IOP Institute of Physics

Physics in Food Manufacturing Group

NEWSLETTER **March 2018**

Issue no. 1

@Physicsoffood #Physicsoffood

See http://www.IOP.org/activity/groups/subject/pifm/newsletter/page_69795.html for further details

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Chair's report

Welcome to the first newsletter of the Physics in Food Manufacturing group.

I am delighted that the group's founding chair – Roger Eccleston – has written a guest Editorial for this first edition, particularly as Roger has had to step down due to increased work responsibilities.

This newsletter is issued now off the back of the success of the group organising its first international conference, and the second in the series of "Physics in Food Manufacturing". PiFM was formally inaugurated in May 2017 as an IOP Special Interest Group following much activity since 2015, these activities are noted in this newsletter.

We have decided to pronounce PiFM as **π FM**, courtesy Wilson Poon who first proposed this idea at his opening address at the Edinburgh conference.

We will issue at least one newsletter a year following our annual conference, and occasional newsletters in between when there is sufficient content to share. After 2 excellent conferences hosted by Universities (Sheffield Hallam 2017 and Edinburgh 2018), we are planning to alternate future conferences between Universities and "food companies" to strengthen engagement with food manufacturers of all sizes. So I'm delighted to confirm that our next conference will be hosted by Campden BRI (9-10 Jan 2019) in Gloucestershire.

We encourage all readers and your networks to engage with PiFM, whether to discuss joint workshops / conferences, link us to events perhaps outside our natural networks, or just to discuss application of interesting physics.

As a new group, we are particularly focused on making physics make more of an impact on food manufacturing's grand and not-so-grand innovation challenges. We look forward to extending our networks with you all.

John Bows, Chair

Editorial

It all started when I took a call from John Bows at PepsiCo (2015). At the time, I was Chair of the East Midlands Branch. John's enquiry was straightforward: "what can the IOP do to support food manufacturing"? I didn't know the answer but I was keen to find out, particularly given Sheffield Hallam's interest in Food Manufacturing, so I started making a few enquiries of my own. Alex Brabbs (Yorkshire and North East Regional Officer and Business Engagement Manager) and then Anne Crean (Head of Science and Innovation) were very quick to respond and gave energy and focus to this endeavour that has been critical to getting the Physics in Food Manufacturing Group (PiFM) off the ground and the summit, report and conference that preceded it.

Food manufacturing is the UK's largest manufacturing sector employing more than 400,000 people and contributing £28bn in GVA to the UK economy. The role physics plays in food manufacture is wide-ranging and critically important. From instrumentation to characterisation, modelling to process improvement; physics helps improve the efficiency with which food is manufactured and the quality of the product. As a consequence, food manufacturing can provide exciting and rewarding careers for physicists, as several of my colleagues on the committee of the Physics in Food Manufacturing Group have demonstrated.

The PiFM Group, brilliantly supported by colleagues at the IOP, has made excellent progress from John's phone call to a recent, successful, second annual conference. I am sad to have to step away at this exciting time but optimistic about the role that the PiFM Group can play in championing the important role Physics plays in food manufacturing.

Roger Eccleston, founding Chair of PiFM
PVC Research and Global Engagement
Sheffield Hallam University

Brief History of PiFM group

As Roger noted in his Editorial, we approached the IOP in 2015. Following a meeting with Anne Crean and Alex Brabbs in July, Anne very quickly set-up a "partners group" including physicists in the food industry (Rob Farr, John Melrose) and ran a series of engagement events.

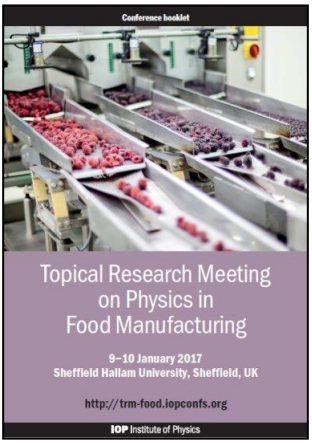
The first was a "Physics in Food Manufacturing" summit in April 2016 (London), well attended by physics researchers, academics and industrialists.

