Jacob Kegerreis

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Research

Planetary impacts – Simulating giant impacts at 100–1000 times higher resolution than the previous norm, allowing the detailed study of topics including: the origin of the Moon; atmospheric erosion; numerical convergence; improved visualisation techniques; and the formation of Saturn's rings.

SWIFT simulation code – Lead planetary developer of the SWIFT high-performance hydrodynamics code, including community support and open-source development of improved numerical methods.

Education

2015–2019	**PhD** – Institute for Computational Cosmology (ICC), Durham University, UK. *Thesis*: *Supervisors*: Vince Eke, Richard Massey.
2011–2015	**Physics (MPhys)** integrated masters, 1st Class (Hons) – Durham University, UK.

Funding and Grants

2025–2030	**STFC Ernest Rutherford Fellowship** Hosted by Imperial College London.
2024–2027	**NASA ROSES Emerging Worlds** "Modelling the formation of Mars's proto-satellite disk" – PI
2025–2027	**NASA ROSES Exoplanets Research Program** "Modelling the Formation of Hot Dense Neptunes" – Science co-lead (PI Jack Lissauer)
2025–2028	**NASA Internal Scientist Funding Model** Ames Outer Planets Research Group – Co-I (PI Paul Estrada)
2021–2024	**NASA Postdoctoral Program Fellowship, USRA / ORAU** Fellowship at NASA Ames. (Postponed 1 year by covid.)
2019–2021	**UK Space Agency** Postdoctoral research associate at Durham University.
2015–2019	**Science and Technology Facilities Council** and **ICC PhD Scholarship Fund** PhD studentship.
2022–2025	**DiRAC RAC 14th Call Computing Time** 30.6M core-hours on the new COSMA8 cluster (CoI).
2020–2021	**DiRAC Director's Discretionary Time** 2.5M core-hours on the new COSMA8 cluster (PI).
2019	**Ogden Trust Alumni Grant** Funding for travel to present at the SPHERIC Workshop 2019.

Selected Prizes and Awards

2022	**DiRAC Research Image Competition** winner, for high-resolution simulations of Moon-forming giant impacts, rendered with Houdini
2020	**Springer Thesis Award**, recognising international 'outstanding PhD reserach'
2019	**Libersky Student Paper Prize** 2nd place, SPHERIC International Workshop
2018	**Career Development Award**, Lunar and Planetary Institute
2015	**D A Wright Prize** for Outstanding Performance in an MPhys Research Project For the highest-marked research project out of a year of 126 students
2015	**Bill Bryson Prize** for Communication in Science For the winning research presentation from all science faculty students
2015	**Audience Choice Award**, Rising Stars Research Symposium, Durham University
2012	**Durham Physics Award** for Outstanding Achievement

Conferences and Media

Invited talks:

- Ogden Centre 20th anniversary symposium (2022), on the origin of planets and life
- CLEVER Planets seminar series (2022), on terrestrial atmospheric erosion
- 'SPH: Greatest Hits' UK Fluids Network meeting (2019), on simulations of planetary giant impacts
- Royal Society and French Academy Bilateral International Meeting (2019), on supercomputing in the physical sciences
- Plenary speaker at the European Simulation and Modelling Conference (2018), on the SWIFT code and Uranus giant impacts
- Frequent institutional colloquia and symposia, e.g. (within the last year): NASA Space Science, Bristol University, UC Santa Cruz, UC Davis.

Numerous press releases and invited interviews and articles with national and international media, e.g.

- **YouTube videos** with >6 million views, the highest on the NASA Ames channel to date
- **Science Friday** segment, US radio show with ∼1.3 million live listeners
- **New Scientist**, Science et Vie, and various newspapers including some 'interesting' headlines

Outreach

Numerous invited talks at e.g. *Pint of Science*, *Café Scientifique*, and public astronomical societies.

- Developed **cinematic visualisations** of simulation research for public and scientific engagement.
- Consultant Editor for the **Learn about Space and Planets** children's astronomy activity book.
- Collaborated on the **Our Universe** Netflix top-10 documentary with industry VFX artists (Lux Aeterna) on rendering simulations of Moon-forming impacts.
- Science advisor for the new **Space Zone** exhibit at the Newcastle Life Science Centre.
- Co-created a **demo supercomputer** cluster of Raspberry Pi's for public engagement.
- Built from scratch a programmable **8-bit computer** on breadboards for Celebrate Science.
- Leading role in designing and demonstrating the **Galaxy Makers** exhibition exhibits.

