Low-Resource CubeSat-scale Sensorcraft for Auroral and Ionospheric Plasma Studies

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Who We Are:

DARTMOUTH COLLEGE
Department of Physics and Astronomy
Lynch Rocket Lab Group

- Prof. Kristina Lynch - Principal Investigator
- Phillip Bracikowski - RocketCube (Graduate MS)
- Lisa Gayetsky - PhD Candidate
- 4 Graduate Students
- 7-10 Undergraduates
What We Study:

- The structure and dynamics of auroral particle acceleration
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  - Principally from Sounding Rockets
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- The structure and dynamics of auroral particle acceleration
  - Principally from Sounding Rockets
- Simulations of the ionospheric plasma environment in our vacuum chamber
  - Used to calibrate and test the operation of our instruments
Unmet Challenge of Auroral studies:

• Auroral phenomena are highly structured

\[ \frac{d}{dt} \text{ vs } \frac{d}{dx} \]
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• How do you tell a change in time from a change in position?

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- How to quantify these changes?

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Unmet Challenge of Auroral studies:

- Auroral phenomena are highly structured
- How do you tell a change in time from a change in position?
- How to quantify these changes?
- Multi-Point Measurements

\[ \frac{d}{dt} \text{ vs } \frac{d}{dx} \]
Unmet Challenge of Auroral studies:

- Previous multipoint Sounding Rockets
  - Cascades 2 (2009); 5 pt
  - AMICIST (1995); 2 pt
  - Enstrophy (1999); 5pt
  - Auroral Turbulence 2 (1997); 3 pt
  - ROPA (2007); 3pt
  - SCIFER 2 (2008), 1 pt

\[
\frac{d}{dt} \text{ vs } \frac{d}{dx}
\]
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  • An array of 12 subpayloads and 1 main

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• Recently proposed a sounding rocket mission, called PALISADES, for 13 point-measurements of density and temperature irregularities
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• Each subpayload is a low resource cubesat-scale sensorcraft

d/dt vs d/dx

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Our Solution:

Arrays of low-resource CubeSat-scale sensorcraft
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**Arrays** of low-resource CubeSat-scale sensorcraft

- 12 sensorcraft in an planar grid; How to coordinate measurements?
Our Solution:

Arrays of **low-resource** CubeSat-scale sensorcraft

- Low-Resource = Low voltage instruments, relatively easy to assemble, mass producible in our lab, relatively cheap
Our Solution:

Arrays of low-resource **CubeSat-scale** sensorcraft

- CubeSat-scale = ~3000cm³, 1-5kg, not tied to specific form factor
Our Solution:

Arrays of low-resource CubeSat-scale sensorcraft

• Sensorcraft = instrumented platform to measure the natural environment
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Arrays of low-resource CubeSat-scale sensorcraft

- Sensorcraft = instrumented platform to measure the natural environment

Our sensorcraft is called **RocketCube**
RocketCube: Many point Measurements

- Purpose: Proof of Concept - Can we build a sensorcraft?
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- Develop the systems and instruments to make multi-point measurements in the aurora and ionosphere from sounding rockets
RocketCube: Many point Measurements

- **Purpose:** Proof of Concept - Can we build a spacecraft?
- Develop the systems and instruments to make multi-point measurements in the aurora and ionosphere from sounding rockets
- **Instruments on board**
  - Thermal ion RPA: Petite Ion Probe (PIP)
  - 3-axis science grade magnetometer
  - GPS
PIP Instrument

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- Undergoing testing in our plasma chamber
  - Look direction sensitive
RocketCube Requirements:
What we need in PALISADES

- Sounding Rocket: ~10 minute flight!
- Sband telemetry system for 1Mbit/s of data (ms level, 1km resolution)
- Spin stable platform for regular pattern of instrument look directions
- Accurate timing and synchronization between subpayloads

• Synchronization allows for analysis of data among each subpayload to separate events in time and events in space

\[ \frac{d}{dt} \text{ v. } \frac{d}{dx} \]
RocketCube Systems

• Subsystems: Details in the paper
RocketCube Systems

- Electronics are a new design.
  - Moved from older 8051 technology to newer FPGA fabric.
  - Moved from through-hole components to entirely surface mount parts to reduce pcb size
  - Includes our own power system
RocketCube Systems

- Electronics
RocketCube Systems

- Electronics: Power
RocketCube Systems

- Electronics: Analog
RocketCube Systems

- Electronics: Digital
RocketCube Systems

- **Instrument:** Magnetometer
RocketCube: Current Status

- Electronics ver 1 is in testing
RocketCube: Current Status

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- Engineering model being built
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RocketCube: Current Status

- Electronics ver 1 is in testing
- Engineering model being built
- PIP ver 1 is in testing
- GPS currently being integrated
Future Work

• Integrate all components
• Full systems test in thermal plasma chamber
• Convert design to a cylindrical form factor for PALISADeS
Conclusion

• RocketCube is a 3U prototype sensorcraft for suborbital flights
Conclusion

• RocketCube is a 3U prototype sensorcraft for suborbital flights
• RocketCube enables our future science missions to study and understand the aurora.
Questions?

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