DISCOVERING THE UNIVERSE

2011–2012 ANNUAL REPORT

Dunlap Institute for
Astronomy & Astrophysics
UNIVERSITY OF TORONTO

DUNLAP INSTITUTE

MESSAGE FROM THE UNIVERSITY OF TORONTO

The Faculty of Arts & Science is very proud to be home to the Dunlap Institute for Astronomy & Astrophysics, the third engine in a research powerhouse that includes the U of T's Department of Astronomy & Astrophysics (DAA) and the Canadian Institute for Theoretical Astrophysics (CITA). Together, this triumvirate positions Toronto as a world leader in astronomy, astrophysics, planetary science and the search for planets beyond the Solar System.

The Dunlap Institute is strengthening Canada's advantage in the field in two key ways: by mounting distinctive programs to train the next generation of designers and builders of advanced astronomical instruments; by developing innovative public education and outreach programs. Since the appointment of its first director—James Graham, a world leader in astronomy instrumentation and adaptive optics—in September 2010, the institute's progress has been remarkable.

New international research and instrumentation collaborations are underway. Among the many you'll read about in this report is a project led by the U of T's Dae-Sik Moon using a new instrument, the Near Infrared Echelle Spectrometer (NIRES); it is designed to study the faintest objects that are reachable with the Keck Observatory telescopes.

A robust outreach program is underway. Graduate students offer interactive planetarium shows, and interpret the stars and planets that visitors view from the observatory atop the McLennan Physical Labs building. A new web portal connects the public—including cubs, guides and students—with real astronomers, through video chats; it lets anyone ask a real astronomer a question and then read the answer.

The institute is no less active on the education front. This year will mark the launch of an exciting new summer school to introduce senior students to cutting-edge astronomical instrumentation for current and future telescope facilities. The critical mass of expertise in astronomy at U of T serves as a magnet for talent from around the world and the Dunlap Institute has begun to recruit new faculty. An exceptional young scientist joined in January; Shelley Wright works on instruments for large telescopes such as the twin Keck 10-metre telescopes and the design of the Thirty Meter Telescope.

Amidst the excitement of this tremendous momentum, a special thank-you goes to CITA's Peter Martin, former chair of astronomy and astrophysics, who had the vision to create the Dunlap Institute and worked with the Dunlap family to make it happen. The Dunlap Institute, together with the DAA and CITA, promises to keep U of T at the forefront of astronomical research for decades to come. We look forward to many exciting developments and discoveries.

Rob Baker
Vice-Dean
Research and Graduate Programs
Faculty of Arts & Science

Cover (background image): Jupiter (left) and Venus (right) in the twilight sky above the Ridge Laboratory on Ellesmere Island, February 2012.

MESSAGE FROM THE DIRECTOR

Welcome to the first annual report of the Dunlap Institute for Astronomy & Astrophysics.

The story of the Dunlap Institute (DI) began over 70 years ago with the foundation of the David Dunlap Observatory. In 1935, when the great 74-inch telescope began operating on Richmond Hill, modern astrophysics was just beginning to take shape.

Only a few years earlier, the nature of spiral nebulae had been established and the expansion of the Universe was first glimpsed. Karl Jansky had just discovered radio emission from the Milky Way Galaxy. Walter Baade and Fritz Zwicky had proposed the existence of neutron stars. And by the end of the decade, Hans Bethe had explained how nuclear reactions powered the stars.

Astronomical discovery in the 1930s was no accident; it was driven by the world's largest telescopes equipped with the best cameras and spectrographs. Giant telescopes and ever more capable instruments employing the latest technological innovations are still engines of astronomical discovery.

Today, astrophysics continues to astonish us with discoveries such as dark matter, dark energy and the first planets beyond our Solar System. And it entices us with the anticipation of discoveries of the first generation of stars and gravitational waves from coalescing black holes. This then, is a remarkable chapter in the history of the Dunlap Institute.

It is the mission of the institute to continue the tradition of innovating observational methods, and designing and developing new instruments, telescopes and observatories. In the following pages, you will see the steps we are taking to establish an observatory in the Canadian Arctic, to image planets outside our Solar System, and to map the dark matter in nearby galaxies.

You will also see our commitment to realize the vision of the extraordinary philanthropy of the Dunlap family through programs in astronomy education—interpreted in its broadest terms—and astronomy outreach to the University of Toronto community, the Greater Toronto Area, and the nation as a whole.

Prof. James Graham
Director
Dunlap Institute for Astronomy & Astrophysics

A MESSAGE FROM DAVID DUNLAP

In the early 1930s, Dr. Clarence Chant, the first Professor of Astronomy at the University of Toronto, approached my grandmother, Jessie Donalda Dunlap, and described to her his vision of a world-class observatory for the university. She was receptive to the idea of financially assisting with his dream; she was seeking a way to memorialize my grandfather, David Alexander Dunlap, who had died in 1924. She wanted a memorial to recognize his generosity to many charities, particularly those in the Toronto area. The concept of an observatory was a perfect fit as my grandfather was an ardent amateur astronomer. Thus was born the University of Toronto's David Dunlap Observatory (DDO).

The observatory enjoyed a wonderful "career" for many years. It was recognized worldwide as being very much at the forefront of astronomy. Its location in those days was perfect; it was close to the university which meant that many students, and indeed the general public, had an opportunity to see, enjoy and discover the wonders of the night sky.

When the observatory opened, it was located in what was very much a rural setting and was completely surrounded by farmers' fields. Over the years, Toronto started to grow, slowly at first, but at an increasingly rapid pace in the last twenty years. As the area around the observatory became more urbanized, light pollution made the site less viable scientifically. Today, the DDO is completely surrounded, in the middle of one of Canada's fastest growing cities, Richmond Hill.

1921 1924 1926 1935

From Richmond Hill to the St. George Campus

1921
David Dunlap attends an astronomy lecture given by Clarence Chant (above)

1863-1924
David Dunlap

1926
Jessie Dunlap donates money in memory of her husband to build the David Dunlap Observatory

1935
David Dunlap Observatory opens in Richmond Hill

[CREDITS:] see Archives, Image Bank

At the same time, more modern and sophisticated telescopes were built around the world, transforming one of astronomy's grand observatories into a facility past its prime.

Over many years, the fate of the observatory was discussed at length. Talks about the observatory's future finally resulted in the idea of a new institute, located on the St. George campus and permanently endowed with the proceeds of the sale of the observatory property. And so the irony is palpable: what caused the very demise of the observatory was the very force tht enabled the endowment and creation of the Institute.

It is easy to describe our family's vision and aspirations for the institute as they are simply those sought by our grandmother many years ago.

To paraphrase the remarks she made at the opening of the observatory, her hope was that the observatory would advance the science of astronomy and, in so doing, would benefit not only Canada but all humanity.

The responsibility of realizing her vision in a new form now lies in the hands of the men and women who work and study at the institute. The institute is off to an ambitious start and we are fully confident that the appellation "world-class" will soon be deservedly earned.

David M. Dunlap 6T1
March 2012

1999 2008 PRESENT DAY

1999
Prof. Peter Martin becomes director of the DDO and begins discussions with the Dunlap family for continuing David Dunlap's legacy

2008
The Dunlap Institute is established on the St. George campus of U of T

THE DUNLAP INSTITUTE FOR ASTRONOMY & ASTROPHYSICS

Faculty and Affiliated Faculty

Prof. James Graham
Director

Assistant Prof.
Shelley Wright

Associate Prof.
Dae-Sik Moon
Department of Astronomy & Astrophysics

Dunlap Institute Graduate Student Scholarship Recipients

Eve Jihyun Lee

Max Millar-Blanchaer

Post-doctoral Fellows

Dr. Quinn Konopacky

Dr. David Law

Dr. Nicholas Law

Dr. Jérome Maire

Dr. María Montero-Castaño

Dr. Suresh Sivanandam

Dr. Anne-Marie Weijmans

THE DUNLAP INSTITUTE FOR ASTRONOMY & ASTROPHYSICS

Education, Outreach and Communications

Dr. Michael Reid
Coordinator/ Director
of Education & Public Outreach

Dr. Johannes Hirn
Communications
& New Media Specialist

Chris Sasaki
Communications
& New Media Specialist

Information Technology

Hugh Zhao
Systems Manager

Rob Figueiredo
IT Technologist

Administration

Angela Choi
Department Manager

Alice Chow
Assistant to the Director
& Office Administrator

Graduate Students associated with the Dunlap Institute

Simona Lam

Etsuko Mieda

Max Millar-Blanchaer

Heidi White

Charles Zhu

Graduate student Etsuko Mieda tests the new OSIRIS diffraction grating

DISCOVERING THE UNIVERSE

INNOVATION IN INSTRUMENTATION

Ever since Galileo turned the newly invented telescope to the sky, new technologies and observing techniques have led to astronomical discoveries. The Dunlap Institute will ensure that breakthroughs continue through the conception, design and development of innovative instrumentation projects. Combined with the next generation of large Earth-based telescopes, space telescopes and revolutionary technologies like adaptive optics, these projects will lead to discoveries that literally span the depths of the Universe—from our Solar System, to the stars of the Milky Way Galaxy, to the galaxies beyond.

