Orbital Debris Detection and Tracking

Fourier Transform Mass Spectrometry
Objective

- Demo feasibility of simulating, detecting, and tracking hypervelocity small space debris
  - Actual/Physical Simulation
    - Charged debris
  - Characterization
    - 1] Fourier Transform Mass Spectrometry
  - Detection
    - Direct Detection - photoacoustic transducer
    - Indirect Detection - Constructive/Destructive Interference, resultant wave deconvolution for soliton detection
Simulation of Charged Debris: - Charged Particles

- Use large “particles” to simulate debris
  - known proteins, synthetic polymers,
  - Pecan pollen
- Charge particles by
  - Glow discharge
  - Electrospray
  - Apply direct current (+, -) for positive vs negative charge
- Inject particles into mass spectrometer
  - Perpendicular to the flow of the spray
  - Use attracting voltage to impart velocity to charged particles
    - Negative DC potential for positively charged debris
    - Positive DC potential for negatively charged debris
- Plasma addition to the flight path of the charged debris
Detection Scheme for Solitons

- Solitons production due to interaction of charged debris and plasma
Characterization of Charged Debris: Fourier Transform Mass Spectrometry

- Cyclotron Motion of charged species is \( f = \frac{qB}{2\pi m} \)
- Trapping motion, trapping in radial direction
- Magnetron motion
- Introduce plasma in the cell while charged debris are trapped
- Use photoacoustic transducer to collect solitons signal in time
- Performed Fourier transform to determine frequencies of solitons
- For indirect detection use interrogation beam
  - Fourier transform of resultant beam
Characterization of Charged Debris: Time-of-Flight Mass Spectrometry

- Introduce plasma in the field free region in the path of the charged debris (red ribbon)
- Use photoacoustic transducer to collect solitons signal in time
- Performed Fourier transform to determine frequencies of solitons
- For indirect detection use interrogation beam
  - Fourier transform of resultant beam
Summary of Soliton Detection Scheme

• Direct Detection of Solitons
  ▪ Perform Fourier Transform to extract frequencies of solitons

• Indirect Detection
  ▪ Use interrogating beam
    – Known frequency not at frequencies associated with solitons
  ▪ Collection of Resultant Waves
  ▪ Constructive, Destructive, Fractional Interference
  ▪ Perform Fourier Transform of resultant waves to extract frequencies of solitons

Proposed Next Step:

• Preliminary design for satellite sensor prototype…
  ▪ Incorporate attenuator that compensates for distance to simulate long distance soliton signal sources and adjust sensor to pick up those signals. . .