2011
College of Science
Faculty Research Symposium

September 23, 2011

Welcome
Schedule

- 1:00-2:30 COS Laboratories
- 2:30-2:45 Break
- 2:45-3:40 FEAD Grant Reports
- 3:40-4:00 COS Sabbatical Reports & Wrapup
- 4:00-5:00 Reception, Discussions, Posters
CACM
(Tony Harkin)
CCRG
(Manuela Campanelli)

http://ccrg.rit.edu
What is CCRG?

- The Center for Computational Relativity and Gravitation (CCRG) is an RIT Academic Center of Excellence, a COS and SMS Research Center, an F&A Return Designated Research Center, etc.

- Its mission is to serve as a focus point for research in key designated areas of gravitational physics, relativistic astrophysics and computation, with the goal of advancing discovery and knowledge of some of the most extreme physical phenomena in the universe.

- The CCRG currently comprises tens of members among faculty, postdoctoral researchers, staff and students mostly residing in the College of Science, but also in the Golisano College of Computing and Information Sciences.

- Faculty are also affiliated with the Astrophysical Sciences and Technology (AST) and Computing and Information Sciences (CIS) graduate programs.

- The Center is an umbrella for a number of externally funded research programs, large scientific collaborations, and advanced, specialized supercomputing facilities.

- A visitor program, workshops and other scientific activities also contribute to the creation of a vibrant research environment.

- Members of the center also participate in outreach activities, with numerous presentations, annual exhibits for teachers and students (at all levels) and the general public.

People

A team of 26 + people:

7 core faculty:
- Hans-Peter Bischof (CS),
- Manuela Campanelli (SMS, Director),
- Joshua Faber (SMS),
- Carlos O. Lousto (SMS),
- David Merritt (PHY),
- John Whelan (SMS),
- Yosef Zlochower (SMS).

5 postdocs:
- Bruno Mundim,
- Hiroyuki Nakano,
- Scott C. Noble,
- Melissa Frei,
- Jason Nordhaus.

9 research students:
- Julio Espinal, John Kaeuper (BS/MS in Computer Science - GCCIS),
- Fabio Antonini, Prabath Peiris, Marcelo Ponce, Billy Vazquez, Ian Ruchlin (PhD in AST– COS),
- Jeremy Berke – Undergraduate Student (BS Electrical Engineering)
- Anthony Castiglia – Undergraduate Student (BA in Applied Mathematics -- SMS/COS).

4 student employees:
- Mayank Bindal. Ayush Manocha (Finance & Administration, MBA students in College of Business),
- Tim Paterson, Steven DuBois (Web administration and computer support, CS).
Research Programs

- **General Relativity and Gravitation.** We are interested in theoretical gravitational physics as it applies to experiments and observations, including solutions to Einstein’s field equations and their fundamental properties in general relativity and in other plausible theory of gravity.

- **Numerical Relativity and Source Modeling.** Our primary purpose is to model astrophysical sources of gravitational radiation, such as for example the inspiral and merger of binary black holes and neutron stars.

- **Relativistic magneto-hydrodynamics.** We study the merger of neutron stars, gravitational core collapse and supernovae, supermassive black-holes and their accretion disks. These phenomena may be the source of powerful gamma ray bursts and relativistic jets.

- **Active galactic nuclei, galactic dynamics and N-body simulation.** We study the evolution of galaxies, stars and central black holes with N-body simulation.

- **Stellar death.** We study the late stages of stellar evolution for both low-mass stars and their high-mass counterparts. Active areas of research include the physics of core-collapse supernovae, white dwarfs, planetary nebulae, neutron stars and binary star systems.

- **Gravitational wave theory, analysis and observations.** As part of the LIGO Scientific Collaboration, we analyze data from the LIGO, GEO-600 and Virgo data to search for gravitational waves from compact binary coalescences, rapidly rotating neutron stars, and the cosmic gravitational-wave background.

- **Advanced Computation, Visualization and Cyberinfrastructure.** Our emphasis is on high-performance computing, visualization, and open source software development for astrophysics and gravitational wave science.

Collaborations

- Einstein Toolkit (NSF – Consortium)
- Collaborative Research with JHU, Princeton
- PRAC (NSF – NCSA)
- Ninja, NR-AR Collaborations
- Ligo Scientific Collaboration

Overall, this includes more than 1000 researchers and 100 of institutions across the globe!
Visitors, Workshops and Research Activities

A visitor program, workshops and other regular research related activities contribute to the creation of a vibrant research environment:

– Over 50 scientists visited CCRG and gave presentations since 2007
– We organized 3 workshops
– We hold weekly research meetings: CCRG lunches, Group Meeting and Journal Clubs

Computers

• Host and manage the largest Supercomputing Laboratory @RIT

• The simulations performed in the CCRG require high performance computing:
  • gravitySimulator: a special-purpose computer cluster for galactic dynamics (N-body simulations).
    – Built in 2004 (cost $600K)
    – 32 compute nodes, each equipped with a GRAPE-6A card.

• newHorizons: state-of-the art 736-processor Linux cluster for numerical relativity simulations.
  – Built in 2007 (cost $742K) and continuously upgraded throughout several grants
  – Infiniband interconnects

• Simulations are also performed at national supercomputing centers such as TeraGrid and at DOE.

• CCRG PIs awarded millions of SUs every year.

• Our computer demand literally duplicates each year!
Funding and Direct Expenses

We are currently supported by external research grants from the following funding sources for a total of $4.7 million (nearly one million per year):


- **NASA awards:** NNG04GJ48G, NNX08AH20G, NNX07AH15G, HST-GO-10861.17YA, HST-ARY-09519.01A, HST-ARY-11763.01-A, HST-ARY-12146.01-A.

Most of our direct expenses is to support research Personnel and equipment.

As F&A return designated research center we receive 20% of F&A funds back to support operating costs (student employees, speakers, computer laboratory, workshops and meetings, postdoctoral developmental activities, etc).

Publications

- **Strong publication records:**
  - Some famous and well-known papers (with over 1000 citations)

- **Approx. 50 talks per year** (most of them invited) in conferences, workshops and other research institutions.

