
IOP**Institute of Physics****Physics in Food****Manufacturing Group**

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See <http://www.iop.org/activity/groups/subject/pifm/index.html> for further details

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Chair's report

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

We have just had the third in our conference series “Physics in Food Manufacturing” hosted at Campden BRI. With probably our strongest programme yet, including a careers panel for the first time, we continued to showcase the role of physics and a physicist's approach in solving diverse challenges in the food and drink manufacturing sector. Read more in the conference report including prizes for best student poster and presentation.

After excellent conferences hosted by Universities (Sheffield Hallam 2017 and Edinburgh 2018), and now Campden BRI in 2019, I'm delighted to confirm that our next conference will be hosted by Leeds University in January 2020.

PiFM was also busy at various external food and physics conferences, with several of the committee organising and presenting their perspectives and research, read more of this later.

A recent [article](#) by the National Center for Universities and Business discussed the “(un)employability of physics graduates in technical careers”, based on a report from the 2018 “Physics Graduate Employability” [workshop](#). Interesting reading for anyone involved in physics, highlighting the need for University / Industry collaboration to align graduate skills and knowledge with innovation needs. PiFM will continue to support bridging this gap.

Following publication of the UK [Industrial Strategy](#) in 2017, the KTN's Food Sector Group produced a [paper](#) in Feb 2018 to define clear priorities and needs for pre-competitive and industrial R&D in the food and drink sector.

EPSRC [revealed](#) in Feb 2019 the 75 University-based Centres for Doctoral Training (CDT) which got £446mn funding over the next 5 years, from the [200 applicants](#) who submitted full CDT proposals mid-2018. Only 16 submissions included a food/nutrition aspect (spanning agriculture to manufacture), of which 5 got funded. PiFM offered non-financial letters of support to 6 submissions, of which 2 were funded.

Clearly PiFM has a continuing role to play in elevating the UK's largest manufacturing sector and its core science challenges amongst the academic community and UK research funding agencies. During 2019 PiFM committee will be reaching out to Professional Body food groups (IChemE, RSC, IFST, FDF etc.) to identify collaboration opportunities which support this need.

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

As a new group, we are particularly focused on helping 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

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, 9-10 Jan 2019

Conference website with abstracts and programme downloads:

<http://foodphysics2019.iopconfs.org/home>

The third Physics in Food Manufacturing Conference was held at [Campden BRI](#), an independent provider of research, training and technical services to the food and drinks industry, and which this year celebrates its centenary, as CEO Professor Steven Walker announced to an audience including delegates from major food manufacturers, universities and technology companies.



The conference demonstrated the rich diversity of applications of physics to food manufacturing, from study of fat microstructure, wetting of powders, and modelling of coffee extraction, through measurement technologies to verify food authenticity, modelling of industrial processes to achieve savings in cost and materials, to human diet and nutrition.

Further reviews published on PhysicsWorld.com:

<https://physicsworld.com/a/physics-and-food-a-multidisciplinary-melting-pot/>

<https://physicsworld.com/a/a-smorgasbord-of-food-science-innovation/>

In addition to oral presentations, this two-day conference included a poster session, exhibits, tours of Campden BRI's laboratories and food processing facilities, and a Careers Panel session. The panel comprised Bertrand Emond from Campden BRI, Beccy Smith from Mondelēz and Arwen Tyler from Leeds

University. Bertrand introduced the session with some [UK food industry statistics](#) including the fact that the industry will need 140,000 new recruits by 2024. There is a demand for talented scientists and technologists in the industry and, as the conference demonstrated, there are challenging opportunities for physicists. Beccy and Arwen presented summaries of their own career paths as physicists working on food applications in manufacturing and academia respectively. The subsequent group discussion highlighted a range of resources, some of which are listed in the [Careers Links](#) section of this newsletter.

A thought-provoking session on Fats, lipids and nutrition challenged several established assumptions. Kevin Smith challenged some of the evidence for links between fat consumption and mortality from cardiovascular disease and Andrew Preece finished the session with a presentation examining the effectiveness of calorie restriction for control of body weight and advocating a more sophisticated approach based on metabolic health. The session also included a demonstration from Megan Povey of how ultrasound can be used to control fat crystallization for food processing. High power systems cause cavitation which can lead to off-flavours. In a fascinating video, Megan showed crystallisation from a melt instead achieved using low-power ultrasound. The session also included presentations on the microstructure of fats, a topic also addressed by Arwen Tyler in a session dedicated to Food microstructure.

