Faculty of Natural & Mathematical Sciences
Department of Physics

KING'S College LONDON

Nanostrand

The Photonics & Nanotechnology Research Group
The Biological Physics & Soft Matter Group
Review of 2019

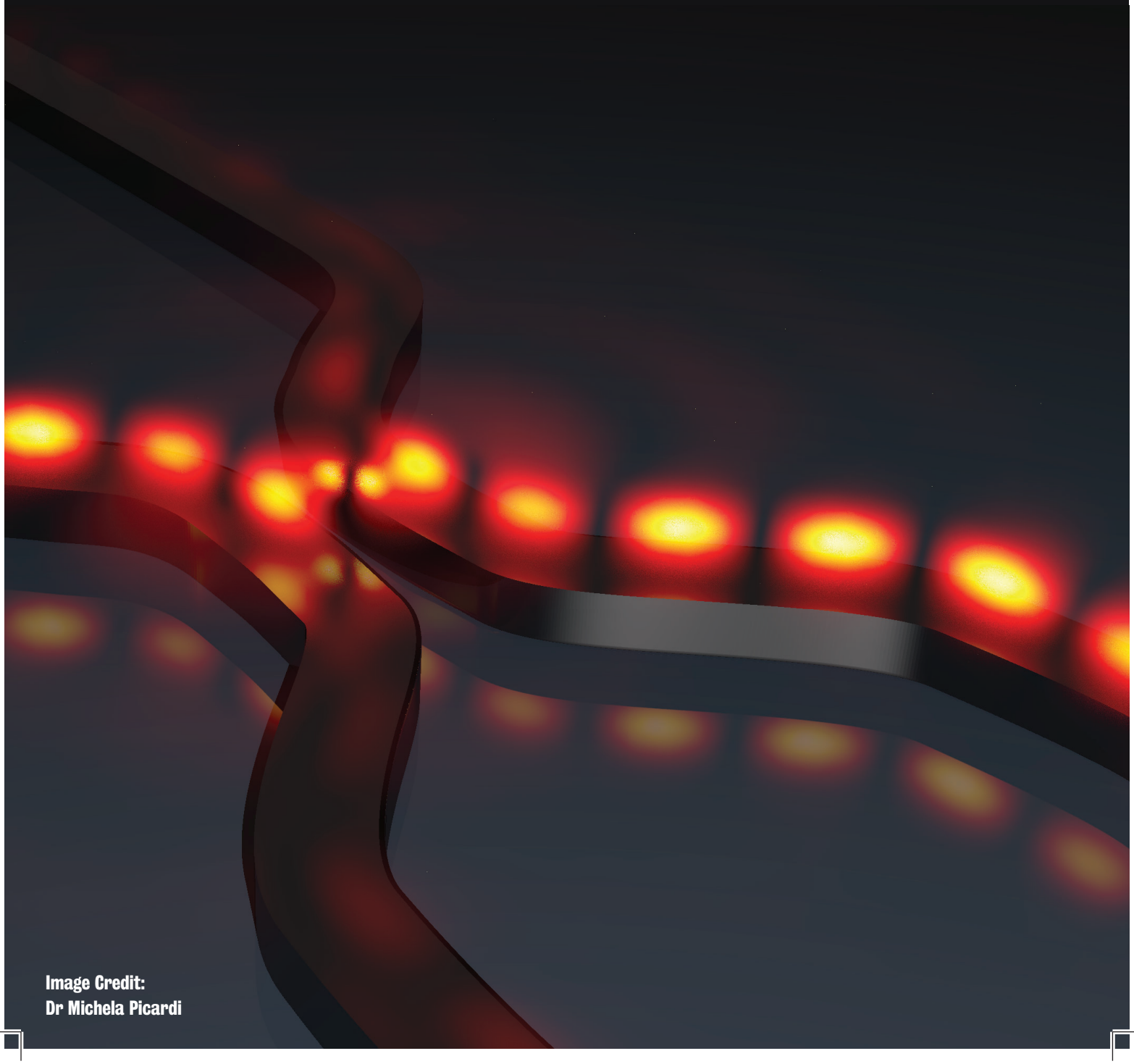


Image Credit:
Dr Michela Picardi

Welcome to Nanostrand, the annual review of the Photonics & Nanotechnology Group and Biological Physics & Soft Matter Group at King's College London

Department of Physics awarded the Athena SWAN Silver Award

The Department of Physics is proud to announce that it has been awarded the Athena SWAN Silver award, a UK charter granted in recognition of commitment and advancement of gender equality in higher education and research.