- **Strong dissemination** with many Press Events in Popular Magazines, TV Channels (History, Discovery, etc), videos (YouTube, etc).
Education & Public Outreach

We participate in outreach activities with presentations and annual exhibits for:

Students of all grades:
- REU program
- Rochester Education Foundation (3rd grade students)
- Nova Academy (9-12 grade students)
- Eagle Projects (K12 students)

General Public:
- Science Cafe’, sponsored by NASA
- Imagine RIT: Innovation and Creativity Festival
- Collaboration with creative studies and arts of NTID

CfD
(Don Figer)
(Substitute = Me???)
Highlights

- **Research**
  - completed two NASA projects – achieved low noise using new detector architecture
  - discovered new interstellar absorption lines (Nature paper on the way)
  - developed first large-format imaging single-photon detector (w/Lincoln Lab)
  - implemented imaging LIDAR detector
  - completed observations using all NASA Great Observatories in CfD Multiwavelength Astrophysics group

- **Communications**
  - published 9 papers
  - gave 7 invited talks, 4 invited reviews at international venues

- **Students**
  - graduated two MS students
  - mentored 9 undergraduate and 7 graduate researchers in a multi-disciplinary, team-based, project-driven environment

- **Cross-Institute Initiatives**
  - completed cross-Institute collaborations with School of Design and College of Business

- **Organization**
  - moved into superb space
  - submitted $55M in proposals (including NSF Center)
  - Annual Report is in preparation

- **New Initiatives**
  - Won two NASA PhD fellowships
  - Received NSF funding for international virtual workshop
Single Photon Imaging Detector

- Now cryogenically testing 256x256 device

Collaboration w/School of Design

- Twenty one School of Design students did their senior projects by designing the new CfD space. The 184-page report is on the CfD web site.
Collaboration w/College of Bus.

• Shivam Bansal, COB student, performed a benchmark analysis of comparable research centers.
• Compared funding structures, industrial partner programs, communications, management, and markets.
• CfD used this as input to organization and new initiatives.

CfD External Funding
Overview of the Digital Imaging and Remote Sensing Laboratory

David W. Messinger, Ph.D.
Director, Digital Imaging and Remote Sensing Laboratory

Chester F. Carlson Center for Imaging Science
Rochester Institute of Technology

http://dirs.cis.rit.edu
The Digital Imaging and Remote Sensing Laboratory

- DIRS consists of
  - 9 full time faculty
  - 16 full time research/support staff
  - ~ 10 undergrad research assistants
  - 7 MS & 25 Ph.D. candidates

- Current research program
  - > 40 funded projects
  - annual research revenue ~ $4M
  - committed research support > $10M
DIRS Research Focus Areas

- Data Exploitation
- Sensing Systems
- Environmental Applications
- Synthetic Image Generation

Extracting 3D Structures from Multiple 2D Images
Downtown Rochester Airborne Collection

Reconstructed 3d Point Cloud from Imagery
Advanced Mathematical Approaches to Spectral Image Processing

Collaboration with School of Mathematical Sciences

• Developing novel graph theory (and other) approaches to extracting quantitative information from spectral imagery

• Algorithms developed so far:
  – Anomaly detection (2)
  – Change detection (3)
  – Image Clustering / Segmentation
  – Large area search (2)
  – Euclidean Commute Time Distance Transformation

• Through funding of Imaging Science (MS & Ph.D.) and Math MS students
Example: Large Area Search

4k x 2k, 4 band, ~2.5 m resolution

Interesting Tile - Center

high resolution pan
Modeling and Simulation

• Modeling and Simulation involves the precise radiometric representation of remote sensing scenes over a wide spectral regime
• RIT developed DIRSIG is leading tool for scene and image chain simulations
• Common uses include:
  – Sensor/system performance evaluation
  – Algorithm training and evaluation
  – Rapid parametric analysis

Tile #1 Specifications:
- 5,000+ objects
- 500+ million facets
- 1.6 km² (0.6 mi²)
Multi-modal Scene Simulation Capability

Airborne Imaging for Disaster Response
Example Imagery: Haiti Earthquake Response

Combined LiDAR and Hi Res Image
Binghamton Floods: Hurricane Lee 2011

Binghamton Floods: Hurricane Lee 2011
Questions?

David W. Messinger, Ph.D.
(585) 475-4538
messinger@cis.rit.edu
Insight
(Jake Noel-Storr)
## Organizational Structure

### Key Working Areas

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### Key operational areas

![External collaborations](image.png)

**External collaborations**

- RMSC
- Rush-Henrietta Central School District
- NASA Goddard
- University of Rochester
- The University of Arizona
- Nazareth College
- Girl Scouts
- Motorola Foundation
- Association for Astronomy Education
- LRO
- Insight Lab
RIT Student Engagement

- $1.2m in active projects (including those shared with other units)
- Averaging:
  - $100k/project
  - 2 years/project
- Supporting
  - Research Faculty Time
  - Undergraduate Students
  - Travel for field work and dissemination

Funding Landscape
Highlights: Projects and Programs

- Engagement of Rush Henrietta Students and Teachers
  - Family Science Programs
  - Education Technology Development
  - Astrophysics Research
- Continuing relationship with Girl Scouts of Western NY
- Honors Special Topics and Interdisciplinary Undergraduate offerings at RIT
- Operate new NSF REU (through CIS) and MSP (through CoS) projects

Highlights: Evaluation Services

- Evaluating effectiveness of NASA Education Projects and Programs for:
  - Solar Dynamics Observatory
  - Lunar Reconnaissance Orbiter
  - Aura Mission
  - Terra Mission
- Evaluation of Outreach Events:
  - AstroZone
  - Exploration Station
  - International Observe the Moon Night
  - NASA Climate Day
Highlights: Educational Technology

- Digital Immersive Scube continues to produce new content
- New “Planeterrainium” system for observing planetary surfaces in 3D
- Digital Solar Explorer (developed by Frontiers of Science II class 2010/3)

Dr. Jake Noel-Storr
Assistant Research Professor and Director

jake@cis.rit.edu
LAMA
(Joel Kastner)

RIT’s Laboratory for Multiwavelength Astrophysics
(LAMA)

http://lama.cis.rit.edu
LAMA: Mission and Role

• The mission of LAMA is to foster the utilization and advancement of cutting-edge techniques in multiwavelength astrophysics by RIT faculty, research staff, and students, so as to improve human understanding of the origin and fate of the universe and its constituents.

