Laudatio on the occasion of the award, by the Oberwolfach Foundation and the Mathematisches Forschungsinstitut Oberwolfach, of the

2019 John Todd Award in Numerical Analysis to
Dr Euan Spence, University of Bath

Euan was an undergraduate and graduate student of mathematics at the University of Cambridge. He obtained his PhD in 2010 for work on “Boundary Value Problems for Linear Elliptic PDEs”, under the supervision of Professor Thanasis Fokas.

From 2009 to 2011 Euan was a post-doctoral research assistant at the University of Bath, working on “Boundary Integral Equation Methods for High Frequency Scattering Problems", a joint project with the University of Reading, funded by EPSRC, the UK Engineering and Physical Sciences Research Council. In 2011 he won a competitive EPSRC three-year personal Postdoctoral Fellowship to work on “New methods and analysis for wave propagation problems", after which he took up a permanent Lectureship, our name for an Assistant Professorship, at Bath in 2014. He was promoted to Reader, our name for an Associate Professor, in 2017. In October 2017 he was awarded an EPSRC five-year “Early-Career Fellowship", supporting his work and that of two postdocs, on a project entitled “At the interface between semiclassical analysis and numerical analysis of wave propagation problems". This award, more than 1 million Euros, was one of only 8 Personal Fellowships awarded in Mathematics, across all levels, in the UK in 2017. Euan is also an investigator for another award in 2018, on “Fast solvers for frequency-domain wave scattering and applications".

As suggested by these grant titles, Euan’s research has focused particularly on numerical methods and analysis for wave scattering and propagation problems. One thread of this work is rigorous analysis of existing numerical algorithms for the Helmholtz equation and generalisations such as the time-harmonic Maxwell system in the difficult high-frequency limit; the other thread is the design of new algorithms that are provably efficient in this limit. This work is in a mature and challenging area of numerical analysis, an area which is important in a huge range of applications, including radar and seismic imaging, non-destructive testing, and acoustic noise control; it is an area of research which has attracted the attention globally in the last 20 years of many of our leading numerical analysts and computational applied mathematicians, including, for example, the organisers of our Boundary Element Methods workshop this week!

Euan has made a series of contributions to this mature research area which have moved the field on in leaps and bounds, in both our theoretical understanding, and in new ideas and new formulations for numerical simulation. Many of these contributions have been unexpected, either because we did not think such things were possible, or for the extent of the step change in understanding.

In large part these contributions have happened because Euan has been the prime mover in efforts to bring to bear on numerical analysis for wave scattering the large, hugely relevant knowledge-base in the field of semiclassical analysis. This central area of research in PDEs, spectral theory, and mathematical physics, has itself attracted work over decades by many leading mathematicians, for example Richard Melrose, Cathleen Morawetz, Terence Tao, Michael Taylor.

It has been completely clear to many numerical analysts for many years that a synthesis of numerical analysis and semiclassical analysis ideas has large potential for impact on numerical analysis for wave problems. But, until the recent work of Euan and his collaborators, very little had been achieved by way of rigorous results, because of the huge

barriers for even the strongest numerical analysts in getting to grips with the language and deep methods of the semiclassical world.

Euan has, in several distinct strands of his work, brought analysis methods and results from this semiclassical world to bear on questions that have been opaque to our community for many years. He has shown how these new tools can be applied to crack long-standing numerical analysis questions; equally, he has surprised and inspired the semiclassical world, and entrained collaborators from that world, by the new uses to which their methods can be put. Very often he has applied these methods in novel ways, and shaped and improved them so that they give the sharpest results.

Let me finish with a couple of examples to illustrate these comments.

One significant tool that Euan has introduced to our community has been the use of Morawetz identities, developed by Cathleen Morawetz in the 70s at the Courant Institute to bound decay of solutions to the wave equation in non-trapping domains. This tool, used in several innovative ways, plays a key role in a number of his papers, for example establishing surprising frequency-explicit ellipticity results, indeed establishing these for operators that have hitherto been thought of as classical examples of highly indefinite differential and integral operators. I know that one of Euan's treasured experiences as a mathematician, one I'm really jealous of, was visiting Cathleen Morawetz at the Courant Institute a few years ago, when she was in her 90s, and discussing with her the new ways in which he had used her work.

He has brought to our community as well a range of other analysis techniques, including propagation of singularity methods of Melrose and Sjöstrand, parametrix estimates of Vainberg - and new sharp versions of these estimates - and new semiclassical results about the norms of restrictions to the boundary of quasimodes of the Laplacian, and how these depend in subtle ways on geometry and the underlying billiard flow. For example, using many of these methods, his recent, 2019 paper in Numerische Mathematik proves by some way the strongest results known to date regarding the convergence, uniform in the wavenumber, of classical h-BEM. This paper also contains the first ever results that rigorously quantify, uniformly in the step-size h and the wavenumber, the convergence of GMRES for the complex, non-Hermitian linear systems that h-BEM produces.

The importance and status of the results Euan has proved are reflected in the outlets where he has published. Indeed, I know of no other numerical analyst at his career stage who already has under his belt two CPAM papers, two SIAM Review papers, and an Acta Numerica paper, in addition to many papers in other leading numerical analysis journals.

He also has already on his CV an impressive list of conference and workshop invitations, for example last summer as plenary speaker in the large and influential Waves conference series, speaking at Waves 2019 in Vienna.

In conclusion, Dr Euan Spence is a very worthy recipient indeed for the 2019 John Todd Prize.