Receipt of the award coincided with the Faculty of Natural & Mathematical Sciences' Women in Science Week, an annual celebration of women working in STEM. This award follows on from the Department's Juno Champion Status which the Institute of Physics awarded in January 2019.

Professor Peter Main, Head of the Department and Chair of the Faculty's Equality and Diversity Committee, commented:

'I am delighted that we have received Athena SWAN Silver, following on from our Juno Champion recognition last year. These awards reflect the enormous effort we have put in over the last few years in all aspects of diversity and inclusion. But we do not see them as the end of our journey, rather as a springboard to further development and improvement.'

EPSRC Showcasing Physical Sciences Impact Event

Dr. James Millen's Levitated Nanophysics group were invited to attend the EPSRC Showcasing Physical Sciences Impact Event in December 2019.

This event, sponsored by the Institute of Physics and the Royal Society of Chemistry, celebrated the significant and wide-ranging impacts that arise from the breadth of physical sciences research: from the fundamental to the applied.

It brought together academics and industrialists from across a broad range of disciplines along with policy makers to share, discuss and celebrate the far-reaching and varied impacts of physical sciences research.

The group from King's exhibited their optical levitation technology, to assist EPSRC in making the case for maintaining a healthy physical sciences research base, and to demonstrate the importance of fundamental physical sciences research for applied research and innovation.

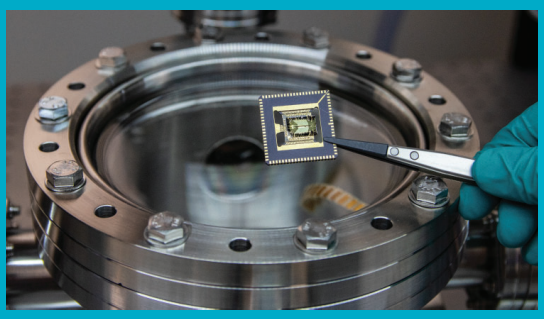
Dr Muddassar Rashid, Dr James Millen & Dr Maryam Nikkhou

P&N opens and new suite of photonics and nanofabrication laboratories

A new suite of photonics and nanofabrication laboratories has been officially opened on the King's Strand Campus. The photonics laboratories house cutting-edge levitated optomechanics experiments and attosecond lasers as well as extending King's capabilities with state-of-the-art cleanroom facilities.

The new cleanroom forms part of the London Centre for Nanotechnology, and the facilities will be run by the Photonics & Nanotechnology Group in the Department of Physics.

This investment in the future of light-based technology comes as the UK photonics industry output exceeds £12.9 billion, growing at twice the national average. The Photonics & Nanotechnology Group has expanded rapidly over the past few years and the new laboratories will allow the group to branch into new research areas of attosecond physics led by Dr Amelle Zaïr and optical levitation led by Dr James Millen.



The Nanophotonics laboratory

To celebrate the opening of these new spaces the Department of Physics hosted an opening event on Wednesday 2 October with talks from both Amelle and James alongside Dr Wayne Dickson, who was instrumental in the commissioning of the atomic layer deposition facilities housed in a cleanroom.

P&N researcher receives career advice from Nobel Laureate Serge Haroche

Once every year, around 30-40 Nobel Laureates convene in Lindau to meet the next generation of leading scientists: 600 undergraduates, PhD students, and post-doc researchers from all over the world. The Lindau Nobel Laureate Meetings foster the exchange among scientists of different generations, cultures, and disciplines.

This year, P&N researcher Margoth Cordova Castro attended the meeting shortly after successfully defending her PhD thesis. Whilst at the meeting, Margoth had the opportunity to talk with Nobel Laureate Serge Haroche who shared the Nobel Prize in Physics in 2012. Serge offered advice to young researchers who like himself and Margoth, come from a developing country.