• LAMA supports the following astrophysics activities at RIT:
  – exploitation of existing and forthcoming national and international ground- and space-based astronomical observing facilities/missions
  – exploitation of the present and forthcoming generations of multiwavelength data archives
  – development of scientific requirements for future astronomical observing facilities/missions and future data archival and mining methods
  – analysis and modeling of multiwavelength astronomical and astrophysical data

LAMA: Personnel

• Faculty: David Axon (Physics), Stefi Baum (CIS), Roger Dube (CIS), Joel Kastner (CIS; LAMA Director), Jacob Noel-Storr (CIS), Chris O'Dea (Physics), Michael Richmond (Physics), Andrew Robinson (Physics)

• Research Staff: Rachel Curran, Preeti Kharb, Rupal Mittal, Rudy Montez

• Graduate students: Marcus Freeman, Davide Lena, Dave Principe, Valerie Rapson, David Saroff, Grant Tremblay, Sravani Vaddi, Billy Vazquez

• Undergraduate students: Kevin Christiansen, Mike Every, Dan Goldberg, Marc Magagnoli
LAMA by the numbers

- Officially designated an RIT Research Center in Jan. 2011
- 42 refereed publications in CY 2010
- 18 new grants awarded in CY 2010
- ~30 active grants in FY 2011
  - 11 LAMA PIs
  - Total expenditures of ~$1.1M

LAMA: Science Themes

- Galactic (stellar) astrophysics
  - Star and planet formation
  - The late stages of stellar evolution
- Extragalactic astrophysics
  - Galaxy clusters
  - Supermassive black holes (active galactic nuclei)
- Space weather
Galactic (stellar) astrophysics

• Star and planet formation
  — Multiwavelength (radio to X-ray) studies of planet-forming disks orbiting the nearest young stars
    • Sponsors: NASA (Herschel, XMM); NSF
    • personnel: Kastner, Principe, Rapson, new postdoc, plus int’l team of ~2 dozen
  — X-ray monitoring of eruptive young stars
    • Sponsors: NASA (XMM, Chandra)
    • personnel: Kastner, Richmond, Principe, plus team @ NASA/GSFC, Vanderbilt U., U. Strasbourg

• The late stages of stellar evolution
  — First systematic X-ray survey of dying, Sun-like stars in the solar neighborhood: the Chandra Planetary Nebula Survey (ChanPlaNS)
    • Sponsor: NASA (Chandra)
    • Personnel: Kastner, Montez, Rapson, Christiansen, Goldberg, plus int’l team of ~2 dozen

Multiwavelength (radio to X-ray) studies of planet-forming disks orbiting the nearest young stars

Left: movie of velocity-resolved Submillimeter Array CO images of the circumbinary disk orbiting the V4046 Sgr star system (courtesy D. Rodriguez, UCLA)
Above: animation of a Keplerian molecular disk
(by RIT Digital Cinema student J. Traver)
First systematic X-ray survey of dying, Sun-like stars in the solar neighborhood: the Chandra Planetary Nebula Survey (ChanPlaNS)

- Goals:
  - Understand stellar wind interactions that generate “hot bubbles” within planetary nebulae
  - Establish presence (or absence) of binary stars at the cores of planetary nebulae

3 (of 21) new ChanPlaNS target PNe

PN detected in X-rays by Chandra or XMM (X-rays: blue)

ChanPlaNS: Multiwavelength Astrophysics 101

The Famous Ring Nebula (Messier 57)

SWIFT UV detection of hot (~100,000 K) stellar remnant (white dwarf) plus high ionization state atomic emission lines from nebula

SWIFT visible-light image: what you might see if you looked through a small telescope

Nested shells of molecular gas and dust surrounding the “famous” nebula, seen in IR (WISE) images

CHANPlaNS, SWIFT nondetections of central star in X-rays
Multiwavelength Astrophysics 101 (cont.): the lesser-known planetary nebula NGC 1514

_CHANPLANS_ detection of hard X-rays from the central star(s)

Double ring system, in the mid-IR (WISE)

Brightest Cluster Galaxies

The Galaxy Cluster group (O’Dea, Baum, Mittal, Kharb, students) is conducting a multiwavelength study of brightest cluster galaxies in cooling flow clusters utilizing the VLA, radio, Herschel and Spitzer infrared, HST near-IR, optical and UV, ground based optical, and Chandra X-ray observatories. Our goal is to understand the processes of heating and cooling in the intracluster medium via studies of star formation and AGN feedback.
Most galaxies undergo an active (quasar) phase during which a central supermassive black hole (SMBH) generates vast luminosities through gravitational accretion of interstellar gas.

- Gas flowing in from the galaxy “fuels” the quasar
- Gas outflows (“winds”) from the quasar regulate black hole growth and galaxy formation

The AGN group is working on 5 main projects in this area:
- Probing gas flows around SMBHs with Spectropolarimetry (NSF)
- A search for Displaced Supermassive Black Holes (NASA – HST)
- Reverberation mapping the Dusty Tori in Active Galactic Nuclei (NASA – Spitzer)
- Feeding and Feedback in Active Galactic Nuclei (NSF)
- Embedded quasars in OH Megamaser Galaxies (NASA)

In AGN, the SMBH and accretion disk are surrounded by a torus-like structure of molecular gas and dust, which is opaque to UV–optical radiation and which emits the bulk of the IR continuum.

