<table>
<thead>
<tr>
<th><strong>Project title</strong></th>
<th>Optimising superoscillatory functions for advances in super-resolution imaging and quantum simulations</th>
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<tbody>
<tr>
<td><strong>Principal supervisor</strong></td>
<td>Katrine Rogers</td>
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<td><strong>Second supervisor</strong></td>
<td>Jim Hague (School of Physical Sciences)</td>
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<td><strong>Discipline</strong></td>
<td>Applied mathematics</td>
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<td><strong>Research area/keywords</strong></td>
<td>Optimisation, Band-limited functions and superoscillations, Numerical modelling, Fourier analysis, Imaging</td>
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<tr>
<td><strong>Suitable for</strong></td>
<td>Full time or part time applicants</td>
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**Project background and description**

Super-resolution images, which break the fundamental diffraction limit, have recently become reality, revealing the microscopic world in new detail. All conventional super-resolution imaging techniques require modifications to biological samples (such as cells), yet superoscillatory imaging has been used to take videos of unmodified living cells.

This technique relies on superoscillatory functions, which are band-limited, yet contain much faster oscillations than their fastest Fourier component. Superoscillatory functions have applications across quantum mechanics, information theory and many other areas.

Superoscillations do, however, come at a cost: superoscillatory regions of the function have low amplitude and are surrounded by high amplitudes. This poses a problem in physical systems, where this translates to the useful, superoscillatory region containing a low proportion of the energy of the system. The amplitude immediately outside the superoscillatory region is normally
the most problematic in applications: for example, it can affect the quality of an image. A goal of this project is to minimise the impact of these undesirable regions.

This project will investigate different objectives and optimisation techniques for producing superoscillatory functions with desirable properties for applications. Both analytic and numeric optimisation techniques will be used, in one, two and three dimensions. This could involve diverse areas of mathematics such as variational techniques, eigenvalue problems, (circular) prolate spheroidal wave functions, genetic algorithms and more. An understanding of physical systems such as imaging will also be developed. The research will build on collaborative work already in progress with The University of Southampton.

*Image courtesy of Edward T.F. Rogers and Nikolay I. Zheludev, University of Southampton.*

**Background reading/references**


**How to apply for this project**

1. Read the Guide for applicants to check eligibility, especially entry and English language requirements.
2. Informal enquiries can be directed to the Director of Research.
3. Complete an application form, and send to the Director of Research by 8th March 2019.