COST MP1205 General Meeting and Conference

11-13 April 2016

General Meeting and Conference
11-13 April 2016
Koç University Campus, Rumelifeneri Yolu Sariyer, Istanbul, Turkey

COST Action MP1205
"Advances in Optofluidics"

PROGRAMME

General Meeting and Conference
11-13 April 2016
Koç University Campus, Rumelifeneri Yolu Sariyer, Istanbul, Turkey

Time	Monday, 11th April	
10:00 – 10:45	Registration + welcome coffee & cookies	
10:45 – 11:00	Welcome and opening remarks	
11:00 – 11:40	Invited talk 1	Yunfeng Xiao: "Single nanoparticle detection using high-Q optical microcavities"
11:40 – 12:00	Optofluidic concepts for biological and chemical sensing	Imran Cheema: "Cavity ring down spectroscopy in whispering gallery mode microcavities for biosensing applications"
12:00 – 12:20		Raimondas Petruskevicius: "Perforated SOI microring resonators for enhanced microfluidic sensing"
12:20 – 12:40		Mustafa Eryurek: "Humidity detection based on polymer optical microdisk resonators"
12:40 – 14:10	Lunch	
14:10 – 14:50	Invited talk 2	Malte Gather: "Optical micro-cavities – cells' new favourite toy"
14:50 – 15:10	Optofluidic applications in life sciences I	Cornelia Denz: "Investigation of morphological and optical lens-like properties of red blood cells using holographic optical tweezers and digital holographic microscopy"
15:10 – 15:30		Pal Ormos: "High precision indirect optical manipulation of live cells with functionalized microtools"
15:30 – 15:50		Elmar Wolff: "Redesign and reconstruction of the optically coupled sensor device"
15:50 – 16:20	Coffee break	
16:20 – 17:20	Work Group Meetings	
17:20 – 19:20	Management Committee Meeting	

Time	Tuesday, 12th April	
10:00 – 10:40	Invited talk 3	Giovanni Volpe: "Active matter: From fundamental science to technological applications"
10:40 – 11:10	Coffee break	
11:10 – 11:30	Light-induced control of colloidal particles	Pavel Zemanek: "Behaviour of non-spherical particles in laser beams"
11:30 – 11:50		Agnese Callegari: "Nonadditivity of critical Casimir forces"
11:50 – 12:10		Denys Kasianiuk: "Light- and electrically-induced manipulation of nanoparticles in arrays of topological defects"
12:10 – 12:30		Ronald Terrazas Mallea: "Controlled particle manipulation using thermocapillary convective flow"
12:30 – 12:50		Artur Alexsanyan: "Helicity-driven optomechanics of flowing chiral microparticles"
12:50 – 14:20	Lunch	
14:20 – 14:40	Novel materials and technologies for optofluidic devices	Alexandr Jonas: "Emulsion droplets of liquid crystals as largely tunable anisotropic optical cavities"
14:40 – 15:00		Mehmet Solmaz: "Femtosecond laser carving and its application to fiber-optic based particle counting"
15:00 – 15:20		Tomas Tamulevicius: "Patterning of diamond like carbon films using silicon containing thermoplastic resist (SiPol) as hard mask"
15:20 – 15:40		Selcuk Akturk: "Femtosecond laser-assisted formation of surface and bulk optofluidic structures"
15:40 – 16:00		Alpan Bek: "Laser assisted Silicon sculpting"
16:00 – 17:00	Poster session + coffee break	
18:00 – 22:00	Conference dinner	

Time	Wednesday, 13th April	
10:00 – 10:40	Invited talk 4	Tal Carmon: "Ripplon Laser"
10:40 – 11:10	Coffee break	
11:10 – 11:30	Light-induced control of fluids	Jean-Pierre Delville: "Optical flow focusing: understanding fragmentation of confined co-flowing capillary threads"
11:30 – 11:50		Leopoldo L. Martin: "Optically stimulated capillary waves"
11:50 – 12:10		Antoine Girot: "Optical cone-jet instability"
12:10 – 12:30		Raphael Dahan: "Droplet Optomechanics"
12:30 – 14:00	Lunch	
14:00 – 14:20	Optofluidic applications in life sciences II	Sedat Nizamoglu: "Biomaterial-based optical waveguides for deep-tissue photomedicine"
14:20 – 14:40		Franz-Josef Schmitt: "Laser switching contrast microscopy to monitor free and restricted diffusion inside the cell nucleus"
14:40 – 15:00		Ryszard Buczynski: "Compact fiber-GRIN lens system for optofluidic applications"
15:00 – 15:20		Thomas Friedrich: "Disruptions of interaction motifs with caveolin and ankyrin slow down diffusion of glial-specific Na,K-ATPase expressed in HEK293 cells as investigated by fluorescence correlation spectroscopy"
15:20 – 15:40	Closing remarks	

Poster Presentations

Mohammad Tahboub Amawi: "Self-propelling Janus particles at the liquid-liquid interfaces"

Suman Anand: "Observation of Whispering Gallery Modes in Elastic Scattering from Optically Trapped Microdroplets in a Microfluidic Channel

Tuğba Andaç: "Self-assembly of active particles in evaporating droplets"

Aykut Argun: "Experimental evidence of the failure of Jarzynski equality in active baths"

Fatemeh Kalantarifarda: "Intra-Cavity Optical Trapping with Fiber Laser"

A. Magazzù: "Experimentally investigation of Critical Casimir forces in water-lutidine mixture by blinking optical tweezers"

Mite Mijalkov: "Engineering Sensorial Delay to Control Phototaxis and Emergent Collective Behaviors"

S. Masoumeh Mousavi: "Optical trapping of the microparticles with low-numerical-aperture objectives using self binding"

Adil Mustafa: "Laminar Flow-Induced Dissolution in Hydrodynamically Trapped Oil Microdroplets"

Dimana Nazarova: "Surface relief gratings parameters in polarization holographic recording in pure azopolymer and hybrid azopolymer based organic/inorganic materials"

Lian Nedelchev: "Birefringence induced at multiple wavelengths in azopolymer films: Kinetics and spectral dependance"

Serdar Öztetik: "A Computational Model and Analysis of Channel Following Active Particles"

I. P. Pinkevych, "Light beams energy exchange in liquid crystal cell with electrically-driven boundary conditions"

Falko Schmidt: "Hot Brownian motion of nanoparticles in a critical binary liquid"

P. Spegni: "Sealing of microfluidic channels by lamination of thin SU 8 films"

Ahmet Yasin Çelik "Computational studies on flow-induced dissolution in hydrodynamically trapped oil microdroplets"

Yaprak Ozbakir "Development of Aerogel Based Optofluidic Microreactors"

INVITED TALKS

Ripplon Laser

Tal Carmon

Mechanical Engineering Department
Technion, Israel Institute of Technology

Energy exchange between light and sound was first suggested by Brillouin in 1922. After Townes established the "phonon-maser" theory, coherent generation of intense hypersonic waves was observed together with stimulated Brillouin Scattering. Here we repeat these experiments, but with capillary-waves that are unique to the liquid-phase of matter and relates to attraction between intimate fluid particles. We fabricate resonators that co-host capillary- and optical-modes, control them to operates at its non-resolved sideband, and observe stimulated capillary-scattering and coherent excitation of capillary resonances at kHz rates (that one can hear in audio files recorded by us). By exchanging energy between electromagnetic- and capillary-waves, we bridge interfacial-tension phenomena at the liquid-phase boundary to optics, and might impact optofluidics by allowing optical-control, -interrogation and -cooling of water waves

Optical micro-cavities – cells' new favourite toy

Malte C. Gather

SUPA School of Physics and Astronomy, University of St Andrews

I will present our recent work on new micro- and nano-photonic, cavity based techniques to study cells and their behaviour. Our lab is probably most well-known for the invention of the biological laser, which recently made it into the Guinness World Records.

Beyond these unique lasers, the lab works on functional imaging modalities to study the mechanical properties of single cells at unprecedented resolution. During my talk, I will cover recent work on biolasers and introduce our micro-cavity based photonic sensor platform which allows us to follow the movement and mechanical action of primary cells over much longer times than possible with current state-of-the-art technology. Time permitting, our recent development of an organic LED based technology platform for optical manipulation of cell behaviour will also be discussed.

Active matter: From fundamental science to technological applications

Giovanni Volpe

Bilkent University
Physics Department, UNAM & Neurosciences

Active Brownian particles, also referred to as microswimmers and nanoswimmers, are biological or manmade microscopic and nanoscopic particles that can self-propel. Because of their activity, their behavior can only be explained and understood within the framework of nonequilibrium physics. In the biological realm, many cells perform active Brownian motion, for example, when moving away from toxins or towards nutrients. Inspired by these motile microorganisms, researchers have been developing artificial active particles that feature similar swimming behaviors based on different mechanisms; these manmade micro- and nanomachines hold a great potential as autonomous agents for healthcare, sustainability, and security applications. With a focus on the basic physical features of the interactions of active Brownian particles with a crowded and complex environment, this seminar will provide a guided tour through the basic principles of active matter, the development of artificial self-propelling micro- and nanoparticles, and their application to the study of nonequilibrium phenomena, as well as the open challenges that the field is currently facing.

Single nanoparticle detection using high-Q optical microcavities

Yun-Feng Xiao

Department of Physics, Peking University, China

Confinement and manipulation of photons using microcavities have triggered intense research interest in both fundamental and applied photonics for more than one decade. Prominent examples are ultrahigh-Q whispering gallery microcavities which confine photons by means of continuous total internal reflection along a curved and smooth surface. The long photon lifetime, strong field confinement, and in-plane emission characteristics make them promising candidates for enhancing light-matter interactions on a chip. In this talk, I will focus on the single-nanoparticle detection by using whispering gallery microcavities, which is highly desirable for applications in various fields, such as in early-stage diagnosis of human diseases and in environmental monitoring.