Grant Campbell presented applications of physics to processing of wheat, including the particle size distribution in milling, and gas bubble creation in dough mixing. Further presentations on food microstructure included study of a soybean derived protein as an alternative to synthetic or animal-derived emulsifiers, and Mingduo Mu and Marco Ramaioli both spoke about reconstitution of food products from dried powders. Mingduo focused on the stability of freeze-dried emulsions, and Marco considered the effects of wetting properties on how to achieve effective reconstitution of powders in liquids.

Another theme of the conference, both in the presentations and exhibits was physical measurement of foods. Roy Goodacre spoke on the problem of food fraud and how to test the authenticity of food products. One approach is Raman spectroscopy, for which hand-held devices are now available and spatially offset Raman spectroscopy (SORS) provides the potential to measure through packaging. The talk was nicely complemented by Luen Yan Wong of exhibitor Renishaw who spoke on further applications of Raman spectroscopy in an imaging mode to study chocolate and bubble gum. In a presentation awarded the prize for best student presentation, Zachary Glover spoke on the use of super-resolution microscopy and ultrasound spectroscopy applied to dairy gels. A more detailed summary of Zachary's presentation is included later in this newsletter. Also in the measurement session, Rob Alfano spoke about the challenges of inspecting closures on bottles and cans on production lines at rates of up to 6M

containers/hour and Imran Mohamed described a comparative evaluation of several 3D imaging technologies to measure wheat ears in trial plots, subject to the challenges of an outdoor environment. Two presentations featured hyperspectral imaging. I presented applications in the short wave infrared range to map composition in foods, such as moisture migration over shelf life and variations in raw material quality between individual wheat grains, cocoa and coffee beans. John Gilchrist of exhibitor Camlin Photonics, a manufacturer of hyperspectral systems, spoke about the widespread potential of this technology in practical food manufacturing.

The final session featured applications of modelling in the food industry. Ritchie Parker showed the breadth of practical applications of modelling at Nestlé. Examples included redesigning a carton to double its strength while achieving a 300 tonne/year saving in material, and vibrational analysis to identify and develop a solution to a failure mode in cyclones that was causing losses equivalent to over \$1M/year in some factories. Other applications included modelling logistics for factory lines and using simulations of food process control systems to train operators. John Melrose presented work on modelling molecular release from coffee during brewing, including the effects of particle size distribution and the porosity of the particles. Julia Yeomans drew a fascinating conference to a close with some amazing computer simulations of bacterial locomotion and colony growth, demonstrating in one simulation an explanation for why bacteria swim faster in a denser medium and, in another which modelled bacteria as a liquid crystal, how topological defects explain effects on colony growth.

Two student prizes were awarded:

Best student presentation: Zachary Glover, University of Southern Denmark, Investigation of the reconstruction, structure and formation of dairy systems and gels

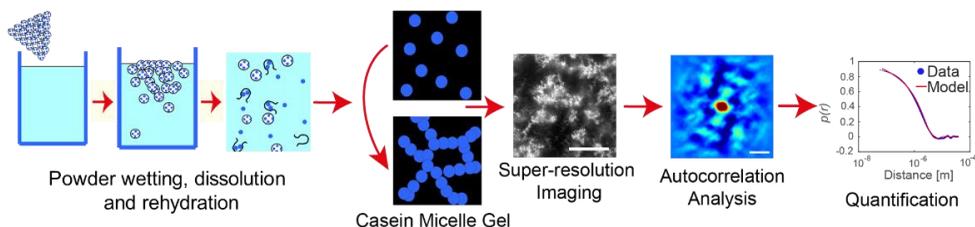
Best student poster: Liam Morris, University of Leeds, Determination of the Metastable Zone Width in α -glycine solution by Ultrasound Reflection Spectroscopy.

The next conference will be held at Leeds University in January 2020.

Martin Whitworth

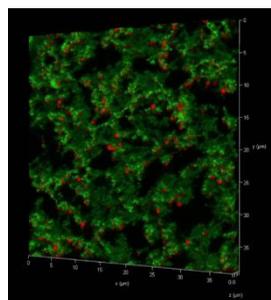
Prize-winners from the PiFM Conference

The presentation prize was awarded to Zachary Glover, for his talk “Investigation of the reconstitution, structure and formation of dairy systems and gels: Use of Super-resolution microscopy and Ultrasound Spectroscopy.” The judges were particularly struck by the wide range of imaging techniques used - many novel to this application. These provided not only beautiful graphics, but in-depth information about milk powder structure and dynamics. The work was a collaboration with a number of colleagues at the University of Southern Denmark, the University of Leeds, UK and Arla Foods. Zachary writes:



The structure and formation of dairy products provide systems in which nano-scale components undergo complex interactions to form structures with a multitude of macroscopic properties. A combination of Super-resolution imaging and Ultrasound spectroscopy has been applied to gain an understanding of the dynamic process of powder rehydration and the final microstructure in dairy gels.

