Michael A. Calkins

CURRENT POSITION:

Assistant Professor
Department of Physics
University of Colorado, Boulder
390 UCB
Boulder, CO 80309-0390

RESEARCH INTERESTS:

Geophysical and astrophysical fluid dynamics; convection; magnetohydrodynamics; dynamo theory; asymptotic methods; computational fluid dynamics.

EDUCATION:

Ph.D., 2010 University of California, Los Angeles, Mechanical Engineering, Thesis Advisors: J.M. Aurnou, J.D. Eldredge

M.S., 2007 University of California, Los Angeles, Mechanical Engineering, Thesis Advisors: J.M. Aurnou, J.D. Eldredge

B.A., 2004 (with honors) University of California, Berkeley, Earth and Planetary Science (Geophysics)

APPOINTMENTS:

2023-present
Associate Professor, Department of Physics, University of Colorado, Boulder

2015-2023
Assistant Professor, Department of Physics, University of Colorado, Boulder

2013-2015
Postdoctoral Research Associate, Department of Applied Mathematics, University of Colorado, Boulder, Mentor: Keith Julien

2011-2013
NSF EAR Postdoctoral Fellow, Department of Applied Mathematics, University of Colorado, Boulder, Mentor: Keith Julien

PUBLICATIONS:

Students and postdocs who I advised are denoted with boldface type. Papers on which I am listed as second author or last author implies that I acted as the primary advisor to the first author of that particular paper.

Nicoski, J. A., **O'Connor A.R.**, and M.A. Calkins. Asymptotic scaling relations for rotating spherical convection with strong zonal flows. *J. Fluid Mech.*, A1 (2024) [36 pages].

Calkins, M.A., **AlRefae, T.**, **Hernandez, A.**, **Yan, M.** and **Maffei, S**. Numerical investigation of quasistatic magnetoconvection with an imposed horizontal magnetic field. *Phys. Rev. Fluids*, 8, 123501 (2023) [21 pages].

Oliver, T. G., **Jacobi, A.S.**, Julien, K. and M.A. Calkins. Small scale quasigeostrophic convective turbulence at large Rayleigh number. *Phys. Rev. Fluids*, 8, 093502 (2023) [20 pages].

Barik, A., Triana, S. A., Calkins, M., Stanley, S., and J. Aurnou. Onset of convection in rotating spherical shells: Variations with radius ratio *Earth Space Sci.*, 10(1), e2022EA002606 (2023) [19 pages].

Yan, M. and M.A. Calkins. Asymptotic behaviour of rotating convection-driven dynamos in the plane layer geometry. *J. Fluid Mech.*, 951 (2022) [33 pages].

Tretiak, K., Plumley, M., Calkins, M.A., and S.M. Tobias. Efficiency gains of a multi-scale integration method applied to a scale-separated model for rapidly rotating dynamos. *Comp. Phys. Comm.*, 273, 108253 (2022) [12 pages].

Yan, M. and M.A. Calkins. Strong large scale magnetic fields in rotating convection-driven dynamos: The important role of magnetic diffusion. *Phys. Rev. Res.*, 915 (2022) [6 pages].

Nicoski, J. A., **Yan, M.**, and M.A. Calkins. Quasistatic magnetoconvection with a tilted magnetic field. *Phys. Rev. Fluids*, 7, 043504 (2022) [21 pages].

Calkins, M.A., **Orvedahl, R.J.**, and N.A. Featherstone. Large-scale balances and asymptotic scaling behaviour in spherical dynamos. *Geophys. J. Int.*, 227(2), (2021) [18 pages].

Orvedahl, R.J., Featherstone, N.A., and M.A. Calkins. Large-scale magnetic field saturation and the Elsasser number in rotating spherical dynamo models. *Mon. Not. Roy. Astron. Soc.*, 507(1), (2021) [5 pages].