Rob Farr presenting at the 2016 summit meeting

Based on the outputs of the summit, the IOP published a report "The Health of Physics in UK Food Manufacturing", with a national launch event hosted at PepsiCo R&D (Leicester) in October 2016 (see page 11).

The publicity surrounding the IOP report led to the first-ever food feature edition of Physics World (Nov 2016), with the cover story on physics at the worlds' largest crisp factory (Walker's, Leicester, UK).

The IOP then funded the first "Physics in Food Manufacturing" conference as a Topical Research Meeting, in Jan 2017 at Sheffield Hallam University, again very well attended.



Following these successes, the partner's group then formally proposed to create an IOP Special Interest Group, which was inaugurated in May 2017 with the national launch event in September at IOP HQ. Current committee members are listed under Group Contacts in this newsletter.

PiFM group's first action was to organise the second "Physics in Food Manufacturing" conference at the University of Edinburgh in Jan 2018, summarised later.

John Bows

PiFM Purpose

Supporting research into areas of physics that impact on the food sector and encouraging collaborative research between academic and industrial physicists.

Promoting the role of physics in the food industry and ensuring that it is more widely understood that this is a field in which there are opportunities to conduct interesting and important research; promoting this fact to early career physicists and policy makers.

Providing a mechanism for physicists in the sector to feed into the IOP and have their views represented to funders and policy makers.

Activities

Organise an annual conference.

Engage with physics academia / other IOP groups e.g. host joint events

Engage beyond IOP (e.g. IChemE, STFC Food Network, Research Councils)

Publish newsletters

Engage early careers physicists

Report from PiFM Conference, 10-11 Jan 2018

The second Physics in Food Manufacturing Conference (the first one organised by the new PiFM committee) was held at the University of Edinburgh on the 10-11 January 2018. The conference covered the full range of physics from the technology of optical sorting machines to the mathematical modelling necessary to optimise the production of chocolate bars.

The invited speakers came from both industry and academia. Tim Kelf of the Buhler Group explained the technical challenges in detecting and removing substandard rice and grains as they flow. This includes rapid image analysis and then air streams to remove the grain. Beccy Smith of Mondelez presented the role of mathematical models in optimising the production of chocolate from bean to bar. The role of processing on gel forming ingredients was presented by Tim Foster from the University of Nottingham.

The menu of contributed talks ranged from hyper-spectral imaging, modelling of microwavable snacks, additive manufacturing and the uses of myco-protein waste. After a packed programme the conference dinner was held at the Playfair Library, including haggis, neeps and tatties. After dinner Lucinda Bryce-Gardyne founder of Genius Gluten Free entertained delegates with her journey to creating the Genius loaf, from 1000 recipe attempts in her to kitchen to the best-selling gluten free bread.

The second day opened with a talk on ice-cream by Unilever's Bill Frith. Possibly the most complicated material discussed at the conference. Frith convinced the audience that ice-cream is both a physicist's dream and nightmare. In the final invited talk Mike Cates gave a very elegant, graphical explanation of the role of friction in the flow behaviour of dense suspensions and what can be done about it.

Once again there was a broad range of submitted talks, including frozen emulsions by Katy Dickinson a PhD student from the University of Edinburgh who won the prize for the best student talk, model gluten gels and the physics of coffee extraction.

A poster session, tours of the facilities of the Edinburgh Complex Fluids Partnership and an exhibition rounded off the programme.

The conference was very well received, Dr Kate Adamson a patent attorney from Marks and Clerk wrote about her experience in the Scotsman. (https://www.scotsman.com/news/opinion/science-and-nutrition-offer-us-much-food-for-thought-1-4695691)

Two student prizes were awarded:

