

Rakesh Arul

RESEARCH FELLOW · PHYSICS

Cavendish Laboratories, University of Cambridge | St. John's College Cambridge

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Professional & Education

University of Cambridge

RESEARCH FELLOW IN PHYSICS

- Host: Prof. Akshay Rao
- St. John's College Title A Research Fellowship

Cambridge, UK
Oct 2023 - present

University of Cambridge

PHD IN PHYSICS

- Supervisor: Prof. Jeremy Baumberg
- Trinity College
- Cavendish Prize in Experimental Physics, Cambridge-Rutherford Scholarship & Winton Scholarship

Cambridge, UK
Oct 2019 - Oct 2023

University of Auckland

MSc IN CHEMISTRY

- First class honours, Frederick Douglas Brown Postgraduate Science Award
- Thesis: Bonds, cavities, and light-Acceleration of organometallic reactions within resonant optical microcavities
- Supervisor: Prof. Cather Simpson & Prof L. James Wright

Auckland, NZ
Feb 2018-Feb 2019

University of Auckland

BSc - PHYSICS & CHEMISTRY AND BE(HONS) - CHEMICAL & MATERIALS ENGINEERING

- Senior Scholar (Top in graduating class), Phillip Graham Crabbe Thesis Prize, First class honours in both (CGPA: 8.83/9)
- Top in Class: Quantum Mechanics & Modern Physics, Electromagnetism, Inorganic Chemistry, Advanced Materials Chemistry, Physical Chemistry, Continuum Mechanics in Bioengineering
- Supervisor: Prof. Wei Gao & Prof. Cather Simpson

Auckland, NZ
2013 - 2017

Publications & Patents

27 published (10 first/co-first or corresponding author, indicated by *), 2 patent applications.

PREPRINTS IN REVIEW/REVISION

1. ***Arul, R.**, Zhu, H., Jiang, Z., Xue, B., van Turnhout, L., Deng, Y., Tew, A., Yu, Z., & Rao, A. (2025). Lanthanide-doped nanocrystals enable organic room-temperature phosphorescence in solution through direct triplet excitation. **Under revision in Nature Chemistry**
2. ***Arul, R.**, Jiang, Z., Li, X., Bell, F.M., Tew, A., Ducati, C., Rao, A., & Yu, Z. (2024). Efficient short-wave infrared upconversion by self-sensitized holmium-doped nanoparticles. **Under revision in Nature Photonics** arXiv:2411.19949
3. Sibug-Torres, S. M., Niihori, M., Wyatt, E.W., **Arul, R.**, Spiesshofer, N., Jones, T., Graham, D., de Nijs, B., Scherman, O., Rao, R., Ryan, M., Squires, A., Savory, C., Scanlon, D., Daaoub, A., Sangtarash, S., Sadeghi, H., & Baumberg, J.J. (2024). How Au-Cl controls gold surfaces with organics. **Under revision in Nature Chemistry**
4. Wyatt, E. W., Sibug-Torres, S.M., **Arul, R.**, Niihori, M.N., Jones, T., Beattie, J.W., Nijs, B.D., & Baumberg, J.J. (2024). Tracking and controlling monolayer water in gold nanogaps using extreme plasmonic spectroscopy. **Under review in Small**. arXiv:2506.10199