Maffei, S., **Krouss, M.J.**, Julien, K., and M.A. Calkins. On the inverse cascade and flow speed scaling behaviour in rapidly rotating Rayleigh-Béndard convection. *J. Fluid Mech.*, 913 (2021) [30 pages].

Yan, M., Tobias, S.M., and M.A. Calkins. Scaling behaviour of small-scale dynamos driven by Rayleigh-Bénard convection. *J. Fluid Mech.*, 915 (2021) [30 pages].

Yan, M., Calkins, M.A., **Maffei, S.**, Julien, K., Tobias, S.M., and Marti, P. Heat transfer and flow regimes in quasi-static magnetoconvection with a vertical magnetic field. *J. Fluid Mech.*, 877, 1186-1206 (2019) [21 pages].

Maffei, S., Calkins, M.A., Julien, K., and Marti, P. Magnetic quenching of the inverse cascade in rapidly rotating convective turbulence. *Phys. Rev. Fluids*, 4, 041801(R) (2019) [10 pages].

Plumley, M., Calkins, M.A., Julien, K., and Tobias, S.M. Self-consistent single mode investigations of the quasi-geostrophic convection-driven dynamo model. *J. Plasma Phys.*, 84 (2018) [32 pages].

Orvedahl, R.J., Calkins, M.A., Featherstone, N.A. and B. W. Hindman. The influence of the Prandtl number on the spectral characteristics of anelastic convection in a spherical geometry. *Astrophys. J.*, 856, 13 (2018) [9 pages].

Calkins, M.A. Quasi-geostrophic dynamo theory. *Phys. Earth Planet. Int.*, 276, 182-189 (2018) [8 pages].

Calkins, M.A., Julien, K., and S.M. Tobias. Inertia-less convectively-driven dynamos in the limit of low Rossby number. *Phys. Earth Planet. Int.*, 266, 54-59 (2017) [6 pages].

Calkins, M.A., **Long, L.**, **Nieves, D.**, Julien, K., and S.M. Tobias. Convection-driven kinematic dynamos at low Rossby and magnetic Prandtl numbers. *Phys. Rev. Fluids*, 1, 083701 (2016) [21 pages].

Marti, P., Calkins, M.A., and K. Julien. An efficient spectral technique for modeling the dynamics of Earth's core. *Geochem. Geophys. Geosyst.*, 17(8), 3031-3053 (2016) [23 pages].

Julien, K., Aurnou, J.M., Calkins, M.A., Knobloch, E., Marti, P., Stellmach, S., and G. M. Vasil. A nonlinear model for rotationally constrained convection with Ekman pumping. *J. Fluid Mech.. J. Fluid Mech.*, 798, 50-87 (2016) [38 pages].

Calkins, M.A., Julien, K., Tobias, S.M., Aurnou, J.M. and P. Marti. Convection-driven kinematic dynamos at low Rossby and magnetic Prandtl numbers: single mode solutions. *Phys. Rev. E*, 93, 023115 (2016) [12 pages].

Calkins, M.A., **Hale, K.**, Julien, K., **Nieves, D.**, **Driggs, D.** and P. Marti. The asymptotic equivalence of fixed heat flux and fixed temperature thermal boundary conditions for rapidly rotating convection. *J. Fluid Mech.*, 784, R2 (2015) [13 pages].

Calkins, M.A., Julien, K., Tobias, S.M., and J.M. Aurnou. A multiscale dynamo model driven by quasi-geostrophic convection. *J. Fluid Mech.*, 780, 143-146 (2015) [24 pages].

Aurnou, J.M., Calkins, M.A., Cheng, J.S., Julien, K., King, E.M., Nieves, D., Soderlund, K.M., and S. Stellmach. Rotating convective turbulence in Earth and planetary interiors. *Phys. Earth Planet. Int.*, 246, 52-71 (2015) [20 pages].