Stimulated Emission Depletion (STED) microscopy has been used to image dairy gels from fresh and reconstituted skim milks. Protein structures have been resolved to 100 nm without having to fix or dry the sample. Quantitative image analysis has been developed to allow the microstructural network to be described with several parameters including the size of protein domains, inter-pore distance and fractal dimension. This image correlation-based analysis method has many potential applications to quantifying different porous, fractal or multi-component systems. Coherent Anti-Stokes Raman Scattering (CARS) microscopy provides a label free negative control for the use of a fluorescent dye required for STED imaging.



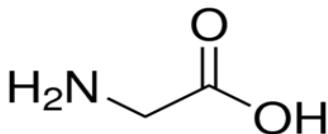
3D reconstruction of dairy gel, using STED

The speed of sound and acoustic attenuation are dependent on the physical properties of a material and therefore changes in these properties can be monitored over time. Ultrasound Reflection Spectroscopy and Acoustic

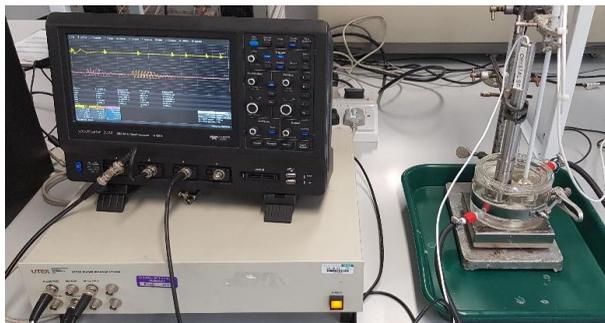
Attenuation Spectroscopy have been used to monitor such changes occurring during rehydration of dairy derived powders. The frequency dependent attenuation spectrum provides unique measurements on concentrated colloidal dispersions without requiring dilution. Effective combination of these techniques provides a unique insight into the entire process of characterising a reconstituted dairy derived gel with novel temporal and spatial resolutions.

The poster prize was awarded to Liam Morris, from the University of Leeds, for his work on “Determination of the Metastable Zone Width in α -glycine solution by Ultrasound Reflection Spectroscopy.” The judges found his discovery of anomalous ultrasound attenuation before crystals had nucleated to be fascinating and suggestive of unsuspected dynamics in this regime: surprisingly, the structure of the solution changes detectably before actual nuclei have formed. Liam writes:

The work presented shows the crystallisation of glycine, specifically the α polymorph. The aim of this work was to determine the metastable zone width (MSZW) of this polymorph.



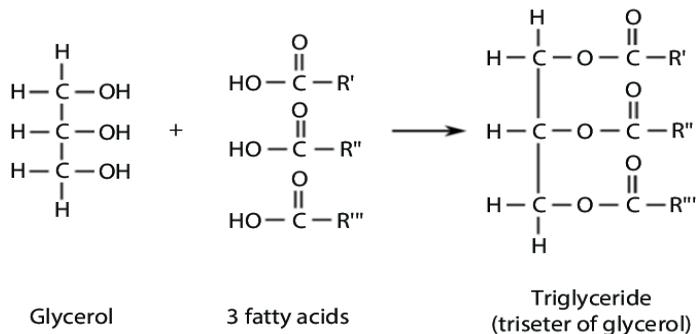
During the work an interesting phenomenon occurred. This was a fluctuation in the speed of sound of the sample before visible crystallisation had occurred. It is thought that this is due to localised fluctuations in the adiabatic compressibility. This suggests the transient formation of solid material which has not reached a critical radius large enough to support crystal growth.



The ultrasound device used is a novel design. URS is a pulse echo technique which utilises low-powered ultrasound. By having a short pulse life time (ns), it allows events of a very small time duration to be studied. The time of flight in a quartz buffer rod and the

sample were measured, as well as acoustic attenuation. The two combined provide an excellent toolbox in the study of phase changes. The data can be used to determine solid volume fraction, solid fat content, density of the sample, melting point of fats and can be used as an extremely accurate thermometer recording temperature to 10 significant figures.