LEADING AND CORRESPONDING AUTHOR WORK

5. Bell, F.M., Jakob L.A., Todd C.A., Lohia I., Roh, Y., ***Arul, R.**, & Baumberg, J. J. (2025). Coherent dynamics of molecular vibrations in single plasmonic nanogaps. **Physical Review Letters** 135, 076901
6. Kerner, P., **Arul, R.**, Thompson, D., Baumberg, J. J., & Nijs, B.D. (2025). Optical Control of Single Atom Dynamics in Plasmonic Nanogaps. **Science Advances** 11, no. 29 ead3216.
7. Chikkaraddy, R., ***Arul, R.**, Jakob, L. A., & Baumberg, J. J. (2023). Single-molecule mid-IR spectroscopy and detection through vibrationally-assisted luminescence. **Nature Photonics**, 17, 865–871.
8. ***Arul, R.**, Menghrajani, K., Chikkaraddy, R., Rider, M.S., Barnes, W.L., & Baumberg, J.J. (2023). Raman-probing the local ultra-strong coupling of vibrational plasmon-polaritons on metallic gratings. **Physical Review Letters**, 131, 126902.
9. ***Arul, R.**, Ye, J., Nieuwoudt, M. K., Dong, J., Gao, W., & Simpson, M. C. (2023). Understanding the chemical mechanism behind photo-induced enhanced Raman spectroscopy. **The Journal of Physical Chemistry Letters**. 14 (19), 4607-4616.

10. ***Arul, R.**, Benjamin-Grys, D., Chikkaraddy, R., Mueller, N. S., Xomalis, A., Miele, E., Euser, T.E. & Baumberg, J. J. (2022). Giant mid-IR resonant coupling to molecular vibrations in sub-nm gaps of plasmonic multilayer metafilms. **Light: Science and Applications** 11, 281 (2022).
11. Rider, M. S., **Arul, R.**, Baumberg, J. J., & Barnes, W. L. (2022). Theory of strong coupling between molecules and surface plasmons on a grating. **Nanophotonics**. 11, 16, 3695-3708.
12. Mueller, N.S., **Arul, R.**, Jakob, L.A., Blunt, M., Foldes, T., Rosta, E., & Baumberg, J.J. (2022). Collective mid-infrared vibrations in surface-enhanced Raman scattering. **ACS Nano Letters** 22, 17, 7254–7260
13. Mueller, N.S., **Arul, R.**, Saunders, A., Johnson, A., Sanchez-Iglesias, A., Hu, S., Jakob, L.A., Bar-David, J., Nijs, B.D., Liz-Marzan, L., Liu, F., & Baumberg, J. J. (2023). Anti-Stokes Photoluminescence in Monolayer WSe₂ Activated by Plasmonic Cavities through Resonant Excitation of Dark Excitons. **Nature Communications**, 14, 5726.
14. ***Arul, R.**, Dong, J., Simpson, M. C., & Gao, W. (2021). LIPSS-Sticks: Laser Induced Double Self Organization Enhances the Broadband Light Absorption of TiO₂ Nanotube Arrays. **Advanced Photonics Research**, 2(5), 2000133.
15. ***Arul, R.**, Oosterbeek, R. N., Robertson, J., Xu, G., Jin, J., & Simpson, M. C. . (2017). The mechanism of direct laser writing of graphene features into graphene oxide films involves photoreduction and thermally assisted structural rearrangement. **Carbon**, 99, 423-431.