Serge Haroche

Margoth Cordova Castro

Since their beginnings in 1951, the Lindau Meetings have evolved into a unique international forum for scientific exchange. It was the two Lindau physicians Franz Karl Hein and Gustav Wilhelm Parade who approached Count Lennart Bernadotte af Wisborg of nearby Mainau Island to jointly develop and implement the idea that marked the start of a long and continuing history.

You can watch the clip on the official Lindau Meetings YouTube channel

Wheatstone Lecture 2019 given by Professor Naomi Halas

The 2019 Wheatstone Lecture was held on 20 February. Professor Naomi Halas from Rice University, presented a lecture entitled 'From Faraday to tomorrow: nanoscale optics for sustainability and societal impact'.

Professor Halas explained the potential impact of developments in her field 'We have previously introduced photothermal effects for biomedical therapeutics; now, years after their initial demonstration, this approach is being utilized in human trials for the precise and highly localized ablation of cancerous regions of the prostate, eliminating the highly deleterious side effects characteristic of conventional prostate cancer therapies. Photothermal effects can also be harvested for sustainability applications including off-grid solar thermal desalination systems.'

Professor Naomi Halas

International Day of Light Celebrations

The London Institute for Advanced Light Technologies (London Light) held an event at King's College London in May 2019 with an evening installations, exhibits and talks organised to coincide with the UNESCO International Day of Light. A virtual institute uniting optics and photonics research, this multidisciplinary research network brings together scientists and industries in London who work on emerging photonic technologies.

The event built around The International Day of Light, which is a global initiative that provides an annual focal point for the continued appreciation of light and the role it plays in science, culture, art, education, and sustainable development, in fields as diverse as medicine, communications, and energy.

The afternoon began with an exhibition in the King's Anatomy Museum featuring light experiments and light art, including work from 15 artists and research groups. The artists responded to an open call and all showcased work that uses light as a medium. The pieces of art included paintings, interactive installations and interpretations of scientific concepts.

Jenny Walsh displayed in impressive piece called Fractured Helix which draws on the rich history of DNA at King's and the work that was pioneers by Rosalind Franklin that was suspended from the balcony of the Anatomy Museum.

Talks followed in the Anatomy Lecture Theatre from Dr Jess Wade of Imperial College London and Dr James Millen the P&N Group and the event concluded with a reception.

In the lead-up to the event, London Light also held writing workshops for early year researchers. One workshop, focused around writing for the general public, was facilitated by the Insitute of Physics. The other workshop, which was centered around writing scintific papers was facilitated by Nature Physics.

In April 2020, London Light is hosting an interdisciplinary sypmosium centered around light.

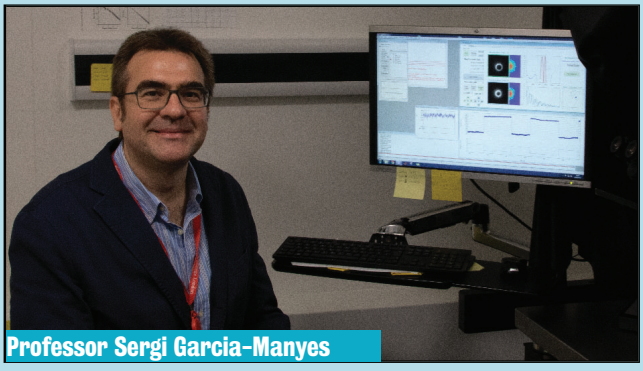
To find out more visit:www.london-light.org.

All photography courtesy of Steve Po

Royal Society Wolfson Fellowship awarded to Professor Sergi Garcia-Manyes

Head of the BPSM Group, Professor Sergi Garcia-Manyes, has been awarded a prestigious Royal Society Wolfson Fellowships. The £8 million scheme, helps UK universities to recruit and retain outstanding senior research scientists.

