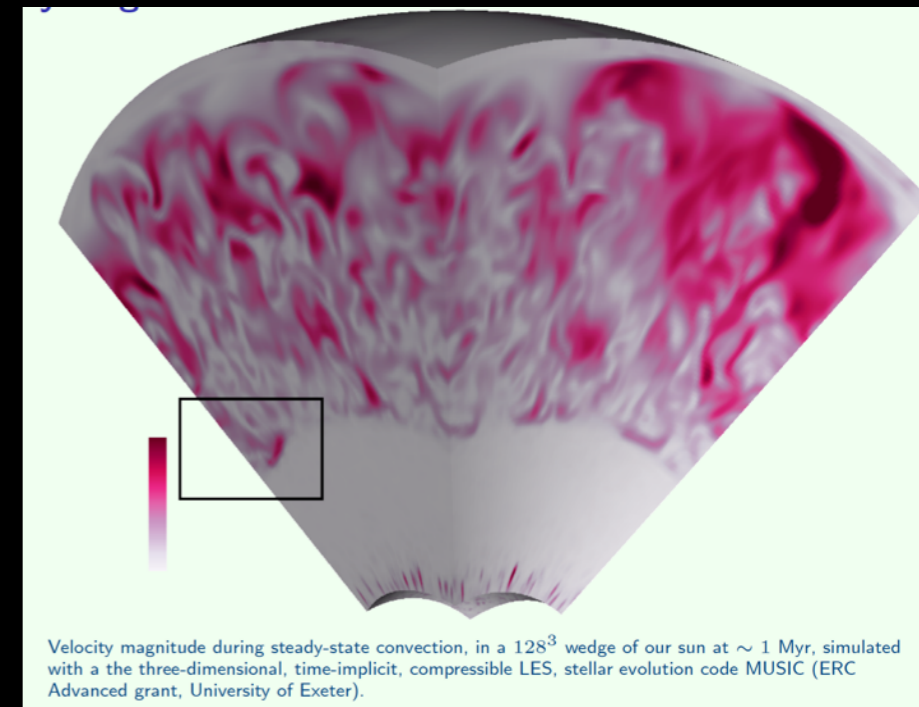
People: Isabelle Baraffe

Postdocs: Tom Goffrey, Jane Pratt, Chris Geroux

- Study of turbulent convection in stellar interior
- Overshooting/undershooting
- Rotation induced mixing and angular momentum transport

➔ Improvement of 1D formalisms

➔ Reduce uncertainties of 1D stellar models



Tools: Fully compressible time implicit code MUSIC
Spherical geometry, realistic EOS/opacities

Facilities: DiRAC HPC facilities and the University of Exeter's supercomputer

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See you next year in Exeter ?

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