Extremely Cool Astronomy

The Dunlap Institute Arctic Observatory

The construction of observatories in Hawaii and Chile is driven by a search for better observing conditions. High atop mountain peaks, telescopes sit above much of the obscuring effect of the Earth's atmosphere. But excellent observing conditions can be found in locations other than those distant summits.

The Dunlap Institute is working with the National Research Council and the National Science Council to establish an observatory at the Environment Canada Ridge Laboratory on Ellesmere Island, at latitude 80° north. Astronomical observing conditions can be excellent in the far north: the air is dry, cold and clean; there is little or no light pollution; and, in the winter, there is uninterrupted darkness.

Lead Scientist Nicholas Law and Optics Lead Suresh Sivanandam are designing and building what will be the main instrument at the observatory: a wide-field imaging telescope with a half-metre primary mirror. Integration and testing of telescope hardware took place in Victoria in June 2011. Currently, the instrument is undergoing testing in New Mexico and is scheduled to make the trip to Ellesmere Island later in 2012.

The telescope has been designed to search for exoplanets—planets outside our Solar System—in orbit around relatively small, cool stars known as M-dwarfs. Twenty years ago, there were no known planetary systems beyond our own. Since then, astronomers have discovered more than 700 exoplanets, mostly by measuring the minute variations in the motion of the stars they orbit.

The DI's Arctic Telescope will detect exoplanets by measuring the brightness of many target stars over long periods. If an exoplanet passes —or transits—in front of one of the stars, its light will dim slightly. If this dimming occurs repeatedly with a precise period, it will signal the discovery of a distant world.

(Left) The Arctic Telescope

The 0.5 metre Arctic Telescope equipped with a wide-field CCD camera

Uninterrupted winter nights mean the Arctic Telescope will detect transits that an observer at lower latitudes would miss because they occur during that observer's daylight hours. For example, if a distant planet has an orbital period of a month or more, an observer at lower latitudes might detect one transit but miss the next because it occurred during the day. Planets with these orbital periods are important; they circle their parent stars at a distance that would result in surface temperatures that allow liquid water—a condition necessary for life.

The Arctic Telescope will not be the only instrument searching for exoplanets from the Ridge Laboratory. The Arctic Wide-Field (CCD) Cameras, or AWCams, were tested in the Arctic in February 2012 and are searching for exoplanets using the same method as the Arctic Telescope—by detecting transits. The AWCam project is led by Law in collaboration with the DAA's Prof. Ray Carlberg.

The Dunlap Institute is preparing for the eventual establishment of the observatory by testing various aspects of observing conditions in the north. In 2011, Sivanandam designed and built a wide-field radiometer and set up the instrument in Eureka, Nunavut. The sky brightness monitor instrument was designed to test the theory that the Antarctic near-IR sky is fainter by a factor of two to three compared to mid-latitude sites. The analysis of this data continues.

Also in preparation for an arctic observatory, Etsuko Mieda and Jérome Maire have developed a Slope Detection and Ranging (SLODAR) seeing-monitoring instrument. It will measure the strength, variability and altitude of atmospheric turbulence which strongly affects the ability to see fine detail and measure brightness, motion and position of observational targets. The SLODAR instrument will make it possible to characterize the effects of atmospheric turbulence and determine instrumental constraints. The instrument will be tested throughout 2012 on the DAA telescope at the university and on the half-metre telescope in New Mexico. The first arctic measurements with the SLODAR instrument are scheduled for the winter of 2012/2013.

Arctic Telescope and AWCam Lead Scientist, Dr. Nicholas Law
Arctic Telescope Optics Lead, Dr. Suresh Sivanandam
Dr. Jérome Maire
Etsuko Mieda
Max Millar-Blanchaer

The Arctic Wide-Field Camera in operation at the Ridge Laboratory

Window on the Universe

Wide Integral-Field Infrared Spectrograph – WIFIS

Since the early nineteenth century, astronomers have studied astronomical objects with instruments called spectrographs which split the incoming light according to wavelength. These spectrographic observations reveal the chemical composition and temperature of planetary atmospheres, stars, nebulae and galaxies. They also reveal the speed of objects toward or away from us. Spectrographic studies of galaxies in the 1920s showed they are receding from us and that the speed of recession increases with distance—revealing that we live in an expanding universe.

Conventional spectrographs sample only a fraction of the light of a target, along a very thin line or "slit." When imaging a galaxy, they miss all of the galaxy's light that falls outside the slit. Integral-field spectrographs represented a quantum leap in instrumentation by obtaining spectra from points across the entire target.

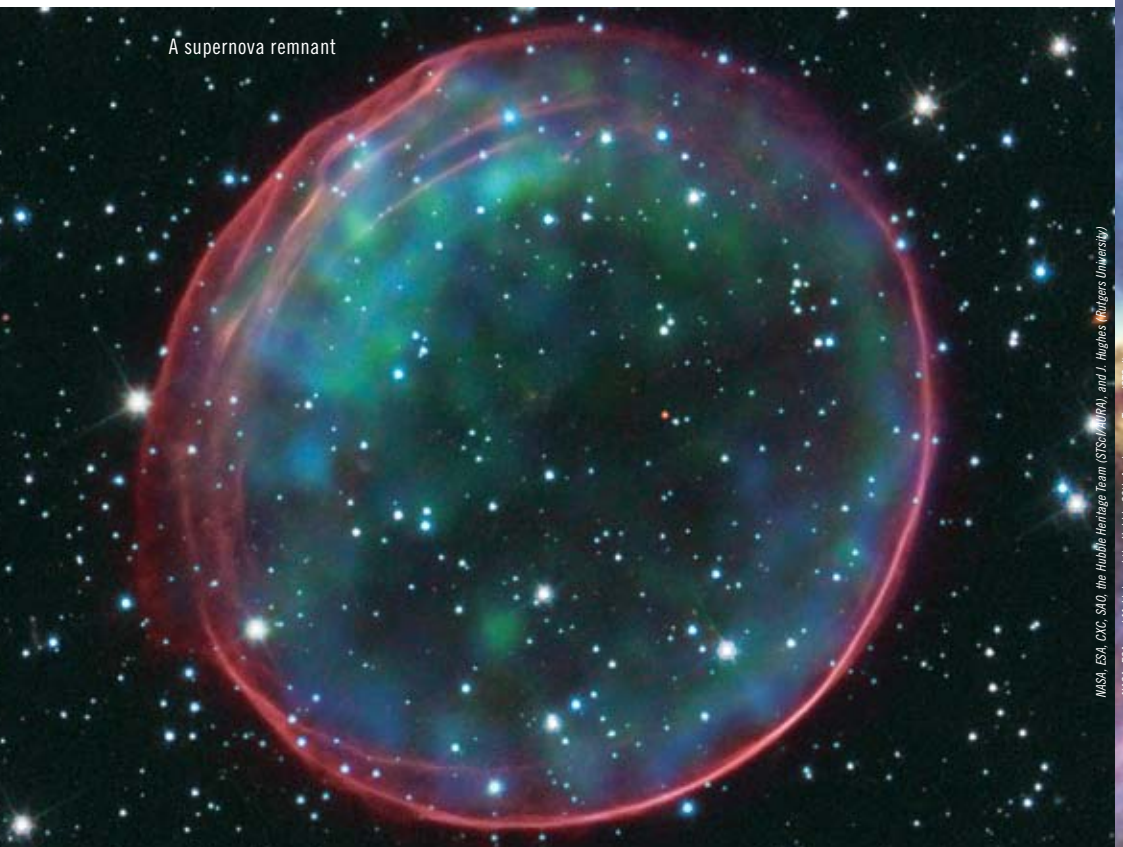
WIFIS represents yet another leap in spectrographic instrumentation. Lead Investigator Dae-Sik Moon and Suresh Sivanandam have been collaborating with institutional partners at the University of Florida, Korea Astronomy and Space Science Institute, and the University of Arizona in developing WIFIS. Notably, most WIFIS developments have been made by students—both graduate and undergraduate—and post-doctoral researchers at the University of Toronto.

(Below) Galaxy NGC 3982

NASA, ESA, and the Hubble Heritage Team (STScI/AURA)

When completed, the Wide Integral-Field Infrared Spectrograph will open a window on the Universe wider than any other, with a field of view that will be unprecedented. On the 10.4-metre telescope of the Gran Telescopio Canarias in the Canary Islands, the field of view will be 11 arcseconds by 5 arcseconds. On the Bok 2.3-metre telescope on Kitt Peak in Arizona, it will be 50 arcseconds by 20 arcseconds. With such large fields of view, WIFIS will be exceptionally powerful in studying extended objects such as supernova remnants, star-forming regions, and galaxies. It is expected that the WIFIS window on the Universe will open with its completion in early 2013.