Calkins, M.A., Julien, K. and P. Marti. The breakdown of the anelastic approximation in rotating compressible convection: implications for astrophysical systems. *Proc. R. Soc. A.*, 471, 20140689 (2015) [16 pages].

Calkins, M.A., Julien, K. and P. Marti. Onset of rotating and non-rotating convection in compressible and anelastic ideal gases. *Geophys. Astrophys. Fluid Dyn.*, 109, 422-449 (2014) [28 pages].

Calkins, M.A., Julien, K. and P. Marti. Three-dimensional quasi-geostrophic convection in the rotating cylindrical annulus with steeply sloping endwalls. *J. Fluid Mech.*, 732, 214-244 (2013) [31 pages].

Calkins, M.A., Noir, J., Eldredge, J.D., and J.M. Aurnou. The effects of boundary topography on convection in Earth's core. *Geophys. J. Int.*, 189, 799-814 (2012) [16 pages].

Calkins, M.A., Aurnou, J.M., Eldredge, J.D., and K. Julien. The influence of fluid properties on the morphology of core turbulence and the geomagnetic field. *Earth Planet. Sci. Lett.*, 359, 55-60 (2012) [6 pages].

Calkins, M.A., Noir, J., Eldredge, J.D., and J.M. Aurnou. Axisymmetric numerical simulations of libration-driven fluid dynamics in a spherical shell geometry. *Phys. Fluids.* , 22, 086602 (2010) [12 pages].

Noir, J., Calkins, M.A., Lasbleis, M., Cantwell, J., and J.M. Aurnou. Experimental study of libration-driven zonal flows in a straight cylinder. *Phys. Earth Planet. Int.*, 182 (2010) [9 pages].

HONORS:

2018 Outstanding Physics Teacher Award, Department of Physics, CU Boulder

2011 NSF EAR Postdoctoral Fellowship

2010 Outstanding Student Paper Award, American Geophysical Union Fall Meeting

FUNDING:

Current

May 2020 - Apr 2025, PI: "CAREER: Unraveling the Multiscale Asymptotic Dynamics of Planetary Dynamos", Source: NSF EAR, Amount $536,039 (all to Calkins)

June 2022 - May 2025, PI: "Collaborative Research: Archeomagnetism of southern Africa and dynamo modeling: Testing the hypothesis of South Atlantic Anomaly-Large Low Shear Velocity Province Agency", Source: NSF EAR, Amount: $320,186 (all to Calkins).

Past

Feb 2018 - Dec 2022, PI: " Understanding the Reversals in Polarity of the Magnetic Fields of Planets and Stars", Source: NSF SPG, Amount $290,000 (all to Calkins)

July 2016 - June 2021, PI: "Synergistic Explorations of Hydromagnetic Core Turbulence via Simulations and Asymptotics", Source: NSF EAR, Amount: $475,046 ($\approx$ $308,000 to Calkins)

July 2013 - June 2016, Co-PI: "Next-generation Modeling of the Geodynamo: Development of the First Multi-scale Dynamo Model", Source: NSF EAR, Amount: $540,000

July 2011 - June 2013, NSF EAR Postdoctoral Fellowship, PI: "Thermochemical Convection Dynamics in Earth's Core", Amount: $170,000

TEACHING EXPERIENCE:

Spring 2023
Instructor, PHYS 1125: General Physics 2 for Majors, Physics, CU Boulder

Fall 2022
Instructor, PHYS 1115: General Physics 1 for Majors, Physics, CU Boulder

Spring 2022
Instructor, PHYS 4230: Thermodynamics and Statistical Mechanics, Physics, CU Boulder

Spring 2021
Instructor, PHYS 3320: Principles of Electricity and Magnetism II, Physics, CU Boulder

Fall 2020
Instructor, PHYS 5030: Intermediate Mathematical Physics I, Physics, CU Boulder

Spring 2020
Instructor, PHYS 3320: Principles of Electricity and Magnetism II, Physics, CU Boulder

