Earl Patrick Bellinger, Ph.D.

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Asteroseismology ★ Stellar Astrophysics ★ Data Science

Education

2015 - 2018 **Ph.D.** Computer Science / Astrophysics
Max Planck Institute for Solar System Research, Germany
Department of Astronomy, Yale University, USA
Institute of Computer Science, University of Göttingen, Germany
Thesis: Inverse Problems in Asteroseismology

2012 - 2014 **M.Sc.** Computer Science, minor: Bioinformatics
School of Informatics & Computing, Indiana University, USA
Graduate Fellow of the National Physical Science Consortium
GPA: 3.95/4.0

2008 - 2012 **B.Sc.** Applied Mathematics, concentration: Scientific Computing
B.Sc. Computer Science, concentration: Artificial Intelligence
State University of New York at Oswego, USA
GPA: 3.81/4.0, *summa cum laude*
Rank #1 overall in Department of Computer Science

Postdoctoral Positions

2021 – present Postdoctoral Research Fellow
Max Planck Institute for Astrophysics, Garching, Germany

2018 – 2021 Postdoctoral Research Fellow
Stellar Astrophysics Centre, Aarhus University, Denmark

Research Positions

2019 – 2020 Visiting Fellow
School of Physics, UNSW Sydney, Australia

2016 – 2017 Visiting Assistant in Research
Department of Astronomy, Yale University, USA

2015 – 2018 Research Assistant / Doktorand
Max Planck Institute for Solar System Research, Germany

2013 – 2015 Research Assistant & Associate Instructor
School of Informatics and Computing, Indiana University, USA

2013 – 2014	Guest Researcher *National Institute of Standards and Technology (NIST), USA*
2013	Research Student *National Institute of Informatics, Tokyo, Japan*
2012	Research Fellow *NASA Jet Propulsion Laboratory, USA*
2011	IRES/NSF Research Student *Federal University of Alagoas, Brazil*
2010	IRES/NSF Research Student *Federal University of Santa Catarina, Brazil*

Teaching

University Courses

2018 – 2021	Assistant, Department of Physics and Astronomy, Aarhus University E20 — *Advanced Stellar Structure and Evolution* F19 — *Advanced Projects in Stellar Evolution*
2017	Assistant, Department of Astronomy, Yale University ASTR 550 — *Stellar Astrophysics*
2016	Assistant, Institut für Astrophysik, Georg-August-Universität Göttingen M.Phy.552 — *Numerical Experiments in Stellar Physics*
2012	Associate Instructor, School of Informatics and Computing, Indiana University CSCI-C211/A591 — *Introduction to Computer Science*
2010	Seminar Leader, Honors Program, SUNY Oswego HON 150 — *Introduction to Honors*

Other Teaching Activities

2023	Organizer & SOC Chair, MESA Summer School, Konkoly, Hungary
2022	Organizer & Lecturer, MESA Summer School, UC Santa Barbara
2022	Invited tutorial, MESA & GYRE, TASC6/KASC13
2022	Invited instructor, MESA@ESO workshop
2022	Research advisor, MPA internship (3 students)
2021	Research advisor, Kavli summer astrophysics program
2019	Research advisor, TESS Ninja
2016	Research advisor, MPS internship

Research supervision

*thesis [P] project *Student-led, peer-reviewed journal publications are indicated*

Doctoral students

* Lynn Buchele (co-supervising Ph.D. with Saskia Hekker)
[P] Arthur Le Saux (via Kavli Summer Program)

[P] Marc Hon (graduated, now: Hubble Fellow), 1 paper
[P] Felix Ahlborn (graduated, now: Postdoc, HITS), 2 papers
[P] Teresa Braun (Ph.D. student, Max Planck for Astrophysics)
[P] Mark Winther (Ph.D. student, Aarhus University)
[P] Tanner Wilson (via TESS Ninja Hackathon)
[P] Mami Deka (Ph.D. student), 1 paper
[P] Pavan Vynatheya (Ph.D. student), 1 paper
[P] Susmita Das (graduated, now: postdoc), 1 paper

Master students

* Felix Ahlborn (co-supervised with Saskia Hekker)
[P] Marcelo Aron Keniger (graduated, now: Ph.D. Student)
[P] Janne Mønster (co-supervised with Vichi Antocci, graduated)