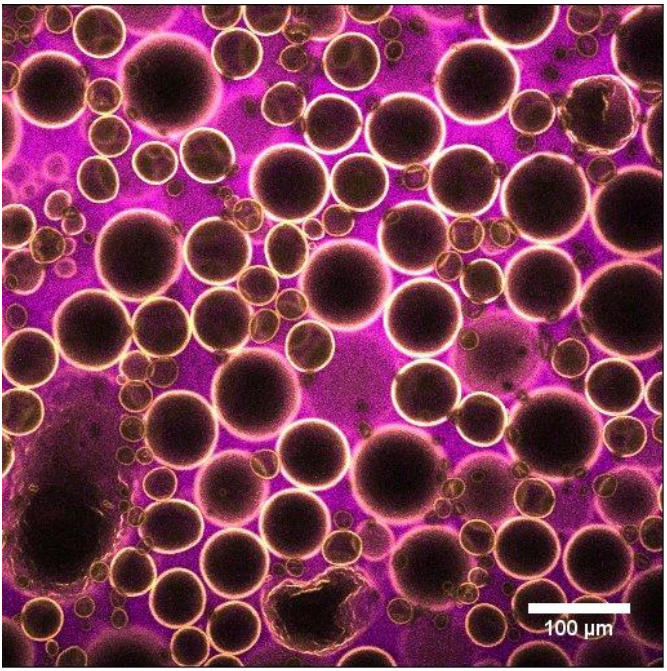
The prize for the best presentation went to **Katy Dickinson**, of Edinburgh University, for her talk on Pickering stabilization of emulsions under freeze-thaw cycles, which she describes below:

Particle-stabilised, or Pickering, emulsions are widely used in the food and personal care industries and are present in common household products such as homogenised milk and food spreads [1]. Within these industries, especially in the food industry, one of the common techniques for improving product shelf life and transportability is to freeze them. This has the potential to alter the taste of food products or the effectiveness of personal care or pharmaceutical products [2]. It is therefore important to understand emulsion behaviour and stability throughout the process.

In this research, we probed the changes in microscopic structure of model water-in-oil Pickering emulsions undergoing freeze-thaw cycles. Confocal fluorescence microscopy was used to allow simultaneous imaging of all three phases (water, oil and particles) as the oil phase freezes and thaws. During both uniform and non-uniform freeze-thaw cycles, we find that the emulsion structure is irreversibly altered as the droplets deform during freezing and are then jammed in those non-spherical shapes after thawing due to the stabilizing particles. The change is more significant in the non-uniform case as biliquid foam regions are formed which are absent from uniformly frozen samples.

Apart from elucidating the stability of particle-stabilised emulsions under industrially relevant processes, our results also help us to understand how hard materials (the ice crystals that form upon freezing) interact with soft materials at the microscopic level.

[1] T.N. Hunter, R.J. Pugh, G.V. Franks and G.J. Jameson, Adv. Colloid Interface Sci, 137, 57 (2008).
[2] S. Ghosh and D. Rousseau, Journal of Colloid and Interface Science, 339, 91 (2009).



Particle (yellow) - stabilised water (black) - in - oil (magenta) emulsion

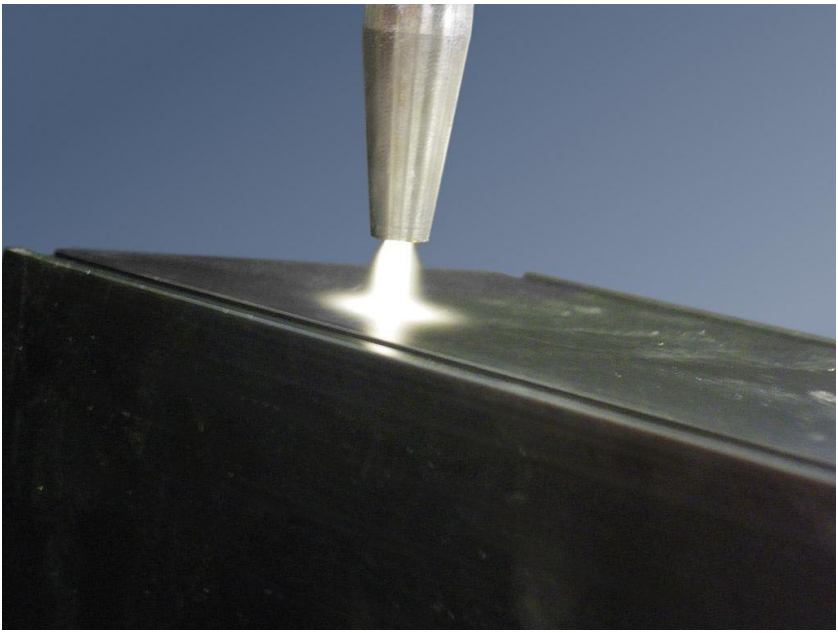
The prize for best poster was awarded to **Louis Free**, of Dublin City University, for his work on sterilization using plasma jets, under the title “Optical emission spectroscopy of an atmospheric pressure plasma jet and resulting anti-microbial properties”, which he describes as follows:

