

Dr. Toby Wood

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Research Career

Newcastle University

2014 – present Lecturer in Applied Mathematics

University of Leeds

2013 – 2014 Postdoctoral Researcher in Applied Mathematics (supported by STFC grant ST/K000853/1)

University of California, Santa Cruz

2010 – 2013 Postdoctoral researcher in Department of Applied Mathematics and Statistics,
Baskin School of Engineering (supported by NSF grants 0847477 and 0933759)

Education

Queens' College, University of Cambridge

2006 – 2010 PhD student in Solar Physics at DAMTP
Advised by Prof. Michael E. McIntyre and Prof. Douglas O. Gough

2005 – 2006 Master of Mathematics
• *Part III (With Distinction)*

2002 – 2005 BA (Hons) in Mathematics
• *Part II (First Class)* — Awarded College Exhibition
• *Part IB (First Class)* — Awarded College Exhibition
• *Part IA (First Class)* — Awarded Foundation Scholarship

Research Interests

My research concerns fluid dynamics in astrophysical objects, and in particular the transport of heat, composition, momentum and magnetic flux by turbulent and laminar flows. My work uses a combination of analytical mathematics and numerical simulations. Some highlights of my research have been:

The first 3D model of the magnetic field in a neutron star.

Quantifying the transport of heat and composition by turbulent, layered semi-convection.

A first-principles derivation of the pseudo-incompressible equations via Lagrangian mechanics.

The first demonstration of confinement of the Sun's interior magnetic field in the relevant parameter regime.

Awards and Prizes

2013 Young Scientist award for best oral presentation at EGdR meeting in Ascona, Switzerland

2008 Fellow of the Geophysical Fluid Dynamics program at Woods Hole, Massachusetts

2007 Awarded Class I in the Smith–Knight & Rayleigh–Knight essay competition at University of Cambridge

2007 Awarded best presentation in fluid dynamics PhD seminar competition, University of Cambridge

Invited Talks

2017 “Incompressible MHD” lecture at Computational MHD Workshop in Leeds, England
2017 “MHD in the core and crust of a neutron star” at GDRI dynamo meeting at IHP, Paris, France
2017 “Electron magneto-hydrodynamics in a neutron star crust” seminar at University of Glasgow, Scotland
2016 “The Role of Compressibility in Rotating Convection” seminar at University of Cambridge, England
2015 “A 3D MHD model of a neutron star crust” seminar at University of Southampton, England
2014 “Electron-MHD Turbulence in Neutron Stars” at IPAM workshop on *Geophysical and Astrophysical Turbulence* at UCLA, California
2013 “No Lights, No Music: the Pseudo-incompressible MHD equations” seminar at City University, London, England
2013 “The Pseudo-incompressible Equations and Hamilton’s Principle” seminar at University of Newcastle, England
2013 “Semi-convection in Giant Planets and Massive Stars” planetary sciences colloquium at UCSC
2013 “Numerical Simulations of the Solar Tachocline” seminar at University of Colorado, Boulder
2013 “Double-diffusive Convection in Stars and Planets” seminar at University of Cambridge, England
2012 “The Dynamics of the Solar Interior” AMS department seminar at UCSC, California
2012 “The Solar Interior Rotation and the Tachocline Problem” astronomy colloquium at UCSC, California
2011 “The Rotation of the Solar Interior” seminar at UCLA, California
2009 “Magnetic Confinement in the Solar Tachocline” seminar at University of Leeds, England
2009 “The Solar Interior: Rotation, Stratification and Magnetic Fields” seminar at ENS Paris, France

Synergistic Activities

Expert referee for STFC Ernest Rutherford fellowship applicants
Participant in the STFC program “Explore Your Universe” through public engagement events
Fellow of the Royal Astronomical Society and the Higher Education Academy
Joint organizer of *Double Diffusive Systems* meeting at UCSC, 2012
President of the Cambridge University Graduate Mathematics Society, 2007/2008
Referee for The Astrophysical Journal, Astronomy & Astrophysics, Geophysical & Astrophysical Fluid Dynamics, and The Journal of Fluid Mechanics

Computing Skills

Programming Fortran, C, MPI, Perl, Visual Basic, Shell scripting
Visualisation Vapor, Matlab, IDL