Lead Investigator, Prof. Dae-Sik Moon
Dr. Suresh Sivanandam



A supernova remnant

NASA, ESA, CXC, SAO, the Hubble Heritage Team (STScI/AURA), and J. Hughes (Rutgers University)

A stellar nursery of gas and dust

NASA, ESA, and M. Livio and the Hubble 20th Anniversary Team (STScI)

Keck II laser-guide-star AO system in operation

© LaurieHatch.com

Across the Universe

Atop the 4,200-metre summit of Mauna Kea on the Big Island of Hawai'i sit the largest optical/infrared telescopes in the world—the twin Keck I and II. At the heart of each is a 10-metre diameter primary mirror. With its laser-guide-star adaptive optics (AO) system, the earthbound Keck II provides astronomers with higher resolution images than the Hubble Space Telescope.

Adaptive optics corrects for the blurring of starlight caused by the Earth's atmosphere. Natural star AO makes corrections using the light of a real star near the target object; laser-guide-star systems create an artificial star high in the Earth's atmosphere with a laser beam. The AO system detects distortions in the light of the guide star; based on these distortions, the system applies corrections to the image of the target object.

Near-Infrared Echelle Spectrograph – NIRES

Co-project Leader Dae-Sik Moon and James Graham are members of a collaboration between the Dunlap Institute, the DAA and the California Institute of Technology that is developing the Near-Infrared Echelle Spectrograph for Keck II.

NIRES will be a work-horse Keck instrument that will make this already powerful eye on the Universe even more powerful. NIRES will be capable of simultaneously capturing, with a single exposure, spectroscopic information from astronomical objects in the entire near-infrared wavebands of 0.8 – 2.4 microns. It will be an extremely effective instrument for exploring a vast array of targets—from planetary neighbours in our own Solar System, to galaxies billions of light-years away. It will be especially effective in observing distant, cold and obscure objects whose nature we know little about.

In 2012, Moon and Graham will form a research group at the University of Toronto that will include students and postdoctoral fellows working with Caltech collaborators. The group will develop a campaign of observations of interesting targets discovered by the recent NASA WISE (Wide Infrared Survey Explorer) full-sky survey. Commissioning of NIRES is currently scheduled for March 2013 on the Keck II telescope.

Co-project Leader, Prof. Dae-Sik Moon
Prof. James Graham

Across the Universe

New Grating for OH-Suppressing Infrared Integrated Spectrograph – OSIRIS

OSIRIS is a near-infrared, integral-field spectrograph and imager designed to exploit the high spatial sampling of Keck Observatory's adaptive optics system. OSIRIS is a unique spectrograph with the ability to take spectra across a wide field of view, as opposed to a traditional spectrograph that uses a slit. Since 2005, astronomers have been using the first generation OSIRIS instrument with the Keck ll adaptive optics system to make new discoveries about an array of targets—from solar system objects to distant galaxies.

Upgrades to the existing OSIRIS instrument are currently being developed by Lead Investigator Shelley Wright, Etsuko Mieda and James Graham to dramatically improve the sensitivity of the instrument by commissioning a new diffraction grating.

The key component of any spectrograph is the diffraction grating. Like a prism, a grating separates a beam of light into its component wavelengths. The Dunlap Institute team is working with Bach Research Corporation to manufacture an improved performance grating for OSIRIS, and develop methods for testing the efficiencies of a new grating in the Dunlap Institute labs.

The new diffraction grating for OSIRIS is expected to increase the sensitivity of the instrument by a factor of 1.5 to 2, and will be critical to new science capabilities and discoveries. Installation of the new grating is scheduled for the end of summer 2012.

Lead Investigator, Prof. Shelley Wright
Etsuko Mieda
Prof. James Graham

(Right) Keck II laser-guide-star AO system in operation

Discovering the Universe with the World's Largest Telescope

Instrumentation for the Thirty Meter Telescope – TMT

When the Thirty Meter Telescope (TMT) makes its first scientific observations later this decade on the summit of Mauna Kea, it will be the largest, most powerful optical telescope on Earth. Its 30-metre primary mirror will gather nine times as much light as a single Keck primary mirror. Its adaptive optics system—the NFIRAOS—will result in diffraction-limited performance, the best possible optical performance that a system can provide. And a suite of innovative instruments will harness that light-gathering power and optical brilliance.

NFIRAOS Science Calibration Unit – NSCU

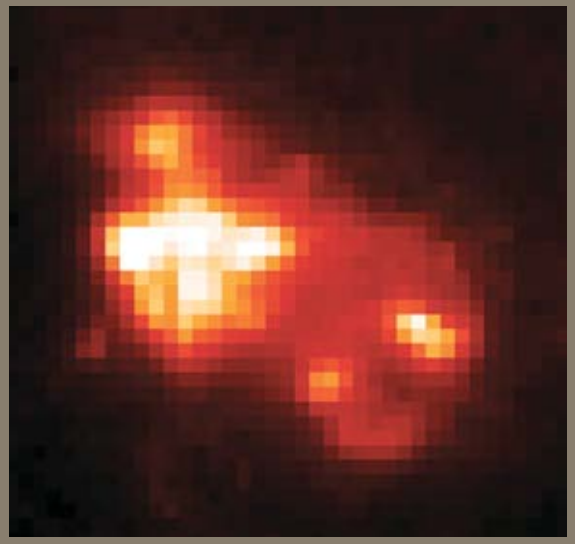
The performance of the telescope's adaptive optics and its suite of infrared instruments will rely on one of the most technically advanced instrument projects in astronomy: the NFIRAOS Science Calibration Unit, or NSCU. Lead Investigator Dae-Sik Moon is leading an international optical, mechanical and electrical design team that includes several undergraduate students with multi-disciplinary backgrounds such as engineering, physics and astronomy who have made substantial contributions to the project.

The NSCU will provide sensitive and accurate calibration of the adaptive optics system and the infrared instruments on the TMT when it begins operation, thereby ensuring the best possible scientific results.

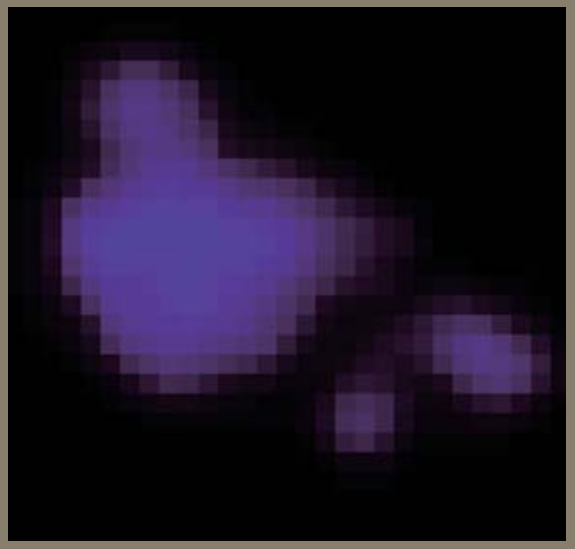
Principal Investigator, Prof. Dae-Sik Moon
Prof. Shelley Wright

Courtesy TMT Observatory Corporation

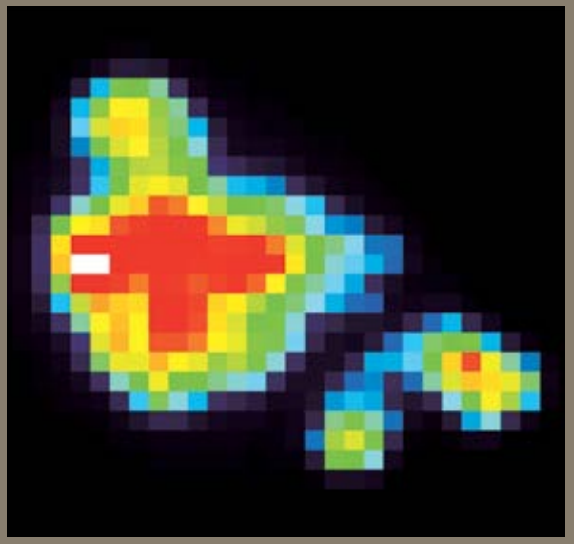
(Right) Photo-illustration of the Thirty Meter Telescope



Hubble Space Telescope image of galaxy



Simulation of IRIS spectrograph image of galaxy with Keck telescope



Simulation of IRIS spectrograph image of galaxy with TMT

Discovering the Universe with the World's Largest Telescope

Infrared Imaging Spectrograph – IRIS

The Infrared Imaging Spectrograph, or IRIS, will be among the instruments in operation when the TMT begins making observations. This innovative integral-field spectrograph and imaging camera, together with the telescope's adaptive optics system, will result in the sharpest images ever obtained with an Earth-based telescope at near-infrared wavelengths.

IRIS is being designed and developed through an international collaboration of researchers in Canada, the U.S. and Japan. IRIS Project Scientist Shelley Wright and the science team—including David Law and future Dunlap Fellow Tuan Do—are setting the requirements for the instrument, investigating its predicted capabilities and performance, and assessing potential capabilities and discoveries.

