Task Book Report Generated on: 04/25/2024

Pl Name: Landhiad, Nathun Ph.D.	Fiscal Year:	FY 2019	Task Last Updated:	FY 05/20/2019
Division Name: Physical Sciences Program/Discipline: Program/Discipline- Element/Subdiscipline- Element/Subdiscipline- Element/Subdiscipline- Element/Subdiscipline- Element/Subdiscipline- Joint Agency Name: TechPort: No Human Research Program Elements: None Human Research Program Elements: None Space Biology Element: None Space Biology Element: None Space Biology Cross-Element None Space Biology Special Category: None PI Email: ninehologibates selu Fax: FY PI Organization Type: UNIVERSITY Phone: 207-786-6321 Organization Name: Bates College PI Address 1: Department of Physics and Astronomy PI Address 2: 44 Campus Ave PI Web Page: City: Lewiston State: MF: Alproduce 04240-6018 Congressional District: 2 Comments: Project Type: FLIGHT Solicitation / Funding 2013 Fundamental Physics NNIH13ZT1002N Soarce: (Cold Atom Laboratory-CAL) Start Date: 0400/2014 End Date: 1030-2020 No. of Post Does: 1 No. of Phat Degrees: 0 No. of Post Does: 0 No. of Master' Degrees: 0 No. of Master' Scandidates: 1 Monitoring Center: NASA JPL Contact Monitor: Callas, John Contact Phone: Contact Monitor: Callas, John Contact Phone: Key Personnel Changes/Previous PI: April 2019 report: New pontoboctral candidate Ryan Carollo was hired (starting September 2018). COI Name (Institution): James Course Ph. (Cultiversity of Illinois of Urbana-Champuign) Grant/Contract No.: JPL 1502172 Performance Gould No.:	PI Name:	Lundblad, Nathan Ph.D.		
Program/Discipline: Program/Discipline- Element/Subdiscipline: Joint Agency Name: TechPort: No Illuman Research Program Element: None Human Research Program Ridos: None Space Biology Cross-Element: None Space Biology Cross-Element: None Space Biology Cross-Element: None Space Biology Cross-Element: None Space Biology Special Category: None PI Email: Introdusciptorse color PI Edular PI Organization Name: Introdusciptorse color Introdusciptorse color PI Edular Introdusciptorse color PI Edular Introdusciptorse color Intr	Project Title:	Microgravity Dynamics of Bubble-Geometry Bose-Einstein Condensates		
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Human Research Program Elements: None Human Research Program Risks: None Space Biology Element Discipline: Space Biology Special Category: None PI Email: plundbla@blates.edu PI Coganization Name: Bates Colleg PI Organization Name: Bates Colleg PI Address 1: Department of Physics and Astronomy PI Address 2: H 44 Campus Ave PI Web Page: City: Lewiston State: ME Congressional District: 2 Comments: Project Type: FLIGHT Solicitation / Funding Solicitation / Funding Solicitation / Funding Solicitation / Funding Cold Atom LaboratoryCAL) Start Date: 04-04-0618 Congressional District: 2 Comments: Project Type: FLIGHT Solicitation / Funding Solicitation / Funding Cold Atom LaboratoryCAL) Start Date: 04-04-0618 Congressional District: 2 Comments: Project Type: FLIGHT Solicitation / Funding Cold Atom LaboratoryCAL) Start Date: 04-04-0618 Congressional District: 2 Comments: Project Type: FLIGHT Solicitation / Funding Cold Atom LaboratoryCAL) Source (Cold Atom LaboratoryCAL) Source (Co		FUNDAMENTAL PHYSICSFundamental physics		
Human Research Program Risks: None Space Biology Element: None Space Biology Cross-Element Discipline: None Space Biology Special Category: None PI Email: nlundbla/cibates.edu Fax: FY PI Organization Type: UNIVERSITY Phone: 207-786-6321 Organization Type: UNIVERSITY Phone: 207-786-6321 Organization Name: Bates College PI Address 1: Department of Physics and Astronomy PI Address 2: 44 Campus Ave PI Web Page: City: Lewiston State: ME Zip Code: 04240-6018 Congressional District: 2 Comments: Project Type: FLIGHT Solicitation / Funding 2013 Fundamental Physics NNH13/T1002N Start Date: 0401/2014 End Date: 1030/2020 No. of Post Does: I No. of PhD Degrees: 0 No. of Post Does: I No. of Master' Degrees: 0 No. of Master's Candidates: I No. of Master' Degrees: 0 No. of Master's Candidates: I Monitoring Center: NASA JPL Contact Monitor: Callas, John Contact Phone: Contact Homito: SS Flight Program: ISS Flight Assignment: SS Flight Assignment: Avein. Avein. David Ph.D. (Jet Propulsion Laboratory) Lamert, Courtney Ph.D. (Smith College) Visibes/Mayara, Smith Ph.D. (University of Illinois at Urbana-Champaign) Grant/Contract No.: JPL 1502172 Performance Goal No.:	Joint Agency Name:		TechPort:	No
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Discipline: Space Biology Special Category: None PI Email: plundha@bates.edu plustine: plustin	Space Biology Element:	None		
PI Email: nhundbla@bates.edu Fax: FY PI Organization Type: UNIVERSITY Phone: 207-786-6321 Organization Name: Bates College PI Address 1: Department of Physics and Astronomy PI Address 2: 44 Campus Ave PI Web Page: City: Lewiston State: ME Zip Code: 04240-6018 Congressional District: 2 Comments: Project Type: FLIGHT Solicitation / Funding Source: (Cold Atom Laboratory—CAL) Start Date: 04/01/2014 End Date: 10/30/2020 No. of PbD Degrees: 0 No. of PhD Candidates: 1 No. of Master' Degrees: 0 No. of PhD Candidates: 1 No. of Master' Degrees: 0 No. of Bachelor's Candidates: 1 Monitoring Center: NASA JPL. Contact Monitor: Callas, John Contact Phone: Contact Email: john Leallas@iipl.nasa.gov Flight Assignment: ISS KS Flight Assignment: April 2019 report: New postdoctoral candidate Ryan Carollo was hired (starting September 2018). COI Name (Institution): Lannert, Courtney Ph.D. (Jet Propulsion Laboratory) Lannert, Courtney Ph.D. (Smith College) Visits welman. Ph.D. (University of Illinois at Urbana-Champaign) Grant/Contract No.: JPL 1502172 Performance Goal No.:		None		
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Task Book Report Generated on: 04/25/2024