Atmospheric Pressure Plasma Jets (APPJs) have a growing role in the agricultural and food industries. Through the creation of reactive Nitrogen species (RNS) and reactive Oxygen species (ROS, collectively RONS), APPJs are increasingly being developed as an alternative method for the inactivation of micro-organisms, surface decontamination, enhanced germination and plant growth.

We developed an atmospheric pressure plasma jet system to investigate these properties. Using optical emission spectroscopy (OES), we were able to detect the generation of RONS including atomic Oxygen and atomic Nitrogen; the

precursors for RONS, the hydroxyl radical (OH) and nitric oxide (NO), species believed to be responsible for the antimicrobial properties of APPJs. The relative concentrations of these species were found to vary with the operating parameters of the plasma.

Black pepper cells, inoculated with Bacillus subtilis were treated with the APPJ to determine its anti-microbial efficacy. Using the plate count method, the number of colony-forming units (CFU) were measured at one hour, 24 hours and 48 hours after treatment.



Atmospheric pressure plasma jet
(original image by Acxys, under the creative commons attribution licence v3)

The next conference will be held 9-10 January 2019 at Campden BRI.

For further information: http://pifm2018.iopconfs.org/home

Details of the 1st conference at Sheffield Hallam University (Jan 2017): http://trm-food.iopconfs.org/home

Dr Anne Pawsey

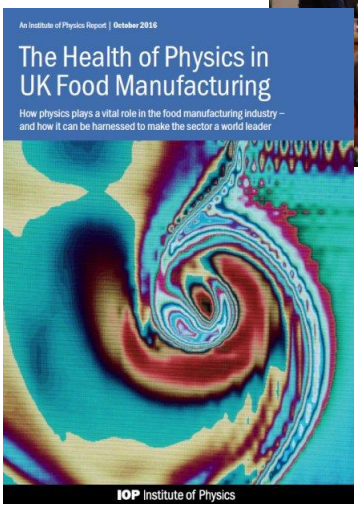
PiFM at Science and Food Manufacturing discussion meeting

The All-Party Parliamentary Group for Food and Drink Manufacturing and the Parliamentary and Scientific Committee held a joint meeting on 5 December 2017 to discuss science and innovation in the Food and Drink manufacturing sector

Introduced by Chairmen Stephen Metcalfe MP (for the Parliamentary and Scientific Committee) and John Stevenson MP (for the food and drink manufacturing APPG) examples were given of how science has and is transforming the food and drink industry.

Speakers were Prof Tim Foster (Director of EPRSC Centre for Innovative Manufacturing in Food), Dr Ian Noble (Mondelez), Helen Mundy (CSO, FDF) and John Bows (PepsiCo).

John presented a summary of IOP's report on the Health of Physics in UK Food Manufacturing report (Oct 2016).



The output of the meeting included a letter to the BEIS Minister reinforcing the case to boost funding to research and innovation in food manufacturing.

http://www.IOP.org/publications/IOP/2016/page_68332.html

John Bows

Scientific and technical needs of the food & drink supply chain

Campden BRI regularly provides a comprehensive survey of the technical needs of the food and drink industry. The latest edition has just been released, and although not all of the topics necessarily require physics solutions, the consultation provides a useful guide to where the industry needs lie and includes many topics where physicists can contribute.

Consultation with the food industry

“Scientific and Technical Needs of the Food and Drink Supply Chain” was compiled by Campden BRI based on consultation with its industrial members. It is the largest and most comprehensive consultation of the industry’s needs and involved over 600 face-to-face contributions as well as a survey of Campden BRI’s 2400 members in 75 countries, and many written submissions.