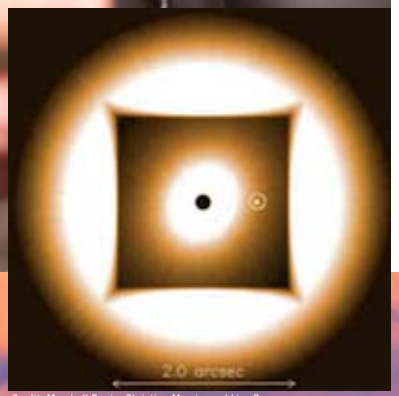
IRIS, operating on the TMT, will yield exciting new discoveries about objects astronomically near and far. It will be used to image asteroids, planets and moons in our Solar System, and discover exoplanets and study their atmospheres. It will be used to study the supermassive black hole at the centre of the Milky Way Galaxy, and enable new tests of Einstein's General Theory of Relativity and investigations of dark matter. It will allow astronomers to measure the mass of black holes beyond what is currently possible. And it will extend our vision back to when the Universe was only 2 billion years old, and the first stars and galaxies were forming.

Project Scientist, Assistant Prof. Shelley Wright
Dr. David Law
Dr. Tuan Do

DISCOVERING THE UNIVERSE

OBSERVATIONAL RESEARCH

The Dunlap Institute's faculty, post-doctoral researchers and students are making discoveries that span the depths of the Universe—in collaboration with astronomers from around the world, and working with the most advanced telescopes on Earth and in space. They are discovering planets outside our Solar System, studying dark matter and its relation to the evolution of galaxies and clusters of galaxies, and examining distant objects at the edge of the visible Universe and at the edge of time.



Credit: Marshall Perrin, Christian Marois, and Lisa Poyneer

Firefly in a Searchlight

The Gemini Planet Imager – GPI

Most of the more than 700 known exoplanets have been discovered through indirect methods: through the detection of transits, or by measuring the minute variations in the motion of their parent stars. Hunting for exoplanets has relied on these indirect methods because it is extremely difficult to image a planet in orbit around a star. A typical planet is one-billionth the brightness of the star it orbits and is hidden in its glare; imaging one is like photographing a firefly buzzing around a searchlight. But in recent years, astronomers have begun to observe these distant stellar fireflies.

The Gemini Planet Imager is a next-generation, adaptive-optics instrument being built for the Gemini South 8-metre telescope in northern Chile. The GPI program will survey roughly a thousand nearby stars to search for Jupiter-size exoplanets orbiting them. The imager's adaptive optics will use the target star's light to detect distortions caused by atmospheric turbulence. Deformable mirrors will cancel the effect of those distortions. Then, coronagraphic masks will block the glare from the parent star, revealing the planet for detailed study.

James Graham is Project Scientist for GPI, leading a science team that also includes Quinn Konopacky, Jérome Maire, and Max Millar-Blanchaer.

When science operations commence in mid-2012, GPI will provide astronomers with insights not provided by indirect planet-hunting techniques. By imaging a distant world directly, the instrument will be able to measure its size, temperature, gravity and atmospheric composition. And because GPI will be surveying many stars, it will help answer questions about the formation, evolution and abundance of planetary systems beyond our own.

Project Scientist, Prof. James Graham Dr. Quinn Konopacky Dr. Jérome Maire Max Millar-Blanchaer

(Top) Max Millar-Blanchaer testing GPI optical component
(Centre) Simulated GPI image of star showing planet (circled)
(Bottom) Gemini South Observatory, Cerro Pachón, Chile

Gemini Observatory/Chris Carter

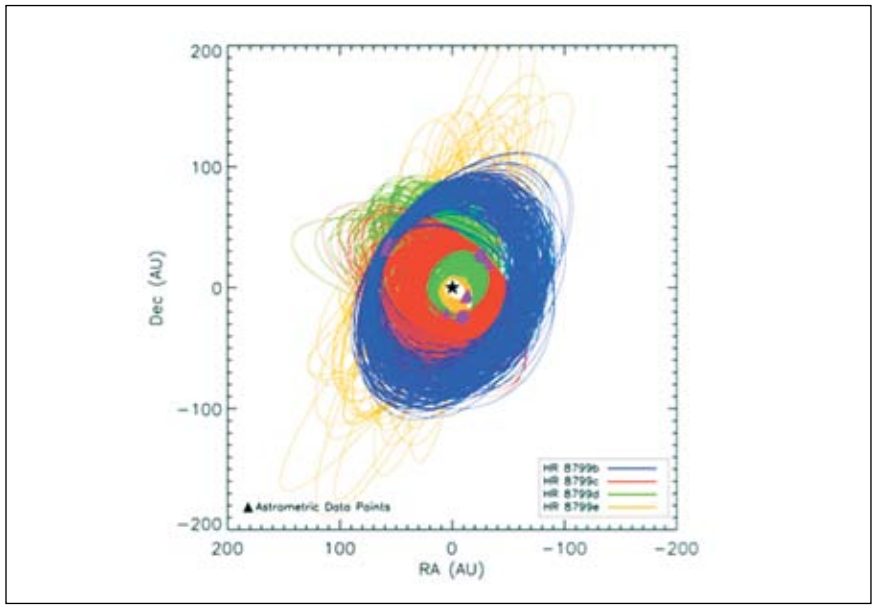
Discovering New Worlds

Orbital Properties of the HR 8799 Planetary System

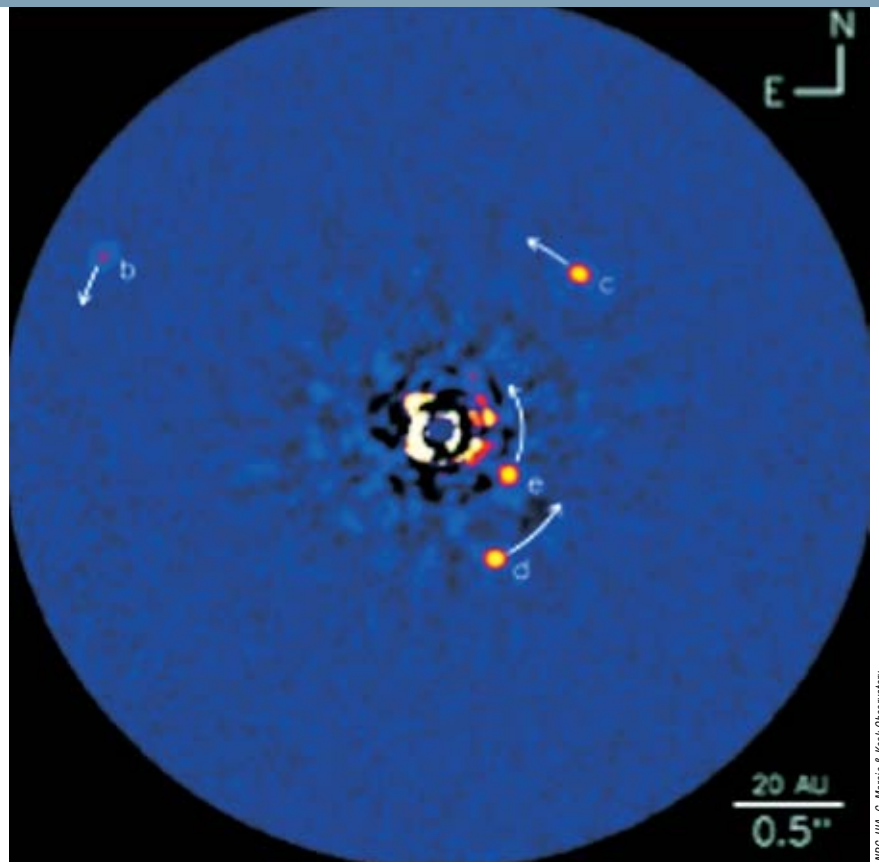
In 2008, a team of astronomers discovered a system of three gas giant planets around the star HR 8799, 130 light-years away. The planets—designated HR 8799b, c and d—were among the first exoplanets to be imaged directly.

Quinn Konopacky is part of a team that has been conducting an extensive follow-up campaign on the system using the near-infrared camera NIRC2 on the Keck II adaptive optics system. In 2010, the group announced the discovery of a fourth planet in the system, HR 8799e. Like those previously discovered, the fourth planet is large: between five and seven times the mass of Jupiter.

Such a planetary system is remarkable. Planets interact with each other gravitationally, and more massive planets interact more strongly than less massive ones; these giant exoplanets could fling each other out of the system or into their parent star.