On receiving the Fellowship, Sergi said 'I am truly honoured to have received such a prestigious award. The Royal Society Wolfson Fellowship provides both recognition of my team's work in the past several years, and, most importantly, an extra motivation to further pursue our scientific agenda at King's with passion and enthusiasm.'



Professor Sergi Garcia-Manyes

London Plasmonics Forum 2019

Dr Rachel Won, Ediz Herkert, Anatoly Zayats & Dr David Pile

The Fifth London Plasmonics Forum was held at Kings College London on 14 June in the Anatomy Museum at the Strand Campus, this time as part of the London Tech Week.

The event has been running since 2015, and it typically attracts approximately 100 participants from London, UK, Europe and beyond. It aims to engage and connect researchers and industry who work in the ever-expanding field of Plasmonics.

Dr Charles Footer from QinetiQ gave the keynote talk; explaining the way that materials and metamaterials are used in industry. Following on from the keynote, we had several talks from early career researchers (you can see the agenda here for more details), Dr Andres Neira from Seagate Technology gave a talk on progress in heat-assisted magnetic recording, and Dr Dominic Gallaher from Photon Design talked about the development of new simulation tools for nanophotonics.

Over lunchtime there was a lab tour of the nanophotonics lab running alongside the annual poster competition. As usual, the standard of the competition was very high; Rachel Won and David Pile from Nature Photonics announced the winner as Ediz Herkert from the University of Stuttgart for his poster entitled 'Computing the influence of disorder in plasmonic metasurfaces'.

Head of the P&N Group Professor Anatoly Zayats said. 'This is the 5th year we've run the London Plasmonics Forum, and it is amazing to see how plasmonic research changed over this relatively short period. It has diversified in so many different areas which we could not even think about 5 years ago. It continues to be a very active and imaginative area of photonics, chemistry and biological research and we always have very lively discussions at the Forum with our colleagues from all around the world.'

The event continues to build on its excellent reputation for researchers and industry to come together to discuss, exchange ideas and disseminate cutting edge research. The 6th London Plasmonics Forum will take place at King's College London on 11 June 2020. Find out more: www.rplasmonics.org

PhD students showcase research worldwide

2019 was a successful year for our PhD students with many of them presenting posters and talks at international conferences. The following people were awarded prizes for their research:

Bethan Cornell won the Thomas Young Centre Student Day Poster Prize.

Emilie Gachon won a Nanoscale Poster Prize at the International Scanning Probe Microscopy (IPSM) Conference at UCLouvain in Belgium

Jack Kingsley-Smith won a Nanoscale and Nanoscale Advances Poster Prize at the International Symposium on Plasmonics and Nanophotonics 2019 in Kobe, Japan.

Michaela Picardi won best talk at Plasmonica 2019, awarded by the Italian Society of Optics and Photonics.

Emilie Steinmark won the main prize in the student poster competition at the Advanced Imaging Methods (AIM) Workshop at University of California, Berkeley.

Anastasia Zaleska won iSPN 2019 Student Poster Award at the International Symposium on Plasmonics and Nanophotonics 2019 in Kobe, Japan.


Anastasia Zaleska & Jack Kingsley-Smith

Many congratulations to the prizewinners and their collaborators.

Mechanical stability regulates the nuclear import rate of translocating proteins

The nuclear pore complex (NPC) is the primary transport gateway for biomolecules to enter and exit the cell nucleus. It has long been known that the passage of proteins through the NPC is highly size-selective, and it was recently shown that the nuclear import rate also depends on the surface chemistry of the translocating cargos – surface-exposed hydrophobic residues massively increase the import rate. BPSM researchers have now shown that the mechanical stability of translocating proteins is an additional factor controlling their nuclear translocation.

The researchers conjectured that the mechanical unfolding of translocating proteins, to expose hydrophobic residues buried within the protein fold to the NPC lumen, would increase their nuclear import rate. To investigate this hypothesis, they used a model system in which protein nuclear translocation could be biochemically initiated on-demand and subsequently monitored – fluorescently-tagged MRTFA (myocardin-related transcription factor A) in an osteosarcoma cell line. MRTFA readily translocates to the nucleus upon serum stimulation and the fluorescent tag allows this process to be monitored by confocal microscopy.

