



# An Introduction to the Lowell Center of Space Science and Technology

Supriya Chakrabarti  
SHOE-PRE-OH CHALK-ROW-BORE-TEA

and the LoCSST Team  
<https://www.uml.edu/Research/LoCSST/>

# The Team (active members only)

## Core Faculty

- Supriya Chakrabarti (Physics)
- Dimitris Christodoulou (Math)
- Ofer Cohen (Physics)
- Timothy Cook (Physics)
- Christopher Hansen (Mech. Eng.)
- Silas Laycock (Physics)

## Research Staff

- Mr. Samuel Fingerman
- **Dr. Susanna Finn**
- Dr. Ivan Galkin
- Mr. Jason Martel
- Dr. Christopher Mendillo

## Administrative Staff

- Ms. Lynne Schaufenbil

## Ph.D. Students

- Qusai Al Shidi
- **Saurav Aryal**
- Rigel Cappallo
- **George Geddes**
- Chrstopher Emma
- Kuravi Hewawasam
- Glenn Howe
- Chen Li
- Sunip Mukherjee

## Undergraduate Students

- 9 Capstone (physics & engineering) students
- 6 Co-op scholars (physics & engineering projects)
- Many (>50) SPACE HAUC students
- 7 Independent study

# LoCSST

One of about 10 University Research Centers

- ▶ It is a research Center with the three primary goals:
  - **Train** next generation of space scientists, technologists, teachers, business leaders and policy makers
  - Provide a home for space science and technology **research** activities on UMass Lowell campus
  - Involve university, industry and government **partners** in curriculum, research as well as in proposal development

# What do we do?

Science and technology for space exploration

## ▶ **Science about space**

- Astrophysics from Earth to exoplanet to extragalactic studies

## ▶ **Science from space**

- Things that cannot be done from the ground

## ▶ **Tools to accomplish both**

- Engineering and technological tools
- Theoretical and modeling tools
- Computational tools

# Our research interests involve science AND technology

## SCIENCE

- **Astrophysics**
  - High energy astrophysics
  - Neutron star – Black Hole binaries
  - Pulsars
  - Time-domain astrophysics
  - Stellar astrophysics
  - Interstellar medium
  - Intergalactic medium
- **Exoplanet**
  - Theory
  - Observations
- **Heliophysics**
  - Space Weather
  - Upper atmosphere
  - Ionosphere
- **Solar-System Science**
  - Planetary atmospheres
  - Interplanetary medium

## TECHNOLOGY/TOOLS

- **Materials**
  - Materials processing
  - Structural composites
  - Fiber-reinforced composites
  - Multifunctional materials
  - Self-healing materials
  - Additive manufacturing
- **Modeling Techniques**
  - Novel methods of statistical inference
  - Radiative transfer
  - Image processing, Tomography
  - High performance computing
- **Observational techniques**
  - Ground-based, sub orbital, orbital
  - From soft X-ray to near-infrared
  - High-contrast imaging, photometry, spectroscopy, interferometry, spectral imaging, LIDAR
  - Photon counting detectors
  - Custom optical configurations

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*Learning with Purpose*

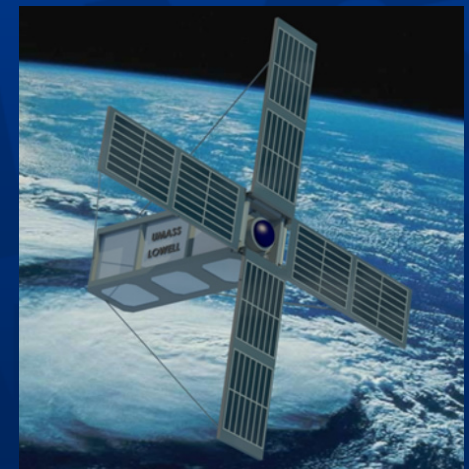
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# Example: SPACE HAUC

## Undergraduate student-led CubeSat mission

- ▶ Demonstrate the practicality of high-data rate, high frequency communications on a CubeSat
- ▶ Achieve rapid beam steering for dynamic pointing of **X-band** uplink/downlink
- ▶ Use **phased array** of patch antennas
- ▶ Camera will take high-res images of Sun to transmit back to Earth
- ▶ **Launch 2018**