Durham University and **STEM.org.uk ambassador**
Frequent demonstrating at public and school events (averaging more than one every month before the pandemic), from national festivals to local planetarium shows.

Service

Development and support of open-source tools with extensive documentation and examples, including active community troubleshooting and tech support: SWIFT – hydrodynamics and gravity code; SEAGen and WoMa – planetary initial conditions; ArCTIc – CTI correction.

Community service

- Organising committee: Bay Area Planetary Science conference (2023–...)
- Journal article reviews: ApJ, MNRAS, Nat. Geosci., PSJ.
- Grant proposal reviews: UKRI/STFC.

Astronomy outreach coordinator (Durham University, 2015–2019)

- Managed the internal astronomy outreach website, enabling ∼150 astronomers to share resources and increase engagement with the public and e.g. local schools.
- Co-organised the weekly postgraduate astronomy journal club (2016).

Teaching and Supervision

2020–...	Co-supervisor for Thomas Sandnes, PhD student, working on hydrodynamic simulation schemes, giant impact simulations, and material strength models.
2018–2022	Co-supervisor for Sergio Ruiz-Bonilla, PhD student, working on giant impact simulations and rotating initial conditions.
2019–...	Co-supervision of multiple MPhys thesis projects.
2018–2021	**Training postgraduate students** • Teaching advanced programming tools to first-year PhD students. • Ran a training workshop on the SWIFT code for postgraduate students.
2015–2016	**Postgraduate student teacher** (Durham University) Demonstrator for the undergraduate Level 2 Computational Physics course.

Other Skills and Leadership Roles

Computing	`Python`: Advanced experience, mostly analysing and visualising large data sets.
	`C`, `C++`, `fortran`: Advanced/intermediate experience, mostly high-performance simulation codes and data analysis.
	`git`, `bash`, `LaTeX`, etc.: Advanced experience, both in solo projects and large development teams.
Languages	Native English speaker
	Intermediate level Spanish; 7 months teaching children in Quito, Ecuador (2011)
	Beginner/intermediate level Japanese
Kendo	BKA certified coach, Kendo 3-dan (2016)
	Founder and coach of the Durham University Kendo Club, teaching three weekly sessions of ∼20 members of all ages and abilities (2012–2019)

References

Dr. Rick Elphic – NPP Advisor richard.c.elphic@nasa.gov
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Dr. Vince Eke – PhD Supervisor v.r.eke@durham.ac.uk
Institute for Computational Cosmology, Durham University, Durham, DH1 3LE, UK

Dr. Jack Lissauer – NPP Co-Advisor jack.lissauer@nasa.gov
NASA Ames Research Center, Moffett Field, CA, USA

Publication List

Lead author

Origin of Mars's moons by disruptive partial capture of an asteroid. **Kegerreis, J. A.**, Lissauer, J. J., Eke, V. R., Sandnes, T. D., Elphic, R. C. *Icarus*, 425:116337, Nov. 2024. doi: 10.1016/j.icarus.2024.116337.

A recent impact origin of Saturn's rings and mid-sized moons. Teodoro, L. F. A, **Kegerreis, J. A.** (science-lead and corr. author), Estrada, P. R., Ćuk, M., Eke, V. R., Cuzzi, J. N., Massey, R. J., Sandnes, T. D. *Astrophys. J.*, 955:2, Oct. 2023. doi: 10.3847/1538-4357/acf4ed.

Immediate Origin of the Moon as a Post-impact Satellite. **Kegerreis, J. A.**, Ruiz-Bonilla, S., Eke, V. R., Massey, R. J., Sandnes, T. D., Teodoro, L. F. A. *Astrophys. J. Lett.*, 937:2 L40, Oct. 2022. doi: 10.3847/2041-8213/ac8d96.

Atmospheric Erosion by Giant Impacts onto Terrestrial Planets: A Scaling Law for any Speed, Angle, Mass, and Density. **Kegerreis, J. A.**, Eke, V. R., Catling, D. C., Massey, R. J., Teodoro, L. F. A., Zahnle, K. J. *Astrophys. J. Lett.*, 901:2, Sept. 2020. doi: 10.3847/2041-8213/abb5fb.

Atmospheric Erosion by Giant Impacts onto Terrestrial Planets. **Kegerreis, J. A.**, Eke, V. R., Massey, R. J., Teodoro, L. F. A. *Astrophys. J.*, 897:2, July 2020. doi: 10.3847/1538-4357/ab9810.