The mechanical stability of MRTFA was controlled by concatenating it with a range of small protein domains whose mechanical stabilities had been individually characterised using single-molecule force spectroscopy. They observed a clear inverse relationship between the nuclear import rate of chimeric MRTFA constructs and the mechanical stability of the concatenating domains, demonstrating for the first time that the mechanical stability of proteins regulates their nuclear import.

Finally, they considered whether this control over MRTFA nuclear translocation has knock-on effects on gene expression levels and cell function, and found that increasing the mechanical stability of MRTFA downregulates and slows migration in osteosarcoma and breast cancer cell lines. The approach suggests that modulating the mechanical stability of transcription factors could be a general mechanism to regulate gene expression.

This research 'The mechanical stability of proteins regulates their tr anslocation rate into the cell nucleus' was published in Nature Physics.

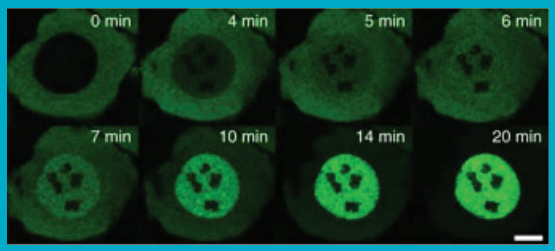


Image Credit: Garcia-Manyes Lab

Quantum light at the nanoscale

A former PhD student from the Photonics & Nanotechnology Group at King's and current postdoctoral fellow at Université de Paris, has experimentally demonstrated, the nanoscale generation of two-photon quantum states enhanced by the nanoscale semiconductor antenna. It is also easy to achieve the desired spectral response by changing the nano-antenna shape and geometry.

'Scalable and integratable nanoscale quantum optical sources are a must if the optical quantum technologies will grow from the lab to real-world applications,' says Professor Zayats, a co-author of the paper, 'these results show that indeed such miniaturised optical sources can be engineered not only without compromising the performance but actually with better performance than their traditional bulky counterparts'.

This research 'Spontaneous photon-pair generation from a dielectric nanoantenna' was published in Optica.

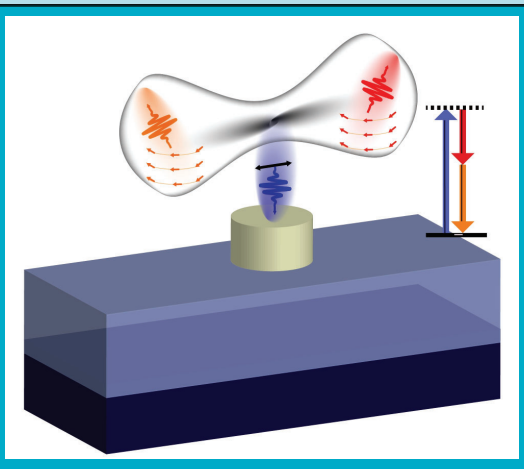


Image Credit: Dr Giuseppe Marino

Controlling optical response with designed electron temperature distributions in plasmonic nanostructures

P&N researchers have discovered how to control light at ultrafast timescales by designing the distribution of energy of electrons in nanostructures. These metallic nanostructures are manmade materials that can have interesting optical properties, not found in naturally occurring materials. It has been found that these nanostructures can have regions of very high light-matter interaction, with the study of this interaction known as the field of plasmonics. By using intense pulses of laser light, electrons in these regions absorb larger amounts of energy, changing the electrons' characteristic temperature.

When the electron temperature increases, the optical properties of the material change. They can become more opaque or transparent at certain wavelengths in the spectrum of light. By altering the distribution of this electron temperature within the nanostructure, the researchers found a way to control the speed at which the optical properties of the nanostructure change. Using this they demonstrated control over the intensity of light passing through the nanostructure on a sub-300 fs time scale.

One of the researchers Luke Nicholls said, 'The ability to change the dynamic optical response of nanostructures by proper design of electron temperature distributions could have wide ranging applications for technology in telecommunications and chemistry.'