References

1. Bo-Qiang Shen, Xiao-Chong Yu, Yanyan Zhi, Li Wang, Donghyun Kim, Qihuang Gong, and Yun-Feng Xiao, "Detection of Single Nanoparticles Using the Dissipative Interaction in a High-Q Microcavity," Phys. Rev. Applied 5, 024011 (2016).*

2. Bei-Bei Li, William R. Clements, Xiao-Chong Yu, Kebin Shi, Qihuang Gong, and Yun-Feng Xiao, "Single nanoparticle detection using split-mode microcavity Raman lasers," PNAS 111(41), 14657-14662 (2014).*

3. Yong-Chun Liu, Xingsheng Luan, Hao-Kun Li, Qihuang Gong, Chee Wei Wong, and Yun-Feng Xiao, "Coherent polariton dynamics in coupled highly-dissipative cavity quantum electrodynamics," Phys. Rev. Lett. 112(21), 213602 (2014).*

4. Linbo Shao, Xue-Feng Jiang, Xiao-Chong Yu, Bei-Bei Li, William R. Clements, Frank Vollmer, Wei Wang, Yun-Feng Xiao, and Qihuang Gong*, "Detection of Single Nanoparticles and Lentiviruses Using Microcavity Resonance Broadening," Advanced Materials 25(39), 5616-5620 (2013). Frontispiece paper*

5. Xiao-Chong Yu, Bei-Bei Li, Pan Wang, Limin Tong, Xue-Feng Jiang, Yan Li, Qihuang Gong, and Yun-Feng Xiao*, "Single Nanoparticle Detection and Sizing Using a Nanofiber Pair in Aqueous Environment," Advanced Materials 26(44), 7462-7467 (2014). Front cover paper*

Dr. Yun-Feng Xiao received the B.S. and Ph.D. degrees in physics from University of Science and Technology of China in 2002 and 2007, respectively. After a postdoctoral research at Washington University in St. Louis, he joined the faculty of Peking University in 2009, and was promoted to Associate Professor with tenure in 2014. During the past few years, he was awarded the Excellent Young Scientist by National Natural Science Foundation of China (NSFC) in 2012, The Rao Yutai First Prize in Fundamental Optics in 2013. His research interests lie in the fields of whispering-gallery microcavity optics and photonics. He has authored or co-authored more than 100 refereed journal papers with over 2000 citations, and has delivered over 50 invited talks/seminars in international/national conferences.

ORAL PRESENTATIONS

Femtosecond laser-assisted formation of surface and bulk optofluidic structures

B. Yalizay,[1] Y. Morova,[1] K.Dincer,[1] Y. Ozbakir,[2] A. Jonas,[1] C. Erkey,[2] A.Kiraz,[3] S.Akturk[1]

[1]İstanbul Technical University, Department of Physics, Istanbul, 34469, Turkey
[2]Koc University, Department of Chemistry, Istanbul, 34450, Turkey
[3]Koc University, Department Of Physics, Istanbul, 34450, Turkey
email: selcuk.akturk@itu.edu.tr

We investigate formation of optofluidic structures in various materials, through ablation by femtosecond laser pulses. Ablation with ultrashort-pulsed lasers allow generation of high-precision and repeatable structures with minimal thermal and stress-related side effects. We apply the method to fabricate microfluidic patterns on surface and also in bulk. In particular, we use laser ablation to control the wettability properties of superhydrophobic surface structures and demonstrate free-form liquid optical waveguides on glass surfaces covered with silica nanospheres. Further, we generate micro-channels inside hydrophobic silica aerogels, through a similar ablation process. Liquids filled in the channels exhibit optical guiding.

Helicity-driven optomechanics of flowing chiral microparticles

Artur Aleksanyan[1,2]*, G. Tkachenko[1,2], Jacques Leng[3] and Etienne Brasselet[1,2]

[1]University of Bordeaux, LOMA, UMR 5798, F-33400 Talence, France
[2]CNRS, LOMA, UMR 5798, F-33400 Talence, France
[3]Solvay, LOF, University of Bordeaux, Pessac, France
***Corresponding author:** artur.aleksanyan@u-bordeaux.fr

Forces exerted by light on matter basically results from the absorption, modification or redirection of the linear momentum of light. A well-known example is the optical radiation pressure exerted by light on the interface between two media. Tailoring the optical radiation forces generally consists to engineer the scattering of light. Here we address the specific situation where the helicity of light is used to control optical forces in the context of optical manipulation of chiral microparticles made of liquid crystals, which has application potential in the development of optical enantioseparation techniques. We will review our progresses in that direction obtained during the course of present COST Action.

Investigation of morphological and optical lens-like properties of Red Blood Cells using holographic optical tweezers and digital holographic microscopy

Alvaro Barroso[a], Francesco Merola[b], Lisa Miccio[b], Pasquale Memmolo[b], Martina Mugnano[b], Cornelia Denz[a,] and Pietro Ferraro[b]

[a]Institute of Applied Physics, Westfälische Wilhelms-Universität Műnster, Corrensstraße 2, 48149 Műnster (Germany)

[b]Institute of Applied Sciences & Intelligent Systems, Via Campi Flegrei, 34, 80078 Pozzuoli NA (Italy)

Red Blood Cells (RBCs) feature a high ability to change their shape under a given level of applied stress, which allows them to pass through capillaries by shrinking and deforming themselves. For this reason, optical manipulation techniques have been extensively used for stretching and rotating RBCs and for studying their shape modifications, for example for diagnostic purposes. Moreover, recently, the lens effect of RBCs has been demonstrated [1] by showing that a discocyte RBC can behave as a biconcave lens and its extremely elastic membrane can be modified converting it, in case, in a biconvex lens.

In this work we present a novel method that enables both the quantitative analysis of RBCs morphology and the study of their optical lens-like properties under optically-induced mechanical stress. For this purpose, a holographic optical tweezers (HOT) system that enables to handle and stretch single RBCs in a contactless way was combined in a single workstation with digital holography microscopy (DHM), which provides retrieval of the complex object wave. Results from investigations on the wavefront refracted by RBCs using comprehensive numerical analysis of Zernike polynomials show that this approach allow to quantify in a quick and effective way the discocyte RBC-lens behavior and the change of its optical properties during implementation of external optomechanical forces. This could open new routes for analyzing cell elasticity by examining optical parameters in analogy to classical optical testing procedures if optical parameters are correlated to deformation ones.

Laser assisted Silicon sculpting

Alpan Bek

Middle Eastern Technical University, Department of Physics, Ankara

Direct writing of photonic and fluidic devices in Si by means of laser processing is of great importance as it promisses low-cost, rapid fabrication of Si devices. Although Si microfabrication techniques are well-established and technologically mature, the fabrication time and costs are still of importance as clean room environment, repetitive photomasking, mask aligning, thermal processing steps are typical requirements. Advancements in fiber laser technology has reached a stage such that high average power, nano to femtosecond pulsed lasers are reduced in dimension to about a square meter breadboard area and system costs are reduced to a fraction of a mask aligner. When integrated to a galvo-, mechano-, acousto- or piezo-scanners, arbitrary 2D and 3D scan patterns of laser focus can easily be achieved. When the beam qualities are carefully selected, compatible materials can be opto-thermally proccesed in 2D and 3D. In this talk I will present sculpting of crystalline Si by a 1550 nm wavelength, ns pulsed fiber laser. I will show some of our preliminary results demonstrating direct writing of holographic phase plates, microelectromechanical systems and buried channels which are fabricated by our novel laser assisted Si sculpting technique.

Compact fiber-GRIN lens system for optofluidic applications

Adam FILIPKOWSKI,[1] Bernard PIECHAL,[1] Dariusz PYSZ,[1] Ryszard STEPIEN,[1] Jarosław CIMEK[1,2], Andrew WADDIE,[3] Mohammad R. TAGHIZADEH,[3] and Ryszard BUCZYNSKI.[1,2,3]

[1] Department of Glass, Institute of Electronic Materials Technology, Wolczynska 133, 01-919 Warsaw, POLAND
[2] Faculty of Physics, University of Warsaw, Pasteura 7, 02-093 Warsaw, POLAND
[3] Department of Physics, School of Engineering and Physical Sciences, Heriot-Watt University, Scottish Universities Physics Alliance, Edinburgh, EH14 4AS, UK
e-mail : ryszard.buczynski@itme.edu.pl

We have developed a new type of optical fiber probe composed of standard single mode fiber integrated with nanostructured gradient index microlens. Since the diameter of the lens module matches the diameter of the optical fiber the system is well suited for optofluidic systems. The performance of the flat-faced GRIN lens is not degraded by low contrast of the refractive index between of the lens and the fluidic environment. The GRIN lens were fabricated using the stack-and-draw optical fiber technology. The principle of the operation of nanostructured elements can be described by the effective medium theory (EMT). The fabricated GRIN lens is 11.9 µm long, which corresponds to 0.12 pitch length of the lens. Experimentally we verified focusing properties of the integrated fiber probe. We measured the focal plane at working distance of 80 µm, which is in agreement of the simulation results. At that distance, the full width at half maximum (FWHM) of the focal spot is equal to 8 µm.

Nonadditivity of Critical Casimir Forces

Sathyanarayana Paladugu[1], Agnese Callegari[1], Yazgan Tuna[1,2], Lukas Barth[1], Siegfried Dietrich[3,4,] Andrea Gambassi[5], Giovanni Volpe[1,2]

[1] Department of Physics, Bilkent University, 06800 Çankaya, Ankara, Turkey
[2] UNAM – Institute of Material Science and Nanotechnology, Bilkent University, 06800 Çankaya, Ankara, Turkey
[3] Max-Planck-Institut fu¨ r Intelligente Systeme, Heisenbergstr. 3, D-70569 Stuttgart, Germany, EU
[4] IV. Institut für Theoretische Physik, Universität Stuttgart, Pfaffenwaldring 57, D-70569 Stuttgart, Germany, EU
[5] SISSA – International School for Advanced Studies and INFN, via Bonomea 265, 34136 Trieste, Italy, EU

In soft and condensed matter physics, effective interactions often emerge as a result of the spatial confinement of a fluctuating field. For instance, micron-sized particles in a binary liquid mixture are subject to critical Casimir forces whenever their surfaces confine the thermal fluctuations of the order parameter of this kind of solvent, the range of which diverges upon approaching the critical demixing point. Critical Casimir forces are predicted to be nonadditive. However, a direct experimental evidence of this fact is still lacking. Here, we fill in this gap by reporting the experimental measurement of the associated many-body effects. In particular, we focus on three colloidal particles in optical traps and observe that the critical Casimir force exerted on one of them by the other two colloids differs from the sum of the forces they exert separately. The magnitude and range of this three-body effect turn out to depend sensitively on the distance from the critical point of the solvent and on the preferential adsorption at the surfaces of the colloids for the two components of the mixture.