The consultation spanned the entire supply chain through primary production, raw materials and ingredients, manufacturing and supply, product and packaging, and food, drink and the consumer. It focussed on drivers of ‘safety’, ‘quality and value’, ‘nutrition, health and well-being’, ‘sustainability, resilience and food security’, and ‘skills and knowledge’.

Industry needs

Campden BRI has carried out the consultation every three years since 1996. Long-standing needs include assuring product safety, encouraging consumer well-being through healthy diets, protecting consumers from food fraud, tackling industry’s skills shortage, and encouraging sustainable practices and reduced use of resources. Newer topics in the current consultation included needs related to rising costs of operations and materials, soil health, human microbiota, anti-microbial resistance and cyber-security.

Within the Manufacturing and Supply area, needs fell under the headings of:

- Managing product safety hazards and risks in processing, distribution and sale
- Maintaining and enhancing quality through cost-effective process technologies
- Preserving and enhancing nutritional value in processing, distribution and supply
- Assuring efficient and resilient manufacturing and distribution
- Developing and maintaining skills, knowledge and “tools” in manufacture, retail and food service.

Many of the needs in this area could benefit from the application of physics as part of the solution. Examples include:

- Reliable detection and prevention of difficult-to-detect foreign bodies (e.g. plastic)
- Improvements to established and emerging technologies and processes for enhanced product quality, production efficiency and product safety.
- Better in-line and near-line analytical methods for relevant parameters.

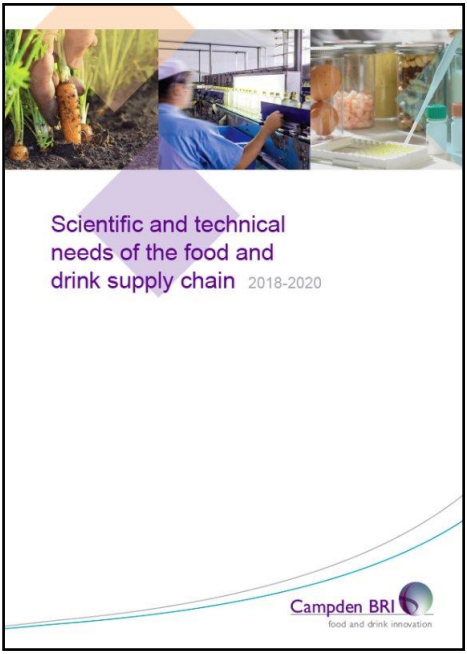
Several of the needs in the Skills and Knowledge category also seem well aligned with the objectives of the PiFM group, including:

- Simplified guidance on accessing research funds
- Promoting education and careers opportunities within the food, drink and allied industries.

Benchmarking and horizon scanning tool

The report is used in many ways. Companies use it as a benchmarking tool for their own strategies, to help with horizon scanning and to keep up-to-date with emerging challenges. It gives funding bodies, universities and research institutes insight into the range of challenges facing the sector – and through this targets for their resources. Previous versions have also been used by universities to give their students insights into the types of challenges they will face when they take up technical roles in the sector. We hope that PiFM members will find it useful.