Bachelor students

[P] Selim Kalici (supervised 2-month internship at MPA)
[P] Hugh Randall (supervised 2-month internship at MPA)
[P] Michele Manno (supervised 2-month internship at MPA)
[P] Marcelo Aron Keniger (graduated, now: Ph.D. student)
* Silke Dainese (graduated, now: Master student)
[P] Kenny Roffo (co-supervised 2-month internship at MPS)

High school students

[P] Alejandra Perea Rojas (supervised 3 year project, graduated, now: student, Harvard)

Presentations

Invited Talks

2022 TASC6/KASC13 – TESS/Kepler Asteroseismic Science Consortium
KU Leuven, Belgium

2019 TASC5/KASC12 – TESS/Kepler Asteroseismic Science Consortium
MIT, USA

2019 Dynamics of the Sun & Stars: Honoring the Life & Work of Michael Thompson
High Altitude Observatory, USA

Invited Seminars

2022 Czech Academy of Sciences, Prague, Czech Republic
2021 KU Leuven, Belgium
2021 University of Victoria, British Columbia, Canada
2020 Macquarie University, Sydney, Australia
2020 Monash University, Melbourne, Australia
2019 University of Sydney, Australia
2018 Stellar Astrophysics Centre, Aarhus University, Denmark
2017 University of Wisconsin–Madison, USA
2013 Kyoto University, Japan

Contributed Talks

2022 European Astronomical Society, Valencia, Spain
2022 Fundamental stellar parameters from asteroseismology, Aarhus, Denmark
2019 Stars in Melbourne, Monash University, Melbourne, Australia
2019 Annual Danish Astronomy Meeting (ADAM) 2019, Nyborg, Denmark
2018 TESS Asteroseismic Science Consortium 4, Aarhus University, Denmark
2017 ERES-III: Emerging Researchers in Exoplanet Science, Yale University, USA
2015 RR Lyrae 2015, Visegrád, Hungary
2015 American Astronomical Society, Washington, USA

Workshops (*Invited talk)

2021 *PLATO WP122 Liege Workshop #4
2021 *MPA–Potsdam Workshop on Hot Subdwarfs, Garching, Germany
2020 TESS Ninja 3, University of Sydney, Australia
2019 8th Aarhus Red Giants Workshop, Astronomical Observatory of Catania
2017 7th Aarhus Red Giants Workshop, MPI for Astrophysics
2016 *6th Aarhus Red Giants Workshop, MPI for Solar System Research
2015 *Indo-US Science Workshop on Variable Stars, Delhi University, India
2014 *Indo-US Science Workshop on Variable Stars, St. Thomas College, India

Awards & Funding

2023 Flanders Research Foundation Postdoctoral Fellowship (KU Leuven, deferred)
2021 Max Planck Institute for Astrophysics Postdoctoral Fellowship
2018 NVIDIA GPU Grant
2018 Stellar Astrophysics Centre Postdoctoral Fellowship
2012 National Physical Science Consortium Graduate Fellowship
2012 SUNY Chancellor's Award for Student Excellence
2012 Oebele Van Dyk Outstanding Computer Science Senior Award
2008 SUNY Oswego Presidential Scholarship

Professional Activities

Associations

2020 – Developer, MESA Stellar Evolution Code
2019 – Junior Member, International Astronomical Union

Observing Time

2018 δ Eridani – the first SONG-TESS simultaneous target (P.I.)
Instrument: **SONG telescope** (50 nights)
2018 Simultaneous observations of oscillations in Procyon with SONG and TESS (co-I)
Instrument: **SONG telescope** (30 nights)

Refereeing

The Astrophysical Journal Letters
The Astronomical Journal
Astronomy & Astrophysics
Monthly Notices of the Royal Astronomical Society
Frontiers in Astronomy and Space Sciences

Scientific Organizing

2022	Organizer and Lecturer, MESA Summer School 2022, UC Santa Barbara
2022	Scientific Organizer, European Astronomical Society 2022 Special Session *"Stellar characterization, large data sets, and Machine Learning"*
2022	Organizer and Leader, MPA Hackathon, MPI for Astrophysics
2022 –	Organizer, Seminar on Stellar Astrophysics (SESTAS), MPI for Astrophysics
2019 – 2021	Organizer, Stellar Astrophysics Centre Seminar, Aarhus University
2015 – 2018	Organizer, SAGE Seminar Series, Max Planck Institute for Solar System Research