Planetary Giant Impacts: Convergence of High-Resolution Simulations using Efficient Spherical Initial Conditions and SWIFT. **Kegerreis, J. A.**, Eke, V. R., Gonnet, P., Korycansky, D. G., Massey, R. J., Schaller, M., Teodoro, L. F. A. *Mon. Not. R. Astron. Soc.*, 487:4, Aug. 2019. doi: 10.1093/mnras/stz1606. †

Consequences of Giant Impacts on Early Uranus for Rotation, Internal Structure, Debris, and Atmospheric Erosion. **Kegerreis, J. A.**, Teodoro, L. F. A., Eke, V. R., Massey, R. J., Catling, D. C., Fryer, C. L., Korycansky, D. G., Warren, M. S., Zahnle, K. J. *Astrophys. J.*, 861:52, July 2018. doi: 10.3847/1538-4357/aac725. †

Evidence for a Localized Source of the Argon in the Lunar Exosphere. **Kegerreis, J. A.**, Eke, V. R., Massey, R. J., Beaumont, S. K., Elphic, R. C., L. F. Teodoro. *J. Geophys. R. (Planets)*, 122:2163–2181, Oct. 2017. doi: 10.1002/2017JE005352.

Supervised PhD students

REMIX SPH – improving mixing in smoothed particle hydrodynamics simulations using a generalised, material-independent approach. Sandnes, T. D., Eke, V. R., **Kegerreis, J. A.**, Massey, R. J., Ruiz-Bonilla, S., Schaller, M., Teodoro, L. F. A. *J. Comp. Phys., in review*, 2024.

Dealing with density discontinuities in planetary SPH simulations. Ruiz-Bonilla, S., Borrow, J., Eke, V. R., **Kegerreis, J. A.**, Massey, R. J., Sandnes, T. D., Teodoro, L. F. A. *MNRAS*, 512:3, May 2022. doi 10.1093/mnras/stac857.

The effect of pre-impact spin on the Moon-forming collision. Ruiz-Bonilla, S., Eke, V. R., **Kegerreis, J. A.**, Massey, R. J., Teodoro, L. F. A. *MNRAS*, 500:3, Jan. 2021. doi 10.1093/mnras/staa3385.

Co-author

SWIFT: A modern highly-parallel gravity and smoothed particle hydrodynamics solver for astrophysical and cosmological applications. Schaller, M., Borrow, J., ..., **Kegerreis,**

J. A., et al. *MNRAS*, 530:2, May 2023. doi 10.1093/mnras/stae922.

Moon-forming impactor as a source of Earth's basal mantle anomalies. Yuan, Q., Li, M., Desch, S. J., Ko, B., Deng, H., Garnero, E. J., Gabriel, T. S. J., **Kegerreis, J. A.**, Miyazaki, Y., Eke, V. R. *Nature*, 623:7985, Nov. 2023. doi 10.1038/s41586-023-06589-1.

Abell 1201: detection of an ultramassive black hole in a strong gravitational lens. Nightingale, Smith, He, O'Riordan, Kegerreis, et al. *MNRAS*, 521:3, May 2023. doi 10.1093/mnras/stad587.

Measurement of the free neutron lifetime using the neutron spectrometer on NASA's Lunar Prospector mission. Wilson, J. T., Lawrence, D. J., Peplowski, P. N., Eke, V. R., **Kegerreis, J. A.**. *Phys. Rev. C*, 104:4, Oct. 2021. doi 10.1103/PhysRevC.104.045501.

Space-based measurement of the neutron lifetime using data from the neutron spectrometer on NASA's MESSENGER mission. Wilson, J. T., Lawrence, D. J., Peplowski, P. N., Eke, V. R., **Kegerreis, J. A.**. *Phys. Rev. Res.*, 2:2, June 2020. doi: 10.1103/PhysRevResearch.2.023316.

Books and Chapters

Learn about Space and Planets: Explore the wonders of our universe. Akass, S., **Kegerreis, J. A.** (Consultant Editor), CICO Kids, Ryland Peters & Small, Nov. 2021. doi: 10.1007/978-3-319-05546-6_203-1.

Noble Gases in *Encyclopedia of Lunar Science.* Eke, V. R., **Kegerreis, J. A.** (ed. B. Cudnik), Springer Intl. Pub., Nov. 2018. doi: 10.1007/978-3-319-05546-6_203-1.

[†]Included as part of Durham Physics REF2021 submission, considered by the department to be in the top 5% of research papers.