Possible orbits of planets b (blue), c (red), d (green) and e (yellow) around the star HR 8799 ★



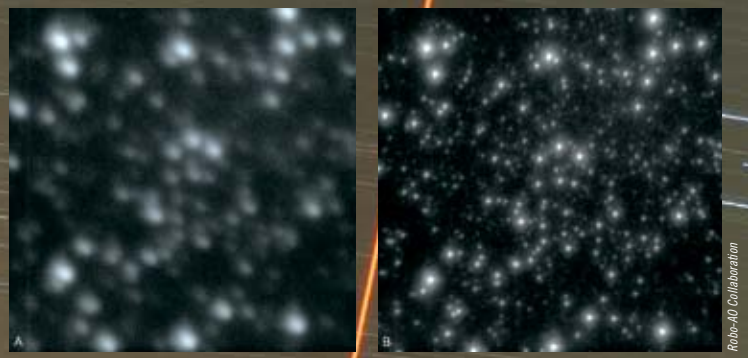
NRC-HIA, C. Marois & Keck Observatory

Four planets b, c, d and e, in orbit around HR 8799

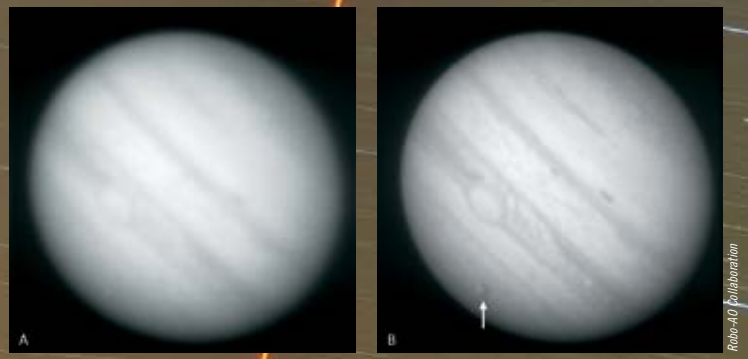
Using precise positional information from the Keck images, Konopacky and her fellow researchers are revealing a more detailed picture of the system and gaining a better understanding of how it remains stable. The orbits of the planets are likely to be close to circular and, as in our Solar System, close to the same plane. The team has also determined that the system can achieve stability if the inner three planets orbit in a 1:2:4 resonance; that is, for every one orbit of HR 8799c, HR 8799d orbits twice, and HR 8799e orbits four times.

Konopacky and the team are continuing to improve the precision of positional measurements in order to unravel the complex dynamical structure of this fascinating system.

Team member, Dr. Quinn Konopacky



(Left) Star-field without AO; (Right) Star-field with AO



(Left) Jupiter without AO; (Right) Jupiter with AO]

Robo-AO Collaboration

The World's First Robotic Laser-Guide-Star Adaptive Optics System

Robotic Astronomy

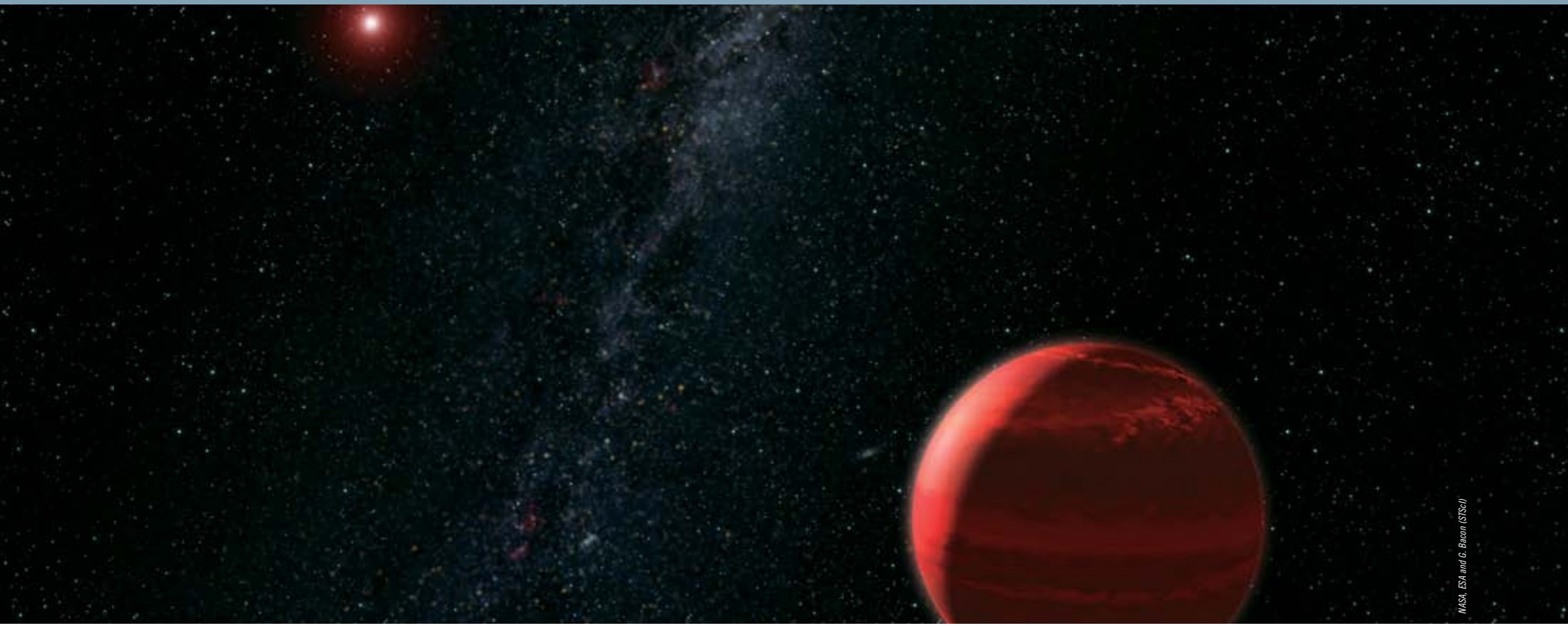
Adaptive optics, combined with the world's largest telescopes, has led to a revolution in observational astronomy. But most adaptive optics systems are expensive and complex, and observing time on very large telescopes is limited. Robo-AO is the world's first robotic, laser-guide-star adaptive optics system designed for moderate-size telescopes. It is far less expensive than other laser-guide-star AO systems, and is designed for use with moderate-size telescopes where observing time is easier to obtain.

This makes Robo-AO an excellent instrument for conducting surveys of large numbers of objects like gravitational lenses, binary star systems and supernovae that require many hours of observing time. The system is also fast: it can capture images of 30 to 40 targets an hour, compared to about four an hour on non-robotic systems.

The Robo-AO project is a collaboration between Caltech Optical Observatories, Pasadena, CA, and the Inter-University Centre for Astronomy and Astrophysics, Pune, India. When it is fully commissioned in 2012, Robo-AO Lead Scientist Nicholas Law will begin the largest ever AO search for planetary and stellar companions to a carefully chosen but diverse set of thousands of stars.

Lead Scientist, Dr. Nicholas Law

(Left) Laser from 60-inch Palomar telescope dome



(Above) Photo-illustration of giant companion around red dwarf star

Planet-finding with the Palomar Transient Factory

Searching for Companions to M-dwarf Stars

Dunlap Institute astronomers are conducting the search for exoplanets on many different fronts. The Palomar Transient Factory, or PTF, is a systematic survey of the visible sky being conducted by seven institutions around the world. PTF is being conducted with two Palomar Observatory telescopes: the Samuel Oschin 1.2-metre and the Palomar 60-inch. PTF astronomers have discovered and classified nearly 1,500 supernovae and published over 40 refereed papers on subjects as diverse as asteroids, exoplanet transits and ultra-luminous supernovae.

Nicholas Law is Lead Scientist on a project to search, not for supernovae, but for companions to M-dwarf stars. Those companions include other stars and Jupiter-like, gas giant planets; they also include the massive objects intermediate between stars and giant planets, known as brown dwarfs. For some target stars, those companions may even include rocky, Earth-like planets.

Using the 1.2-metre telescope, Law monitors 100,000 M-dwarf stars in many different parts of the sky. When he detects a drop in brightness of a star, follow-up observations are conducted with other telescopes. As of April 2012, the program has discovered 44 previously undetected companions, including other M-dwarfs and white dwarfs.

Lead Scientist, Dr. Nicholas Law

Dark Matter and the Lives of Galaxies

Eighty-five percent of the mass of the Universe is made of dark matter. As its name suggests, we can't observe dark matter directly, the way we observe stars and nebulae; we can only detect its presence from the effects of its gravity. Anne-Marie Weijmans' research focuses on galaxies and the clouds, or haloes, of dark matter enveloping them. The dark matter halo is the most massive component of a galaxy and it plays a critical role in the galaxy's formation and evolution.

Weijmans is analyzing data collected as part of the ATLAS3D project, an integral-field spectrographic survey of 260 elliptical and lenticular galaxies within roughly 42 megaparsecs of Earth, or roughly 137 million light-years. The ATLAS3D team uses this information to study the history and evolution of these objects.