Languages

Human	English (native) German (B2) Spanish (A2) Portuguese (A2)
Computer	**Expert**: Python, R, Bash, LaTeX, CLISP, Scheme, Java, MATLAB
	Proficient: C, Javascript, HTML, CSS, Perl, SQL, FORTRAN 77/95/08
	Familiar: ActionScript, Assembly, BASIC, C++, Haskell, Mathematica, ML, PHP, Prolog, Ruby, VB

Publications – Earl Patrick Bellinger

Number of publications = 49 || first author = 19 || citations = 595 || h-index = 16
Google scholar profile: https://scholar.google.com/citations?user=Woj_Tu4AAAAJ

[I] *denotes most important publications*

Publications in peer-reviewed scientific journals
(total = 31, first author = 10, single author = 2, student-led = 6)

1. **Bellinger, E. P.** & Christensen-Dalsgaard, J. (2022). Towards solar measurements of nuclear reaction rates. *Monthly Notices of the Royal Astronomical Society*, 517 (4).

2. [I]**Bellinger, E. P.**, Basu, S., Hekker, S., Christensen-Dalsgaard, J., Ball, W. (2021). Asteroseismic Inference of the Central Structure in a Subgiant Star. *The Astrophysical Journal*, 915 (2).

3. [I]**Bellinger, E. P.** (2020). A seismic scaling relation for stellar age II. The red giant branch. *MNRAS Letters*, 492 (1).

4. [I]**Bellinger, E. P.**, Kanbur, S. M., Bhardwaj, A., Marconi, M. (2020). When a Period Is Not a Full Stop: Light Curve Structure Reveals Fundamental Parameters of Cepheid and RR Lyrae Stars. *Monthly Notices of the Royal Astronomical Society*, 491 (4).

5. [I]**Bellinger, E. P.** & Christensen-Dalsgaard, J. (2019). Asteroseismic constraints on the cosmic-time variation of the gravitational constant from an ancient main-sequence star. *The Astrophysical Journal Letters*, 887 (1).

6. **Bellinger, E. P.**, Basu, S., Hekker, S., Christensen-Dalsgaard, J. (2019). Testing stellar evolution with asteroseismic inversions of a main sequence star harboring a small convective core. *The Astrophysical Journal*, 885 (2), 143.

7. **Bellinger, E. P.** (2019). A seismic scaling relation for stellar age. *Monthly Notices of the Royal Astronomical Society*, 486 (4).

8. **Bellinger, E. P.**, Hekker, S., Angelou, G. C., Stokholm, A., Basu, S. (2019). Stellar ages, masses and radii from asteroseismic modeling are robust to systematic errors in spectroscopy. *Astronomy & Astrophysics*, 622, A130.

9. **Bellinger, E. P.**, Basu, S., Hekker, S., Ball, W. (2017). Model-independent Measurement of Internal Stellar Structure in 16 Cygni A and B. *The Astrophysical Journal*, 851 (2), 80.

10. [I]**Bellinger, E. P.**, Angelou, G. C., Hekker, S., Basu, S., Ball, W., Guggenberger, E. (2016). Fundamental Parameters of Main-Sequence Stars in an Instant with Machine Learning. *The Astrophysical Journal*, 830 (1), 20.

***** *denotes paper was led by a student*

11. *****Ahlborn, F., **Bellinger, E. P.**, Hekker, S., Basu, S., Mokrytska, D (2022). Improved asteroseismic inversions for red-giant surface rotation rates. *Astronomy & Astrophysics*.

12. *****Deka, Kanbur, Deb, Das, Kurbah, **Bellinger**, Bhardwaj (2022). Period-Colour and Amplitude-Colour relations for OGLE δ Scuti stars in the Galactic Bulge and LMC. *Monthly Notices of the Royal Astronomical Society*.

13. *****Vynatheya, P., Hamers, A. S., Mardling, R. A., **Bellinger, E. P.** (2022). Algebraic and machine learning approach to hierarchical triple-star stability. *Monthly Notices of the Royal Astronomical Society*.

14. Jermyn, Bauer, Schwab, Farmer, Ball, **Bellinger**, et al. (2022). Modules for Experiments in Stellar Astrophysics (MESA): Time-Dependent Convection, Energy Conservation, Automatic Differentiation, and Infrastructure. *The Astrophysical Journal Supplement Series*, accepted.

15. Caplan, M. E., Freeman, I. F., Horowitz, C. J., Cumming, A., **Bellinger, E. P.** (2021). Cooling Delays from Iron Sedimentation and Iron Inner Cores in White Dwarfs. *The Astrophysical Journal Letters*, 919 (1).