Fall 2019
Instructor, PHYS 3310: Principles of Electricity and Magnetism I, Physics, CU Boulder, FCQ 'Instructor Overall' Rating: 5.6

Spring 2019
Instructor, PHYS 3310: Principles of Electricity and Magnetism I, Physics, CU Boulder, FCQ 'Instructor Overall' Rating: 4.6

Spring 2018
Instructor, PHYS 2210: Classical Mechanics and Mathematical Methods I, Physics, CU Boulder, FCQ 'Instructor Overall' Rating: 5.6

Fall 2017
Instructor, PHYS 2020: General Physics II (Algebra-based), Physics, CU Boulder, FCQ 'Instructor Overall' Rating: 5.7

Spring 2017
Instructor, PHYS 2210: Classical Mechanics and Mathematical Methods I, Physics, CU Boulder, FCQ 'Instructor Overall' Rating: 5.6

Fall 2016
Instructor, PHYS 2020: General Physics II (Algebra-based), Physics, CU Boulder, FCQ 'Instructor Overall' Rating: 5.5

Spring 2016
Instructor, PHYS 2020: General Physics II (Algebra-based), Physics, CU Boulder, no FCQ issued

Fall 2015
Teaching Assistant, PHYS 1110: General Physics I (Calculus-based), Physics, CU Boulder, FCQ 'Instructor Overall' Rating: 4.4

Spring 2014
Instructor, APPM 2360: Differential Equations with Linear Algebra, APPM, CU Boulder, FCQ 'Instructor Overall' Rating: 5.1

Fall 2013
Guest Lecturer, Partial Differential Equations, APPM, CU Boulder

Spring 2013
Guest Lecturer, Approximation Methods, APPM, CU Boulder

ADVISING:

Current

Justin Nicoski, graduate student, CU Boulder Physics

Tobias Oliver, graduate student, CU Boulder Physics

Talal Al Rafae, graduate student, CU Boulder Physics

Angel Hernandez, undergraduate student, CU Boulder Physics

Maya Greene, REU undergraduate student, Whitman College

Past

Meredith Plumley, CU Boulder Applied Mathematics, PhD 2018, NASA Earth and Space Science Fellowship recipient, American Geophysical Union Donald L. Turcotte Dissertation Award (now in industry)

Ming Yan, graduate student, CU Boulder Physics, PhD 2021 (now in industry)

Ryan Orvedahl, graduate student, CU Boulder Astrophysical and Planetary Sciences, PhD 2021 (now in industry)

Stefano Maffei, postdoctoral researcher, CU Boulder Physics (now postdoc at ETH Zürich)

Adam Harris, undergraduate student, CU Boulder Physics (now graduate student at CU)

Adrienne Jacobi, undergraduate student, CU Boulder Physics (now graduate student at UC Irvine)

Anne R. O'Connor, undergraduate student, CU Boulder Physics

Justin Nicoski, undergraduate student (honors, summa cum laude), CU Boulder Physics (now graduate student at CU)

Talal Al Rafae, undergraduate student (honors, summa cum laude), CU Boulder Physics (now graduate student at CU)

Mitchell Krouss, undergraduate student (honors, magna cum laude), CU Boulder Physics (now at Lockheed Martin)

Kevin Hale, visiting undergraduate student, Harvey Mudd College Physics, BA 2015 (now graduate student at UC San Diego)

Derek Driggs, undergraduate student, CU Boulder Applied Mathematics, BS/MS 2016, Goldwater Scholarship recipient (now graduate student at Cambridge University)

Louie Long, undergraduate student, CU Boulder Applied Mathematics/Engineering physics, BS 2016 (now scientist at Los Alamos National Laboratory)

PRESENTATIONS:

"Rapidly rotating convection and the many scales of core dynamics" (invited keynote), Study of Earth's Deep Interior Meeting, ETH Zürich, July 2022