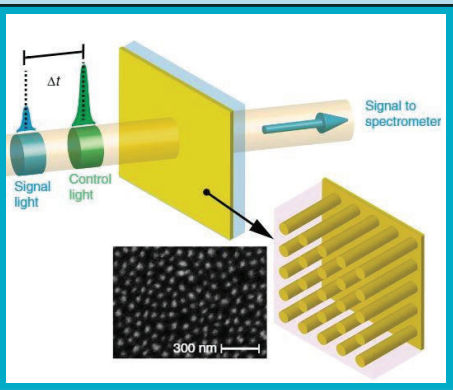


Image Credit: Dr Luke Nicholls, King's Nano-Optics

The switching of optical properties at faster speeds in data processing and communication, would help with the ever-growing demand on access to data. Furthermore, the ability to generate hot electrons in specific locations within a nanostructure could provide added functionality in photo-assisted catalysis and nonlinear optics.

This reserch ' Designer photonic dynamics by using non-uniform electron temperature distribution for on-demand all-optical switching times' was published in Nature Communications.

Photonic skyrmions discovered

Skyrmions, 'hedgehogs' of electron spins, are well known in magnetic materials and were long considered for applications in spintronics and high-density data storage. However, electromagnetic waves also carry spin and orbital angular momenta.

In a recent paper, P&N researchers have discovered the skyrmion structures made of photon spin alongside colleagues from Shenzhen University in China.

The team has shown a direct analogy between photonic spin structures observed in optical field with orbital angular momentum and skyrmions in magnetic materials.

Head of P&N Anatoly Zayats said, 'Electrons and photons are very different animals with different properties defining their behaviour, such as spin and statistics. However, in the specially designed environments photon exhibit very similar behaviour to electrons, such as, for example, topologically protected states (something unheard for photons until very recently). The demonstrated photonic skyrmions is another example of how well-known electron phenomena can be transposed into the photonic domain, where they can be used for developing new applications.'

This research 'Deep-subwavelength features of photonic skyrmions in a confined electromagnetic field with orbital angular momentum' was published in Nature Physics.

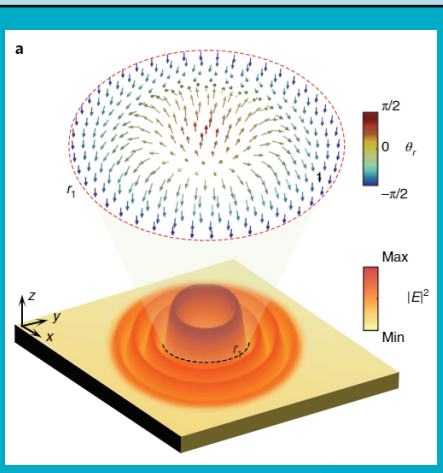


Image Credit: Luping Du

A selection of our recent publications

Kepiro, IE Marzuoli, I, Hammond, K, Ba, X, Lewis, H, Shaw, M, Gunnoo, SB, De Santis, E, Łapinska, U, Pagliara, S, Holmes, MA, Lorenz, CD, Hoogenboom, BW, Fraternali, F & Ryadnov, MG (2019) Engineering chirally blind protein pseudocapsids into antibacterial persisters' ACS Nano. https://doi.org/10.1021/acsnano.9b06814

The PLUMED consortium (2019). Promoting transparency and reproducibility in enhanced molecular simulations., Nature Methods. https://doi.org/10.1038/s41592-019-0506-8

Infante, E, Stannard, A, Board, SJ, Rico-Lastres, P, Rostkova, E, Beedle, AEM, Lezamiz, A, Wang, YJ, Gulaidi Breen, S, Panagaki, F, Sundar Rajan, V, Shanahan, C, Roca-Cusachs, P & Garcia-Manyes, S (2019) 'The mechanical stability of proteins regulates their translocation rate into the cell nucleus', Nature Physics. https://doi.org/10.1038/s41567-019-0551-3

Mesquida, P, Kohl, D & Schitter, G (2019). 'Signal reversal in Kelvin-probe force microscopy', Review of Scientific Instruments. https://doi.org/10.1063/1.5118357