Cavity Ring Down Spectroscopy in Whispering Gallery Mode Microcavities for Biosensing Applications

Imran Cheema

Lahore University of Management Sciences (LUMS)
imran.cheema@lums.edu.pk

The large photon lifetime of whispering gallery mode (WGM) microcavities makes them a strong candidate for ultrasensitive sensing. In a microcavity sensor, the sensing event can be correlated to various measurement parameters including the resonant wavelength and the quality factor, Q. A variety of approaches have been introduced to measure these parameters. However, these approaches suffer from various drawbacks; some of them do not allow for real time measurement, and their signal is limited by many noise sources. Moreover, it is often assumed in the literature that optimum sensing performance is obtained by operating a microcavity at its highest possible Q. Finally, previous investigations have not explored the opportunity to combine measurements of two different microcavity parameters in order to obtain a more accurate estimation of a sensing event. In this talk, with the solutions of the aforementioned issues, I will describe novel techniques (Cavity Ring down Spectroscopy) and analyses towards optimal performance of WGM microcavity sensors.

Droplet Optomechanics

Raphael Dahan, Leopoldo L. Martinand and Tal Carmon

Mechanical Engineering Department
Technion, Israel Institute of Technology

Unlike capillary resonance (Rayleigh, 1879) and optical resonance (Ashkin, 1977), acoustic resonance in fluid droplets has rarely been studied. Here we use droplets and optically excite and interrogate their acoustic resonances at a rate 1000 times faster than their capillary oscillation. We observe acoustical vibrations at 40 MHz that start at an optical threshold of 68 μW. Their high optical quality factor suggests that droplets might also exhibit continuous-time optical nonlinearities and opto-capillary interactions. We believe that our work will enable photonic MEMS and droplet optomechanics in devices made strictly of liquid.

Optical flow focusing: understanding fragmentation of confined co-flowing capillary threads

Matthieu Robert de Saint Vincent,[1,2,3], Hamza Chraïbi,[2,3] and Jean-Pierre Delville[2,3*]

[1]IPR, UMR CNRS 6251, Campus Beaulieu, Université Rennes 1, 35042 Rennes, France
[2]Univ. Bordeaux, LOMA, UMR 5798, F-33400 Talence, France
[3]CNRS, LOMA, UMR 5798, F-33400 Talence, France

Flowing liquid threads, naturally instable (convectively or absolutely) in three dimensions, are absolutely stable when confined by solid walls. A local squeezing, as imposed by flow-focusing through a geometric constriction can break this stability and lead to the fragmentation of the thread into a droplet trains. We use optocapillarity, i.e. laser-induced localised Marangoni stresses and interface deformation, to actively pinch the thread, force this fragmentation at the beam location and unveil the general mechanisms leading to destabilisation. Under continuous optical forcing, we show that the thread-to-droplet transition is, surprisingly, rather continuous as the instability induced by the laser pinching evolves from convective to absolute. We then demonstrate that the confinement imposes high-periodicity droplet regimes that build a robust bifurcation diagram that finally reconnects onto a monodisperse periodic fragmented regime, the size of the produced droplets being mainly controlled by the most unstable mode of the Rayleigh–Plateau instability. Continuous forcing in confined environment prevents any control of the drop size. Conversely, temporally modulating the optocapillary coupling reveals that the forced fragmentation results either from a triggered Rayleigh–Plateau instability, or purely from a strong optocapillary pinching. By forcing the fragmentation of stable capillary threads beyond the constraints of both confinement and Rayleigh–Plateau instability, this active control allows producing on demand monodisperse calibrated droplets. 'Optical flow-focusing' thus provides a new arm on tunable manipulation of liquids by light and more generally brings a new way to flow-focus fluid threads at low Reynolds number in a simple channel.

Humidity Detection Based on Polymer Optical Microdisk Resonators

M. Eryürek[1], Z. Teşdemir[2], Y. Karadağ[3], S. Anand[1], N. Kılınç[4], B. E. Alaca[2], A. Kiraz[1,5]

[1] Department of Physics, Koç University, İstanbul, Turkey
[2] Department of Mechanical Engineering, Koç University, İstanbul, Turkey
[3] Department of Physics, Marmara University, İstanbul, Turkey
[4] Department of Mechatronics Engineering, Niğde University, Niğde, Turkey
[5] TÜPRAŞ Energy Center (KÜTEM), Koç University, İstanbul, Turkey

Humidity sensors are required for applications such as weather forecasting, agricultural activities, semiconductor fabrication and high purity gas preparation. Optical detection methods allow very sensitive and precise sensing applications. In this work, whispering gallery mode (WGM) shifts of SU-8 polymer optical microdisk resonators are used as humidity sensors. Low percentages of relative humidity (RH) are detected with potential detection limit of 0.05% RH, which is limited by the wavelength resolution of the laser. The detection relies on the WGM spectra shifts of an SU-8 optical microdisk resonator fabricated on a thick-oxide Si wafer. A tunable laser light is coupled from an optical fiber to SU-8 waveguide, then to the resonator. Transmission spectrum is collected by another optical fiber and analyzed by Lorentzian fitting code. There are two phenomena contributing to the WGM shifts, volume expansion and refractive index change. Simulations about the expansion of microdisk under different RH levels and refractive index measurements on SU-8 under different RH levels suggest that refractive index change is dominant over the volume change. Further analysis on the sensing signal reveals between 50 and 100 s for both response and recovery times. This sensing scheme allows quick detection of low RH levels using sensors fabricated by only one-step standard UV photolithography.

Disruptions of interaction motifs with caveolin and ankyrin slow down diffusion of glial-specific Na,K-ATPase expressed in HEK293 cells as investigated by fluorescence correlation spectroscopy (FCS)

Cornelia Junghans[1], Vladana Vukojevic[2], Thomas Friedrich[1]

[1] Technical University of Berlin, Institute of Chemistry PC 14, Straße des 17. Juni 135, 10623 Berlin, Germany

[2] Karolinska Institutet, Department of Clinical Neuroscience, Center for Molecular Medicine CMM L8:01, 17176 Stockholm, Sweden

The Na,K-ATPase is a plasma membrane ion transporting enzyme, which is of high physiological importance in excitable and non-excitable cells of the CNS. Mutations in the genes coding for Na,K-ATPase isoforms lead to severe human pathologies like familial hemiplegic migraine (FHM type 2), alternating hemiplegia of childhood (AHC) or epilepsy. Many of the reported mutations lead to molecular loss- or change-of-function, but others lead to e.g. reduced protein stability or defective cellular localization. In this work we investigated whether mutational disruption of binding sites of the Na,K-ATPase with ankyrin-B and caveolin-1 entails changes in plasma membrane targeting of the enzyme or changes of the diffusion behavior of the enzyme. To determine the diffusion of single Na,K-ATPase molecules, we generated fusion proteins of Na,K-ATPase with eGFP and expressed these constructs in HEK293 cells, which enabled the observation of Na,K-ATPase molecules for single-molecule imaging and FCS studies using a ConfoCor3 microscopic system. Our studies reveal a surprisingly complex diffusion behavior of Na,K-ATPase, which is characterized by two diffusion times (about 500 µs and 60 ms), which both are significantly shortened by ankyrin-B- or caveoli-1-site mutations, with the most profound effect observed for the ankyrin-B site mutation. Moreover, the ankyrin-B site mutation also entailed a profound reduction in the number of Na,K-ATPase molecules in the plasma membrane. Combinations of interaction site mutations cause a synergistic further reduction of Na,K-ATPase diffusion times. These studies set the stage for investigating targeting and diffusion dynamics of Na,K-ATPase carrying mutations identified in human neurological pathologies, in order to expand the range of possible assay techniques from intrinsic (molecular) dynamics to cellular protein dynamics.

Optical cone-jet instability

Antoine Girot, Romain Pascalie, Julien Petit, Hamza Chraïbi, Ulysse Delabre, Jean-Pierre Delville

Univ. Bordeaux, LOMA, UMR 5798, F-33400 Talence, France.
CNRS, LOMA, UMR 5798, F-33400 Talence, France.

A century ago, Zeleny [1] demonstrated that fluid interfaces may become unstable under sufficiently intense electric fields. When the electric pressure exceeds the Laplace pressure, the interface takes a conical shape and emits a fine jet that usually breaks up into a spray. Such conical menisci are now often termed as Taylor cones and the fine jets emission from the tip of a cone is known as electrospraying.
Here we extend this electro-hydrodynamic cone-jet manifestation to the optical regime considering instead the optical radiation pressure of a continuous laser wave. It is already known that light can destabilize a soft liquid interface and gives birth to a jet [2]. Here we demonstrate for different fluid systems that a cone-jet shape can also emerge from this instability, especially when the contrast of the index of refraction between the liquids is increased. As for electrified interfaces, this conical shape is very stable and robust. We experimentally analyze the semi-angle of this conical shape as a function of the incident beam power, the beam waist and the index contrast. A numerical investigation is able to account for the observed variations. For large index contrast and beam waist, we also show a hierarchical multiple jet formation for increasing beam power, as in strong field electro-hydrodynamics. This new optical manifestation suggests an analogy between electro- and opto-hydrodynamics.