https://www.campdenbri.co.uk/research/pdfs/needs2018.pdf

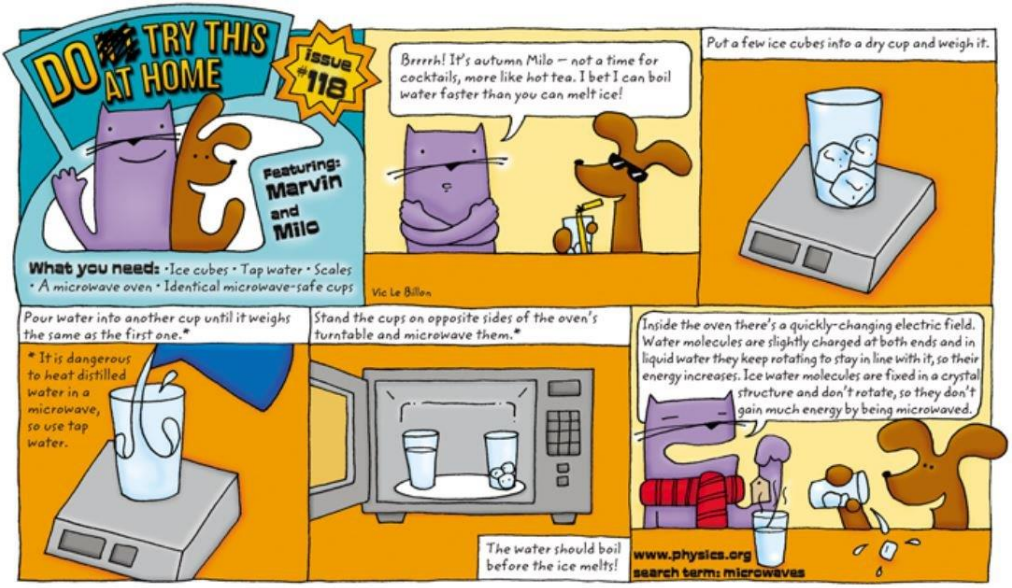


Dr Martin Whitworth

Physics in Food

We are looking for fun experiments to bring to life the physics behind everyday food & drink experiences, such as this one from IOP's Marvin and Milo series …

Microwave Marathon



What you need	Instructions	Results & explanation
Ice cubes Tap water Scales A microwave oven Identical microwave-safe cups	Put a few ice cubes into a dry cup and weigh it. Pour water into another cup until it weighs the same as the first one (it is dangerous to heat distilled water in a microwave, so use tap water). Stand the cups on opposite sides of the oven's turntable and microwave them. The water should boil before the ice melts!	Inside the oven there's a quickly-changing electric field. Water molecules are slightly charged at both ends and in liquid water they keep rotating to stay in line with it, so their energy increases. Ice water molecules are fixed in a crystal structure and don't rotate, so they don't gain much energy by being microwaved.

http://www.physics.org/marvinandmilo.asp?id=117

Group Contacts

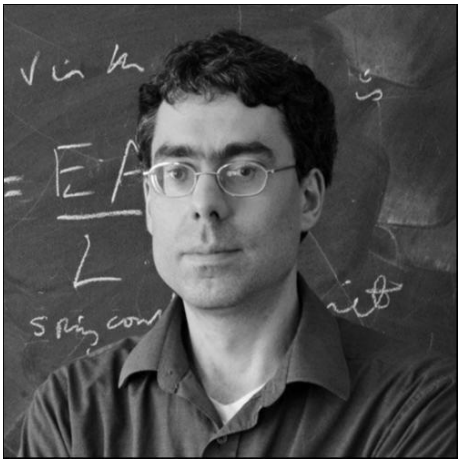
John Bows, Chair

John Bows is an R&D Director within PepsiCo Global Snacks R&D, working on new process development. After graduating with a Physics degree from Exeter University, John spent 14 years at Unilever R&D before joining PepsiCo in 2005.

John works on application of “field physics” process technologies to create great tasting & healthy snacks.

Aspirations for PiFM
Physics is under-represented amongst the usual skill sets (Engineering, Chemistry, Food Science, Nutrition) employed within food & beverages R&D, hence physics academia and physics graduates rarely appreciate how interesting and rewarding the challenges are in food manufacturing. I hope PiFM can be a change agent to encourage more physics academics to work on our challenges, and graduates to develop life-long careers in food manufacturing.

Dr Rob Farr, Treasurer



Dr Robert Farr is a physicist at Jacobs Douwe Egberts, based at Banbury in Oxfordshire. For the past 20 years he has been helping to solve problems in materials science, heat & mass transfer and processing. His interests lie in the theory and simulation of the relation between the structure and the mechanical, thermal and diffusive properties of materials. As well as his research role at JDE, he is a visiting fellow at the London Institute for Mathematical Sciences.

Aspirations for PiFM
Food processing is full of grand old unit operations that have been run successfully for decades, but never fully understood nor well optimised. Physics may give us the opportunity to unlock that hidden potential.