Weijmans is also obtaining new data using the integral-field spectrograph on the Harlan J. Smith telescope at the McDonald Observatory in Texas. With the ATLAS3D data and the new observations, she is mapping the motion of stars at the outer edges of galaxies. Just as the speed of a planet around its parent star tells us the mass of the star, these motions tell us the mass of the galaxy. The difference between this mass and the mass of the matter we can see gives us the mass of the dark matter halo.

Weijmans is using the data to study many questions: What is the relationship between halo mass and host galaxy properties? Is there as much dark matter in galaxies as predicted? What shape are the haloes? In answering these questions, she is shedding light on dark matter and providing a much clearer understanding of the lives of galaxies.

ATLAS3D Team Member, Dr. Anne-Marie Weijmans
Charles Zhu

NASA, ESA, and the Hubble Heritage Team (STScI/AURA)

An elliptical galaxy

Harlan J. Smith telescope dome, McDonald Observatory

Marty Harris/McDonald Observatory

2.7-metre Harlan J. Smith telescope, McDonald Observatory

Marty Harris/McDonald Observatory

Looking Inside Galaxies

MaNGA – Mapping Nearby Galaxies

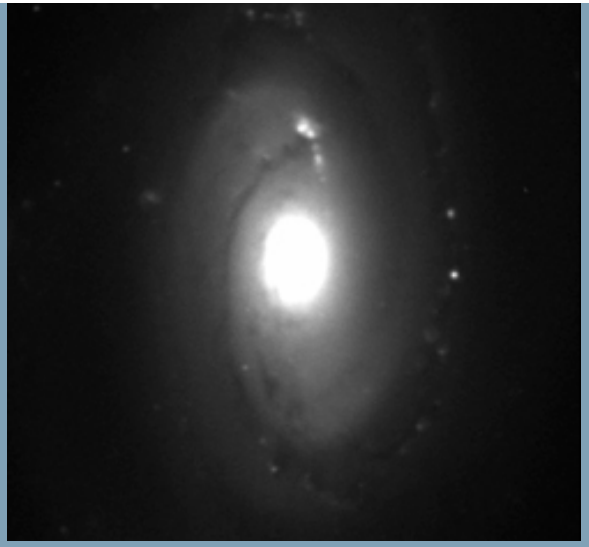
Since 2000, the Sloan Digital Sky Survey (SDSS) has been imaging and mapping the sky in a survey that encompasses more than a quarter of the sky, nearly a million galaxies and over a hundred thousand quasars. The SDSS has been an unprecedented success in advancing our understanding of galaxy formation through the power of large statistical samples.

MaNGA, part of the next phase of the SDSS, will take the survey into a new dimension by looking "inside" galaxies using integral-field-unit spectroscopy. Starting in 2014, the program will run for six years and obtain millions of individual spectra of 10,000 nearby galaxies using 15 separate integral-field spectrographs.

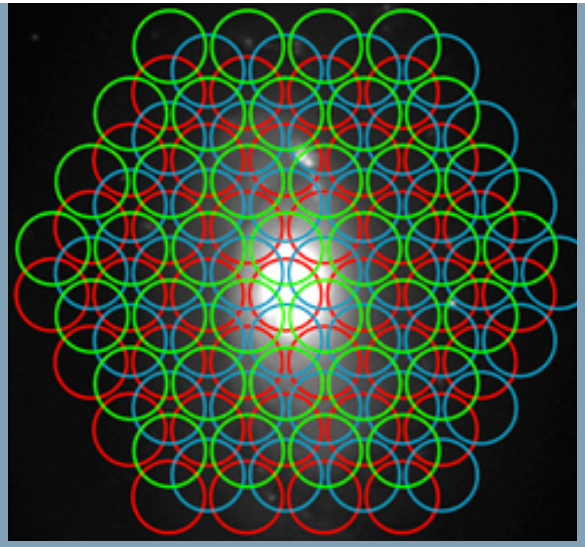
David Law and Anne-Marie Weijmans are members of the MaNGA team that will use the data collected to study the kinematics, chemistry and gas content of galaxies in great detail. Law and Weijmans co-lead the MaNGA Data Development Team and the data analysis and simulations workgroup, and are currently preparing the software needed to reduce the data and analyze the spectra. Weijmans also hosted the first MaNGA team meeting, held at the Dunlap Institute in June 2011.

Over the course of the next decade, the MaNGA team expects the program to reveal many insights into important questions about galaxies. How are galactic disks growing through the accretion of gas and how is the growth affected by the mass of the galaxy's dark matter halo? What roles do stellar accretion, major mergers and disk instabilities play in the growth of galactic bulges? How does the energy of accreting black holes affect star formation? They are confident that the answers to these questions can be found inside the galaxies.

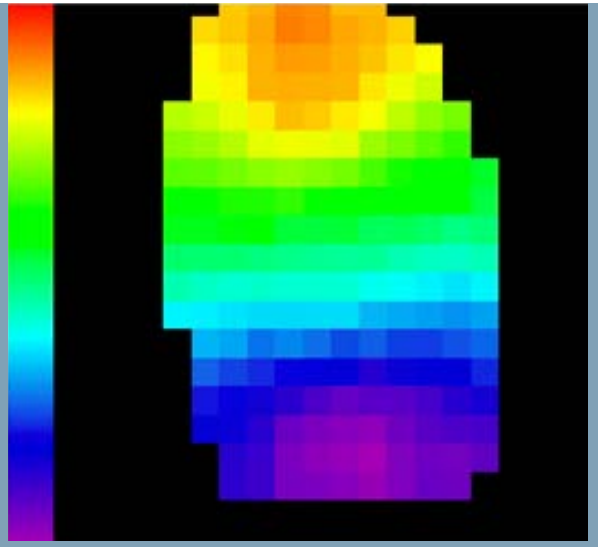
Data Development Co-Lead, Dr. David Law
Data Development Co-Lead, Dr. Anne-Marie Weijmans
Prof. Shelley Wright



Galaxy NGC 4450



MaNGA fibre bundle superimposed on image of galaxy



Simulation of resulting MaNGA spectra

Dust in the Wind

Observing Gas Clouds in Growing Galactic Clusters

Clusters of galaxies are the largest, self-gravitating objects in the Universe. Millions of light-years in diameter, they contain hundreds to thousands of members. Cluster galaxies differ from the population of non-cluster galaxies; there are fewer spirals and fewer that are rich in star-forming gas. As a result, star formation in a significant fraction of nearby cluster galaxies is low or non-existent. Clusters also harbour vast quantities of gas at temperatures of tens of millions of degrees. Referred to as the intra-cluster medium, the gas glows in X-rays as a cloud that envelops the entire cluster.

Lead Investigator Suresh Sivanandam is exploring the relationship between cluster galaxies and the intra-cluster medium. Clusters evolve over time, accreting new galaxies, and Sivanandam is testing the theory that in-falling galaxies experience a "wind" as they move through the intra-cluster medium for the first time, and that the wind is so strong, it strips them of their star-forming gas.

In 2012, Sivanandam will use the European Space Agency's Herschel Space Observatory to search for dust grains blown from galaxies falling into clusters. The dust cohabits the same space as star-forming molecular hydrogen gas, so detection of the dust will trace how the gas is being stripped from galaxies. The search will be the first of its kind and could confirm that star formation in many cluster galaxies is low or non-existent because the galaxies have been stripped of their star-forming fuel.

Lead Investigator, Dr. Suresh Sivanandam

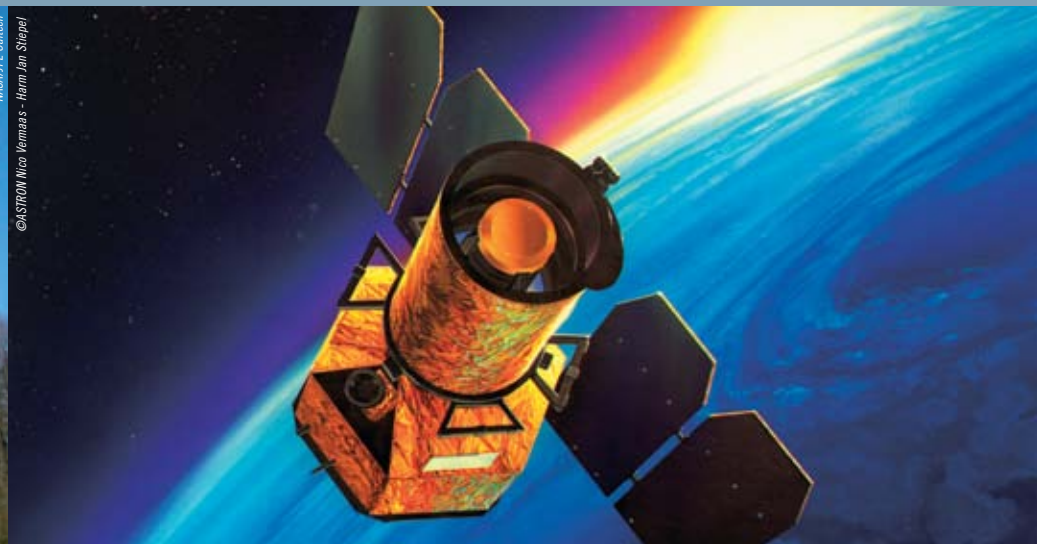
ESA/AOES Medialab; background: Hubble Space Telescope image (NASA/ESA/STScI)

(Left) Herschel Space Observatory used in this study

(Right) The intra-cluster medium of galactic cluster Abell 1689 shown in purple.