[1] J. Zeleny, "Instability of electrified liquid surfaces", Phys. Rev. 10, 1 (1917).
[2] J. P. Delville, et al. "Laser microfluidics: fluid actuation by light", J. Opt. A: Pure Appl. Opt. 11, 034015 (2009)

Emulsion droplets of liquid crystals as largely tunable anisotropic optical cavities

A. Jonáš[1], M. Aas[2], A. Kiraz[2], Z. Pilát[3], J. Ježek[3], S. Bernatová[3], and P. Zemánek[3]

[1]Istanbul Technical University, Department of Physics, Maslak, 34469 Istanbul, Turkey
[2]Koc University, Department of Physics, Rumelifeneri Yolu, Sariyer, 34450 Istanbul, Turkey
[3]Institute of Scientific Instruments of the Czech Academy of Sciences, Královopolská 147, 612 64 Brno, Czech Republic

Active fluid-based optical cavities containing a suitable gain medium serve as the starting point for developing integrated optofluidic sources of laser light. Liquid microdroplets with spherical geometry and smooth surfaces capable of hosting high-quality whispering gallery modes (WGMs) represent attractive self-assembled optofluidic cavities providing large flexibility in adjusting the cavity properties. Liquid crystals (LCs) are complex fluids combining solid-like long-range organization with fluidity that allows easy control of the molecular orientation. Anisotropy of LC fluids then leads to optical birefringence that can be adjusted by controlling orientation of LC molecules using external driving such as electric field, mechanical stress, or temperature changes.
We present our work focused on the development and characterization of tunable optofluidic cavities based on dye-doped LC emulsion droplets suspended in an immiscible host liquid with the refractive index smaller than the refractive index of the LC material, thus supporting WGM resonances. To this end, we explore various combinations of fluorescently dyed LCs and host liquid – surfactant systems. We show that emission spectrum of an LC droplet-based cavity can be largely and (almost) reversibly tuned by controlled changes of the ambient temperature that induce phase transitions in the LC droplets. We also study the possibility of tuning the cavity WGMs by modifying the spatial profile of the effective refractive index of the cavity via external AC electric field. Our results indicate feasibility of these approaches for creating miniature tunable sources of coherent light that can be integrated into microfluidic chips.
The authors want to acknowledge support from TÜBİTAC (114F253), TACR (TA03010642), CSF (P205/11/P29), and MEYS (LH12018, CZ.1.05/2.1.00/01.0017, CZ.1.07/2.4.00/17.0032).

Light- and Electrically-induced Manipulation of Nanoparticles in Arrays of Topological Defects

Denis Kasyanyuk[1*], Pasquale Pagliusi[2,3], Alfredo Mazzulla[3,] Victor Reshetnyak[4], Yuriy Reznikov[1], Clementina Provenzano[2], Michele Giocondo[3], Michail Vasnetsov[1], Oleg Yaroshchuk1 & Gabriella Cipparrone[2,3]

[1]Institute of Physics, National Academy of Sciences of Ukraine
[2]Physics Department, University of Calabria
[3]CNR-NANOTEC, LiCryL and Centre of Excellence CEMIF. CAL, Italy
[4]Taras Shevchenko National University of Kyiv, Ukraine

Optical tweezers that able to control single particles with a range typically restricted to the micro-scale. However, the capability to assemble and to manipulate particles, especially of nanoscale, at large range remains challenging. We report a new strategic approach based on using topological defects, i.e. disclination lines, created in liquid crystals [2]. We demonstrate that the topological defects efficiently trap nanoparticles, forming the chains. These chains can be moved over large distances (up to centimeters) by manipulating with the disclination by low power light or electric field. Large angle rotation, translation and deformation of light-emitting chains of quantum dots are demonstrated. Full reconfigurability and time stability make this strategy attractive for future developments and practical applications.

References

[1] Fan J. A., Wu C. H., Bao K., Bao J. M., Bardhan R., Halas N. J., Manoharan V. N., Nordlander P., Shvets G., Capasso F. Self-Assembled Plasmonic Nanoparticle Clusters, Science 328, 1135-1138 (2010).

[2] D. Kasyanyuk, P. Pagliusi, A. Mazzulla, V. Reshetnyak, Yu. Reznikov, C. Provenzano, M. Giocondo, M. Vasnetsov, O. Yaroshchuk, G. Cipparrone. Light manipulation of nanoparticles in arrays of topological defects. Scientific Reports - Nature, 6:20742 | DOI: 10.1038/srep20742 (2016).

Controlled particle manipulation using Thermocapillary convective flow

Ronald Terrazas Mallea[a], Pierre Lambert[a], Aude Bolopion[b], Michael Gauthier[b]

[a] Universite Libre de Bruxelles, Ecole Polytechnique de Bruxelles, Bio, Electro And Mechanical Systems Department, Av. Franklin Roosevelt 50, 1050 Brussels, Belgium
[b] FEMTO-ST, Automatic Control and Micro-Mechatronic Systems Department, Av. de l'Observatoire 32, 25000 Besançon, France

Fast and accurate positioning of micron size components is of the utmost importance, both from the applicative point of view (electronic and packaging industries, biological cells handling and sorting) as well as from the scientific side. The goal of this research project is to manipulate micrometric scale objects at the fluid interface using thermocapillary convective flows induced by laser heating as actuating principle on a closed-loop system. Experimental test have been already carried on, in which a 500-μm-diameter spherical steel particle is displaced at velocities up to 4-5 mm/s. The system was experimentally identified and the results are used to develop a controller for the system. The experiments show that the particle can be displaced towards a target position without any major problem.
The experimental results show that the particle manipulation becomes difficult when the particle velocity is at noise level (around 0.8 mm/s), which tends to ocurr when the particle is close to the target position. In consequence, the particle position stabilization becomes difficult, so this is a problem to tacke in the future. Currently different solutions are being analyzed, among them: changing the gains depending if the particle velocity is at noise level using an adaptive control law, or enclosing the particle with a laser circle around it that will push the particle towards its center and will keep the particle there. Another future goal is to develop a model that allows to estimate the system behavior for particles with different characteristics: size, material and shape. To do so, the different parameters affecting the particle movement have to be identified and analyzed in order to quantify their effect.

Optically stimulated capillary waves

Leopoldo Martin

Mechanical Engineering Department Technion, Israel Institute of Technology

We experimentally demonstrate stimulated capillary-scattering and coherent excitation of capillary modes. We do so by fabricating a special type of liquid-walled micro-cavity that not only contains an optical modes, but also co-hosts a capillary resonances. Our micro-spherical resonator is made of a low-viscosity liquid that is also highly transparent so that its capillary quality-factor (Qcap) is 18 while it's optical one (Qopt) is 10 million. We manipulate the resonator by means of optical tweezers to allow evanescent coupling to a taper fiber located in a microfluidic chamber. Once coupled , we tune the laser coupled to to our hybrid optocapillary-cavity to operate at its non-resolved sideband regime where energy transfer from light to capillary oscillations (Stokes) is preferred over the reversed one. Coherent capillary-resonance at audio-band rates (kHz) is optically excited at pump threshold of 77 μW, while generating stimulated capillary-scattering. Our device might extend its impact beyond just ripplon lasers. Possible unexplored areas that will be accessible with optocapillary cavities include sideband-cooling and coherent-control of capillaries as well as resonantly-enhanced optical interrogation of capillary phenomena.

Biomaterial-based optical waveguides for deep-tissue photomedicine

Sedat Nizamoglu

Koç University, Department of Electrical and Electronics Engineering
Rumelifeneri Yolu, 34450 Sariyer, Istanbul

The depth of light penetration in tissue is still the fundamental limitation for all of the photomedical techniques. When penetrating through tissue from an external light source, light is quickly attenuated by scattering and absorption. Light delivery into the body of a patient or an animal is currently achieved via fiber-optic catheters or lens-based endoscopes that are made of materials such as glass or plastic, which are readily available, but generally not biocompatible. Such devices can only be used for bringing a light source close to the target tissue in the body and they must be removed from the body soon after use. Therefore, delivering the light further into the tissue has remained a challenge. In this talk, I will present a new class of biomaterial-based optical devices for light-based therapy, surgery and diagnosis. I will discuss bioabsorbable optical waveguides for wound closure and cell-integrated hydrogels for in vivo optical-sensing and therapy.

High precision indirect optical manipulation of live cells with functionalized microtools

A. Buzas, G. Vizsnyiczai, B.L. Aekbote, L. Kelemen and P. Ormos

Biological Research Centre of the Hungarian Academy of Sciences
Szeged, Temesvari krt. 62, 6726, Hungary

Optical micro manipulation of live cells has been extensively used to study a wide range of cellular phenomena with relevance in basic research or in diagnostics. The approaches span from manipulation of many cells for high throughput measurement or sorting, to more elaborated studies of intracellular events on trapped single cells when coupled with modern imaging techniques. In case of direct cell trapping the damaging effects of light-cell interaction must be minimized, for instance with the choice of proper laser wavelength. Microbeads have already been used for trapping cells indirectly thereby reducing the irradiation damage and increasing trapping efficiency with their high refractive index contrast. We show here that such intermediate objects can be tailor-made for indirect cell trapping to further increase cell-to-focal spot distance while maintaining their free and fast maneuverability. Carefully designed structures were produced with two-photon polymerization with shapes optimized for effective manipulation and cell attachment. Functionalization of the microstructures is also presented that enables cell attachment to them within a few seconds with strength much higher that the optical forces. Fast cell actuation of 6 degrees of freedom is demonstrated with the outlook to possible applications in cell imaging.

Text summary

We introduce tailor-made 3D microstructures as intermediate objects for indirect live cell manipulation. These tools ensure a safe several micrometers cell-to-focal spot distance to prevent radiation damage of the cells while maintaining their free and fast maneuverability. The microstructures were produced with two-photon polymerization with shapes optimized for effective manipulation and cell attachment. Functionalization of the microstructures is also presented that enables cell attachment to them within a few seconds with strength much higher that the optical forces. Fast cell actuation of 6 degrees of freedom is demonstrated with the outlook to possible applications in cell imaging.

Perforated SOI Microring Resonators for Enhanced Microfluidic Sensing

Raimondas Petruškevičius[1], Darius Urbonas[1], Martynas Gabalis[1], Konstantinas Vaškevičius[1], Armandas Balčytis[1,2], Saulius Juodkazis[2]

[1]Center for Physical Sciences and Technology, Savanorių ave. 231, Vilnius LT-02300, Lithuania,
[2]Centre for Micro-Photonics, Swinburne University of Technology, Hawthorn, VIC 3122, Australia
email: raimisp@ktl.mii.lt

A novel perforated microring resonator structure with subwavelength defects has been proposed for enhancement of light matter interaction, biosensing and applications in microfluidics. The device is fabricated on a Silicon-on-Insulator (SOI) platform. The performance has been analyzed in bulk and surface sensing schemes. Our design not only achieves high sensitivity, but also increases the total area of the interface between the microring resonator and the surrounding aqueous medium, which enhances the light matter interaction, and has high potential for microfluidic biosensing applications.
The initial device fabrication results are discussed. It is shown that microring resonator with subwavelength perforations enhances SOI ring sensor sensitivity up to 3-5 times. The microring resonator with a first order Bragg grating and a defect mode has large spatial detection resolution and wider free spectral range. On the other hand, if the microring is modified with a second order Bragg grating, the resulting structure can be used for generation of optical vortices and micro-manipulation of nanoparticles.