- Science Goals
  - Determine size and structure of torus by measuring response of torus near IR emission to variations in AGN optical luminosity
  - Coordinated monitoring in IR (Spitzer Space Telescope) and optical (network of ground-based telescopes)
- Personnel
  - Axon (PI); Robinson; Richmond
  - Billy Vazquez (MS student)
  - Large international collaboration
- Funding: Spitzer/NASA
  - Awarded 20% of Cycle 8 Spitzer time!
Space Weather Technologies

• 1) Space weather early warning system
  – Determining when high energy particles from the sun will strike the Earth or other planets
    • Usually from a Coronal Mass Ejection (CME)
  – Recent progress
    • 3D imaging of CMEs => absolute speed and direction
    • 2-3 day advanced warning
      – Working on predictions of solar storm strengths

• 2) Starspots and Pulsating Stars
  – Algorithms for finding starspots in Kepler and other databases
  – Algorithms for identifying pulsation frequencies in "slowly pulsating" hot stars

• Personnel: Dube & students
  – Santosh Suresh – PhD thesis on automated flare and CME detection using Solar Dynamics Observatory
  – Greg Shute (Amherst; NSF REU) – algorithms for starspot and SPB studies

LAMA: looking ahead...

• New multi-year NSF grants awarded:
  – “Feeding and Feedback in Active Galactic Nuclei,” $239K, 2 years (PI: Robinson)
  – “Radio and Infrared Line Studies of Irradiated Protoplanetary Disks,” $339K, 3 years (PI: Kastner)

• Activities to be supported (potentially):
  – AST speaker series
  – Publication page charges
  – Student & postdoc travel
    • conferences, observatories
  – Seed funding for proof-of-concept studies
    • e.g., Astron. Telescope for NY
  – Fellowships for visitors
    • Pre-doctoral visitors
    • Visiting postdocs
    • Faculty on sabbatical
MCSL
(Roy Berns)
(Substitute = Mark Fairchild)
Research in Color Imaging

Roy Berns, Mark Fairchild Jim Ferwerda, Jinwei Gu

MCSL Founding

Munsell Color Science Laboratory
Made possible by a gift from
Munsell Color Foundation, Inc.
1983

Albert H. Munsell
Objectives

1. To provide undergraduate and graduate education in color science,
2. To carry on applied and fundamental research,
3. To facilitate spectral, colorimetric, photometric, spatial, and geometric measurements at the state-of-the-art, and
4. To sustain an essential ingredient for the success of the first three — namely, liaison with industry, academia, and government.

Mark Fairchild
Mark Fairchild

- HDR Imaging and Appearance Modeling
- Lightness Scaling
- Brightness/Colorfulness Tradeoffs in Displays
- Image Quality Evaluation & Modeling
- Observer Variability & Displays

HDR Imaging

- Capture, Display, & Perception of HDR Scenes and Images
- Current Focus: Scaling Lightness and Colorfulness Across Wide Ranges
Lightness Scaling

- Perceptual Scaling and Mathematical Modeling of Lightness Perception for Colors “Brighter than White”
- Extending the Range of Color Spaces

Brightness-Colorfulness

- Brighter Images Appear More Colorful
- Examining Tradeoffs Between Brightness and Saturation of Primaries for HDR Displays
Image Quality Evaluation

• Psychophysical Scaling of Image Quality
• Various Imaging Systems
• Exploring Image Content Effects

Observer Variability

• How can displays be designed or optimized to reduce the effects of difference in color vision?
• E.g., More Primaries, Broadband Primaries
• Applications in Digital Cinema
A framework for realistic image synthesis

modeling

scene description

rendering

light transport simulation

imaging

tone/gamut mapping

geometry materials lighting

radiance values

goniometric validation radiometric validation psychophysical validation

Modeling material appearance

- dimensions:
  - $c$ = contrast gloss (contrast of reflected image)
  - $d$ = DOI gloss (sharpness of reflected image)
  - confirmation of Hunter from first principles?
Predicting visible image differences

- Images processed through vision model to represent visual responses
- Responses compared to predict visible differences
- Visualized as an image difference map
- State-of-the-art, many applications in imaging and graphics


Tangible display systems

- Simulate changes in appearance caused by variations in surface orientation and viewpoint
- Allow natural interaction with virtual surfaces
• New faculty member in CIS/MCSL
  – Join the center in September 2010

• Education:
  – PhD, 2010, Computer Science, Columbia University
  – MS, 2005, Automation, Tsinghua University
  – BS, 2002, Automation, Tsinghua University

• Research Interests:
  – Computational Photography
  – Appearance Measurement, Modeling, & Rendering
  – Computer Vision, Computer Graphics, Pattern Recognition
1. Computational Imaging

• Efficient & Flexible Sampling
2. Physically-based Appearance

- Controllable Rendering, Editing & Restoration
  - De-weathering
  - Lens Artifacts
  - Time-Varying BRDF

Curriculum Development

- Developing a new graduate course “Computational Photography”, Spring 2011.

- Topics:
  - FrankenCamera (Camera 2.0)
  - HDR Imaging/Display
  - Computational Camera
  - Computational Illumination
  - Light Transport Analysis
  - Novel Display & Printing
  - Large Photo Collections
  - …
Roy Berns

Art Conservation Science

Before treatment

Digital rejuvenation

After treatment

Virtual cleaning
3D Imaging of Artwork

In Conclusion...
MVRL
(Jeff Pelz)
SMERC
(Scott Franklin)
Break until 2:50

FEAD Grants
Proteomic Analysis of NOS Inhibition in *B. subtilis*

Thomas D. Kim
Department of Chemistry
Comparative 2DGE

Reverse Transcriptase PCR
Morphological Switch

(Suzanne O’Handley)
Determination of Anti-malarial Drug Interactions with Hematin

Dr. Scott Williams

2011 FEAD Research
UG Research Support and Travel

Malaria Drug Target
Lumefantrine

\[ aH + bL \rightleftharpoons HL, \text{ assuming } 1:1 \text{ complex} \]

\[ Keq = \frac{[HL]}{[H]^a \times [L]^b} \]

\[ [H]_T = [H] + [HL] \]

\[ [HL] = [H]_T + [H] \]

\[ Keq = \frac{[HL]}{([H]_T - [HL]) \times ([L]_T - [HL])} \]