"Energetically robust large scale dynamos driven by rapidly rotating convection", AGU Fall Meeting, San Francisco CA, Dec 2021

"The distinguished limit for energetically robust large scale dynamos driven by rapidly rotating convection", APS DFD Meeting, Phoenix AZ, Nov 2021

"The inverse cascade and flow speed scaling behavior in rapidly rotating convection", AGU Fall Meeting, San Francisco CA, Dec 2019

"The inverse cascade and flow speed scaling behavior in rapidly rotating convection", APS DFD Meeting, Seattle WA, Nov 2019

"Planar convection-driven dynamos yield magnetically-guided jets and large-amplitude dynamo cycles", Study of the Earth's Deep Interior Meeting, University of Alberta, Canada, July 2018

"A scale-separated analysis of forces in rapidly rotating convection in a spherical shell" (invited), Lorentz Center, University of Leiden, Netherlands, May 2018

"A scale-separated analysis of forces in rapidly rotating convection and convection-driven dynamos in a spherical shell", AGU Fall Meeting, New Orleans LA, Dec 2017

"Balanced models for rapidly rotating convection-driven magnetohydrodynamics" (invited), Fifty Years after Roberts' MHD: dynamos and planetary flows today (PHR2017), The Royal Astronomical Society, London UK, Nov 2017

"Convection-driven magnetohydrodynamics in the limit of rapid rotation", 2nd Conference on Natural Dynamos, Valtice Czech Republic, Jun 2017

"Dynamo action in the limit of small Rossby and magnetic Prandtl numbers", AGU Fall Meeting, San Francisco CA, Dec 2016

"Convection-driven dynamos in the limit of rapid rotation", APS DFD Meeting, Portland OR, Nov 2016

"Convection-driven dynamos in the limit of rapid rotation" (invited), Turbulence and Waves in Flows dominated by Rotation: Lessons from Geophysics and Perspectives in Space Physics and Astrophysics, NCAR HAO, Boulder CO, Aug 2016

"Understanding core dynamics with reduced models" (invited), Study of Earth's Deep Interior, Nantes France, Jul 2016

"A multiscale dynamo model driven by quasi-geostrophic convection", AGU Fall Meeting, San Francisco CA, Dec 2015

"Compressible quasi-geostrophic convection without the anelastic approximation" (invited), AGU Fall Meeting, San Francisco CA, Dec 2014

"Compositional turbulence in planetary interiors: is there an ultimate regime?", AGU Fall Meeting, San Francisco CA, Dec 2013

"Some thoughts on when geometry is important in rapidly rotating convection" (invited), Large Eddy Simulations of MHD Turbulence, NCAR, Boulder CO, 2013

"Asymptotically reduced models for convection in Earth's core", Gordon Research Conference, Mount Holyoke College, 2013

"Asymptotically reduced models of rapidly rotating convection", Ecole de Physique, Les Houches France, 2013

"Anelastic models of rotationally constrained convection", AGU Meeting of the Americas, Cancun Mexico, 2013

"A three-dimensional model for quasi-geostrophic convection in a rotating cylindrical annulus with steeply sloping endwalls" (invited), AGU Fall Meeting, San Francisco CA, 2012

"Numerical Simulations of Low Rossby Number Convection on an f-plane", Frontiers in Computational Physics, Boulder CO, 2012

SYNERGISTIC ACTIVITIES:

NSF Review Panel Member: 2018, 2022

Session organizer, American Geophysical Union Fall Meeting

American Geophysical Union Awards Committee Member

Referee: The Journal of Fluid Mechanics, Physics of Fluids, Geophysical Journal International, Geophysical and Astrophysical Fluid Dynamics, Earth and Planetary Science Letters, Geophysical Research Letters, Nature, Physical Review Letters, Physical Review Fluids, Physical Review Research, Physics of the Earth and Planetary Interiors, The Journal of Plasma Physics, Frontiers in Earth Science