Electric field controlled switching from planar to twisted state in liquid crystal on nano-patterned substrate

V. Yu. Reshetnyak[1], T.J. Bunning[2] and D. R. Evans[2]

[1]Physics Faculty, Taras Shevchenko National University of Kyiv, Kyiv, Ukraine
[2]Air Force Research Laboratory, Materials and Manufacturing Directorate, Wright-Patterson Air Force Base, USA

We study a liquid crystal (LC) sandwiched between two substrates, one of the substrates (bottom one) has a 2D spatially periodic nano-array deposited onto it. We speculate that this nano-array results in a two mutually orthogonal easy axes for the liquid crystal director anchoring at the patterned substrate. The easy axis at the patterned substrate , where for the first easy axis and the azimuthal anchoring energy coefficient is W1, and for the second easy axis with the anchoring energy coefficient W2. It is supposed that the easy axis direction at top substrate is given by , and there is a strong anchoring at that substrate. Following the work of Fukuda et al. [1] we assume the following functional dependence of the director anchoring in the azimuthal plane at nano-patterned substrate . Minimizing the total free energy of the LC slab subject to the applied voltage we find that under a certain value of the applied voltage it possible to switch the LC director from the initial planar configuration to a twisted one. This phenomenon can be used to control the surface plasmons excitation in the nano-array antenna.

References

[1] Jun-ichi Fukuda, Makoto Yoneya, and Hiroshi Yokoyama, Phys. Rev. Lett. 98, 187803 (2007)

Acknowledgements: The work was partially supported by COST Action MP1205 and EOARD Grant P521a. We also acknowledge discussions with Yu-Cheng Hsiao, Kuo-Ping Chen and Wei Lee (National Chiao Tung University, Taiwan).

Laser switching contrast microscopy to monitor free and restricted diffusion inside the cell nucleus

Franz-Josef Schmitt[1*], Cornelia Junghans[1], Matthias Sturm[2], Csongor Keuer[1], Hans Joachim Eichler[2], Thomas Friedrich[1]

[1] Technical University of Berlin, Institute of Chemistry PC 14, Straße des 17. Juni 135, D-10623 Berlin, Germany
[2] Technical University of Berlin, Institute of Optics and Atomic physics ER1-1, Straße des 17. Juni 135, D-10623 Berlin, Germany
***corresponding authors mail:** schmitt@physik.tu-berlin.de

A novel microscopic technique termed laser switching contrast microscopy (LSCM) allows for the imaging of the dynamics of optically switchable proteins in single cell compartments. We present an application for the monitoring of diffusive properties of single molecules of the photo-switchable fluorescent protein Dreiklang (DRK). LSCM in the cell nucleus of Chinese hamster ovary (CHO) cells cytoplasmically expressing DRK unravels quick diffusive equilibration of the DRK molecules inside the whole cytoplasm and inside the cell nucleus within seconds. The nuclear membrane is also highly permeable for DRK. Inside the nucleus entirely distinct regions are found that only partially enable diffusive protein redistribution with mean square displacement proportional to time while in other regions the mobility of the proteins seems to be restricted.
After photo-switching string like patterns of light DRK molecules are observed in the cell nucleus. In addition a fraction of these DRK molecules appears immobile. The findings support recent theories of the cell interior described as a random obstacle model with an additional immobile fraction of DRK.
Numerical simulations show that at different illumination intensity and different distance from the laser focus similar patterns for fluorescence recovery might be obtained in spite of strongly varying diffusion constants.

Efficient optofluidic laser based on Fabry-Perot cavity realized by femtosecond nanofabrication

F.Simoni, D. E. Lucchetta, P. Spegni
Dipartimento SIMAU, Università Politecnica delle Marche, Ancona , Italy

L. Criante, S. Bonfadini, S. Lo Turco
Center for Nano Science and Technology@PoliMi, Istituto Italiano di Tecnologia, Milano, Italy

We report the last development on the realization of optofluidic lasers by femtosecond nanofabrication based on Fabry-Perot cavity. In the past decade a lot of work has ben performed in order to realize optofluidic lasers with low threshold and narrow linewidth. The interest in developing such devices is in the great potential they have to be used in lab-on-chip (LOC) technology for biomedical application, security and environment monitoring. In the past Fabry-Perot cavities have been realized using multistep photo-litographic fabrication, with threshold of few tens of μJ/mm^2 and linewidth not lower than 3-4 nm.
We report the demonstration of optofluidic laser based on a Fabry-Perot optical cavity where femtosecond laser processing in glass is coupled to ink-jet technology, necessary to realize integrated mirrors through a fine control of surface coating. By using a solution of Rh6G as active medium we were able to get reliable laser emission with threshold down to 2 μJ/mm^2 and linewidth below 0.5 nm getting a quality factor Q>10^3.

Femtosecond laser carving and its application to fiber-optic based particle counting

Murat Serhatlioglu[1], Bulend Ortac[1], Caglar Elbuken[1], Necmi Biyikli[1], Mehmet E. Solmaz[2]*
[1]UNAM - National Nanotechnology Research Center, Bilkent University, Ankara, Turkey
[2]Department of Electrical and Electronics Engineering, Izmir Katip Celebi University, Izmir, Turkey
*mehmete.solmaz@ikc.edu.tr

We demonstrate our first results of femtosecond laser carving of fused silica to fabricate an optofluidic device for counting polystyrene particles. Femtosecond laser is used to irradiate the fused silica in a predefined pattern to create surface channels. A novel 3D hydrodynamic focusing architecture is used to align the particles in the middle of the channel. Fiber optic cables are integrated into for flow based particle counting. Our device avoids any bulky optical component, and integrates microfluidics with optical fibers for precise and permanent alignment.

Patterning of diamond like carbon films using silicon containing thermoplastic resist (SiPol) as hard mask

D. Virganavicius [a,b], V.J. Cadarso [a], H. Schift [a], T. Tamulevičius[b], S. Tamulevičius[b]

[a] Paul Scherrer Institute, Laboratory of Micro- and Nanotechnology, 5232 Villigen PSI, Switzerland
[b] Kaunas University of Technology, Institute of Materials Science, 51423 Kaunas, Lithuania

Patterning of materials such as diamond-like carbon (DLC) and DLC nanocomposites is of interest for an increasing number of applications. We demonstrate a nanoimprint process based on the use of silicon containing thermoplastic resist combined with plasma etching to straightforwardly pattern such films. Variety of different structures with few hundred nanometer feature size and moderate aspect ratios including subwavelength diffraction grating were successfully realized. Quality of the produced patterns was directly investigated by the means of optical and scanning electron microscopy (SEM). Optical measurements of guided mode resonance (GMR) effect in grating type patterns were also used to assess quality of the produced gratings comparing measured response spectra with numerical simulations.

We demonstrated the successful use of a hard mask based on the new thermoplastic resist SiPol to pattern DLC films by thermal NIL process. SiPol can serve as efficient hard mask for etching DLC coatings, ensuring 1:4 selectivity for undoped and 1:2.5-2.8 for silver doped DLC coatings. Adhesion issues can be solved by using low temperature imprint in combination with incomplete filling of stamp cavities. The low temperature imprint approach, combined with incomplete filling of stamp cavities did not only allow a zero residual layer imprint but also facilitated the original SiPol process involving an organic transfer layer by removing intermediate etchings resulting into minimum number of processing steps. DLC coatings (and to some extent DLC coatings doped with silver) can be effectively etched with oxygen plasma (ICP) with high precision and vertical sidewalls at least up to 500 nm depth. This enables the homogeneous transfer of relatively large area patterns of a 20x20mm2 into DLC. The current applications have moderate aspect ratio and resolutions down to several hundred nanometers, which does not seem to be the final limit. Optical response of leaky-waveguide chips based on DLC produced using the new thermoplastic resist show high sensitivity to refractive index changes in the ambient and was equal to 319nm/RIU. These results in high degree agree with RCWA simulations of ideally rectangular grating, indirectly confirming transferred pattern quality. The observed pronounced GMR signal implies that DLC based gratings can be used as corrosion and wear resistant refractive index sensors. This enables to use thermal NIL for patterning of DLC based devices with a high degree of reproducibility. The proposed method of fabrication can be successfully applied to fabricate such sensor chips in high throughput and cost efficient way.

Redesign and reconstruction of the optically coupled sensor device

Dr. Elmar Wolff, Inst. of Applied Biotechnology and Systemanalysis at Univ. Witten/Herdecke, Witten, Germany
Prof. Andras Der, Institute of Biophysics, Biological Research Center, Szeged, Hungary

Overall, the STSM was very useful to acquire experimental expertise and finding ways for redesign and reconstruction of the the basis of optically coupled sensor device. On the basis of our new results, automating the construction technology of these devices seem now possible. Assuming we use a mono-mode optical fiber with a cladding diameter 125 µm, the precision is better than 0.5 µm. Fixing the light guide to the V-channel, the central of the light guiding core with a diameter of 3 - 5 µm lies between 61,7 to 55,8 µm with a precision of 0,14 to 0,35 µm depending on the with of the channel. Even the uncertainty of the cladding diameter can be partially compensated. To be able to couple the separate produced sensor-structure to optical devices, a baseplate of 56 to 60 µm has to be used to print it on. Unfortunately we had only thicker plates, but it can be bought as special order. What is now the advantage of our method, we will develop in the future? Until now every sensordevice had to be coupled by hand under the microscope in X,Y,Z and all associated angel. So it is a lot of work by hand, which is very subjective and not optimizable. Especially if you want to couple
several devices together is becomes impossible. In our case we can adjust to the reference structure of the channel optically under the Microscope by little movements in the X-Y-plane under little angular changes. But the main feature is, the hole process is automatable with a microscope coupled robot, which exists in the lab of IBiS in Witten. This way sets of sensors will be possible. Moreover, discussions, experiments and theoretical calculations led to interesting preliminary results and new promising ideas for future collaborative researches. It is planed, after finishing the
remaining work, which can be done separately in each lab, to visit again in next summer BRC, to establish the coupling and determine the exact parameter for the automatization. BRC and IBiS will than submit a common European project proposal on the use of this technique in sensor applications.

