Developing Numerical Simulations to Assist in Isolating Excited Nitrous Oxide States

Pratik Saripalli and Raymond Sedwick
University of Maryland, College Park
University of Maryland
Department of Aerospace Engineering
3179 Glenn L. Martin Hall, College Park, MD 20740
301-405-8562 | pratik.saripalli@gmail.com

Background/Motivation:

There have been numerous experiments focusing on the use of nitrous oxide as a propellant because of its exothermic dissociation properties, its classification as a non-toxic chemical, its ability to remain stable under normal conditions, and its ability to be stored in space.

Research conducted in the Space Power and Propulsion Laboratory (SPPL) at the University of Maryland, College Park focused on the use of nitrous oxide in developing a green propellant station-keeping thruster using a dielectric barrier discharge (DBD). The current hypothesis is that by rendering a portion of the gas in an excited state as opposed to direct ionization, the effective activation energy for dissociation due to collisions may be reduced, similar to the effect of using a catalyst, but without any material being present. The ionization energy for nitrous oxide is approximately 12.8 eV. Achieving any excited nitrous oxide states below this level would reduce power requirements.

Current Work:

In order to control how much energy is imparted onto the neutral nitrous oxide gas, a monoenergetic electron beam will be required. The idea is to have neutral nitrous oxide as the background gas in the operational setup, allowing collisions to occur between the nitrous oxide and the electron beam. Therefore, similar to past research, an emitter electrode system will be used to generate a constant stream of electrons.

Numerical simulations are being developed to help identify the required system parameters to successfully emit electrons at the necessary energy levels. These simulations employ a fluid model to simulate the plasma and update all species densities across the system. Eventually, the system will include “extractor” plates that will extract electrons at certain energy levels. In order to apply proper flux boundary conditions to the cell walls, the Scharfetter-Gummel (SG) Method is being adopted. The SG method assumes all variables except densities are constant across the cell, providing a simple 1st order ODE for the flux.

Current models are in 1-D but will be extended to 2-D once all elements of the SG method are implemented. The source terms for all species will be a function of various collisional events that will dictate the state of the plasma. The flux terms will be a function of the surrounding electric field and the temperatures.