16. Grunblatt, S. et al. including **Bellinger, E. P.** (2021). Age-Dating Red Giant Stars Associated with Galactic Disk and Halo Substructures. *The Astrophysical Journal*, 916 (2).

17. Plachy, E. et al. including **Bellinger, E. P.** (2021). TESS observations of Cepheid stars: first light results. *The Astrophysical Journal Supplement Series*, 253 (1).

18. *****Hon, M., **Bellinger, E. P.**, Hekker, S., Stello, D., Kuszlewicz, J. S. (2020). Asteroseismic Ages of Subgiant Stars with Deep Learning, *Monthly Notices of the Royal Astronomical Society*, 499 (2).

19. *****Ahlborn, F., **Bellinger, E. P.**, Hekker, S., Basu, S., Angelou, G. C. (2020). On the asteroseismic sensitivity to internal rotation along the red-giant branch. *Astronomy & Astrophysics*, 639, A98.

20. Angelou, G. C., **Bellinger, E. P.**, Hekker, S., Mints, A., Elsworth, Y., Basu, S., Weiss, A. (2020). Convective boundary mixing in low- and intermediate-mass stars I. Core properties from pressure-mode asteroseismology. *Monthly Notices of the Royal Astronomical Society*, 493 (4).

21. Angelou, G. C., **Bellinger, E. P.**, Hekker, S., Basu, S. (2017). On the Statistical Properties of the Lower Main Sequence. *The Astrophysical Journal*, 839 (2), 116.

22. Glover, M., **Bellinger, E. P.**, Radivojac, P., Clemmer, D. (2015). Penultimate Proline in Neuropeptides. *Analytical Chemistry*, 87 (16), 8466–8472.

23. *Das, S., Kanbur, S. M., **Bellinger, E. P.**, Bhardwaj, A., Singh, H. P., Meerdink, B., Proietti, N., Chalmers, A., Jordan, R. (2020). The stellar photosphere-hydrogen ionization front interaction in Classical Pulsators: a theoretical explanation for observed period-colour relations. *Monthly Notices of the Royal Astronomical Society*, 493 (1).

24. Bo Nielsen, M. et al. including **Bellinger, E. P.** (2020). TESS asteroseismology of the known planet host star λ^2 Fornacis, *Astronomy & Astrophysics*, 641, A25.

25. Christensen-Dalsgaard, J. et al. including **Bellinger, E. P.** (2020). The Aarhus Red Giants Challenge II: Stellar oscillations in the red giant branch phase. *Astronomy & Astrophysics*, 635, A165.

26. Silva Aguirre, V. et al. including **Bellinger, E. P.** (2020). The Aarhus Red Giants Challenge I: Stellar structures in the red giant branch phase. *Astronomy & Astrophysics*, 635, A164.

27. Tang, Y., Basu, S., Davies, G. R., **Bellinger, E. P.**, Gai, Ning (2018). Asteroseismology of KIC 8263801: Is it a member of NGC 6866 and a red clump star? *The Astrophysical Journal*, 866 (1), 59.

28. Guggenberger, E., Hekker, S., Basu, S., Angelou, G. C., **Bellinger, E. P.** (2017). Mitigating the mass dependence in the $\Delta\nu$ scaling relation of red-giant stars. *Monthly Notices of the Royal Astronomical Society*, 470 (2).

29. Guggenberger, E., Hekker, S., Basu, S., **Bellinger, E. P.** (2016). Significantly improving stellar mass and radius estimates: A new reference function for the $\Delta\nu$ scaling relation. *Monthly Notices of the Royal Astronomical Society*, 461 (2).

30. Ji, C., Li, Y. F., **Bellinger, E. P.**, Li, S., Arnold, R. J., Radivojac, P., Tang, H. (2015). A maximum-likelihood approach to absolute protein quantification in mass spectrometry. In refereed proceedings of *the 6th ACM Conference on Bioinformatics, Computational Biology and Health Informatics* (pp. 296-305).

31. Ngeow, C. C., Kanbur, S. M., **Bellinger, E. P.**, Marconi, M., Musella, I., Cignoni, M., & Lin, Y. H. (2012). Period-luminosity relations for Cepheid variables: from mid-infrared to multi-phase. *Astrophysics & Space Science*, 341(1), 105-113.