Behaviour of Non-spherical Particles in Laser Beams

P. Zemánek[1], O. Brzobohatý[1], A. V. Arzola[2], M. Šiler[1], S. Simpson1, L. Chvátal[1], P. Jákl[1]
[1]Institute of Scientific Instruments of CAS, Czech Academy of Sciences, Královopolská 147, 612 64 Brno, Czech Republic
[2] Instituto de Física, Universidad Nacional Autónoma de México, Apdo. Postal 20-364, 01000 México, D.F. México
corresponding author : zemanek@isibrno.cz,

Optical trapping of a particle is based on exchange of linear momentum between incident photons and the particle which leads to an optical force acting upon the particle. In the case of a non-spherical particle, this optical interaction is inevitably enriched by the exchange of angular momentum between photons and the particle. Consequently, the optical torque orients the particle in the laser beam. However, particle orientation strongly influences the trapping force and equilibrium position of the particle in the beam and thus makes the particle behaviour more complex.
In this contribution we demonstrate how a natural non-spherical shape of gold nanoparticles enables their three-dimensional trapping even in a single focused beam with numerical aperture as low as 0.2-0.37[1,2]. In the case of larger particles of spheroidal shape, we demonstrate their rotation due to transfer of spin angular momentum in counter-propagating Gaussian beams of opposite circular polarization. In the case of several rotating particles [3] we observed synchronization of their rotation due to optical interaction.
The authors acknowledge support from CSF (GA14-16195S, GA14-36681G), COST Action MP1205, MEYS (LD14069, LO1212) and EC (CZ.1.05/2.1.00/01.0017).
[1] O. Brzobohatý et al., Three-dimensional optical trapping of a plasmonic nanoparticle using low numerical aperture optical tweezers, Scientific Reports 5, 8106, (2015)
[2] O. Brzobohatý et al., Non-spherical gold nanoparticles trapped in optical tweezers: shape matters, Optics Express 23, 8179, (2015)
[3] O. Brzobohatý et al., Complex rotational dynamics of multiple spheroidal particles in a circularly polarized dual beam trap, Optics Express 23, 7273, (2015)

POSTER PRESENTATIONS

Self-propelling Janus particles at the liquid-liquid interfaces

Mohammad Tahboub Amawi[1], Sabareesh K.P. Velu[1], Ivo Buttinoni[2], Lucio Isa[2], Giovanni Volpe[1, 3]

[1]Soft Matter Lab, Department of Physics, Bilkent University, Cankaya, 06800 Ankara, Turkey
[2]Laboratory for Interfaces, Soft matter and Assembly, Department of Materials, ETH Zurich, Switzerland
[3]UNAM – National Nanotechnology Research Center, Bilkent University, Ankara 06800, Turkey

Examples of microswimmers capable of self-propulsion include biological entities, such as bacteria and chemotactic cells, and artificial particles, such as Janus particles immersed in hydrogen-peroxide-enriched solutions or in quasi-critical mixtures. Here, we study a novel self-propulsion mechanism where metal-coated Janus particles are confined in a quasi-two-dimensional space constituted by a water-oil interface. When the Janus particles are illuminated with light of the appropriate wavelength, they generate temperature gradients and start self-propelling due to local Marangoni flows. We study the active motion as a function of various parameters including the particle size and the illumination intensity.

Observation of Whispering Gallery Modes in Elastic Scattering from Optically Trapped Microdroplets in a Microfluidic Channel

S.Anand[1] , M. Eryürek[1], Y. Karadağ[2] , A. Jonas[3], A. Serpengüzel[2] , And A.Kiraz[1]

[1]Koç University, Department of Physics, Rumelifeneri Yolu, 34450, Sarıyer, ˙Istanbul, Turkey
[2]Marmara University, Department of Physics, 34722, Göztepe, ˙Istanbul, Turkey
[3]Istanbul Technical University, Department of Physics, ˙Istanbul, Turkey

Whispering gallery modes (WGMs) of oil droplets, optically trapped in water inside a microfluidic channel is excited by using a single mode optical fiber. The droplets with diameters ranging between 15-50 μm were transferred into a microfluidic channel and optically trapped near the tip of a single mode fiber that was used for excitation of the droplet WGMs using a tunable laser. Elastically scattered light from individual droplets was collected in 90˚ geometry. WGMs with quality factors (Q-factors) of more than 104 were observed for larger droplets. In some cases WGMs were observed to shift to blue colors due to droplet dissolution. Spectral diffusion to blue and red colors was also observed in some other cases. These were attributed to contaminants in the droplet or host liquids, showing the suitability of optically trapped droplet resonators for optical sensing.

Self-assembly of active particles in evaporating droplets

Tuğba Andaç[1], Naveed Mehmood[1], Sabareesh K. P. Velu[1], Doruk Engin[2], Giovanni Volpe[1,3]

[1] Soft Matter Lab., Department of Physics, Bilkent University, Çankaya, 06800 Ankara, Turkey
[2] Biotechnology Institute, Ankara University, Tandoğan, 06560 Ankara, Turkey
[3] UNAM – National Nanotechnology Research Center, Bilkent University, Çankaya, 06800 Ankara, Turkey

Self-assembly is a process in which disordered components of a system get organized/ ordered through local interaction. Examples of it can be found at macroscopic and even microscopic scales. Few of them include flocks of birds, swarms of fish, formation of snowflakes and DNA helix. Among several methods, evaporation driven self-assembly became an effective way of understanding the mechanisms underlying the self-assembled patterns thanks to the ease and simplicity of the method. In this research line, there are a lot of studies that have been performed but mostly focused on passive particles which undergo random Brownian motion due to the thermal fluctuations. Here, in this work, we experimentally study the self-assembly of evaporating droplets containing active particles which have the ability to self propel using digital video microscopy. Our results demonstrate that the motility of active particles plays an important role in the formation of self-assembled patterns.

Experimental evidence of the failure of Jarzynski equality in active baths

Aykut Argun,[1] Ali-Reza Moradi,[1, 2, 3] Er43cag Pince,[1] Gokhan Baris Bagci,[4] and Giovanni Volpe[1, 5]

[1]Soft Matter Lab, Department of Physics, Bilkent University, Cankaya, 06800 Ankara, Turkey
[2]Department of Physics, University of Zanjan, PO Box 45195-313, Zanjan, Iran
[3]Optics Research Center, Institute for Advanced Studies in Basic Sciences, PO Box 45137-66731, Zanjan, Iran.
[4]Department of Materials Science and Nanotechnology Engineering, TOBB University of Economics and Technology, 06560 Ankara, Turkey
[5]UNAM { National Nanotechnology Research Center, Bilkent University, Ankara 06800, Turkey
(Dated: January 8, 2016)

Most natural and engineered processes, such as biomolecular reactions, protein folding, and population dynamics, occur far from equilibrium and, therefore, cannot be treated within the framework of classical equilibrium thermodynamics. The Jarzynski equality holds the promise to calculate the free-energy difference between two states from the Boltzmann-weighted statistics of the irreversible work done along trajectories arbitrarily out of equilibrium. This equality is the subject of intense activity. However, the applicability of the Jarzynski equality to systems far from equilibrium such as living matter has not been investigated yet. We present an experimental test of the Jarzynski equality predictions on a paradigmatic physical model, i.e. a Brownian particle held in an optical potential, coupled either to a thermal bath or to an active bath. While in the thermal bath we nd that the Jarzynski equality correctly retrieves the free-energy difference from nonequilibrium measurements, in the active bath the Jarzynski equality fails because of the presence of non-Boltzmann statistics. We corroborate our experimental ndings with theoretical arguments and numerical simulations.

[1] A. Argun, A-R Moradi, E. Pince, G.B. Bagci, and G. Volpe, \Experimental evidence of the faileure of the jarzynski equality in active baths," ArXiv 1601.01123 (2016).

Intra-Cavity Optical Trapping with Fiber Laser

Fatemeh Kalantarifard[a], Parviz Elahi[b], Ghaith Makey[b], F. Ömer Ilday[b,c,] and Giovanni Volpe[a,d]
[a]Soft Matter Lab, Department of Physics, Bilkent University, 06800 Ankara, Turkey.
[b]Department of Physics, Bilkent University, 06800 Ankara, Turkey
[c]Department of Electrical and Electronics Engineering, Bilkent University, 06800 Ankara, Turkey
[d]National Nanotechnology Research Center (UNAM), Bilkent University, 06800 Ankara, Turkey

We propose a novel approach for trapping micron-sized particles and living cells based on optical feedback. This approach can be implemented by a lens at low numerical aperture (NA=0.5) and long working distance. In this Configuration, an optical tweezers is constructed inside a ring cavity fiber laser and the laser signal (optical feedback) in the ring cavity is controlled by the light scattered from a trapped particle.
In particular, once the particle is trapped, the laser operation, optical feedback and intra-cavity power are affected by the particle motion. This is due to the fact that the trapped particle changes the loss of the system while moving due to Brownian motion and this, in turn, will change the laser signal power which traps the particle. Using this configuration is possible to stably hold micron-sized particles and single living cells in the focal spot of the laser beam.