POSTDOCTORAL COLLABORATIVE WORK

16. Jakob, L., Juan-Delgado, A., Mueller, N.S., Hu, S., **Arul, R.**, Boto, R., Esteban, R., Aizpurua, J., & Baumberg, J.J. (2025). Optomechanical Pumping of Collective Molecular Vibrations in Plasmonic Nanocavities. **ACS Nano** 19 (11), 10977-10988
17. Tew, A., van Turnhout, L., Deng, Y., **Arul, R.**, Ye, J., Liu, T., Jiang, Z., Dai, L., Zhu, H., Zhang, Y., Rao, A., & Yu, Z. (2024). Heterostructures enhance the absorption of lanthanides. **Applied Physics Reviews**, 11, 2
18. van Turnhout, L., Congrave, D. G., Yu, Z., **Arul, R.**, Dowland, S. A., Sebastian, E., Jiang, Z., Bronstein, H., & Rao, A. (2024). Distance-Independent Efficiency of Triplet Energy Transfer from π -Conjugated Organic Ligands to Lanthanide-Doped Nanoparticles. **Journal of the American Chemical Society**, 146, 32, 22612-22621
19. Hu, S., Huang, J., **Arul, R.**, Sanchez-Iglesias, A., Xiong, Y., Liz-Marzan, L., & Baumberg, J.J. (2024). Robust consistent single quantum dot strong coupling in plasmonic nanocavities. **Nature Communications**, 15, 6835
20. Kang, G., Hu, S., Guo, C., **Arul, R.**, Sibug-Torres, S. M., & Baumberg, J. J. (2024). Design rules for catalysis in single-particle plasmonic nanogap reactors with precisely aligned molecular monolayers. **Nature Communications**, 15(1), 9220
21. Jakob, L.A., Deacon, W.M., **Arul, R.**, de Nijs, B. & Baumberg, J.J. (2024). Accelerated Vibrational Decay and Suppressed Electronic Nonlinearity in Plasmonic Cavities using Coherent Raman Scattering. **Phys. Rev. B**, 109, 195404
22. Guo, C., Benzie, P.A., Hu, S., Nijs, B.D., Miele, E., Elliot, E.E., **Arul, R.**, Benjamin, H., Baumberg, J.J. (2024). Extreme photochemical reorganisation of molecule-metal surfaces under room light. **Nature Communications**, 15, 1928
23. Tew, A., van Turnhout, L., Deng, Y., **Arul, R.**, Ye, J., Liu, T., Jiang, Z., Zhu, H., Zhang, Y., Rao, A., & Yu, Z. (2024). Heterostructures enhance the absorption of lanthanides. **Applied Physics Reviews**, 11, 2

COLLABORATIVE WORK

24. Ye, J., Ren, A., Dai, L., Baikie, T., Guo, R., Pal, D., Gorgon, S., Heger, J.E., Huang, J., Sun, Y., **Arul, R.**, Grimaldi, G., Zhang, K., Shamsi, J., Huang, Y.T., Wang, H., Wu, J., Koenderink, A.F., Murciano, L.T., Schwartzkopf, M., Roth, S.V., Muller-Buschbaum, P., Baumberg, J.J., Stranks, S.D., Greenham, N.C., Polavarapu, L., Zhang, W., Rao, A., and Hoyer, R.L.Z. (2024). Direct Linearly-Polarised Electroluminescence from Perovskite Nanoplatelet Superlattices. **Nature Photonics**, 18, 586–594
25. Grys, D.B., Niihori, M., **Arul, R.**, Sibug-Torres, S.M., Wyatt, E., Nijs, B.D., & Baumberg, J.J. (2023). Controlling Atomic-Scale Restructuring and Cleaning of Gold Nanogap Multilayers for Surface-Enhanced Raman Scattering Sensing. **ACS Sensors**, 8, 7, 2879–2888.
26. Vargas, M.J.T., Nieuwoudt, M.K., **Arul, R.**, Williams, D.E., Simpson, M.C. (2023). Direct laser writing of hydrophobic and hydrophilic valves in the same material applied to centrifugal microfluidics. **RSC Advances**, 13 (32), 22302-22314.
27. Ye, J., Li, Z., Kubicki, D.J., Zhang, Y., Dai, L., Otero-Martínez, C., Reus, M.A., **Arul, R.**, ..., Rao, A. and Hoyer, R.L.Z. (2022). Elucidating the Role of Antisolvents on the Surface Chemistry and Optoelectronic Properties of CsPbBr₃ 1-x Perovskite Nanocrystals. **Journal of the American Chemical Society**. 144, 27, 12102–12115
28. Niihori, M., Foldes, T., **Arul, R.**, Grys, D.B., Readman, C., de Nijs, B., Rosta, E., & Baumberg, J.J. (2022). SERS sensing of dopamine with Fe (III) sensitized nanogaps in recleanable AuNP monolayer films. **Small**, 19 (48), 2302531.

