The Development of a Vector Neutral Particle Spectrometer for Space environment Measurements

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Satellite performance and lifetime is strongly dependent on the orbital environment. Models of the neutral atmosphere, derived from experimental mass spectrometric data, show drastically fluctuating number densities, especially in response to solar activity. These variations can affect several aspects of satellite and sensor performance, most notably spacecraft drag. Therefore, it is desirable to measure neutral particles in situ, to better understand the instantaneous effects of thermospheric variations. This requires the ability to accurately measure reactive species and to reject the thermal background signal due to local outgassing, while minimizing demands placed on valuable spacecraft resources. We are developing a compact Vector Neutral Particle Spectrometer (VNPS) with a variety of novel features intended to address the unique aspects of space environment measurements. The radially symmetric sensor has a very large toroidal field-of-view (2.83 □ sr), to avoid imposing spacecraft orientation requirements. Neutrals with incoming elevation angles from -45 to +45º, and throughout the entire range of azimuth angles (0 to 360º), are analyzed and detected simultaneously without the use of moving parts or scanning potentials. A collisionless, open ionizer utilizes a well-defined electron beam to facilitate the detection of reactive species with minimal perturbation of the incoming velocity vector. A laboratory prototype ionizer has been demonstrated to efficiently transmit an intense (several milliamp) electron beam of 1 mm diameter over a 2 mm gap. Mesh-based ion optics components include a retarding potential analyzer, acceleration grid, and hemispherical deflection grid. Ions follow unique trajectories according to their precursor neutral entrance angles, and are detected by an imaging microchannel plate / cross delay-line anode operated in pulse counting mode. Ion trajectory simulations (SIMION 3D 7.0) indicate that incoming neutral angles can be determined with 1º accuracy. In addition to this 'imaging mode', the instrument may be operated in 'MS mode', in which acceleration and deflection potentials are tuned to produce a modulated ion beam suitable for time-of-flight analysis. Laboratory testing of the ion optics subassemblies is underway, with initial data showing excellent agreement with theoretical predictions.