Publications in conference proceedings
(total = 14, first author = 6)

32. **Bellinger, E. P.**, Basu, S., Hekker, S. (2020). Inverse analysis of asteroseismic data: a review. *Dynamics of the Sun & Stars*.

33. **Bellinger, E. P.**, Angelou, G. C., Hekker, S., Basu, S., Ball, W., Guggenberger, E. (2017). Fundamental Parameters in an Instant with Machine Learning: Application to Kepler LEGACY Targets. *Seismology of the Sun and Distant Stars*, EPJ Web of Conferences,

Volume 160, id.05003.

34. **Bellinger, E. P.**, Wysocki, D., Kanbur, S. M. (2015). Measuring amplitudes of harmonics and combination frequencies in variable stars. *Communications from the Konkoly Observatory of the Hungarian Academy of Sciences*, 105.

35. **Bellinger, E. P.**, Kanbur, S. M., & Ngeow, C.-C. (2012). New insights into the Cepheid PL Relation through the use of multiphase relations. *Proceedings of the 20th Stellar Pulsations Conference*.

36. **Bellinger, E. P.** (2012). Multiphase Relations of Magellanic Cloud Cepheids. *Proceedings of the 2012 National Conference on Undergraduate Research*.

37. **Bellinger, E. P.**, Kanbur, S. M., & Ngeow, C.-C. (2011). Multiphase Comparison of Period-Luminosity Relations for Magellanic Cloud Cepheids. *Proceedings of the 9th Pacific Rim Conference on Stellar Astrophysics*, 451, 311.

38. Kanbur, S. M., **Bellinger, E. P.**, Bhardwaj, A., Marconi, M. (2020). Light Curve Structure Reveals Fundamental Parameters of Cepheid and RR Lyrae Stars. Proceedings of *RR Lyrae 2019*.

39. *****Das, S., Kanbur, S. M., **Bellinger, E. P.**, Bhardwaj, A., Singh, H. P. (2020). A study of the stellar photosphere-hydrogen ionisation front interaction in pulsating variables using period-color relations. *ASP Conference Series*, 529.

40. *****Ahlborn, F., **Bellinger, E. P.**, Hekker, S., Basu, S., Angelou, G. C. (2020). Rotational inversions along the lower part of the red-giant branch. *Stars and their Variability Observed from Space*.

41. Kanbur, S. M., **Bellinger, E. P.**, Bhardwaj, A., Marconi, M. (2020). Light Curve Structure Reveals Fundamental Parameters of Cepheid and RR Lyrae Stars. *RR Lyrae 2019*.

42. Reyner, S., **Bellinger, E. P.**, & Kanbur, S. M. (2012). The approximation of RR Lyrae and eclipsing binary light curves using cubic polynomials. *Proceedings of the 20th Stellar Pulsations Conference*.

43. Das, S., Kanbur, S. M., **Bellinger, E. P.**, Bhardwaj, A., Singh, H. P. (2020). A study of the stellar photosphere-hydrogen ionisation front interaction in pulsating variables using period-color relations. *RR Lyrae 2019*.

44. Bhardwaj, A., Kanbur, S. M., Marconi, M., Das, S., **Bellinger, E. P.**, Singh, H. P., Rejkuba, M., Ngeow, C.-C. (2018). Time-series analyses of Cepheid and RR Lyrae variables in the wide-field variability surveys. *IAUS347: Early Science with ELTs*.

45. Hekker, S., Elsworth, Y., Basu, S., **Bellinger, E. P.** (2017). Evolutionary states of red-giant stars from grid-based modelling. *Seismology of the Sun and Distant Stars*, EPJ Web of Conferences, Volume 160, id.04006.

Additional publications
(total = 4, first author = 3)

46. **Bellinger, E. P.** (2019). An idea to an image: the prediction and confirmation of black holes. Invited book review, *Metascience*, 29 (1), Cambridge: Harvard University Press.

47. **Bellinger, E. P.** (2018). Inverse Problems in Asteroseismology. Doctoral thesis, *International Max Planck Research School*.

48. **Bellinger, E. P.**, Conner, D., Mittman, D., Magee, K., & Heventhal, B. (2012). CASSIUS: the Cassini Uplink Scheduler. *Jet Propulsion Laboratory: National Aeronautics and Space Administration*, hdl:2014/43122.

49. The MSE Science Team et al. including **Bellinger, E. P.** (2019). The Detailed Science Case for the Maunakea Spectroscopic Explorer.