Let \( x = \frac{[HL]}{[H]_T} \)

\[ Keq = \frac{x}{(1-x) \times ([L]_T - [H]_T \times x)} \]
Results

Keq, Hematin: Ligand

310

0.19

0.12

Jan van Aardt
Development of geometric registration and object extraction tools for laser point clouds derived from multiple ground-based LiDAR scans

Jan van Aardt*, Jonathan Lueders**, Kevin Bloechl**, Linnea Tullson**, Thomas Yang**, Harvey Rhody*, and Nathan Cahill*

* Faculty
** Senior students

Contents:
- Objectives
- Remote sensing primer: Modalities
- Students involved
- Data collected
- Next steps
Original objectives:
Use existing in-house ground-based LiDAR system to
(i) develop an algorithm to register multiple point clouds along a transect to each other
(ii) assess the application of ground-based LiDAR data for extraction of detailed, accurate, and precise object structure

Deviation:
(i) collect data for various senior capstone projects
(ii) integrate these data in projects for publication, operational code, and proposal development

Primer: Hyperspectral sensing
Examples and implementation

Photosynthesis revealed in a Spectrum
6H₂O + 6CO₂ + photons ➔ C₆H₁₂O₆ + 6O₂

Chlorophyll
Sugar, Lignin and Cellulose across the spectrum
**Primer: Lidar remote sensing**

- Light detection and ranging (optical analogue of radar)
- Emits laser pulse and measures return trip distance

**Basics**

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<th>Laser pulses</th>
<th>Geographically located</th>
<th>Multiple returns</th>
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Images courtesy of OPTECH, Inc.

**Primer: Lidar remote sensing**

- Ground-based lidar
**Students involved:**

- Jonathan Lueders (senior): Assessment of vineyard moisture status using hyperspectral sensing
- Kevin Bloechl (senior): Registration of lidar point clouds
- Linnea Tullson (senior): Extraction and quantification of 3D natural objects from lidar point clouds
- Thomas Yang (senior): Extraction and quantification of 3D man-made objects from lidar point clouds

**Data collected:**

- Vineyard moisture status (Cornell University; *in situ*) and associated spectral measurements
Data collected:

• Ground-based lidar scans (Cornell University & University of Kentucky; *in situ*)

Scanning vineyards and forests
Data collected:

• Ground-based lidar scans (Cornell University & University of Kentucky; in situ)

Next steps:

• The capstone projects start in all earnest over two quarters
• Analysis of data + publishing (peer-reviewed) papers
• Fodder for at least two NSF, USDA, DOE-type proposals related to assessment of plant physiology and structure
Gene Expression Analysis Using Microarrays of Prion Positive and Negative Yeast Strains
Irene M. Evans
Prions Have a Nasty Rap

• These unusual proteins are widely believed to be infectious and responsible for many mammalian Transmissible Spongiform Encephalopathies (TSEs).

• Including:
  - Scrapie in sheep  
  - Kuru in humans  
  - Creutzfeldt-Jakob disease in humans.

  - BSE or Mad Cow disease  
  - Chronic Wasting disease in deer and elk

Prions May Actually Be Beneficial (At Least in Yeast)

• The strain of yeast with a prion protein grows faster under certain conditions

• One gene (DNA) codes for a protein that can exist in several conformations each of which can change the properties of the yeast it is in

• Prions might actually help organisms adapt to certain (stressful) environments by subtly altering the proteins manufactured by the cells
Two Congenic Yeast Strains
Same Genome (Genes)
Same Proteins, BUT
One Protein is in a different prion conformation in [PSI+] strain

What Changes Does the Prion Protein Cause?

• Look at changes in mRNAs
• Use microarrays; Grow on rich media
• Found 130 yeast genes (out of a total of 6400) that had altered mRNA levels
• Genes are in oxidative stress, mitochondrial (bioenergetics), nitrogen catabolism and other pathways.
• Changes were small. No 2x changes
2011 FEAD GRANT?

• Are 2x mRNA changes found when yeast are grown in minimal stressful media?

• Yes! See 6-10 gene changes.

What Does It Mean?

• Maybe Yeast Prions are involved in cell regulation.

• Proteins may switch between the prion and the normal functional conformation to better adapt to stressful conditions!
PRIONS
Proteinaceous Infectious Particles

“That a genetic trait property carried by protein shape can be responsible for inheritance from generation to generation or for an infection is a revolutionary concept.”

-Susan Lindquist, Ph.D
Director of Whitehead Institute for Biomedical Research MIT

(André Hudson)
Characterization of meso-diaminopimelate decarboxylase from *Arabidopsis thaliana*: a target for herbicide development

André O. Hudson
School of Life Sciences

DAP/Lysine anabolic pathways

- Tetrahydridopicolinate [THDPA]
- N-acyl-2-amino-6-ketopimelate
- N-acyl-L,L-2,6-ketopimelate
- L,L-2,6-diaminopimelate [L,L-DAP]
- meso-diaminopimelate [m-DAP]
- L-Lysine

A

B

C

DapD
DapC
DapE
DapF
Ddh
DapL
MurE
Cell Wall
Complementation of *E.coli* lysA mutant with *Arabidopsis thaliana* cDNAs

Recombinant expression/purification of LysAs from Arabidopsis

Development of coupled enzyme system for LysA detection using lysine dehydrogenase

Clone the codon optimized lysine dehydrogenase gene from *Pyrococcus horikoshii* to be used in the coupled assay system

Characterize both LysA enzymes using traditional biochemistry techniques with respect to physical and kinetic properties
A novel property of propolis (beehive glue): anti-pathogenic activity by inhibition of quorum-sensing mediated signaling in bacteria

Michael Savka
School of Life Sciences

What is Bacterial Quorum Sensing?
Signal-mediated bacterial regulatory mechanism that governs the cell density dependent expression of specialized gene systems
What is Bacterial Quorum Sensing?

