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	Grant/Contract No.:	NNX17AC74G		
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Task Description:	Paramagnetic ferrofluids are familiar as suspensions of magnetic particles in solvents that become strongly magnetized in applied fields. A longstanding challenge has been to make such fluids ferromagnetic, so that they exhibit spontaneous macroscopic ferromagnetic orientation of magnetic anapollates in colloidal suspensions, either by dispersion in a thermotropic nematic liquid crystal (LC) host or by spontaneous nematic ordering in an isotropic solvent. These novel materials are optically birefringent, dichroic, and translucent, so that structures and textures can easily be visualized in polarized light. They manifest a variety of interesting and distinctive magnetic interaction effects and, because of the static magnetization, display ultrahigh sensitivity to externally applied magnetic fields. Field-induced changes in the shape of fluid drops, such as interfacial magnetic spike instabilities, occur even in the Earth's magnetic field, and readily achievable benchtop magnetic fields are expected to induce spectcular magnetofluidic responses. Ferromagnetic nematics also exhibit distinctive magnetic spike instabilities, occur even in the Sarth's magnetic domains arranged in closed flux loops that in microgravity should strongly affect the shape of free-floating drops. Freely suspended smeetic LC films in the form of bubbles, the LC geometry currently studied in OASIS (Observation and Analysis of Smeetic Islands in Space), will be rendered ferromagnetic by doping with magnetic annoplates and manipulated magnetically. In suspensions studied on Earth, the typically more dense liquid crystal phase sediments to the lower parts of test cells, leaving a sharp interface with the co-existing isotropic phase. Microgravity offers the opportunity to perform critical experiments that are not possible on Earth, such as the observation of ferromagnetic droplets and other fluid interface shapes as a function of an applied magnetic field, investigations of magnetic convective instabilities and thermocapillary effects resulting	
Rationale for HRP Directed Research:		
Research Impact/Earth Benefits:	Paramagnetic ferrofluids are familiar as suspensions of magnetic particles in solvents that become strongly magnetized in an applied field. A longstanding challenge has been to make such fluids ferromagnetic, so that they exhibit spontaneous macroscopic ferromagnetic ordering even in the absence of an applied field. Recently, ferromagnetic fluid phases have been achieved by the ferromagnetic orientation of magnetic nanoplates in colloidal suspensions, either by dispersion in a thermotropic nematic liquid crystal host or by spontaneous nematic ordering in an isotropic solvent. These novel materials are optically birefringent, dichroic, and translucent, so that structures and textures can easily be visualized in polarized light.	
Task Progress:	NOTE: The NASA Physical Sciences Program has indicated that the project completed its investigations in December 2021 and there is no additional progress to submit for this reporting period. Please see the FY22 report for the most recent progress update, as well as the Cumulative Bibliography for this investigation (Ed., 8/7/23).	
Bibliography Type:	Description: (Last Updated: 08/07/2023)	
Abstracts for Journals and Proceedings	Shuai M, Smith G, Zhu C, Glaser M, Maclennan J, Clark N. "Liquid Crystal Phases of Colloidal Mixtures of Ferromagnetic and Non-magnetic Nanoplates." APS March Meeting 2021, Virtual, March 15-19, 2021. Bulletin of the American Physical Society. 2021;66:Abstract: R05.00005. , Mar-2021	
Articles in Peer-reviewed Journals	Chowdhury RA, Green AA, Park CS, Maclennan JE, Clark NA. "Topological defect coarsening in quenched smectic-C films analyzed using artificial neural networks." Phys. Rev. E. 2023 Apr 3;107(4):044701. https://doi.org/10.1103/PhysRevE.107.044701, Apr-2023	
Articles in Peer-reviewed Journals	Shirai T, Shuai M, Nakamura K, Yamaguchi A, Naka Y, Sasaki T, Clark NA, Le KV. "Chiral lyotropic chromonic liquid crystals composed of disodium cromoglycate doped with water-soluble chiral additives." Soft Matter. 2018 Feb 5;14(9):1511-6. <u>http://dx.doi.org/10.1039/C7SM02262J</u> , Feb-2018	
Articles in Peer-reviewed Journals	Zeng M, Huang D, Wang P, King D, Peng B, Luo J, Lei Q, Zhang L, Wang L, Shinde A, Shuai M. "Autonomous catalytic nanomotors based on 2D magnetic nanoplates." ACS Appl. Nano Mater. 2019 Jan 3;2(3):1267-73. https://doi.org/10.1021/acsanm.8b02153, Jan-2019	