

ELECTRIC PROPULSION-PART I, 1 DECEMBER till 3 DECEMBER 2021

All Virtual Review / Workshop

AGENDA coupled plasma/material system in non-equilibrium states-IN-SPACE

ELECTRIC PROPULSION

1 DECEMBER 2021-Wednesday-Advanced Electric Propulsion Concepts for all Orbits:

Urgent need for very high efficiency and long life Hall Effect Thrusters, capable of accurate short time ground tests, and extrapolating to the actual lifetime, and accurate to on-orbit conditions using dynamic data driven models. Several electric propulsion concepts with variable thrust and specific impulse such as Hot Magnetized Plasma Acceleration Devices, should be investigated to provide extended lifetime, range, speed and maneuver agility through dual-mode operation for satellite systems ranging from cube sat to large SVs for dominant space operations, in addition to the combined chemical and electric propulsion systems, some also should be air-breathing for low earth orbit conditions.

Existing research activities and possibilities (3 hours total):

Each talk is 15 minutes with 3 slides (one slide introduction, one slide what achieved, one slide what else needs to be done in order to meet the goals of the research activity)

12:00-12:10	AFOSR Introduction-10 minutes- Lt. Col Krisak / Birkan
12:10-12:30	RQRS-introduction-20 minutes- Dr. Daniel Eckhardt, AFRL/RQRS
12:30-12:45	Data-driven Models for Prediction and Control of Plasma Processes and Applications with Poorly Understood Physics, Jorns, Benjamin (Univ. of Michigan-YIP)
12:45-13:00	Rapid Optimization of Non-Equilibrium Plasmas using New Breakthroughs in Data Science, Little, Justin (Univ. of Washington-YIP)
13:00-13:15	Coherent Structures in Magnetized ExB Discharges and Mechanism(s) of the Anomalous Electron Current, Smolyakov, Andrei (University of Saskatchewan)
13:15-13:30	Experiment, Modeling, and Simulation of Advanced Materials - Plasma Interactions in the Space Environment, Rovey, Joshua (UIUC)
13:30-14:00	BREAK
14:00-14:15	Methods of Control of Self-Organized Plasma Structures in Devices Relevant to Electric Propulsion, Raitses, Yevgeny (Princeton University)

14:15-14:30 Extrapolating ground test data of Hall Effect thrusters to in-space operation, Hara, Ken, (Stanford University)

14:30-14:45 Hot Magnetized Plasma Acceleration Devices and Modes for Agile Plasma Thrusters, Cappelli, Mark (Stanford University)

14:45-15:00 Exploring New Concepts towards Multi-mode Low-power Robust Electric Propulsion, Keidar, Michael (George Washington University)

15:00-15:45 LUNCH BREAK

DISCUSSION FOR WHAT ELSE IS PROPOSED FOR THIS TOPIC, 15:45-18:00

Moderator (with chat option): Dr. Daniel Eckhardt, AFRL/RQRS

Potential participants with one slide to explain (5 minutes) if necessary, The purpose of this discussion period is to identify what else should be investigated in these areas to meet US Air and Space Force demands and needs, without duplicating the existing research activities, in a public domain.

5 minute talks:

Aluminum rod propulsion, CisLunar Industries

Gas-fed pulsed plasma thrusters (Princeton, Stanford)

Microstrip Sources for Adaptable Satellite Propulsion, Riverside Research

2 DECEMBER 2021-Thursday-Air breathing Electric Propulsion for Very Low Earth Orbit, and concepts that need attention

For Very low Earth Orbit, research is needed to identify and assess the suitability of new electric propulsion candidates that may make use of large amounts of beamed energy and the harvesting of air as a propellant. Concepts may include pulsed and/or continuous (steady-state) electric propulsion schemes that include understanding issues associated with efficient collection, conditioning, ionization, and subsequent acceleration of air to produce thrust at a sufficient specific impulse needed to maintain orbit. Existing studies were identified in another workshop to find how to efficiently ionize air molecules at VLEO orbits with weak compression (to minimize drag on the Spacecraft) and with reduced ionization cost (from 200 eV to around 40 for Nitrogen Molecule) and what is the best concept to accelerate ionized air at a given altitude?, plus the prediction material erosion rates by “air” plasma and

associated thruster lifetime. In addition, for all orbits including cis-lunar orbits and beyond, other concepts may be proposed including beam energy based propulsion concepts.