NASA, ESA, E. Jullo (JPL/LAM), P. Natarajan (Yale) and J-P. Kneib (LAM)

Westerbork Synthesis Radio Telescope, Netherlands Institute for Radio Astronomy



©ASTRON Nico Vermaas - Harm Jan Stiepel
NASA/JPL-Caltech

GALEX orbiting telescope

The Lives of Galaxies in Clusters

The Blind Ultra-Deep HI Environmental Survey – BUDHIES

Distant clusters of galaxies differ remarkably from nearby clusters. Distant clusters are dominated by spiral galaxies containing young stars and the atomic HI gas used in star formation. Nearby clusters are dominated by elliptical and lenticular galaxies, with older stars and little star-forming gas.

When we observe distant astronomical objects like clusters of galaxies, we are looking back in time. For example, when we observe a cluster 1 billion light-years away, we are seeing it as it was 1 billion years ago; when we observe a cluster 5 billion light-years away, we are seeing it as it was 5 billion years ago. In other words, when we observe clusters of galaxies at different distances from us, we are observing them at different stages in their history.

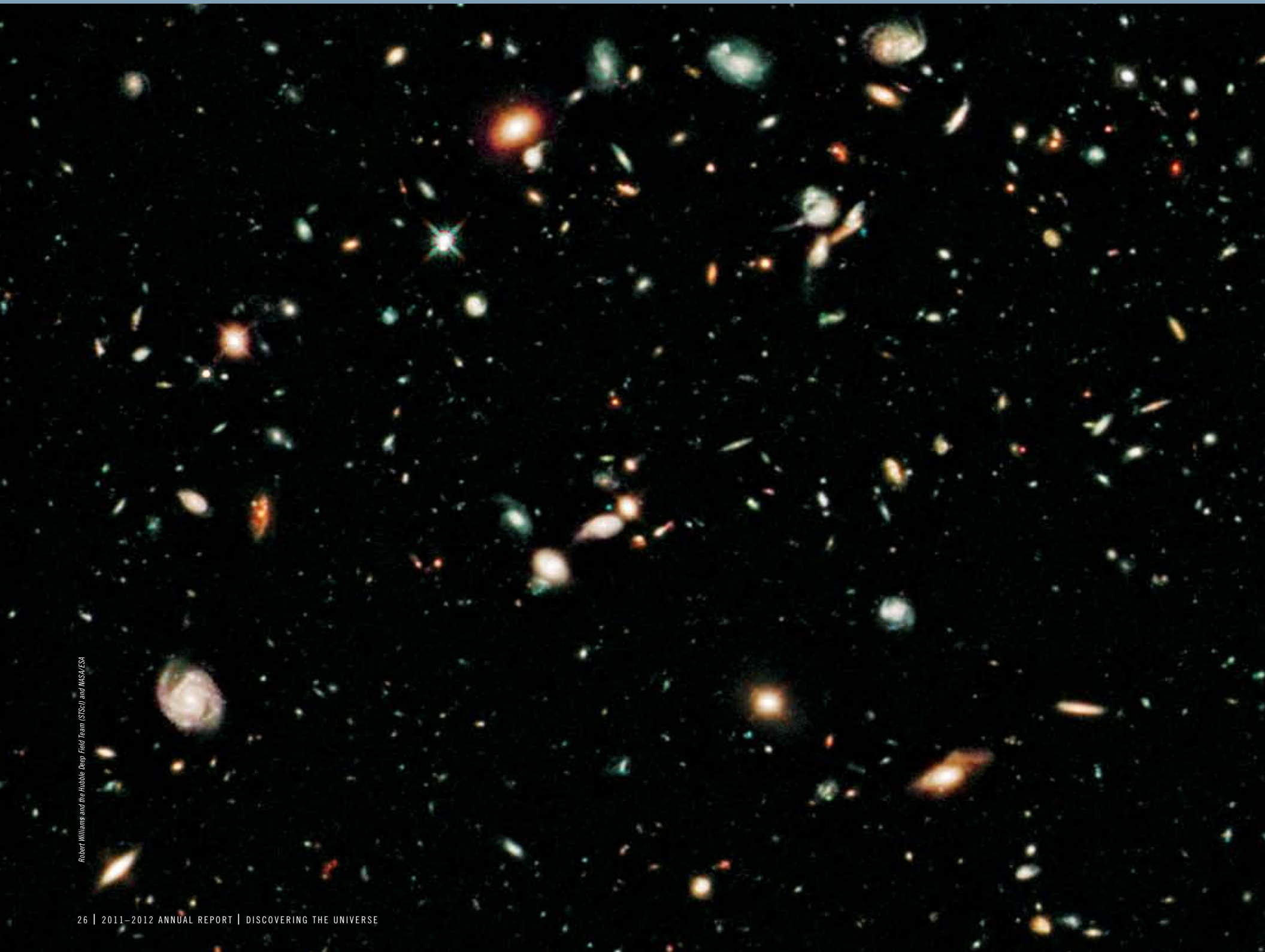
María Montero-Castaño is a member of the Blind Ultra-Deep HI Environmental Survey (BUDHIES) team that is looking into the evolution of these clusters and their constituents. The group is conducting a multi-wavelength study of two clusters of galaxies which lie at a distance of roughly 800 megaparsecs, or 3 billion light-years.

The BUDHIES team is making the most distant measurements of the atomic HI star-forming gas in cluster galaxies yet. In detecting the presence of this gas, the BUDHIES team has shown that the galaxies in these clusters haven't yet been depleted of fuel for making stars.

The group is combining these observations with the ultraviolet (UV) observations of the Galaxy Evolution Explorer (GALEX) orbiting telescope. Young stars are strong emitters of UV light and GALEX's detection of UV emissions from the cluster galaxies reveals the presence of young stars. Together, the observations give a snapshot of cluster galaxies in their star-formation era, and enable the group to study the connection between gas content and star formation at a distance never before explored.

But clusters are dynamic environments in which galaxies interact gravitationally, and cluster evolution is far from simple. Montero-Castaño and the BUDHIES team are seeking to understand whether the cluster galaxies transform according to the standard understanding of galactic evolution—that the gas in spirals is used up in star formation—or whether other processes related to the cluster affect the transformation. The team's ongoing work aims to understand the complex forces that govern the lives of galaxies in clusters.

BUDHIES Team Member, Dr. María Montero-Castaño



Robert Williams and the Hubble Deep Field Team (STScI) and NASA/ESA

Galaxies in the Young Universe

The Morphology of High-Redshift Star-Forming Galaxies

Even with large telescopes like Keck and Palomar, it is difficult to discern the form of galaxies 10 billion light-years away because the Earth's atmosphere limits our ability to resolve detail. Also, since these galaxies are so distant, the expansion of the Universe has redshifted their optical-wavelength emission into the near-infrared. The new Wide Field Camera 3 (WFC3), recently installed aboard the Hubble Space Telescope (HST), lets us resolve these distant galaxies at infrared wavelengths for the first time.

David Law is Principal Investigator on the HST Imaging Program that is using the WFC3 to study the shapes of over 300 galaxies of widely varying masses. The program is one of the first infrared surveys of such a large and representative population.

Compared to the symmetrical and uniform shapes of nearby galaxies, the distant objects are small and "clumpy", with irregular forms unlike the spiral and elliptical galaxies common in the local Universe. Although previous cameras on HST had shown that these galaxies had clumpy ultraviolet-wavelength emission, Law and the HST imaging team have demonstrated that these galaxies are clumpy, tri-axial (i.e. width, length and thickness are all different values) and asymmetric at optical wavelengths as well.

This shows that the clumps contain both old and young stars, and are therefore important features that will govern the galaxies' evolution. These data suggest that the galaxies are likely evolving rapidly. By measuring their sizes, we can understand how the galaxy population grew over time into the spirals and ellipticals with which we are familiar today.

Study of these galaxies is ongoing using both the HST and the OSIRIS spectrograph at the Keck Observatory. By combining OSIRIS spectroscopy with HST imaging, Law and collaborators will study the movements of stars within these galaxies and learn why they show such strange physical forms.