Dr John Melrose, Secretary

John worked as an academic soft matter physicist until 2000. Then John joined industry Unilever, Kraft, Mondelez and lastly Jacobs Douwe-Egberts. Between management tasks, I found time to apply my physics to a range of problems in food micro-structure and engineering. I am now a retired consultant.

Aspirations for PiFM
One reason I strongly believe and support this new IOP group, is that whilst physics brings much to foods research, I know, from experience, that food research challenges in turn offer a variety of opportunities to develop both new physics and to engage the skills of a physicist.

Dr Anne Pawsey
Early Career Champion

Anne Pawsey works for Edinburgh Complex Fluids Partnership, part of the Soft Matter Physics Group, University of Edinburgh as Impact Acceleration Associate; using soft matter physics to solve industrial challenges.

Anne has an MSci in Physics from the University of Bristol and a PhD from the University of Edinburgh. Following her PhD Anne worked as a post-doctoral researcher at the University of Aberdeen working on encapsulation for functional foods. In 2013 she was awarded the IOP/Shell Very Early Career Women in Physics Award in recognition of her outreach

Aspirations for PiFM
I hope the group can highlight that there are interesting research questions and opportunities for early career researchers from across physics in the food manufacturing sector.

Dr Beccy Smith

Dr Beccy Smith leads the Modelling & Simulation group at Mondelez International. She joined the company when it was Cadbury, 16 years ago, following her PhD in Theoretical Condensed Matter Physics from the University of Birmingham. She is a keen promoter of science to children: having started up a company to create science & maths magazines for children, and presented a regular science slot on Blue Peter. Beccy is also very interested in food & sustainability: she lives with her three children & partner in a self-built eco-house on their smallholding with polytunnels, rare-breed sheep and poultry.

Aspirations for PiFM
I am hopeful that PiFM can serve the dual purpose of encouraging more physicists to take an interest in the exciting & complex physics of food, and of encouraging more food companies to reap the benefits of employing more physicists.

Prof Malcolm Povey

Malcolm is a Physicist and Food Scientist who has worked with the Food Industry since 1976. In addition to being a prolific innovator of ultrasound instrumentation and processing equipment, he is co-Director of the Leeds-Jiangsu Food Sensing Laboratory which aims to deliver low cost, mass produced sensors for monitoring the entire food chain from soil to sewage. He developed with Stable Microsystems the standard industry technique for the objective measurement of crispness and crunchiness.

Aspirations for PiFM
To transform Food Processing in the UK so that it becomes the best in the world, producing high quality food, economically and sustainably. To enable food consumers with the best science so that appropriate and healthy choices can be made, and so that we neither simply eat to live or live to eat. To enhance the experience of eating through improved understanding of our human sensory appreciation of food.

Dr Felix Oppong

Felix is a Research Scientist / Rheology Expert at Unilever R&D, Colworth Science Park, Sharnbrook, UK since 2009. I hold an MSc in Physics from the Memorial University of Newfoundland in Canada and a PhD in Physics from the University of Western Ontario, Canada. My main area of expertise is the rheology of soft matter, in particular food materials. He applies physical principles to study the correlation between the microstructure of complex fluids and their bulk behaviour such as flow, texture and physical stability. Impact of processing conditions on the microstructure and rheology of food materials is also of interest.

Aspirations for PiFM
Physics is critical to food innovation but this is often overlooked in favour of other disciplines. My involvement in PiFM is to help raise the awareness of the many physical challenges encountered in food innovation with the view of triggering research collaborations to tackle these challenges. I am also keen to contribute to the training of next generation physicists to work in the food industry.

Prof Sarah Bridle

Prof. Sarah Bridle is a Professor of Astrophysics at the University of Manchester and lead of the new STFC Food Network+, which brings together food research and industry with STFC capabilities from astro, particle and nuclear physics and the UK's largest science facilities. Most of her work so far has focussed on trying to uncover the nature of dark energy using gravitational lensing.

Aspirations for PiFM
I am passionate about the potential for physicists to get involved in transformational food research and industry innovation, particularly at a time when we need new ideas to meet the challenge of producing more food in the face of a changing climate, while producing less greenhouse gas emissions.