Each talk is 15 minutes with 3 slides (one slide introduction, one slide what achieved, one slide what else needs to be done in order to meet the goals of the research activity)

Existing research activities and possibilities (2 1/2 hour total):

12:00-12:30 Introduction and the lab research on “Tightly Coupled Multi-physics Modeling of High Power Electric Propulsion for Very Low Earth Orbit”, Bilyeu, David, RQRS

12:30-12:45 Comprehensive Study of Plasma-Wall Sheath Transport Phenomena, and Ionization and Acceleration of N₂/O₂ Mixtures for Air-Breathing Electric Propulsion, Walker, Mitchell (Georgia Tech)

12:45-13:00 Electron-Beam Generated ExB Plasma for Air-Breathing Propulsion, Raitses, Yevgeny (Princeton University)

13:00-13:30 BREAK

13:30-13:45 Air-Breathing Magneto-Deflagration Propulsion for Sustained Very Low Earth Orbit, Underwood, Thomas, (the University of Texas at Austin-YIP)

13:45-14:00 Physics of Beamed-Microwave Plasmas in Supersonic Flows, (Bilen, Sven, Penn State)

14:00-14:15 Plasmonic metamaterials for high delta-V laser ablation propulsion in cislunar orbits, Davoyan, Artur (UCLA)

14:15-15:00 LUNCH BREAK

15:00-15:20 Cathode Materials for Electric Propulsion, Mackey, Jon (NASA), invited talk

DISCUSSION FOR WHAT ELSE IS PROPOSED FOR THIS TOPIC (15:20-18:00)

Moderator (with chat option): Dr. David Bilyeu, AFRL/RQRS

Potential participants with one slide to explain (5 minutes) if necessary, The purpose of this discussion period is to identify what else should be investigated in these areas to meet US Air and Space Force demands and needs, without duplicating the existing research activities in a public domain.

5 minutes talks:

Air-breathing concepts, Viridian space

State-specific high-fidelity models for Air-Breathing Electric Propulsion in VLEO, The University of Texas at Austin

3 DECEMBER 2021- Friday- ELECTROSPRAYS

12:00-12:15 Introduction, Eckhardt, Dan, RQRS

12:15-12:30 Designing High Molecular Weight Ionic Liquids for In-Space Propulsion, Ghiassi, Kamran, RQRP

12:30-12:45 A new facility for electrospray propulsion studies with spatial resolution of the full beam and high-resolution mass and energy analysis, De La Mora (Yale University)

12:45-13:00 Precise molecular composition and fluid control to improve the performance and lifetime of electrospray thrusters, Lozano, Paulo (MIT)

13:00-13:15 BREAK

13:15-13:30 Prediction of Basic Operation of Electro-Spray Thrusters Using High Fidelity Modeling. Boyd, Iain (University of Colorado-Boulder)

13:30-13:45 Multiscale, Multiphysics, and Multifidelity Modeling of Electrospray Propulsion, Daoru (Frank) Han, (Missouri University of Science and Technology-YIP)

13:45-14:00 Mass and Charge Evolution in Electrospray Plumes for High Delta-V Thrusters, Wirz, Richard (UCLA)

14:00-14:15 Modeling of Ion-Emitting Taylor Cones for Electrospray Propulsion, Gamero-Castano, Manuel (UCI)

14:15-14:30 BREAK

DISCUSSION FOR WHAT ELSE IS PROPOSED FOR THIS TOPIC, 14:30-16:00

Moderator (with chat option): Dr. Kamran Ghiassi, AFRL/RQRP