29. Gallop, N.P., Ye, J., Greetham, G., Jansen, T.L.C., Dai, L., Zelewski, S., **Arul, R.**, Baumberg, J.J., Hoye, R.L.Z. & Bakulin, A.A. (2022). The Effect of Caesium Alloying on Ultrafast Structural Dynamics in Hybrid Organic-Inorganic Halide Perovskites. **Journal of Materials Chemistry A**, 10, 22408-22418
30. Koczor-Benda, Z., Boehmke, A. L., Xomalis, A., **Arul, R.**, Readman, C., Baumberg, J. J., & Rosta, E. (2021). Molecular Screening for Terahertz Detection with Machine-Learning-Based Methods. **Physical Review X**, 11(4), 041035.
31. Sk, M. H., Abdullah, A. M., Ko, M., Ingham, B., Laycock, N., **Arul, R.**, & Williams, D. E. (2017). Local supersaturation and the growth of protective scales during CO₂ corrosion of steel: Effect of pH and solution flow. **Corrosion Science**, 126, 26-36.
32. Martin, J. W., McIntosh, G. J., **Arul, R.**, Oosterbeek, R. N., Kraft, M., & Söhnel, T. (2017). Giant fullerene formation through thermal treatment of fullerene soot. **Carbon**, 125, 132-138

PATENTS

33. Arul, R., Baumberg, J.J., Chikkaraddy, R., & Xomalis, A. Mid-infrared detector (14 Mar 2022). UK Patent Application No. 2203507.5.
34. Arul, R., Baumberg, J.J., Grys, DB., Niihori, M., Sibug-Torres, S.M., & Wyatt, E.W. Surface-enhanced spectroscopy substrates (20 Mar 2023). UK Patent Application No. 2304765.7.

Awards & Fellowships

- 2023 **Title A Research Fellowship**, St. John's College, Cambridge
- 2023 **Chemical Science Prize**, Royal Society of Chemistry, Optical Probes Conference
- 2022 **Cavendish Prize in Experimental Physics**, University of Cambridge
- 2019 **Cambridge-Rutherford Memorial Scholarship**, Royal Society of New Zealand Te Aparangi
- Winton Scholarship**, Winton Programme for the Physics of Sustainability
- 2018 **Senior Scholar Award**, Faculty of Science, University of Auckland
- AOF Synchrotron School Scholarship 2018**, Royal Society of New Zealand Te Aparangi
- Frederick Douglas Brown Postgraduate Science Award**, University of Auckland
- University of Auckland Research Masters Scholarship**, University of Auckland
- 2017 **Dennis Brown Prize for Experimental Physics**, University of Auckland
- Siphala Foundation Stage III Chemistry Prize**, University of Auckland
- AINSE Winter School Scholarship**, Australian Institute of Nuclear Science and Engineering
- DWC Industry New Ideas Competition Winner**, Dodd-Walls Centre
- 2016 **Phillip Graham Crabbe Prize for Best Materials Engineering Thesis**, University of Auckland
- 2016 **Society for Materials NZ (SMNZI) Prize for Best Materials Engineering Final Year Talk**,
- 2013-16 **Dean's Honour's List**, University of Auckland

Research and outreach grants

- 2025 **EPSRC-NSF grant: "Nanoscale spin entanglement and chemistry (NanoSPINEC)" Principal Investigator**, EPSRC £500,000
- 2023 **Diamond Synchrotron grant: "Identification of molecular species in cleared gaps of nanoplasmonic sensors" SI34784 Principal Investigator**, Diamond Light Source
- 2022 **Royce Institute grant: "Tuning intermolecular coupling of vibrations in molecular monolayers"** CAM-YR7-UI-004, Henry Royce Institute
- 2019 **Australian Synchrotron soft x-ray beamtime - proposal 13974**, ANSTO
- 2018 **Australian Synchrotron far-IR/THz beamtime - proposal 12344**, ANSTO
- SPIE Education Outreach Grant**, SPIE—The International Society for Optical Engineering