Experimentally investigation of Critical Casimir forces in water-lutidine mixture by blinking optical tweezers

A. Magazzù [1]; F. Schmidt [1]; A. Callegari [1]; G. Volpe [1,2];

[1] Soft Matter Lab, Department of Physics, Bilkent University, Ankara 06800, Turkey
[2]UNAM – National Nanotechnology Research Center, Bilkent University, Ankara 06800, Turkey

As Casimir forces arise by zero point vacuum fluctuations of the electromagnetic field confined between two surfaces, as (in a similar way) critical Casimir forces are due to the concentration fluctuations, between two close surface, of a binary liquid mixture close to its critical point [1,2].
The range of critical Casimir forces is strongly temperature dependent because it is given by the bulk correlation length of the binary mixture, which diverges upon approaching the critical point [3].
Critical Casimir forces, despite quantum-electrodynamical Casimir force show a universal scaling behavior, which is only due to the internal symmetries of the system and it does not depend on the specific material properties and it does not depend on boundary conditions [1].
For this reason considering two silica beads immersed in a water-lutidine solution near its critical point, we can observe that at a sufficiently small distance, the concentration fluctuations of the solvent are confined between the surfaces, modifying the particles interaction [4].
We use blinking optical tweezers to investigate the interaction between two silica particles immersed in a water-lutidine critical solution in order to understand and quantify the effect of critical Casimir forces occurring near the critical point [5].
This technique allow us to trap and release a couple of conveniently close silica particles with a proper frequency in order to track their Brownian motion without the present of the confining optical potential.
By tracking the particles when they are not subjected to the optical potential we are able to find experimentally the temperature depending potential acting on them, which is the sum of electrostatic and critical Casimir potential [4].

[1] Krech, M. "Fluctuation-induced forces in critical fluids." arXiv preprint cond-mat/9909413 (1999).
[2] Hertlein C. et al. "Direct measurement of critical Casimir forces." Nature 451.7175 (2008): 172-175. [3] Nellen U. et al. "Salt-induced changes of colloidal interactions in critical mixtures." Soft Matter 7.11 (2011): 5360-5364. [4] Sathyanarayana P., Volpe G. "Nonadditivity of Critical Casimir Forces." arXiv preprint cond-mat.soft/1511.02613v1 (2015) [5] Sainis, Sunil K., Vincent Germain, and Eric R. Dufresne. "Statistics of particle trajectories at short time intervals reveal fN-scale colloidal forces." Physical review letters 99.1 (2007): 018303.

Engineering Sensorial Delay to Control Phototaxis and Emergent Collective Behaviors

Mite Mijalkov, Austin McDaniel, Jan Wehr, and Giovanni Volpe

Collective motions emerging from the interaction of autonomous mobile individuals play a key role in many phenomena, from the growth of bacterial colonies to the coordination of robotic swarms. For these collective behaviors to take hold, the individuals must be able to emit, sense, and react to signals. When dealing with simple organisms and robots, these signals are necessarily very elementary; e.g., a cell might signal its presence by releasing chemicals and a robot by shining light. An additional challenge arises because the motion of the individuals is often noisy; e.g., the orientation of cells can be altered by Brownian motion and that of robots by an uneven terrain. Therefore, the emphasis is on achieving complex and tunable behaviors from simple autonomous agents communicating with each other in robust ways. Here, we show that the delay between sensing and reacting to a signal can determine the individual and collective long-term behavior of autonomous agents whose motion is intrinsically noisy. We experimentally demonstrate that the collective behavior of a group of phototactic robots capable of emitting a radially decaying light field can be tuned from segregation to aggregation and clustering by controlling the delay with which they change their propulsion speed in response to the light intensity they measure. We track this transition to the underlying dynamics of this system, in particular, to the ratio between the robots' sensorial delay time and the characteristic time of the robots' random reorientation. Supported by numerics, we discuss how the same mechanism can be applied to control active agents, e.g., airborne drones, moving in a three-dimensional space. Given the simplicity of this mechanism, the engineering of sensorial delay provides a potentially powerful tool to engineer and dynamically tune the behavior of large ensembles of autonomous mobile agents; furthermore, this mechanism might already be at work within living organisms such as chemotactic cells.

Optical trapping of the microparticles with low-numerical-aperture objectives using self binding

S. Masoumeh Mousavi[1], Agnese Callegari[1], Onofrio Maragò[2] and Giovanni Volpe[1,3]

[1] Department of Physics, Bilkent University, Cankaya, Ankara 06800, Turkey
[2] CNR-IPCF Messina, I-98158 Messina, Italy
[3] UNAM, Bilkent University, Cankaya, Ankara 06800, Turkey

Optical tweezers are a well established technique for the trapping and manipulation of particles. Tightly focused laser beams, obtained by using high-numerical-aperture (high-NA) objectives, are used commonly for 3D trapping. In the case of low-numerical-aperture (low-NA) objectives, usually only 2D trapping can be achieved, because in the axial direction the scattering force overcame the gradient force, so that in the axial direction the particle is usually pushed away. Here, we propose a novel technique to trap particles with low-NA objectives using a novel phenomenon we name self-binding. In self binding, the dielectric particle interacts with its scattered light after it has been reflected by a mirror. We show that in this situation the scattered rays reflected from the mirror can exert a force on the particle that can overcome the scattering force and effectively trap the particle. We show that in some conditions, the trapping stiffness for a low-NA self-binding optical trap is even larger than the stiffness of a high-NA optical trap. We emphasize that such a technique is potentially important when dealing with sensitive samples such as biomolecules and living cells: such systems benefit from the trapping with small optical intensity because it helps preventing photo damage and the degradation of the sample.

Laminar Flow-Induced Dissolution in Hydrodynamically Trapped Oil Microdroplets

A. Mustafa[1], A. Eser1, O. Kayıllıoğlu[1], A. Erten[1], M. Irfan[2], M. Muradoglu[2], M. Tanyeri[3], and A. Kiraz[1,4]

[1] Department of Physics, Koç University, Sariyer, Istanbul, Turkey,
[2] Department of Mechanical Engineering, Koç University, Sariyer, Istanbul, Turkey
[3] Department of Electrical and Electronics Engineering, Istanbul Sehir University, Uskudar, Istanbul, Turkey
[4] Department of Electrical and Electronics Engineering, Koç University, Sarıyer, Istanbul, Turkey
E-mail: melikhantanyeri@sehir.edu.tr; akiraz@ku.edu.tr

In this work we studied the dissolution of oil microdroplets using a novel trapping technique known as Hydrodynamic Trapping in a microfluidic chip. Planar extensional flow is required to hydrodynamically trap a microdroplet at a point in microfluidic chip that point is called stagnation point and that particular part of the device is known as trapping region. Recently, hydrodynamic trapping has been introduced as a powerful tool for trapping and manipulation of microbeads, DNA molecules, and cells. The dissolution of liquid microdroplets in aqueous solutions have been a key research area for a long time. One parameter characterizing the dissolution is diffusion coefficient or in other terms mass transfer coefficient. Diffusion coefficient is an important parameter for industrial applications such as separation/sorting processes and drug delivery/design.

In our work we observe the dissolution using microdroplets of benzyl benzoate and n-decanol trapped in water and surfactant (DSS) solution at different flow rates. The dissolution of these microdroplets is explained by the presence of planar extensional flow that enhances the solubility of oil in water. The results show that rate of dissolution of microdroplets increases at high flow rates. The rate of dissolution also changes from benzyl benzoate to n-decanol with n-decanol dissolving faster than benzyl benzoate. The results obtained from the experiments were analyzed and used to modify the Epstein-Plesset equation. Our scheme can be extended to show single cell trapping.

Surface relief gratings parameters in polarization holographic recording in pure azopolymer and hybrid azopolymer based organic/inorganic materials

D. Nazarova[1], L. Nedelchev[1,2], N. Berberova[1], D. Daskalova[1], E. Stoykova[1]

[1]Institute Of Optical Materials And Technologies, Bulgarian Academy Of Sciences, Acad.g.bonchev Str., Bl.109, Sofia 1113, Bulgaria
[2]University Of Telecommunications And Post, Acad. St. Mladenov 1 Str, Sofia 1700, Bulgaria

We present study of the parameters of polarization holographic gratings in pure azopolymer PAZO (Poly[1-[4-(3-carboxy-4-hydroxyphenylazo) benzenesulfonamido]-1,2-ethanediyl, sodium salt]) and hybrid PAZO-based organic/inorganic materials with incorporated ZnO nanoparticles with size below 50 nm. For the recording, a laser emitting at 491 nm is used. The kinetics of the diffraction efficiency is probed with a diode-pumped solid-state laser at 635 nm. Surface relief gratings with different spatial frequencies are inscribed by varying the recording angle and analyzed by AFM. The kinetics of the diffraction efficiency, as well as the height of the relief gratings are measured and compared. The results allow to optimize the recording process in these materials for applications including holographic data storage and formation of diffractive optical elements with special polarization properties.

Birefringence induced at multiple wavelengths in azopolymer films: kinetics and spectral dependance

Lian Nedelchev[1,2], Dimana Nazarova[2], Deyan Ivanov[2], Blaga Blagoeva[2]

[1]University of Telecommunications and Post, Acad. St. Mladenov 1 Str, Sofia 1700, Bulgaria
[2]Institute of Optical Materials and Technologies – Bulgarian Academy of Sciences, Acad.G.Bonchev Str., bl.109, Sofia 1113, Bulgaria
Contact e-mail: l.nedelchev@utp.bg

One of the most important optical parameters of the azopolymers is the value of the birefringence Δn induced in them on illumination with polarized light. Usually, laser beam at a single wavelength is used as a pump and the birefringence is measured at another single wavelength, different from the pump one. Data about the spectral behavior of Δn are given rarely and even in these cases, the birefringence is induced at a single wavelength. To our best knowledge, there are no reports about the influence of the recording laser wavelength on the photoinduced birefringence spectrum Δn(λ). Therefore, in this work we present experimental data for the spectrum of birefringence, induced with pump lasers at different wavelengths (from 350 nm to 550 nm) within the absorbance band of the azopolymer used. The photoinduced birefringence kinetics – Δn(t) is monitored in real time, measuring the Stokes parameters of a probe He-Ne laser beam (λ = 633 nm) passing through the sample.
The spectral dependence of Δn is measured in the range 390-700 nm. The results show that Δn varies from 0.05 at the longer wavelengths up to 0.12 close to 400 nm. Good coincidence is observed between the value of Δn obtained from the real-time measurement and Δn(@633 nm) from the spectral dependence. As indicated by our experiments, these azopolymer films can be used for polarization diffractive elements, operating in the entire visible range of the spectrum.

