

Fiscal Year:	FY 2017	Task Last Updated:	FY 03/27/2017
PI Name:	Yokoyama, Hiroshi Ph.D.		
Project Title:	Structure and Dynamics of Monodisperse Liquid Crystal Domains created on Suspended, Molecularly-Thin Smectic Films using Sub-Femtoliter Inkjet Technology		
Division Name:	Physical Sciences		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:	COMPLEX FLUIDS/SOFT MATTER--Complex Fluids		
Joint Agency Name:	TechPort:	No	
Human Research Program Elements:	None		
Human Research Program Risks:	None		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	44242-0001	Congressional District:	13
Comments:			
Project Type:	FLIGHT	Solicitation / Funding Source:	2015 NNH15ZTT002N MaterialsLab Open Science Campaigns for Experiments on the International Space Station
Start Date:	12/30/2016	End Date:	12/29/2021
No. of Post Docs:	No. of PhD Degrees:		
No. of PhD Candidates:	No. of Master' Degrees:		
No. of Master's Candidates:	No. of Bachelor's Degrees:		
No. of Bachelor's Candidates:	Monitoring Center: NASA GRC		
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Flight Program:	ISS		
Flight Assignment:	Liquid Crystal Facility		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Tin, Padetha Ph.D. (Universities Space Research Association) Emelyanenko, Alexander Ph.D. (Co-PI/ Lomonosov Moscow State University) Tabe, Yuka Ph.D. (Co-PI/ Waseda University, Japan)		
Grant/Contract No.:	NNX17AD68G		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	<p>Small domains or islands of liquid crystal embedded in a few molecular layer-thick smectic liquid-crystal ultrathin films offer an ideal system to study two-dimensional colloidal phenomena. The smectic film has fluidity and orientational order of molecular axis that, in combination, result in complex island-island interactions which do not exist in ordinary colloidal systems. Liquid crystal molecules also possess a symmetry property such as chirality and polarity that macroscopically manifest in structural symmetries, and in elastic and hydrodynamic properties. The molecular chirality further gives rise to a unique non-equilibrium molecular dynamics, arguably referred to as molecular motors, which are known to play a significant role in the biological energy transduction. Although the elasticity and flow induced island-island interactions are expected to open a novel route to self-assembled ordered structures, the meniscus or capillary forces, convective flows and sedimentation caused by gravitational field make it difficult to explore the anticipated possibility with sufficient clarity as to be compared with theoretical predictions. The proposed project investigates the static and dynamic 2D structures in smectic film-based 2D colloid, by the use of advanced inkjet technique to dispense small liquid crystal islands of fixed size (<20micron) on the smectic film in a prescribed pattern at the right point at the right time. The structural evolution of the 2D island system thus created will be observed and compared with theoretical simulations to elucidate the underlying island-island forces and their molecular origins. For this flight experiment, we develop a compact sub-femtoliter droplet dispenser compatible with flight experiments, using the super inkjet which has a capability to deliver sub-femtoliter droplets, and study the 2D self-organization of domains and nonequilibrium behaviors such as domain coalescence, Oswald ripening, Lehmann rotations and collective orientational excitations and 2D flow. We develop an integrated inkjet chip that is capable of depositing fine droplets of liquid crystals in prescribed pattern. The structural evolution of a certain pattern of islands in 2D allows a rigorous theoretical treatment, thereby enabling us to study the colloidal behaviors in an unprecedented detail. Specifically, we study Oswald ripening and spontaneous reconfiguration of islands.</p> <p>Of particular fundamental significance in the liquid crystal molecular science is the coupling between molecular rotation and flow vortex. This is a multiscale phenomenon, covering the length scale from a single molecule to macroscopic flow. The microgravity environment, combined with a highly accurate theoretical modelling, is expected to address this subtle, yet fundamental issue in liquid crystal science that has evaded full understanding for decades due to the experimental difficulty in the ground-based studies.</p> <p>Although liquid crystal is a macroscopic state of matter, the local interaction inside and between the molecules is decisive in determining the critical material parameters such as the rotational viscosity. The outcomes of the proposed microgravity study will shed new light on the rational design of high performance liquid crystals with regard to the underexploited yet attractive features of liquid crystals.</p>
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	
Task Progress:	New project for FY2017.
Bibliography Type:	Description: (Last Updated: 12/04/2023)