Publications

Journal articles

- [14] **T. S. Wood** & N. H. Brummell, “A self-consistent model of the solar tachocline”, *The Astrophysical Journal*, 2018, vol. 853, 97
- [13] A. Seta, A. Shukurov, **T. S. Wood**, P. J. Bushby & A. P. Snodin, “Relative distribution of cosmic rays and magnetic fields”, *Monthly Notices of the Royal Astronomical Society*, 2018, vol. 473, 4544
- [13] A. Shukurov, A. P. Snodin, A. Seta, P. J. Bushby & **T. S. Wood**, “Cosmic rays in intermittent magnetic fields”, *The Astrophysical Journal Letters*, 2017, vol. 839, 16
- [12] **T. S. Wood** & P. J. Bushby, “Oscillatory convection and limitations of the Boussinesq approximation”, *Journal of Fluid Mechanics*, 2016, vol. 803, 502
- [11] K. N. Gourgouliatos, **T. S. Wood** & R. Hollerbach, “Magnetic field evolution in magnetar crusts through three-dimensional simulations”, *Proceedings of the National Academy of Sciences*, 2016, vol. 113, 3944
- [10] **T. S. Wood** & R. Hollerbach, “Three dimensional simulation of the magnetic stress in a neutron star crust”, *Physical Review Letters*, 2015, vol. 114, 191101
- [9] **T. S. Wood**, R. Hollerbach, & M. Lyutikov, “Density-shear instability in electron magneto-hydrodynamics”, *Physics of Plasmas*, 2014, vol. 21, 052110
- [8] C. Guervilly, **T. S. Wood** & N. H. Brummell, “Effect of metallic walls on dynamos generated by laminar boundary-driven flow in a spherical domain”, *Physical Review E*, 2013, vol. 88, 053010
- [7] G. M. Vasil, D. Lecoanet, B. P. Brown, **T. S. Wood** & E. G. Zweibel, “Energy conservation and gravity waves in sound-proof treatments of stellar interiors: II. Lagrangian constrained analysis”, *The Astrophysical Journal*, 2013, vol. 773, 169
- [6] **T. S. Wood**, P. Garaud & S. Stellmach, “A new model for mixing by double-diffusive convection (semi-convection): II. The transport of heat and composition through layers”, *The Astrophysical Journal*, 2013, vol. 768, 157
- [5] L. A. Acevedo-Arreguin, P. Garaud & **T. S. Wood**, “Dynamics of the solar tachocline: III. Numerical solutions of the Gough and McIntyre model”, *Monthly Notices of the Royal Astronomical Society*, 2013, vol. 434, 720
- [4] **T. S. Wood** & N. H. Brummell, “Transport by meridional circulations in solar-type stars”, *The Astrophysical Journal*, 2012, vol. 755, 99
- [3] G. M. Mirouh, P. Garaud, S. Stellmach, A. L. Traxler & **T. S. Wood**, “A new model for mixing by double-diffusive convection (semi-convection): I. The conditions for layer formation”, *The Astrophysical Journal*, 2012, vol. 750, 61
- [2] **T. S. Wood**, J. O. McCaslin & P. Garaud, “The Sun’s Meridional Circulation and Interior Magnetic Field”, *The Astrophysical Journal*, 2011, vol. 738, 47
- [1] **T. S. Wood** & M. E. McIntyre, “Polar confinement of the Sun’s interior magnetic field by laminar magnetostrophic flow”, *Journal of Fluid Mechanics*, 2011, vol. 677, 445

PhD thesis

“The solar tachocline: A self-consistent model of magnetic confinement”, 2010, University of Cambridge

Conference proceedings

T. S. Wood, “Magnetic confinement in the solar interior”, in *Astrophysical Dynamics – from Stars to Galaxies*, proceedings IAU Symposium No. 271, 2010

T. S. Wood, “Crumpling of a thin ice sheet due to incident flow”, in *Perspectives and Challenges in GFD*, Proceedings of the Woods Hole GFD program, 2008

T. S. Wood & M. E. McIntyre, “Confinement of the Sun’s interior magnetic field: some exact boundary-layer solutions”, in *Unsolved Problems in Stellar Physics*, AIP Conference Series, vol. 948, 2007