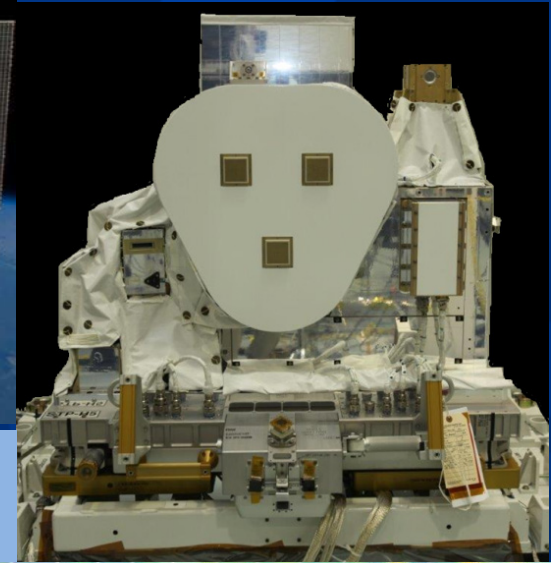
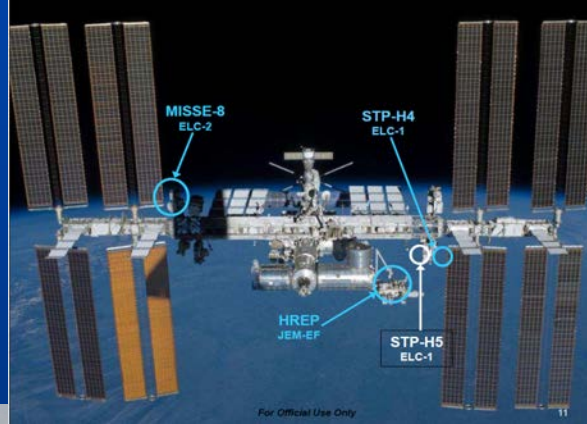
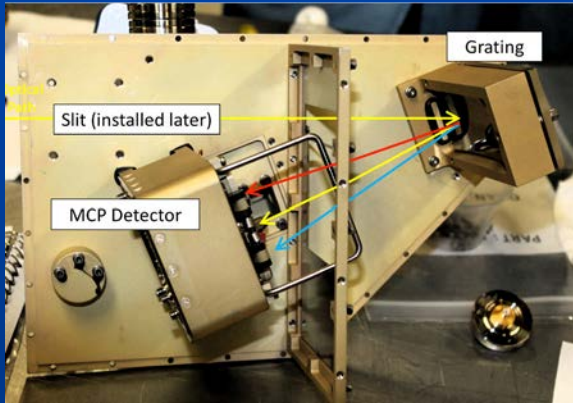
See: <https://www.uml.edu/Research/LoCSST/Research/spacehauc/about.aspx>

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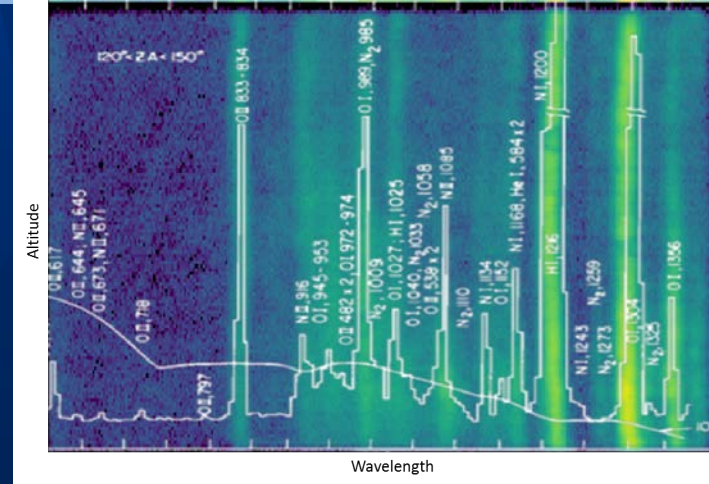
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# Example: LITES on ISS

## A Precursor to ICON's UV observations



Launch: 19 February 2017  
Payload Installed: 27 February 2017  
LITES First Light: 6 March 2017



LITES: Limb-imaging Ionospheric and Thermospheric Extreme ultraviolet Spectrograph