Signal-mediated bacterial regulatory mechanism that governs the cell density dependent expression of specialized gene systems

Example: Light Production in Vibrio fischeri

Cell Density

Time

Bioluminescence or Cell Density

A Model of Bacterial Quorum-Sensing (QS)

QS: Assess local population density and/or physical confinement of signal
A Model of Bacterial Quorum-Sensing (QS)

**QS:** Assess local population density and/or physical confinement of signal

**Response:** Coordinate production of disease-causing factors or virulence factors

Disease in host & Enhance fitness of bacterial pathogen!

Graphical Abstract:

Propolis (beehive glue) inhibits quorum-sensing controlled phenotypes

Bioluminescence in bacterial biosensors

Swarming motility in *P. aeruginosa*

Violacein production in *C. violaceum*

Bulman Z, Le PT, Hudson A, Savka MA. Journal of Ethnopharmacology (Accepted)
Acknowledgements: Funding and Support

Zack Bulman,
RIT Biotechnology Graduate 2011
Currently in PharmD program, University at Buffalo,
School of Pharmacy and Pharmaceutical Sciences

Ryan Sorenson
RIT Undergraduate, Senior,
COS Undergraduate Research Student

Nazrin Abd Aziz
RIT Biotechnology Undergraduate, Senior,
American Society for Microbiology,
Summer Undergraduate Research Fellow

Andre O. Hudson
RIT, School of Life Sciences

College of Science, FEAD, Summer 2011

(Susan Smith)
Neotropical migration of Boreal breeding birds

Project Goal:
Investigate the nutritional and physiological implications of seasonal frugivory for migrating songbird populations

Study Objectives:
1) determine nutritional value of common wild fruits consumed by migrating songbirds
2) monitor avian consumption of native versus invasive fruits
3) use plasma metabolite profiling to assess refueling performance of birds in relation to wild fruit abundance
4) involve RIT students in nutritional ecology field/lab research and provide preliminary data for continued projects and external funding
Value of native and invasive fruits for migrating songbirds

- Nutritional value of fruits at RIT Bird Observatory and Braddock Bay Bird Observatory (S. DeSando, 4th year BIO)
  - Macronutrient and caloric content: % fat, % sugar, total N, energy density
  - Chemical composition: total phenols, specific antioxidants

**Native Species**
- Gray Dogwood (Cornus racemosa)
- Silky Dogwood (Cornus amomum)
- Red Osier Dogwood (Cornus sericea)
- Common Buckthorn (Rhamnus cathartica)
- Multiflora Rose (Rosa multiflora)
- Bush Honeysuckle (Lonicera spp.)

**Invasive Species**

<table>
<thead>
<tr>
<th>Species</th>
<th>Fat Content</th>
<th>Sugar Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Buckthorn</td>
<td>15.74</td>
<td>27.16</td>
</tr>
<tr>
<td>Multiflora Rose</td>
<td>17.16</td>
<td>21.23</td>
</tr>
<tr>
<td>Bush Honeysuckle</td>
<td>16.77</td>
<td>18.83</td>
</tr>
</tbody>
</table>

**Preliminary Fruit Composition Results**

- Invasive fruits have lower fat and energy density than natives
- Site differences
Value of native and invasive fruit for migrating birds: *planned analyses*

- **Additional fruit species at RITBO/BBBO:**
  - Arrowwood Viburnum, Riverbank Grape, Sumac, Highbush Cranberry, Spicebush, Autumn Olive

- **Protein Content**

- **Fruit phenols/antioxidant capacity**
  - Total phenols: microplate modification of Folin-Ciocalteu assay *in progress* (G. Wink, NTID-LST)
  - Flavenoids, anthocyanins, tannins (S. Schroeder, EnvSci MS program)

---

**Seasonal frugivory in migratory songbirds**

- **Consumption of native fruits versus invasive fruits by songbirds during fall migration (S. DeSando):**
  - Fruit enclosure experiments started Sept 9th
  - Weekly fruit counts through mid-October
  - RITBO versus BBBO
Refueling performance of birds at RIT versus BBBO in relation to fruit availability/quality

- Plasma metabolite profiling as indicators of substrate use during migration
- Simultaneous blood sampling at both sites to assess differences in stopover site use in relation to fruit resources (A. Miller, 4th yr. BIO)
  - Fall 2011 sampling of focal species through Oct
  - Plasma analyses Nov-Dec
  - Triglycerides, glycerol, uric acid, ketone bodies, nonesterified fatty acids,

(Sandra Connelly / Loraine Tan)
An assessment of vitamin D metabolite conversion and uptake by microcrustaceans (*Daphnia* spp.) as ultraviolet (UV) protection in freshwater systems

Sandi Connelly and Loraine Tan
Dept’s of Biology and Chemistry
College of Science, RIT
Faculty Development Funds Presentation
Friday, September 23, 2011

General Background

- Global climate change
  - Stratospheric ozone is decreasing worldwide
  - UV radiation (UV-A and UV-B) are increasing at the Earth’s surface (McKenzie et al., 2003)
- Freshwater invertebrates are highly susceptible to climate change
  - Variable response to environmental stressors
- Vertebrates shown to use various compounds to combat environmental stress
  - Vitamin D
    - Previously shown to increase invertebrate fitness
Research Goals

- Test fitness of *Daphnia* in presence of UVR and vit D₃
  - Find optimal concentration of vit D₃ to induce photoprotective properties

- Isolate vit D₃ and metabolites in *Daphnia*, food source, and aqueous growth media using HPLC

- Identify metabolites
  - Potential for intermediate or ultimate photoprotection

- Correlate vit D₃ and metabolite concentrations to

Daphnia Methods

- Culture *Daphnia* under “normal” conditions

- Expose juvenile *Daphnia* to UVR ± vit D₃
  - Extractions for HPLC
  - Fitness testing (survival & reproduction)

- Extract vit D₃ from *Daphnia*, algal food, and freshwater media (Cody Group)

- Analyze extractions using HPLC (Tan Group)
HPLC Analysis

- Develop a method to separate compounds in biological samples
- Identify and quantify vit D₃ and metabolites
  - Analyze standard solutions with known concentration
  - External calibration curves
  - Limit of detection and limit of quantitation
  - Determine percent recovery

Future Directions

- Continue collection of fitness data
  - Add UV-B exposures
- Identify other metabolites
- Isolate metabolites to determine photoprotective potential
- Expand to other invertebrates and algae
  - Data suggest algae are key
Vitamin D Research Team

- Faculty:
  - Jeremy Cody, Chemistry
  - Sandi Connelly, Biology
  - Loraine Tan, Chemistry

- Graduate Students
  - Pamela (Major) Meehl [Chemistry 2011]

- Undergraduate Students
  - Kelly Walling
  - Joy Valerie Carrera
  - Cailin Monaghan [Chemistry 2011]
  - Diane Catlin

(Ephraim Agyingi)
Modeling the effect of topical oxygen therapy on wound healing.

