Fiscal Year:	FY 2022	**Task Last Updated:**	FY 01/20/2022
PI Name:	Gatsonis, Nikolaos Ph.D.		
Project Title:	Multiscale Computational Modeling of Dusty Plasmas Near Space Surfaces		
Division Name:	Physical Sciences		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:	FUNDAMENTAL PHYSICS--Fundamental physics		
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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Comments:			
Project Type:	Physical Sciences Informatics (PSI)	**Solicitation / Funding Source:**	2020 Physical Sciences NNH20ZDA014N: Use of the NASA Physical Sciences Informatics System – Appendix G
Start Date:	10/18/2021	**End Date:**	10/17/2023
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 JPL
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Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Han, Daoru Ph.D. (University of Missouri, Rolla)		
Grant/Contract No.:	JPL Task - RSA# 1670489		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	The goals of the proposed two-year research are to: develop and validate with Physical Sciences Informatics (PSI) data a state-of-the-art computational capability for modeling the release and transport of dust particles near floating and biased surfaces in space plasmas and use the multiscale capability and explore release and transport phenomena for spherical and non-spherical dust particles, under plasma and surface conditions beyond those addressed in the PSI experiment. The first objective is to develop a state-of-the-art dusty plasma computational modeling capability from the grain-scale to multiscale. The microscopic (grain-scale) Dusty Parallel Immersed Finite Element Particle-in-Cell (D-IFEPIC) model will be developed on the existing Parallel Immersed Finite Element Particle-in-Cell (PIFEPIC), a parallelized Particle-in-Cell (PIC) platform. The D-IFEPIC model will include spherical and non-spherical grains and will account for both surface and in-depth charging of each grain. D-IFEPIC will resolve the geometrical and material properties (permittivity) of each grain and model the unsteady and stochastic charging of grains via a deposition process. The multiscale Dusty Electrostatic Unstructured Particle-in-Cell with Collisions (D-EUPICC) model will be developed on the existing EUPICC, a parallelized hybrid PIC-Monte Carlo platform. The D-EUPICC model will include charging and transport of dust grains embedded into a plasma with electrons, ions, and neutrals. Forces on a grain will include gravity, Lorentz, Coulomb, neutral/ion drag, and adhesive van der Waals. The unsteady/stochastic charging of grains will be modeled with a multi-step Monte Carlo absorption collision with electrons and ions. The potential on a grain will be evaluated with a surface capacitance model. Electron motion will be integrated at inverse plasma frequency timesteps but ions and neutrals will use much larger timesteps following a sub-cycling scheme. The second objective is to simulate the PSI experiment, validate the D-IFEPIC and D-EUPICC models, and quantify the plasma conditions under which the fluctuating charge on grains near a floating surface reaches a threshold such that the electric field force overcomes the adhesive van der Waals force. The two codes will be used with direct inputs from the PSI data and address comprehensively the multiscale interactions from grain-scale to system-scale observed in the PSI experiment. The third objective is to use D-EUPICC and D-IFEPIC and investigate the parametric dependence of dust charging and release near floating and biased surfaces for a broad range of plasma and surface conditions beyond those found in the PSI experiment. These simulations will use spherical grains from 0.1-100 um and irregularly shaped grains (D-IFEPIC only), floating and biased surfaces in fully ionized plasmas found in low-Earth orbit (LEO), geosynchronous orbit (GEO), solar, and planetary environments. The results will document the dependence of charge and release time on these parameters and relative role of forces on grains. The comparisons will demonstrate the difference between the capacitance and the surface/in-depth charging models. The D-IFEPIC simulations with non-spherical grains will also demonstrate for the first time the impact of grain shape on sheath electrodynamics. The proposed research directly addresses the scope of the solicitation: provides testing of hypothesis of dust charging and dust release mechanisms from surfaces in the PSI experiment; provides estimates of dust charging and release time for a wide range of grain sizes, surface potentials, and plasma conditions relevant to NASA missions using surface and surface/in-depth charging models; delivers an advanced modeling capability that can assist in the design of future ground-based and International Space Station (ISS)-based dusty plasma experiments as well, in the development of active methods for dust removal from extravehicular activity (EVA) suits or instruments exposed to plasmas; and enhances NASA's science readiness with the delivery of a validated capability for dusty plasmas that appear in broader areas of science and engineering.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The comparison with the PSI data allows validation of the multiscale modeling capability. The project entails use D-IFEPIC and D-EUPICC in an expanded parametric investigation of dust release for spherical and non-spherical grains under surface and background plasma conditions of interest to NASA beyond those in the PSI experiment.
Task Progress:	New project for FY2022.
Bibliography Type:	Description: (Last Updated: 03/20/2023)