Ph.D.: Geddes – check out his poster

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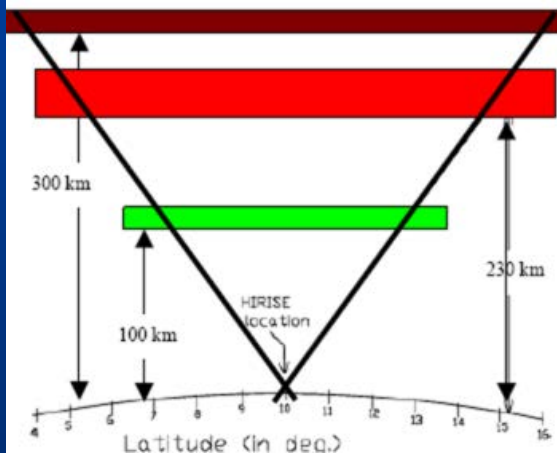


# Example: Ground-based aeronomy

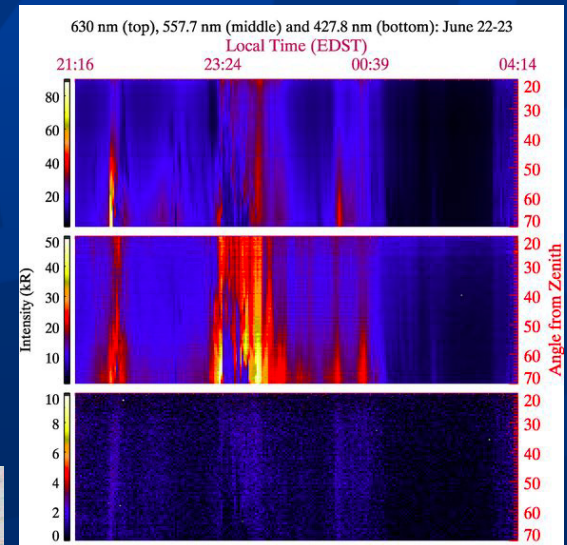
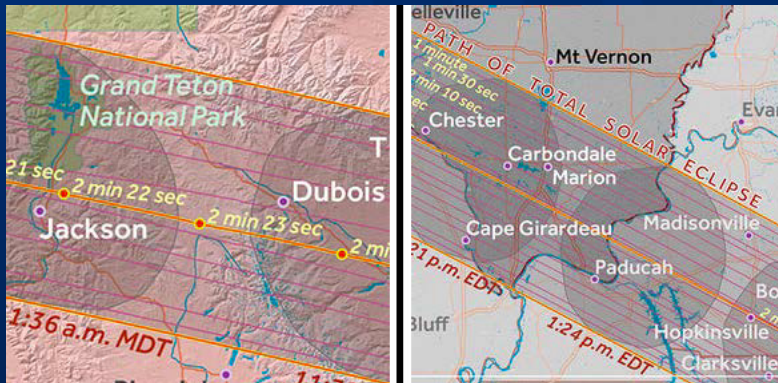
## Round-the-clock optical observations from Haystack



HiT&MIS: High Throughput & Multi-slit Imaging Spectrograph



7774 Å  
6300 Å  
5577 Å



Ph.D.: Aryal – check out his poster



# Example: High energy astrophysics

We work on a variety of science areas

## Pulsars, Black Holes and Accretion: High Energy Astrophysics in the Time Domain

- Accretion lights up the **Neutron Star or Black hole**
- Direct access to fundamental astrophysical quantities (Mass, Spin, B-field, Age, Equation of state).
- X-rays probe large distances and dark corners
- Companion bright at optical and infrared wavelengths

Accretion Disk

Black Hole or  
Neutron Star

Massive O/Be/WR star  
Mass loss =  $10^{-7}$ - $10^{-4} M_{\odot} \text{yr}^{-1}$   
 $V_{\text{wind}} = \text{few } 10^3 \text{ km s}^{-1}$

- 100 galactic examples, similar number known in other galaxies
- Many more NS than BH formed
- Set by the initial mass function and the binary fraction

Christodoulou and Laycock's article on retrograde accretion disks of Neutron stars received attention from the world-wide science community including the LIGO team, in what was probably the year's "most read" astrophysics paper.