Ephraim Agyingi

Co-authors: Sophia Maggelakis and David Ross

School of Mathematical Sciences
Rochester Institute of Technology

The Human Skin

HUMAN SKIN

- Hair
- Stratum corneum
- Granular cell layer
- Spinous cell layer
- Basal cell layer
- Sebaceous gland
- Erector pili muscle
- Sweat gland
- Nerves
- Hair follicle
- Collagen and elastin fibres
- Artery
- Vein
- Fat (adipose) tissue

1. Epidermis
2. Dermis
3. Subcutaneous tissue
**Stages of wound healing**

- **Inflammatory Phase**
  - Initial response to injury
  - Platelet aggregation and activation
  - Macrophages and several growth factors release

- **Proliferative Phase**
  - Fibroblast proliferation stimulated by growth factors
  - Increased rate of collagen synthesis by fibroblast
  - Granulation tissue and neovascularization

- **Remodeling Phase**
  - Characterized by increase in tensile strength
  - Scar formation

**Wound healing an as aspect**

- Low Oxygen concentration
  - Macrophages appear
  - Macrophage derived growth Factors (MDGF)
  - MDGF trigger nearby capillaries

- Higher Oxygen Concentration
  - Capillaries density
Oxygen therapy

- Hyperbaric oxygen therapy (HBOT)
  - A clinical procedure that involves the use of 100% oxygen under increased atmospheric pressure intermittently.
  - HBOT increases the oxygen transport capacity of the blood and as a consequence elevate the amount of oxygen delivered to the wound site.
  - HBOT is an expensive procedure that can only be administered in an approved medical facility.
  - It also carries the risk of oxygen toxicity to some anatomical organs since patient is exposed to above normal level of oxygen

- Topical oxygen therapy (TOT)
  - A more recent procedure
  - Can be applied directly to the wounded skin
  - Less expensive and can be administered anywhere.

Oxygen chambers
**Mathematical Model - Processes**

- Growth factor production, diffusion & depletion (G)
- Growth of capillary density (N)
- Oxygen diffusion and consumption (O)
The model

\[
\frac{\partial N}{\partial t} = \frac{\partial}{\partial x} \left( D_2 \mu^* GN (1 - N / L) \frac{\partial N}{\partial x} \right) + \mu GN (1 - N / L)
\]

\[
\frac{\partial O}{\partial t} = D_3 \frac{\partial^2 O}{\partial x^2} + \eta O + \lambda_1 N - \lambda_2 ON - \lambda_3 O
\]

\[
\frac{\partial G}{\partial t} = D_1 \frac{\partial^2 G}{\partial x^2} + \gamma_1 (1 - (1 + \eta) O / \Delta) - \gamma_2 GN - \gamma_3 G
\]

FIGURE 1. Numerical simulation of a normal wound.
FIGURE 2. Numerical simulation of continuous TOT.

FIGURE 3. Numerical simulation of intermittent DOT.
FIGURE 4. Production of MDGFs at the location $x = 0.8$. 

"QUARKS, NEUTRONS, MESONS, ALL THOSE DAMN PARTICLES YOU CAN'T SEE. THAT'S WHAT DROVE ME TO DRINK, BUT NOW I CAN SEE THEM!"
The End

(Tamas Wiandt)
Investigation of Pulsations in the Lang-Kobayashi System with the Homotopy Analysis Method

RIT

September 23, 2011

Lang-Kobayashi system

\[
\frac{d\mathcal{E}}{dt} = (1 + i\alpha)N(t)\mathcal{E}(t) + \eta e^{-i\omega_0 \tau} \mathcal{E}(t - \tau),
\]

\[
T \frac{dN}{dt} = P - N(t) - (1 + 2N(t))|\mathcal{E}|^2.
\]

Here \(\alpha\) is the linewidth enhancement factor, \(\omega_0\) is the angular frequency of the solitary laser, \(T\) is the ratio of the carrier lifetime to the photon lifetime, \(\eta\) is the external feedback level, \(P\) is the dimensionless pumping current and \(\tau\) is the external cavity round-trip time.
Transforming the equation

If we denote the absolute value of the electric field by $E$, the phase by $\phi$ and the phase delay by $\Delta(t) = \phi(t) - \phi(t - \tau)$, we obtain the equations

$$
\dot{E} = NE + \eta E(t - \tau) \cos(\Delta(t) + \phi_0) \\
\dot{\phi} = \alpha N - \eta \frac{E(t - \tau)}{E(t)} \sin(\Delta(t) + \phi_0) \\
T \dot{N} = P - N - (2N + 1)E^2,
$$

where $\phi_0 = \omega_0 \tau$. This is the LK equation in real dimensionless form, still a delay differential equation.
Transforming the equation

After truncating the series expansions: $E(t - \tau) = E(t)$ and by using

$$\Delta(t) = \phi(t) - \phi(t - \tau) = \dot{\phi}(t)\tau - \ddot{\phi}(t)\tau^2/2 = \dot{\phi}(t)\tau - \dot{\Delta}(t)\tau/2,$$

so $\dot{\phi} = \Delta/\tau + \dot{\Delta}/2$, we obtain a system of ODE’s:

$$\begin{align*}
\dot{E} &= NE + \eta E \cos(\Delta + \phi_0) \\
\dot{\Delta} &= -\frac{2\Delta}{\tau} + 2\alpha N - 2\eta \sin(\Delta + \phi_0) \\
T\dot{N} &= P - N - (2N + 1)E^2.
\end{align*}$$