A Computational Model and Analysis of Channel Following Active Particles

Serdar Oztetik[1]
(**email:** serdar.oztetik@bilkent.edu.tr)
Giovanni Volpe[1; 2]
(**email:** giovanni.volpe@fen.bilkent.edu.tr)

[1]Soft Matter Lab, Department of Physics, Bilkent University, Cankaya, Ankara 06800, Turkey
[2]UNAM - National Nanotechnology Research Center, Bilkent University, Cankaya, Ankara 06800, Turkey

Cars trying to move through a trac jam or people trying to move in a crowd can be modelled as active particles creating and subsequently following `channels'. Analogously, an active particle moving through a bath of passive particles creates a channel in the bath. A torque introduced on the active particle may increase the active particles' success of following a channel depending on the conditions of the system. We have modelled such a system to be able to see the eects of torque on the success of following previously created channels within various baths of passive particles. With this model, we are able to determine the optimized parameters for a bath to maintain a channel and maximize the transfer of active particles.

Light beams energy exchange in liquid crystal cell with electrically-driven boundary conditions

I. P. Pinkevych[1], **S. I. Subota**[1], **V. Yu. Reshetnyak**[1], **D. R. Evans**[2]

[1]Physics Faculty, Taras Shevchenko National University of Kyiv, Kyiv, Ukraine
[2]Air Force Research Laboratory, Materials and Manufacturing Directorate, Wright-Patterson Air Force Base, USA

Energy exchange between two coherent light beams incident onto nematic liquid crystal (LC) cell with photorefractive substrates is studied. The space charge field arising in photorefractive substrates penetrates into the LC cell, causing director periodic reorientation, and hence creating a diffraction grating. We show that diffraction grating induced in the LC is a result of summation of two in-phase gratings: flexoelectric grating arising due to the photorefractive field interaction with the LC flexopolarization, and boundary driven grating arising due to the director easy axis modulation by photorefractive field at the LC cell walls. Each light beam diffracts from the induced grating, leading to energy gain and loss within each beam. We solved equations for the LC director linked with Maxwell's equations for light beams propagation, and calculated gain coefficient. It is shown that magnitude of the boundary driven grating and gain coefficient for this grating increase with an increase of the director anchoring energy at the cell substrates. Magnitude of the flexoelectric grating decreases with the anchoring energy increase but gain coefficient for the flexoelectric grating has non-monotonic dependence on the anchoring energy. The total gain coefficient maximum shifts towards higher grating spacing with an increase of both the anchoring energy and strength of the director easy axis modulation.

Acknowledgements.
The work was partially supported by the COST Action MP1205 and EOARD Grant P649.

Hot Brownian motion of nanoparticles in a critical binary liquid

Falko Schmidt[1], Alessandro Magazzu[1], Giovanni Volpe[1], Frank Cichos[2]

[1]Physics Department, Bilkent University, Ankara, Turkey,
[2]Physics Department, University of Leipzig, Leipzig, Germany

The study of Brownian motion is a powerful tool to understand transport processes of particles in various environments. Deterministic forces can further influence the Brownian motion of particle such that these forces can, for example, be produced by optical light fields.
Here, we study the influence of critical fluctuations of a binary mixture of water and 2,6-lutidine on the Brownian fluctuations of heated gold nanoparticles in an optical tweezer. Close to the critical point of the mixture i.e. water and lutidine, density fluctuations occur that influence the particle's fluctuations in the optical trap. Depending on the temperature difference $\Delta T = Tcrit - Tsample$ between sample and critical temperature, the characteristic frequency of fluctuations and the size of the water- and lutidine-rich regions change [1, 2]. Additionally, this phenomenon depends on the temperature profile generated around the heated gold nanoparticle. We measure the effective stiffness of the optical trap depending on ΔT. We first investigate the diffusion of silica particles in water-2,6-lutidine and compare it to their Brownian motion in water. Then we study the influence of the critical fluctuations on hot Brownian motion. Therefore gold nanoparticles were tracked as the critical temperature is gradually approached. Finally, we analyze the behavior of differently sized nanopar- ticles thus changing their plasmonic resonance frequency and absorption cross-section.

References

[1] O. Vasilyev, A. Gambassi, A. Macio lek, and S. Dietrich. Universal scaling functions of critical casimir forces obtained by monte carlo simulations. Phys. Rev. E, 79:041142, Apr 2009.
[2] C. Hertlein, L. Helden, A. Gambassi, S. Dietrich, and C. Bechinger. Direct measurement of critical casimir forces. Nature, 451(7175):172–175, 01 2008.

Generation and manipulation of microfluidic droplets on hydrophobic pdms surfaces

B. Yalizay[1], Y. Morova[1], A. Asikoglu Bozkurt[2], M. Z. Rashid[2], A. Jonas[1], S. Akturk[1], and A. Kiraz[2,3]

[1]Istanbul Technical University, Department of Physics, 34469 Maslak, Istanbul, Turkey.
[2]Koç University, Department of Physics, Rumelifeneri Yolu, 34450 Sariyer, Istanbul, Turkey
[3]Koç University, Department of Electrical and Electronics Engineering, Rumelifeneri Yolu, 34450 Sariyer, Istanbul, Turkey
email: yalizay@itu.edu.tr

We present a new method of droplet generation and guiding on hydrophilic rails over hydrophobic PDMS surfaces. In order to form hydrophilic rails, we ablated PDMS coatings by femtosecond laser. We created "S" shaped patterns on PDMS coatings with the thicknesses of between 0.1 µm - 4 µm, and placed the microfluidic chip on the surface. When the droplets were generated by T-junction and transmitted to the microfluidic chip, they started to follow these hydrophilic channels due to surface effects. The work finds it's novelty due to the fact that droplet guiding and control reported so far has been due to gain in surface energy of the droplet as it enters an area of local depression.

Development of Aerogel Based Optofluidic Microreactors

Yaprak Ozbakira[b], Can Erkey[a], Alper Kiraz[b], Alexander Jonas[c], Selçuk Aktürk[c]

[a] Department of Chemical and Biological Engineering, Koc University, 34450 Sarıyer, Istanbul, Turkey
[b] Department of Physics, Koc University, 34450 Sarıyer, Istanbul, Turkey
[c] Department of Physics, Istanbul Technical University, 34469, Maslak, Istanbul, Turkey

A wide variety of photoreactors are used to treat liquid waste streams and carry out photochemical reactions. The main problem in such photoreactors is accomplishment of uniform and fine distribution of light through the reaction medium maintaining perfect interaction of light, fluid and the solid photocatalyst particles which are either dispersed in the liquid or immobilized on the surface. An alternative is to use liquid core optofluidic waveguides in microchannels which enable distinctively guiding of light. In this approach, a suitable material confines the core liquid within internal channels and, simultaneously, behaves like waveguide cladding. For the propagation of non-lossy optical modes guided in the liquid by total internal reflection of light from the channel walls, the cladding material should have a low absorption coefficient at working light wavelength and a lower refractive index than that of the core liquid (ncore>ncladding). In applications with aqueous solutions, a refractive index around 1.33 is required and only a narrow choice of solid host materials with the refractive index below that of water is available. Aerogels are highly porous materials with extremely low refractive index of ~1.05 which makes them remarkable as rigid cladding of liquid-core optofluidic waveguides without any additional coating based on total internal reflection of light. Straight microchannels of ~5mm length with controlled cross-sections inside monolithic aerogels were initially formed using fast scanning of the focused laser ablation beam synchronized with the motion of the aerogel sample. Subsequent to the ablation, the channels were filled with high-refractive index ethylene glycol, thus forming multimode liquid core–solid cladding optofluidic waveguides and overall optical attenuation of light in these waveguides were measured. The characterization of waveguide transmission yielded values of propagation losses lower than 10 dB cm_1, demonstrating that the liquid-core waveguides with laser-ablated aerogel cladding represent an attractive alternative in optofluidic applications. Moreover, an optofluidic photoreactor based on a monolithic cylindrical aerogel block with a microchannel inside with a 2.3 mm in diameter and 5 cm in length constructed parallel to the cylinder axis by manual drilling was created The microchannel was illuminated by coupling light at 400 nm into a solarization-resistant multimode optical fiber with a large core that subsequently delivers the light to the reactor to stimulate the photocatalytic reactions. The performance of the microreactor was evaluated by pumping organic dye solutions of methylene blue (70 μM) with different flow rates of between 25 μL/min and 50 μL/min. Conversion of methylene blue decreased with increasing flow rate from 30% to 18%. Additional experiments were also performed in batch mode for 2h, resulting in 80% conversion and reaction rate constant was found to be 0.013 min-1 assuming that the dependence of the reaction rate on reactant concentration is first order.

Computational Studies on flow-induced dissolution of hydrodynamically trapped oil microdroplets

Ahmet Yasin Celik*, Metin Muradoglu**, Alper Kiraz*,
and Melikhan Tanyeri*****

*Department of Physics, Koc University, Turkey
**Department of Mechanical Engineering, Koc University, Turkey
***Department of Electrical Engineering, Istanbul Sehir University, Turkey

We present computational modeling of a novel flow-based method to study the dissolution of individual oil microdroplets in aqueous solutions. For most two-phase systems, liquid-liquid miscibility is characterized by a small and often negligible quantity, thereby leading to the assumption that many emulsion systems are immiscible. Similarly, for applications in digital microfluidics, vast quantities of aqueous microdroplets are produced in host oil-based solutions, and are considered stable for long periods of time. A careful study of oil-water miscibility at the microscale will provide valuable insight into these systems.
In this study, we performed COMSOL-based simulations of dissolution of individual oil microdroplets in aqueous solutions under planar extensional flow. Specifically, we confined single oil microdroplets at the stagnation point of a planar extensional flow generated at the junction of two perpendicular microchannels. We observed the deformation and dissolution of an oil microdroplet by acquiring consecutive images of the microdroplet. In this manner, we quantitatively analyzed microdroplet dissolution by measuring the change in average droplet diameter as a function of time. We demonstrated that dissolution of the oil phase in host aqueous solution could be substantial under laminar flow. In the absence of flow, the size of the oil microdroplets does not significantly change over a long period of time, as expected. We hypothesize that the presence of planar extensional flow enhances the solubility of oil microdroplets in aqueous solutions.

This study demonstrates flow-induced dissolution of immiscible fluid-fluid systems at the microscale and shows that the dynamics of dissolution can be predicted accurately by a numerical model. We expect that this novel method will enable fast and precise measurement of solubility for immiscible two-phase (liquid-liquid and gas-liquid) fluid systems.