Notions of geometry, topology, and dimensionality have directed the historical development of quantum-gas physics. With a toolbox of forces used to confine, guide, and excite Bose-Einstein condensates (BEC) or degenerate Fermi gases (DFG), physicists have used quantum gases to test fundamental ideas in quantum theory, statistical mechanics, and in recent years notions of strongly-correlated many-body physics from the condensed-matter world. We propose a specific program to explore a trapping geometry for quantum gases that is both tantalizing theoretically and prohibitively difficult to attain terrestrially: a quantum gas in a bubble geometry, i.e., a trap formed by a spherical or ellipsoidal shell structure, confining a 2D quantum gas to the surface of an experimentally-controlled topologically-connected "bubble." The physics of a quantum gas confined to such a surface has not been explored terrestrially due to the limitations of gravitational sag; interesting work has certainly been done with gases confined to the lower regions of bubble potentials, but the fully symmetric situation has yet to be explored. The low-energy excitations of such a system are unexplored, and notions of vortex creation and behavior as well as Kosterlitz-Thouless physics are tantalizing aims as well. The solid-state modeling goals of the optical-lattice physics community are also fundamentally connected to the system, as the canonical Mott-insulator/superfluid transition features superfluid shells isolated between insulating regions. The central method to reach the sought-after bubble-geometry BEC or DFG is that of rf or microwave dressing of the bare trapping potentials provided by the Cold Atom Laboratory (CAL) "chip trap." Radiofrequency dressing has been used conceptually through "rf-knife" evaporative cooling, but more recently through explicit construction of adiabatic potentials for interferometry, and shell-trap construction for both thermal and quantum gases. The proposed work is a window into a physical regime that is quite difficult to achieve terrestrially due to trap distortion; given the advantages of a microgravity environment, NASA CAL is uniquely positioned to realize the physics goals of this proposal. Rationale for HRP Directed Research: Research Impact/Earth Benefits: The fifth year of this work focused on immediate preparation for CAL launch and further modeling of the radiofrequency-dressing process that will occur aboard CAL and how it can be used to create shell-geometry Bose-Einstein condensates in the presence of practical limitations. After launch in May 2018, several rounds of data were taken through the end of this reporting period and are currently undergoing analysis. Data focused on understanding residual micromotion in the expanded atom traps ('sloshing') and validation of trap models--preliminary results largely show agreement at the few-percent level in trap frequencies. Initial attempts at generating shell-trapped ultracold clouds-- the central goal of this project-- were made, and showed preliminary positive signs, although anticipated inhomogeneities appear to play expected roles. Further communication took place between Co-Investigator (Co-I) Aveline and Principal Investigator (PI) Lundblad regarding flight hardware, and detailed communication took place between Co-I Lannert and PI Lundblad regarding numerical simulation of these CAL experiments. Lundblad also extended collaborative work with other theorists in the field regarding specific modeling issues, particularly Barry Garraway of Sussex. Progress on the construction of CAL-like prototype hardware at Bates was begun using a newly-arrived atom chip apparatus from ColdQuanta. Lundblad's work continued to focused mostly on understanding potential issues with trap inhomogeneity aboard CAL that could result in incomplete shell-BEC population or asymmetric shells, as well as beginning to model adiabaticity in these systems. Lannert and Vishveshwara's work continued to focus on simulation of collective modes, and led to a paper published (Sun, K., Padavic, K., Yang, F., Vishveshwara, S. & Lannert, C. Static and dynamic properties of shell-shaped condensates. Phys Rev A 98, 013609 (2018).) Description: (Last Updated: 06/20/2023) Sun K, Padavic K, Yang F, Vishveshwara S, Lannert C. "Static and dynamic properties of shell-shaped condensates." **Articles in Peer-reviewed Journals** Phys Rev A. 2018 Jul;98:013609. https://doi.org/10.1103/PhysRevA.98.013609, Jul-2018 Gibney E. " 'Universe's coolest lab set to open up quantum world.' Article in Nature News section about research on the Cold Atom Laboratory." Nature. 2018 May 10;557:151-2. https://www.nature.com/articles/d41586-018-05111-2. Significant Media Coverage

Significant Media Coverage

Task Description:

Task Progress:

Bibliography Type:

Chen S. "Article about research on the Cold Atom Laboratory, 'The Quest to Make Super Cold Quantum Blobs in Space.' "Wired Magazine, June 25, 2018.

https://www.wired.com/story/the-quest-to-make-super-cold-quantum-blobs-in-space/, Jun-2018