URS is also being used to study fat crystallisation. The work with glycine is a proof of concept study. This device is novel and glycine presents a good model system in which to see what the device is capable of.



The study of fat crystallisation will determine whether different molecular structures of triglycerides have different behaviours with regards to their phase transitions. We are currently using the technique to study emulsions, but it will also be used to study pure melted fats, and this device can ultimately be used in food manufacturing procedures as a means of non-destructive process monitoring.



Zachary Glover
Winner: Best student presentation



Liam Morris
Winner: Best student poster

Vacuum in Food conference co-sponsored by PiFM



In October 2018, PiFM jointly sponsored the “Vacuum in Food Manufacturing” session of the 9th Vacuum Symposium UK, which took place at the Ricoh arena in Coventry. Vacuum physics, like food physics, is a crossroads for many different disciplines in the physical and biological sciences, and the session on food applications (chaired by Prof. Hazel Assender of the materials group at Oxford University) didn’t disappoint, bringing together a wide range of talks on both methods and applications.

The Ricoh arena is home to the “Wasps” rugby football club, and for those who haven’t been there, is a vast building with a slightly post-apocalyptic feel outside, when approached on a day without a match. However, once inside, the cavernous exhibition area was full of polished steel vacuum equipment and coloured lights (from the concurrent symposium on laser optics), and abuzz with enthusiastic engineers and physicists.

The Foods session was in a more cosy lecture theatre, under the main hall, and featured a range of excellent talks: A presentation on vacuum cooling was given by Pierre Lantheaume (Leybold GmbH), and was eye-opening as to the range of applications, as well as raising interesting questions about moisture transport through complex microstructures. Zachary Glover (SDU, Denmark) talked about spray-drying of dairy powders, and brought a range of novel-to-the-field techniques to bear, including stimulated emission-depletion microscopy (STED), and scanning helium ion microscopy (the latter providing advantages over the more traditional scanning electron microscopy: high resolution, great depth of field, and the ability to mill the sample back, to expose internal structure). Finally, Glen West (Manchester Metropolitan University) spoke about the development of transparent barrier films for foods. These are based on aluminium oxide (or nitride) formed as nanometre-thick, vacuum-deposited layers on polymer films. They require consideration not just of the deposition process (and maintaining quality on large rolls produced at high speed), but also bring in contact mechanics, since the small particles used to prevent film-to-film adhesion on the final rolls can also damage the inorganic layer.

The 10th symposium is being planned now (see [here](#) for the website), will take place at Coventry on the 9th and 10th October 2019, and will once more be free of charge to attendees (except for training sessions).

Rob Farr

PiFM Committee Members at external events during 2018

Sarah Bridle represented PiFM at the “**Priming Food Partnerships**” [event](#) organised by BBSRC (15 Mar 2018, Birmingham).

The [launch](#) conference of IOP’s “**The Health of Photonics**” report on 16 May 2018 was attended by John Bows, who presented “Photonics in Food Manufacturing” as part of a session on photonics solving industry challenges.

The **N8 Agri-Food Annual Conference** 2018 (13-14 June, Liverpool) ran a parallel panel session on “Physics in Food” chaired by PiFM committee members Sarah Bridle and Thomas Krauss.

The panel included two presentations from PiFM committee members (John Bows and Beccy Smith) who discussed physics in food manufacturing challenges.

The biennial [conference Photon 2018](#) (3-6 Sep, 2018), organised by several IOP groups, ran on a session on “Photonics for the food and agri-tech industry” as part of the Industry Technology Programme. John Bows attended and presented on “physics in food manufacturing”.

The [3rd Edwards Symposium](#) – **New Horizons in Soft Matter** (5-7 Sep, 2018) – was sponsored by Unilever with a programme highlighting latest developments in soft matter science with a strong fundamental physics focus. In a Soft Matter Industry Challenges session, John Bows presented on Physics in Food challenges ([download](#)).

PepsiCo first food company to win an IOP Award

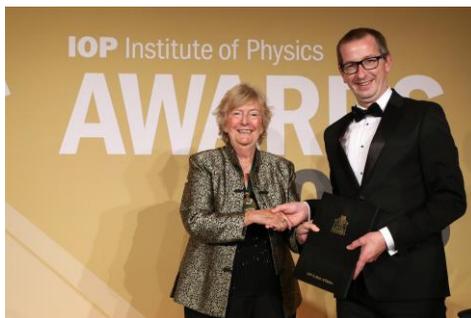
[PepsiCo](#) was the first food company to win a prestigious IOP 2018 Business Innovation Award.