Professional/Outreach Experience

- 2024 **Climate Crisis Committee**, St. John's College Cambridge
- 2024 **Estates Strategy Committee**, St. John's College Cambridge
- 2024 **Physics Research Staff Committee**, Cavendish Laboratory Cambridge
- 2023 **Pint of Science Outreach presenter**, Pint of Science Cambridge
- 2020 **Cavendish Graduate Student Conference 2020 Organizer**, University of Cambridge
- 2020-21 **Physics at Work Cavendish outreach**, University of Cambridge
- 2019 **Research engineer**, Photon Factory, University of Auckland
- 2019 **Summer research internship**, Dept. of Physics (Prof. Yuanbo Zhang), Fudan University, China
- 2018 **Vice President of SPIE—The International Society for Optical Engineering Student Chapter**, University of Auckland
- 2015-2018 **Science outreach coordinator**, Museum of Transport and Technology, Auckland

Teaching Experience

- 2023-2024 **Masters in Sustainability Leadership**, Workshop Lecturer, Judge Business School, Cambridge
2020-2024 **Part III Physics & Chemistry**, Final year research project supervisor, Cambridge
2021 **Part II Computational Physics**, Supervisor, Cambridge
2019-2022 **Part IB Oscillations, Waves & Optics**, Lab Demonstrator, Cambridge

Research Project supervision

- 2022-now **Caleb Todd**, PhD in Physics, Cambridge
2022-now **Lille Borresen**, PhD in Physics, Cambridge
2023-2024 **Dylan Cleveland**, Part III Chemistry: "Chemistry under vibrational strong coupling", Cambridge
2023-2024 **Zhenyao Jiang**, Part III Physics: "Optical cooling in CdSe quantum dots", Cambridge
2021-2022 **Charlotte Pincher**, Part III Physics: "Modelling disorder in a chain of gold nanoparticles", Cambridge
2020-2021 **Elle Wyatt**, Part III Physics: "Spectral analysis for correction of distortions in attenuated total reflectance infrared spectra and mapping of surface enhanced Raman spectra", Cambridge
2018-2019 **Xiao Liu**, Masters in Engineering: "Enhancement of Raman spectroscopy by self-organized WO₃-Ag porous nanostructures", Auckland
2017-2018 **Junzhi Ye**, Final year project: "Self-organized nanoparticles on defective titanium dioxide for photo-induced enhanced Raman spectroscopy", Auckland

Presentations

INVITED TALKS

- 2025** "Nanophotonics to control mid-infrared light and polariton condensation". Surface Plasmon Photonics SPP11 Tokyo
2025 Oxford Solid State Chemistry Seminar (Prof. Andrew Goodwin)
2024 "Bridging the visible and mid-infrared". Gordon Research Seminar on Nanoplasmonics
2024 "Nano-optics for mid-IR technology". Imperial College London Chemistry (Prof. Artem Bakulin)
2023 "Bridging the visible and mid-infrared". Utrecht University Nano Seminar. Debye Institute. (Prof. Marlous Kamp)
2023 "Collective phenomena enabled by extreme light confinement". Cavendish Theory of Condensed Matter Seminar.

CONTRIBUTED TALKS

- 2025** "Nanophotonics for polariton condensation." Strong Coupling in Organic Materials (SCOM5)
2024 "Bridging the visible and mid-IR with exciton plasmon-polaritons." Condensed Matter & Quantum Materials Conference (IOP)
2024 "Complex infrared nanophotonics". Complex Nanophotonics EU Science Camp
2022 "Integrating visible and mid-infrared light for sensing, chemical reactions, and light emission". NFO16
2022 "Integrating visible and mid-infrared light for sensing, chemical reactions, and light emission". Complex Nanophotonics EU Science Camp. **Best runner-up talk prize**
2019 "Lighting up chemical bonds - Can quantum optics be used to control chemical reactions?". AMN-9 Conference. **Best talk prize**
2019 "Vibro-polaritons for control of chemical reaction kinetics". International Conference on Advanced Vibrational Spectroscopy
2018 "Pattern formation and self-organization in the growth of titanium dioxide nanotubes". SPIE Photonics West **2018** "Quantum optics to control chemistry". Dodd-Walls Centre Symposium. **Best talk prize**

OUTREACH TALKS

- 2023** "Bridging the visible and invisible worlds by looking through gold nanoparticles". Pint of Science Cambridge