<http://faculty.uml.edu/u/slaycock/>

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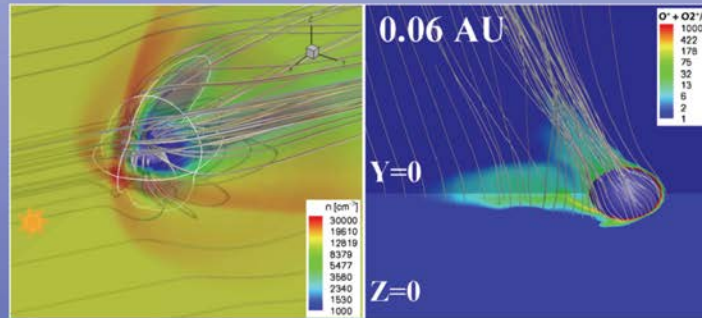
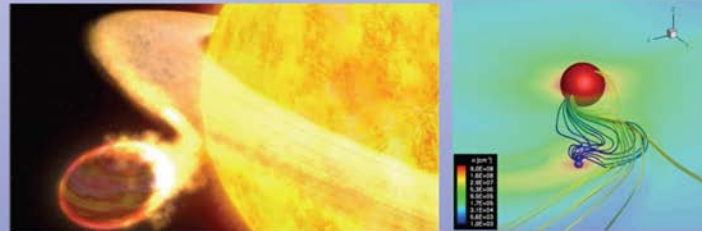
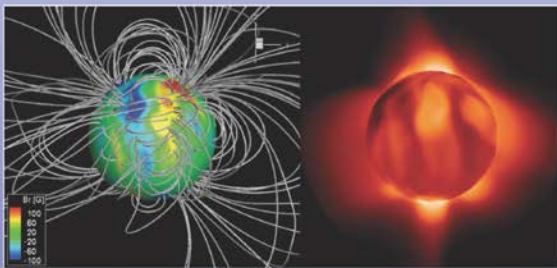
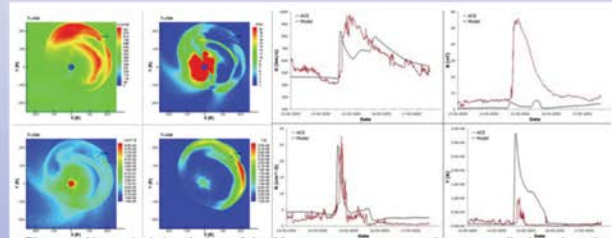
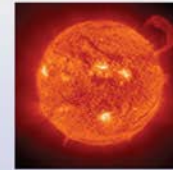


# More examples

## Computational studies with diverse applications

### Applications of computational plasma physics:

1. Solar Physics
2. Space Weather and Heliophysics
3. Stellar Astrophysics
4. Extra-solar Planets
5. Planetary Atmospheres



Professor Cohen's work on habitability exoplanets have been highly cited in popular press such as the National Public Radio and the Forbes magazine.

<https://sites.google.com/site/ofercohenuml/group>

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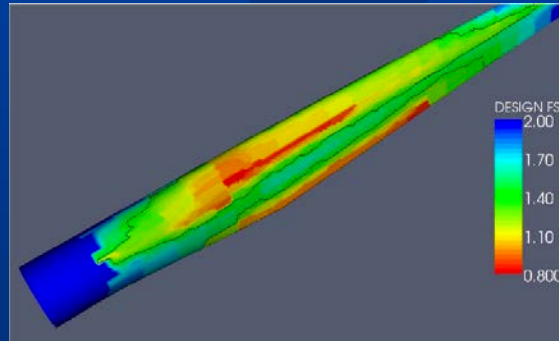
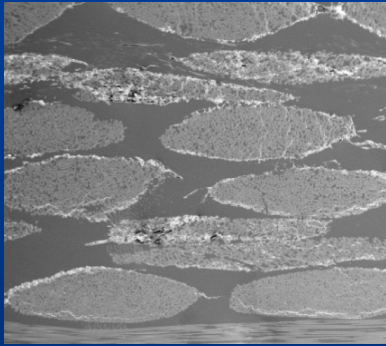
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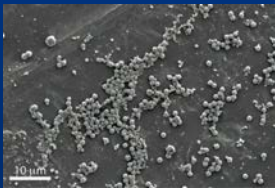
# and for the technology minded

## Multifunctional composite materials world of Prof. Hansen

### SELF-HEALING MATERIALS FOR WIND BLADES



One of seven NASA Early Career Faculty Space Technology Research Grant.winner in 2014

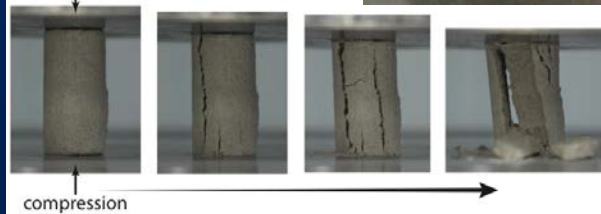


Micro-capsules containing healing liquid are able to slow or reverse damage

### 3D PRINTING FOR COMPOSITES



Extruded fiber for 3D Printing, ATP



... and other aerospace applications see: [http://faculty.uml.edu/Christopher\\_Hansen/](http://faculty.uml.edu/Christopher_Hansen/)

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# What else do we do?