A soft matter physics approach was applied to the development of new snack products for consumers in emerging markets (including India, Thailand, and Indonesia), unlocking significant cost reductions (sales price of £0.05 per bag) and a reduced reliance on raw materials imported from Europe.

Lay's is one of the world's largest food brands and is aspirational to consumers everywhere seeking an assurance of safety, quality and great taste.

To meet the needs of consumers on product design (Lay's branding) and cost, the project team demonstrated that potato-character products need not rely on high potato formulations, requiring a new framework to address the challenge by understanding the process in a new way.

In collaboration with Prof van der Sman (Wageningen University), the team applied soft matter physics tools such as Complex Disperse System methodology with fundamental characterisation methods such as microscopy, to define and understand ingredient and product functionality from a microstructural perspective.



Dr James Williams (project leader) receiving an IOP Award from Prof Dame Julia Higgins (IOP President) at the Awards Dinner on 20th November 2018



John Bows

Careers Links

- Emma Weston at Nottingham University has prepared an interactive tool on [Competencies for Food Graduate Careers](#).
- Tasty Careers in food and drink: <https://tastycareers.org.uk/>
- Graduate Recruitment Bureau: [food industry](#)

Food companies offering placements

- PepsiCo R&D – [student placements](#) (UK R&D, Leicester) are posted Oct-Nov for 12 month placement starting July in the following year.
- Unilever R&D offer [12-week placements](#)
- Mondelēz offer [internships and traineeships](#)

Training courses

Campden BRI provides a wide range of courses, tailored training, conferences and seminars for the food industry [Campden BRI training courses and events](#)

The AgriFood Training Partnership [AFTP](#) based at the University of Reading provides short courses.

Food industry professional bodies

Institute of Food Technologists (IFT) <https://www.ift.org/>

Institute of Food Science and Technology (IFST) <https://www.ifst.org/home>

European Federation of Food Science and Technology (EFFoST) <https://www.effost.org/default.aspx> “facilitates knowledge and technology exchange among food professionals.”

Food & Drink Federation (FDF) <http://www.fdf.org.uk/>

Student competition

Ecotrophelia UK <https://www.ifst.org/ecotrophelia> is the national competition for the creation of eco-innovative food products. The winning UK team goes on to represent the UK at the European final and in 2017 went on to secure the silver award. It would be great to see a Physics student on one of the teams. Closing date for this year's competition is **29 March 2019**.

Finally Physics

Finally, we highlight more unusual physics stories, experiments, features ...

International Physicists' Tournament

17 problems are created each year, and teams of students gather to compare their solutions. Food challenges included devising a method to estimate popcorn kernel jump height based on the sound of the pop, stirring a cup of tea with a tea spoon of honey at the bottom, and making fruit/vegetable powered radios.

<http://2019.iptnet.info/problems/>

Solving your scientific identity crisis

Physics World (Dec 2015) featured in their *Lateral Thoughts* off-beat physics essays a flowchart to allow readers to determine if they are actually a physicist or an alternative scientist.

<https://physicsworld.com/wp-content/uploads/2015/12/PW-WKOSAY-infographic-web.png>

<https://physicsworld.com/a/solving-your-scientific-identity-crisis/>

Experiments

The Royal Institution have many videos on YouTube of interesting science experiments, such as why diet soda floats and regular soda sinks ...

<https://www.youtube.com/watch?v=KatJF4ejSj8>

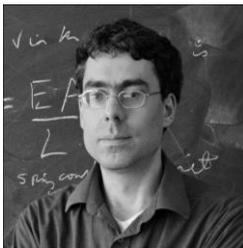
The Institute of Physics have a website physics.org and a food physics section ...

<http://www.physics.org/food-physics/>

Group Committee Contacts



John Bows, Chair
PepsiCo



Dr Rob Farr, Treasurer
Jacob Douwe Egberts



Dr John Melrose, Secretary



Dr Beccy Smith
Mondelez International



Prof Megan Povey
Leeds University



Prof Wilson Poon
University of Edinburgh



Prof Sarah Bridle
University of Manchester



Prof Thomas Krauss
University of York



Prof Doug Cleaver
Sheffield Hallam University



Dr Martin Whitworth
Campden BRI



Dr Felix Oppong
Unilever



Dr Anne Pawsey
University of Glasgow



Dr Marco Ramaioli
INRA (from May '19)

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

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The Institute of Physics, 37 Caledonian Road, London N1 9BU.

Tel: +44 (0)20 7470 4800

Fax: +44 (0)20 7470 4848