Pulsations survive

A typical solution of the ODE model after the bifurcation is illustrated on the next figure.
Another transformation

Let’s introduce the transformations

\[
\begin{align*}
    s & \rightarrow \omega t \\
    N & \rightarrow \frac{N\omega}{\alpha} \\
    E & \rightarrow \sqrt{P}\left(1 + \frac{R}{\alpha}\right).
\end{align*}
\]

Here \( \omega = \sqrt{2P/T} \). We also introduce \( \Theta = \tau \omega, \Lambda = \eta\alpha/\omega \) and \( \xi = (1 + 2P)/\sqrt{2PT} \). After the transformations and eliminations of some high order terms we obtain

\[
\begin{align*}
    \dot{R} &= N + \Lambda \cos(\Delta + \phi_0) \\
    \dot{\Delta} &= -\frac{2\Delta}{\Theta} + 2N - \frac{2\eta}{\omega} \sin(\Delta + \phi_0) \\
    \dot{N} &= -\xi N - R.
\end{align*}
\]

Closing the system

We obtain from the second equation

\[
N = \frac{1}{2} \dot{\Delta} + \frac{\Delta}{\Theta} + \frac{\eta}{\omega} \sin(\Delta + \phi_0).
\]

Using the third

\[
\frac{1}{2} \ddot{\Delta} + \frac{\dot{\Delta}}{\Theta} + \frac{\eta}{\omega} \cos(\Delta + \phi_0) \dot{\Delta} = -\frac{\xi}{2} \dot{\Delta} - \frac{\xi \Delta}{\Theta} - \frac{\xi \eta}{\omega} \sin(\Delta + \phi_0) - R.
\]

Differentiate both sides again and use the first equation. Introduce \( \Psi = \Delta + \phi_0 \) and \( \Omega_0 = -2\phi_0/\Theta \). We closed the system:

\[
\dddot{\Psi} + \frac{2}{\Theta} + \xi + \frac{2\eta}{\omega} \cos \Psi \ddot{\Psi} + \left[ 1 + \frac{2\xi}{\Theta} + \frac{2\xi \eta}{\omega} \cos \Psi \right] \dot{\Psi} - \frac{2\eta}{\omega} \sin \Psi \cdot (\dot{\Psi})^2 + \\
\quad + \frac{2}{\Theta} \Psi + \frac{2\eta}{\omega} \sin \Psi + 2\Delta \cos \Psi + \Omega_0 = 0.
\]
A basic description of the Homotopy Analysis Method (HAM): an analytic technique based on the idea of homotopy. Consider a nonlinear differential equation

\[ \mathcal{N}[u(t)] = 0, \]

where \( \mathcal{N} \) is a nonlinear operator, and \( u(t) \) is the solution we wish to approximate. Let \( u_0(t) \) be an initial approximation of \( u(t) \) and \( \mathcal{L} \) denote an auxiliary linear operator. We construct the so-called homotopy

\[ \mathcal{H}[\phi(t; q); q] = (1 - q)\mathcal{L}[\phi(t; q) - u_0(t)] + q\mathcal{N}[\phi(t; q)], \]

where \( q \in [0, 1] \) is an embedding parameter and \( \phi(t; q) \) is a function of \( t \) and \( q \). For \( q = 0 \), we obtain that \( \phi(t; 0) = u_0(t) \) and for \( q = 1 \), \( \phi(t; 1) = u(t) \).

The idea is that the solution \( \phi(t; q) \) of the equation

\[ \mathcal{H}[\phi(t; q); q] = 0 \]

depends upon the embedding parameter \( q \) and varies from the initial approximation \( u_0(t) \) to the actual solution \( u(t) \). HAM enables us to set up a family of linear differential equations for these deformations, and then by a choice of control parameters and a family of base functions, analytic approximations can be found for the solution \( u(t) \).
In this problem,

\[ \mathcal{N}[\Psi(t)] = \frac{\partial^3 \Psi}{\partial t^3} + \left[ \frac{2}{\Theta} + \xi + \frac{2\eta}{\omega} \cos \Psi \right] \frac{\partial^2 \Psi}{\partial t^2} + \left[ 1 + \frac{2\xi}{\Theta} + \frac{2\xi \eta}{\omega} \cos \Psi \right] \frac{\partial \Psi}{\partial t} + \]

\[ + \frac{2\eta}{\omega} \sin \Psi \cdot \left( \frac{\partial \Psi}{\partial t} \right)^2 + \frac{2}{\Theta} \Psi + \frac{2\eta}{\omega} \sin \Psi + 2\Lambda \cos \Psi + \Omega_0. \]
Soil and Biochar at the Nano Level: Structure and Elemental Mapping

Rich Hailstone

Center for Imaging Science
Soil Motivation

- Most soil characterization >= micron level
- STXM has spat res ~ 50 nm
- What is the nanostructure?
- How are the elements distributed?
- How do the different components interact at the nano level?

- Establish a collaborative relationship!

Ultramicrotome
Australian Soil TEM

kaolinite (aluminosilicate)

EELS
Elemental Mapping

Tomogram
Tomogram Slices

Biochar Motivation

Biochar, Lehmann and Joseph, Eds., 2009
Biochar Structure

Biochar, Lehmann and Joseph, Eds., 2009

10’s of microns

Biochar TEM

Biochar, Lehmann and Joseph, Eds., 2009
Summary

• Developed reproducible sample prep that produces fairly stable samples in beam
• Identified phases in Australian soil and determined radiation sensitivity
• Elemental mapping with UltraSTEM
• Explored feasibility of TEM tomography on Australian soil and identified path(s) forward
• Embedding of fresh biochar in ice

Wrapup
Other Events

Suggestions
COS Webpage

Research Interests
Research Highlights

Enjoy the Reception