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)

Ph.D. Students

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

Research Staff

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

Undergraduate Students

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

Administrative Staff

- Ms. Lynne Schaufenbil

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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
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](https://www.uml.edu/Research/LoCSST/Research/spacehauc/about.aspx)
Example: LITES on ISS
A Precursor to ICON’s UV observations

LITES: Limb-imaging Ionospheric and Thermospheric Extreme ultraviolet Spectrograph

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

Ph.D.: Geddes – check out his poster
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 = $10^{-7} - 10^{-4} \, M_\odot \, yr^{-1}$
$V_{\text{wind}} = \text{few } 10^3 \, \text{km s}^{-1}$

- 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/slaycock/
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
and for the technology minded

Multifunctional composite materials world of Prof. Hansen

SELF-HEALING MATERIALS FOR WIND BLADES

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

3D PRINTING FOR COMPOSITES

Extruded fiber for 3D Printing, ATP

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

... and other aerospace applications see:
http://faculty.uml.edu/Christopher_Hansen/
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
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 U imaging spectrograph (with Jeff Baumgardner/BU)

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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/](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
In summary

Let's 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