Kratek opis usposabljanja mladega raziskovalca (*Short description of the Young Researcher's training)*

1. Raziskovalna organizacija (*Research organisation)*:

Univerza v Ljubljani, Medicinska fakulteta

2. Ime, priimek in elektronski naslov mentorja (*Mentor's name, surname and email*):

Uroš Tkalec, uros.tkalec@mf.uni-lj.si

3. Šifra in naziv raziskovalnega področja (*Research field*):

1.02 Fizika

4. Kratek opis usposabljanja mladega raziskovalca (*Short description of the Young Researcher's training)*:

Navedite tudi morebitne druge zahteve, vezane na usposabljanje mladega raziskovalca (npr. znanje tujih jezikov, izkušnje z laboratorijskim delom, potrebne licence za usposabljanje…).

slo:

Na zunanje dražljaje odzivni mehki materiali na osnovi tekočih kristalov so danes vroča tema na področju biofizike in fizike mehke snovi [1]. Uporabljajo se kot biosenzorji, aktuatorji in medicinski pripomočki v obliki funkcionaliziranih površin [2], tub [3] in mikrokapljic [4]. Slednje lahko v velikih količinah proizvajamo v mikrofluidičnih napravah [5], kar omogoča kontroliran nadzor nad velikostjo, količino, vsebino in izbiro materialov za pripravo takšnih emulzij. Opisane teme so v ospredju raziskav laboratorija za fiziko kompleksnih tekočin na Inštitutu za biofiziko, kjer smo skupaj s sodelavci (University of Chicago, KAIST, Univerza v Ljubljani) nedavno raziskali nova stanja in topološke strukture v tokovih nematikov [6,7]. Sedaj želimo ta potencial v znanju nadgraditi in ga v navezi z mladim raziskovalcem usmeriti v raziskave odzivnih tekoče kristalnih emulzij, ki temeljijo na metodah kapilarne mikrofluidike.

Osrednja tema raziskav mladega raziskovalca bo razvoj, uporaba in analiza eksperimentalnih metod kapljične mikrofluidike za pripravo tekoče kristalnih kapljic in emulzij v vodnem mediju ter študij njihovih interakcij z različnimi surfaktanti in funkcionaliziranimi površinami. Raziskati želimo možnosti sproščanja in reguliranja dispergiranih barvil oziroma potencialnih učinkovin, vendar za razliko od nedavnih raziskav [8], v bistveno manjših kapljicah mikrometrskih dimenzij. Predvidena je uporaba polarizacijske optične mikroskopije, metod mehke litografije, produkcije kapljic in laserske pincete, s katero lahko nadzorovano sprožamo lokalizirane fazne prehode v tekočih kristalih. Posebna pozornost bo posvečena uporabi najrazličnejših površinsko aktivnih snovi, ki lahko v stiku s kapljicami tekočega kristala vodijo do izjemno raznovrstnih geometrijskih in dinamičnih pojavov, ki spominjajo na rast in samourejanje biološke snovi [9]. Znanstveno delo bo temeljilo na eksperimentiranju s tekoče kristalnimi fazami v stiku z vodnim medijem, dopanti, surfaktanti in zunanjimi polji, med katere sodi tudi manipulacija hidrodinamičnih pojavov na mikrostrukturiranih površinah in analiza hitrih strukturnih sprememb v tankih plasteh z visokoločljivo hitro kamero. Od mladega raziskovalca pričakujemo poglobljena znanja iz fizike in optike, izkušnje z delom v laboratoriju, znanje angleškega jezika in motiviranost za eksperimentalno delo.

[1] YK Kim, J Noh, K Nayani, NL Abbot, *Soft Matter* **15**, 6913 (2019).
[2] C Howell, A Grinthal, S Sunny, M Aizenberg, J Aizenberg, *Adv. Mater.* **30**, 1802724 (2018).
[3] J Lv *et al.*, *Nature* **537**, 179 (2016).
[4] M Urbanski *et al.*, *J. Phys. Condens. Matter* **29**, 133003 (2017).
[5] AS Utada *et al.*, *Science* **308**, 537 (2005).
[6] T Emeršič *et al.*, *Sci. Adv.* **5**, eaav4283 (2019).
[7] S Čopar, Ž Kos, T Emeršič, U Tkalec, *Nat. Commun.* **11**, 59 (2020).
[8] YK Kim, X Wang, P Mondkar, E Bukusoglu, NL Abbott, *Nature* **557**, 539 (2018).
[9] WS Wei, Y Xia, S Ettinger, S Yang, AG Yodh, *Nature* **576**, 433 (2019).

eng:
Stimuli-responsive soft materials based on liquid crystals are a hot topic in biophysics and soft matter physics [1]. They are used as biosensors, actuators, and medical tools that are prepared in the form of functionalized surfaces [2], tubes [3], and microdroplets [4]. The droplets can be produced in large quantitites in microfluidic devices [5], which allow good control over the size, quantity, content, and choice of materials for the preparation of such emulsions. The topics are at the forefront of research in the Laboratory for Physics of Complex Fluids at the Institute of Biophysics, where we together with our colleagues from University of Chicago, KAIST, and University of Ljubljana, investigate new states and topological structures in nematic flows [6,7]. Now, we want to expand this potential in knowledge, and in conjunction with a young researcher, direct it to research of responsive liquid crystal emulsions that are based on capillary microfluidics.

The main focus of the young researcher's work will be development, application, and analysis of experimental methods of droplet microfluidics for the preparation of liquid crystal emulsions in an aqueous medium, and the study of their interactions with various surfactants and functionalized surfaces. We want to explore the possibilities of releasing and regulating dispersed dyes and potential active ingredients, but in contrast to recent research [8], by using significantly smaller droplet volumes and dimensions. The researcher will use polarized light microscopy, soft lithography, microfluidic droplet production techniques, and laser tweezers which can trigger localized phase transitions in liquid crystals in a controlled manner. Special attention will be paid to the use of a wide variety of surface active agents, which in contact with liquid crystal droplets can lead to diverse geometric and dynamic phenomena, reminiscent of the growth and self-assembly in biological matter [9]. The scientific work will be based on experimentation with liquid crystalline phases in contact with aqueous media, dopants, surfactants, and external fields, including manipulation of hydrodynamic phenomena on microstructured surfaces, and analysis of rapid structural changes in thin layers with a high resolution high-speed camera. From the young researcher, we expect in-depth knowledge of physics and optics, experience in laboratory work, good knowledge of English language, and strong motivation for experimental work.

[1] YK Kim, J Noh, K Nayani, NL Abbot, *Soft Matter* **15**, 6913 (2019).
[2] C Howell, A Grinthal, S Sunny, M Aizenberg, J Aizenberg, *Adv. Mater.* **30**, 1802724 (2018).
[3] J Lv *et al.*, *Nature* **537**, 179 (2016).
[4] M Urbanski *et al.*, *J. Phys. Condens. Matter* **29**, 133003 (2017).
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[6] T Emeršič *et al.*, *Sci. Adv.* **5**, eaav4283 (2019).
[7] S Čopar, Ž Kos, T Emeršič, U Tkalec, *Nat. Commun.* **11**, 59 (2020).
[8] YK Kim, X Wang, P Mondkar, E Bukusoglu, NL Abbott, *Nature* **557**, 539 (2018).
[9] WS Wei, Y Xia, S Ettinger, S Yang, AG Yodh, *Nature* **576**, 433 (2019).