Nicholls, L, Stefaniuk, T, Nasir, ME, Rodríguez-Fortuño, FJ, Wurtz, GA & Zayats, AV (2019) 'Designer photonic dynamics by using non-uniform electron temperature distribution for on-demand all-optical switching times', Nature Communications. https://doi.org/10.1038/s41467-019-10840-7

Du, L, Yang, A, Zayats, AV & Yuan, X (2019) 'Deep-subwavelength features of photonic skyrmions in a confined electromagnetic field with orbital angular momentum', Nature Physics. https://doi.org/10.1038/s41567-019-0487-7

Yang, Z, Albrow-Owen, T, Cui, H, Alexander-Webber, J, Gu, F ,Wang, X, Wu, TC, Zhuge, M, Williams, C, Wang, P, Zayats, AV, Cai, W, Dai, L, Hofmann, S, Overend, M, Tong, L, Yang, Q, Sun, Z & Hasan, T (2019) 'Single nanowire spectrometers', Science. https://doi.org/10.1126/science.aax8814

Picardi, MF, Neugebauer, M, Eismann, J, Leuchs, G, Banzer, P, Rodriguez Fortuno, FJ & Zayats, AV (2019) 'Experimental demonstration of linear and spinning Janus dipoles for polarisation- and wavelength-selective near-field coupling', Light: Science & Applications. https://doi.org/10.1038/s41377-019-0162-x

Picardi, MF, Zayats, AV & Rodríguez-Fortuño, FJ (2019) 'Amplitude and phase control of guided modes excitation from a single dipole source: engineering far- and near-field directionality', Laser & Photonics Reviews. https://doi.org/10.1002/lpor.201900250

Marino, G, Zayats, A, Solntsev, AS, Xu, L, Gili, V, Carletti, L, Poddubny, AN, Rahmani, M, Smirnova, D, Chen, H, Lemaitre, A, Zhang, G, De Angelis, C, Leo, G, Sukhorukov, AA & Neshev, DN (2019) 'Spontaneous photon-pair generation from a dielectric nanoantenna', Optica. https://doi.org/10.1021/acs.accounts.9b00325

Wang, P, Nasir, ME, Krasavin, A, Dickson, W, Jiang, Y & Zayats, AV (2019) 'Plasmonic metamaterials for nanochemistry and sensing', Accounts of Chemical Reseach. https://doi.org/10.1021/acs.accounts.9b00325

Roth, DJ, Ginzburg, P, Hirvonen, LM, Levitt, JA, Nasir, ME, Suhling, K, Richards, DR, Podolskiy, V & Zayats, AV 2019, 'Singlet-triplet transition rate enhancement inside hyperbolic metamaterials', Laser and Photonics Reviews. https://doi.org/10.1002/lpor.201900101

Córdova-Castro, RM, Casavola, M, Van Schilfgaarde, M, Krasavin, AV, Green, MA, Richards, D & Zayats, AV (2019) 'Anisotropic plasmonic CuS nanocrystals as a natural electronic material with hyperbolic optical dispersion', ACS Nano. https://doi.org/10.1021/acsnano.9b00282

Wachter, G, Kuhn, S, Minniberger, S, Salter, C, Asenbaum, P, Millen, J, Schneider, M, Schalko, J, Schmid, U, Felgner, A, Hüser, D, Arndt, M & Trupke, M (2019) 'Silicon microcavity arrays with open access and a finesse of half a million', Light: Science & Applications. https://doi.org/10.1038/s41377-019-0145-y

Amini, K, Biegert, J, Calegari, F, Chacón, A, Ciappina, MF, Dauphin, A, Efimov, DK, Figueira De Morisson Faria, C, Giergiel, K, Gniewek, P, Landsman, A, Lesiuk, M, Mandrysz, M, Maxwell, AS, Moszynski, R, Ortmann, L, Perez-hernandez, JA, Picon, A, Pisanty, E, Prauzner-bechcicki, JS, Sacha, K, Suárez, N, Zair, A, Zakrzewski, J & Lewenstein, M 2019, 'Symphony on Strong Field Approximation', Reports on Progress in Physics. https://doi.org/10.1088/1361-6633/ab2bb1