Fiscal Year:	FY 2024	**Task Last Updated:**	FY 11/30/2023
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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City:	Kent	**State:**	OH
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:**	12/29/2022
No. of Post Docs:	0	**No. of PhD Degrees:**	1
No. of PhD Candidates:	0	**No. of Master' Degrees:**	0
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA GRC
Contact Monitor:	Hatch, Tyler	**Contact Phone:**	216.433.5073
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Flight Program:	ISS		
Flight Assignment:	Liquid Crystal Facility NOTE: End date changed to 12/29/2022 per NSSC information (Ed., 1/26/22)		
Key Personnel Changes/Previous PI:	October 2022 report: No change during this term.		
COI Name (Institution):	Emelyanenko, Alexander Ph.D. (Co-PI/ Lomonosov Moscow State University, Russia) Tabe, Yuka Ph.D. (Co-PI/ Waseda University, Japan)		
Grant/Contract No.:	NNX17AD68G		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	3D coarsening dynamics in emulsions, foams, and other non-equilibrium systems is an important and relatively well-studied problem. 2D coarsening dynamics of 1D interfaces is of increasing importance, but detailed studies are complicated by the lack of appropriate model systems. The proposed experiments on smectic films and bubbles offer a well-characterized, homogeneous platform for the study of 2D coarsening dynamics. The study of non-equilibrium molecular dynamics focused on the Lehmann rotation in an ideal condition is expected to provide definitive insight into the foundation of hydrodynamics of complex fluids and the dissipation mechanisms associated with molecular rotation, which is of central interest to develop new liquid crystals for industrial applications. The combination of theoretical simulations and the ground-based experiments as proposed here will elucidate the effect of microgravity on the self-organization of 2D fluid emulsions with embedded orientational degrees of freedom. Being molecularly thin, smectic films are highly susceptible to gravitational disturbances through meniscus forces and sedimentation of islands, as well as to thermal convection of the surrounding air. The knowledge to be attained by performing zero-gravity experiments in the International Space Station (ISS) will give us important clues to understanding the complex terrain of structure formation in complex soft matter. Two-dimensional fluids are experimentally attractive systems that are both accessible and complex enough to enable us to discover new routes to useful structures of emulsions in such fields as biological molecular recognition.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The principal scientific objective of this flight experiment is to explore the hidden phenomena in free standing smectic liquid crystal films in the microgravity environment in which the capillarity-induced forces disappear. Generally, interactions of microscopic particles and islands freely suspended in two-dimensional liquid films are of central significance in a wide range of industrial fields ranging from oil and mineral recovery, food processing, pharmaceuticals, coating and wet processes, as well as in basic sciences dealing with protein-protein interactions in cell membranes to name a few. In Earth's gravitational field, intricate molecular interactions are often overwhelmed by capillarity forces and are hardly accessible in direct physical experimentations. Microgravity in space enables us to approach these phenomena such as Ostwald ripening, molecularly mediated island-island interactions and the Lehman rotation in liquid crystalline islands and films driven by the transmembrane molecular flow through the observation of configurational evolution of liquid crystalline islands on the smectic thin film. To prepare the required initial arrangement of islands, we develop and employ the sub-femtoliter inkjet deposition technology, which is integrated to an automated film preparation and observation hardware. Crucial for the liquid crystal science and technology is the understanding of intermolecular interactions responsible for the formation of liquid crystal phases. This space research aims to provide novel information that is hardly acquired from ground-based experiments.
Task Progress:	As noted in the FY23 annual report, we have focused our efforts during the year of project extension to improving the practical performance of the thickness mapping method, and to exploring its applications beyond the free-standing smectic films. The last year has been devoted to proving the feasibility of the multi-color analysis as an alternative to the conventional white-light interferometry by developing a working prototype multi-color interferometer. The basic idea of utilizing the color information in multi-dimensional space can have a broader significance in a wide range of photometric and image analysis areas. The prototype interferometer has been successfully applied to plane mirrors, concave mirrors, and patterned metal films. We believe this technique has a wider range of applications including, but not limited to, the characterization of liquid crystal cells and materials, as well as semiconductor chips. During this reporting year, the team was also awarded a provisional patent on the technology concept for Multi-Dimensional Color-Space Interferometry: A Single-Shot, 2pi-Ambiguity-Free Interferometry [Ed. Note: See Bibliography.]
Bibliography Type:	Description: (Last Updated: 12/04/2023)
Patents	63/433,934 Provisional patent issued December 2022. Dec-2022 Yokoyama H. "Multi-Dimensional Color-Space Interferometry: A Single-Shot, 2pi-Ambiguity-Free Interferometry."