Example: We gathered great thinkers to campus last April

To commemorate 60 years of space exploration and...

to plan our role in the future of space exploration

<https://www.uml.edu/Research/LoCSST/symposium/default.aspx>

UNIVERSITY OF MASSACHUSETTS LOWELL SPRING 2017



Space Exploration in the Upcoming Decade:  
**THE DOMESTICATION OF SPACE**

To commemorate the 60th anniversary of the launch of Sputnik 1 and the dawning of the Space Age, UMass Lowell's Lowell Center for Space Science and Technology (LoCSST) and the Massachusetts Space Grant Consortium are hosting a two-day symposium that features NASA and space industry experts and researchers. Invited speakers include:

**APRIL 21** 3-9 p.m.  
**APRIL 22** 8 a.m.-6:30 p.m.  
UMass Lowell Inn & Conference Center  
50 Warren Street, Lowell, MA  
*Open to the public*

 <p>Catherine (Cady) Coleman, former NASA astronaut</p>	 <p>James A. Abrahamson, former associate administrator of NASA and former director of President Ronald Reagan's Strategic Defense Initiative</p>
 <p>Robert D. Cabana, former NASA astronaut and current director, NASA Kennedy Space Center</p>	 <p>John Connolly, Mars Study Capability Team Lead, NASA Johnson Space Center</p>
 <p>Kenneth R. Sembach, astronomer and director, Space Telescope Science Institute</p>	<p>Panelists will include experts from OmniEarth, KinEX Aerospace, BAE Systems, L-3 Communications-SSG, Raytheon, Axiom Research, BoldyGo Institute and many more.</p>

This event is open to the public.  
For UML registration, contact Lynne Schaufenbil at [Lynne\\_Schaufenbil@uml.edu](mailto:Lynne_Schaufenbil@uml.edu).

For more information, go to [www.uml.edu/Research/LoCSST/symposium](http://www.uml.edu/Research/LoCSST/symposium).



Engineering, in the College of Technology, of

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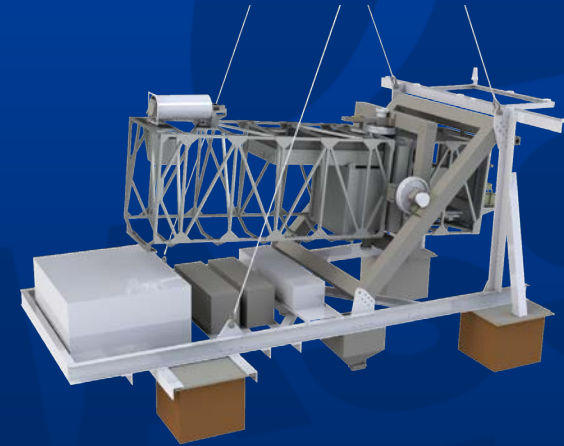
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# Training and Research

Interesting problems involving our students

- ▶ New academic programs
  - Aerospace engineering minor
  - Astrophysics options
- ▶ We are still young
  - Expect faculty growth to continue
- ▶ Our next flight mission
  - A balloon experiment for exoplanetary studies
- ▶ New tools
  - A  $<1 \mu$  imaging spectrograph (with Jeff Baumgardner/BU)



# Partnerships

Continue, strengthen and expand



- ▶ Other Universities and academic institutions
  - BU, UNH, Harvard (CfA)
  - Boston Area Exoplanet Science Meeting on December 4
    - <https://sites.google.com/view/bostonareaexoplanets/>
- ▶ MIT/Haystack
  - LITES
  - HiT&MIS and SPACE HAUC host site
  - 2018 ISR Summer school
- ▶ Industry
  - BAE
    - Helping with an instrument validation
  - BoldlyGo
    - Project Blue
- ▶ NASA Centers
  - Ames Research Lab, Wallops Flight Facility



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# In summary

Lets get into trouble together

- ▶ A lot of good stuff happening
- ▶ The students are learning amazing things and doing things that we could not imagine
- ▶ In a few years we have established a thriving research center
- ▶ We are always looking for ways to work together – please come visit