Prof Thomas Krauss

Professor of Photonics and University Research Champion “Technologies for the Future”
Prof Krauss leads the Photonics research group at the University of York where he also oversees the University strategy relating to novel technologies. He has led a number of EU and EPSRC projects in fundamental and applied aspects of photonic crystal devices, such as slow light, optical interconnects and, more recently, biosensing. His current focus is to explore novel physical concepts for the detection of biomarkers and the characterisation of bacteria, both in a healthcare and a food context. He has published 300 refereed journal articles and holds 6 patents. Prof Krauss is a Fellow of the Institute of Physics, the Royal Society of Edinburgh and the Optical Society. In 2015, he was awarded a Royal Society Wolfson Merit Award.

Aspirations for PiFM
Thomas is particularly interest in exploring the requirements of the food industry in the context of biophysics research, antimicrobial resistance and by making links to the N8 Agri-Food and the STFC+ networks.

Prof Doug Cleaver

Doug Cleaver is Professor of Materials Modelling and Director of the Doctoral School at Sheffield Hallam University. His research is focused on utilising computational approaches to investigating soft matter systems and self-assembly processes. As well as attracting research-council funding, he has undertaken numerous industry-funded projects with partners including HP, Seiko-EPSON, QinetiQ and Unilever. Through this, he has applied fundamental research approaches to industrially relevant scenarios such as display devices, composite binders and food systems. In 2012, he was awarded the Hilsum Medal of the British Liquid Crystal Society.

Aspirations for PiFM
Bring together scientists and engineers (particularly research students) from a range of disciplines to enable them to develop disruptive, multidisciplinary solutions which improve understanding and realisation of food systems.

Dr Martin Whitworth

Martin Whitworth is a Principal Scientist in Campden BRI's Production and Processing Research Department. He has a PhD in Physics from Cambridge University. He specialises in physical characterisation of food products and raw materials, with particular emphasis on imaging technologies including measurement of colour and appearance, hyperspectral NIR imaging of composition, and X-ray micro CT of food structure. Martin carries out research in cereal science and technology. He is a leading expert on bubble structure of doughs and baked products and is the inventor of the C-Cell instrument for measurement of bread quality.

Aspirations for PiFM
I hope that PiFM will demonstrate that the food manufacturing sector presents many interesting technical challenges, inspiring more physicists to work in this sector and to help develop solutions to improve the quality and safety of our food.

Prof Wilson Poon

Wilson Poon is the Professor of Natural Philosophy at the University of Edinburgh. He is internationally known for his work using very well characterised 'model' colloids to study phenomena that are ubiquitous across condensed matter and statistical physics, particularly the structure and dynamics of arrested states such as glasses and gels.

Understanding such states is a grand challenge facing 21st century physics; at the same time, they occur widely in a very large range of industrial processes and products. To exploit the latter connections, Wilson set up the Edinburgh Complex Fluids Partnership (ECFP) a few years ago to coordinate industrial consultancy. ECFP clients now span many sectors, from food and confectioneries through personal care to speciality and agri-chemicals.

Dr Marco Ramaioli

Marco Ramaioli is Senior Lecturer at the University of Surrey. Marco obtained a doctorate “ès sciences” from EPFL, Switzerland with a thesis on the simulation of granular media flow and their application to food processes.
As a Process Modelling Specialist at Nestlé R&D, he focused on coupled heat, mass and momentum transfer phenomena in food processes, leading to the launch of many new products and five patents.
As a Senior Research Scientist at Nestlé Research, he studied powder-liquid flows, the dissolution of food powders and the biomechanics of human swallowing.
His research considers the effect of process conditions on food physical properties and function and current projects focus on wetting phenomena, food oral processing, food 3d printing and the drying of emulsions.

Aspirations for PiFM
Food and eating habits play a pivotal role in promoting health and wellbeing in a sustainable society. PiFM should i) promote the use of physics to solve these societal challenges ii) disseminate the passion for physics by leveraging on the emotional bond to food and on the interesting scientific challenges arising from understanding food production and consumption.

This newsletter is also available on the web and in larger print sizes

John Bows is an employee of PepsiCo Inc. The views expressed in this presentation are those of the author and do not necessarily reflect the position or policy of PepsiCo Inc.

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