<u>WHITEHEAD PRIZE: citation for Maria Bruna</u>

Short citation:
Dr Maria Bruna, of the University of Cambridge, is awarded a Whitehead Prize in recognition of her outstanding research in asymptotic homogenisation, most prominently in the systematic development of continuum models of interacting particles systems.

Long citation:
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Bruna has developed a systematic asymptotic procedure to derive continuum partial differential equation models describing the collective motion of individuals. The standard mean-field approach always includes an ad hoc closure assumption. Such an approach works well for long-range interactions, but it fails for short-range interactions such as excluded-volume interactions. These arise from the mutual impenetrability of finite-size particles and are crucial in biological systems and confined geometries. Bruna's approach using matched asymptotic expansions solves this and shows how to incorporate finite-size exclusion effects into the continuum model in a systematic way.

Her extension of this initial analysis to multi-component systems highlights and explains two contrasting notions of diffusion in correlated systems: that of self-diffusion and collective-diffusion. These different notions of diffusion are often confused, and can lead to counter-intuitive effects (self-diffusion is impeded by excluded-volume effects, for example, while collective-diffusion is enhanced). Bruna's approach is able to explain both notions systematically with a single system of equations. Another generalisation of her results concerns the diffusion of finite-sized particles through confined domains (in which the effective diffusion coefficient depends in an interesting way on the relative size of the particles and the domain).

In addition to her work on particle systems, Bruna has made a significant contribution to the theory of asymptotic homogenisation in spatially varying media. This has important applications in engineering such as groundwater flow systems, membrane filtration and battery electrodes, where one looks for effective-medium models that can capture macroscopic variations (porosity gradients). Bruna has worked with industry to apply the techniques she developed in the context of air filtration, designing an optimal porosity profile in order to enhance the lifetime of porosity-graded filters.