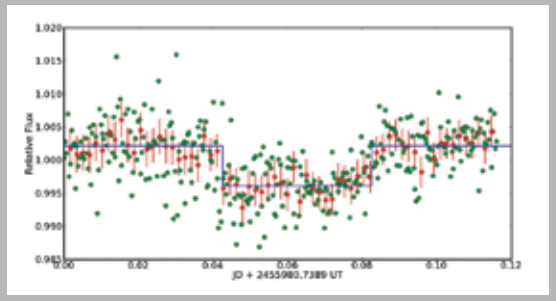
Principal Investigator, HST Imaging Program, Dr. David Law

Canadian scientists developing the Atacama Large Millimeter Array (ALMA) discussing plans for early science for the array. The regional meeting included representation from Quebec, New Brunswick and Ontario, and was hosted by the Dunlap Institute and facilitated by the Herzberg Institute, B.C., and the US National Radio Astronomy Observatory.

DISCOVERING THE UNIVERSE

EDUCATION AT THE DUNLAP INSTITUTE

As the Dunlap Institute develops new techniques for discovering the Universe, it also seeks to produce new generations of astronomers—through the Dunlap Fellowship program, graduate student scholarships, Instrumentation School, and summer research institute. By training our faculty, staff and post-doctoral fellows in the latest pedagogical techniques, we aim to produce the highest calibre of students, able to lead the teams that will solve the technological challenges of tomorrow. We also provide innovative training programs to astronomers around the world to help them solve major challenges in astronomical instrumentation.



Andrey Vayner

Data collected and analyzed by U of T undergraduates showing the detection of the Neptune-sized planet orbiting the star GJ 436. The observations are from the 0.5 metre Dunlap Telescope.

The Next Generation of Discovery

Astronomy Undergraduate Laboratory

Since the fall of 2011, University of Toronto students have participated in a two-semester astronomy lab designed to be the culmination of their undergraduate studies. The course is intended for students going on to graduate school in astronomy and astrophysics, but also benefits students who can apply the lab's teachings in a broader context; for example, in remote sensing or medical imaging.

The astronomy lab trains students in modern astronomical techniques, and in the use of research methods and tools that form the foundation of modern practical methods in the physical sciences. It includes traditional instruction, practical demonstrations, tutorials, and inquiry-based lab modules, with students spending most of their time in lab-based activities. Traditional lectures are augmented with methods chosen to reflect the real-world research environment, where new skills are acquired through a combination of active learning methods.

Students spend most of their time progressing through a series of lab-based activities or experiments of increasing sophistication, with each building on the concepts and tools acquired from the previous. The activities draw on both core curriculum material and state-of-the-art technical coursework and include: photo-detection; spectroscopy; astrometry; and orbit determination.

For example, students used the 0.5-metre Dunlap telescope to detect a Neptune-sized exoplanet orbiting the star GJ 436. As the planet passes in front of the star, the star appears to dim by about one percent. The depth of the transit measures the relative size of the star and planet; the frequency of the transits measures the size of the planet's orbit around its parent star.

Dunlap Institute funding made possible the use of state-of-the-art equipment, including photon detectors and fibre-fed spectrometers, as well as access to the 0.5-m DI telescope. Course designers and instructors, including James Graham and Dae-Sik Moon (DAA), and teaching assistants Mubdi Rahman and Michael Williams took an informal, non-hierarchical pedagogical approach. Their approach, and the exercises themselves, encourage peer instruction and communication between students in a collaborative lab setting that fosters, among other things, the engagement of women in the physical sciences.

U of T undergraduate lab students use the U of T telescope to measure the speed of rotation of the Sun using the Doppler effect.

2011 SUMMER STUDENT PRESENTATIONS:

Aida Ahmadi: Making the Dunlap Institute proud this winter: the Arctic Wide-Field Camera
Mélanie Chevance: Are the majority of high-redshift compact massive galaxies dominated by disks?
Shenglin Jing: Integral-field spectroscopy of a ram-pressure-stripped galaxy
Mark Ma: Cryogenic system for H2RG detector testing
Elliot Meyer: Testing transit detection efficiency
Max Millar-Blanchaer: Integral-field unit tests for the WIFIS spectrograph
Stefania Raimondo: Reduction of optical spectra from the ultra-luminous X-ray source Holii X-1
Emil Terziev: Detecting blends in stellar images: methods and applications
Ritchie Zhao: Optical design process of the TMT NFIRAOS Science Calibration Unit

Introduction to Discovering the Universe

2011 Dunlap Institute Summer Student Program

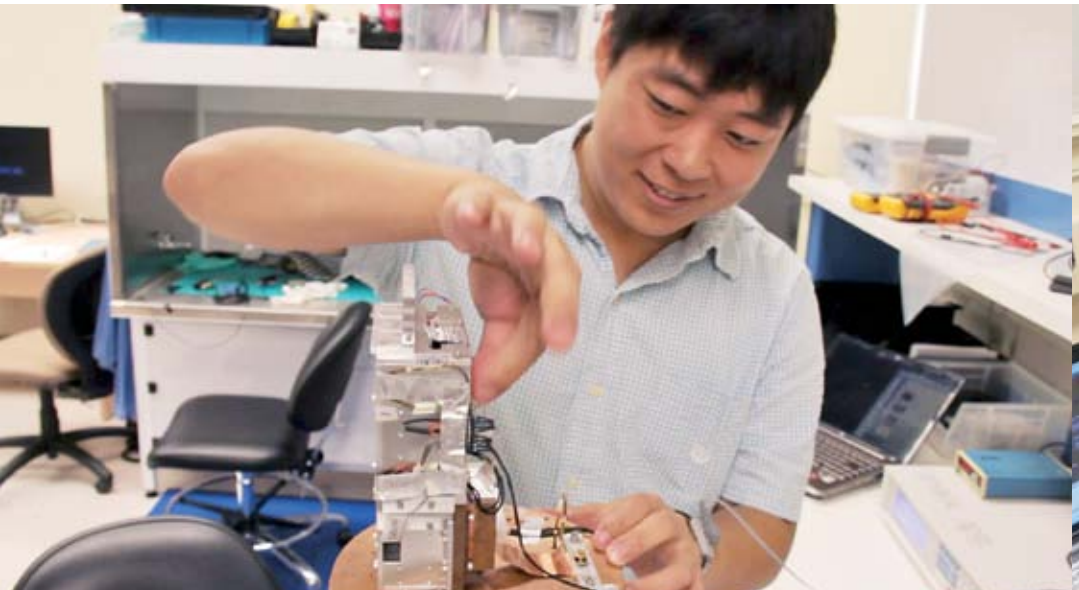
In the summer of 2011, the Dunlap Institute conducted its first annual summer program for undergraduate students interested in observational astronomy and instrumentation. Organized and run by Anne-Marie Weijmans, the program is aimed at improving students' research and communication skills in support of their further studies and careers.

Nine students participated in the 16-week program: three with support from the Dunlap Institute, one with support from the Dunlap Institute and the Thirty Meter Telescope project, four with the support of an Undergraduate Student Research Awards grant from the Natural Sciences and Engineering Research Council of Canada, and one international student with the support of her home institution, École Normale Supérieure Cachan, France.

With the help of Dunlap Institute faculty and research fellows, students conducted their own research projects over the course of the program. They discussed their research results in weekly meetings, attended regular astronomy lectures specifically organized for them, and participated in various outreach activities. The program concluded with the students' own presentations, which covered an impressive range of topics.

Plans are well under way for the 2012 program for a total of 20 students: five Dunlap Institute, six DAA and nine CITA. The 2012 program will also feature a two-day session designed by Dunlap Institute participants in the Professional Development Program.

Student Mark Ma



Students Ritchie Zhao and Stefania Raimondo

Inferring the Invisible

Professional Development Program

In April 2012, a contingent of three graduate students and three post-docs from the Dunlap Institute, DAA and CITA attended the Professional Development Program (PDP) of the Institute for Scientist & Engineer Educators (ISEE), UC Santa Cruz, California. The PDP is a highly regarded program that prepares graduate students and post-docs to teach science and engineering using the inquiry method of science education. In the program, participants view a problem from the learner's perspective, then use that experience to design inquiry-based activities that will lead to effective teaching.

The program comprises of a 3½-day inquiry workshop and a 2½-day design workshop in Santa Cruz. Five of the U of T group were sponsored by the Dunlap Institute, and the sixth by CITA. They were the first participants from an institution outside the US to attend the ISEE program.

Based on the PDP's inquiry method, the U of T participants are designing a two-day "short course" that will be incorporated into the Dunlap Institute's 2012 Summer Student Program, making that program unlike anything else offered in Canada. The course will prepare those students for their summer research projects. It will help them understand the basics of astronomical research through an activity called "Inferring the Invisible." The activity will show students how astronomers—like those at the Dunlap Institute—use the tool of Newtonian gravity to infer the existence of objects that can't be detected by direct observation, including exoplanets, black holes and dark matter.

Design Team Leader, Dr. Quinn Konopacky
Venue Leader, Dr. Anne-Marie Weijmans
Co-Logistics Leader, Etsuko Mieda
Co-Logistics Leader, Kelly Lepo
Co-Documentation Leader, Adrienne Erickcek
Co-Documentation Leader, Matt Russo

Kelly Lepo, Etsuko Mieda, Adrienne Erickcek and Matt Russo (l. to r.) at ISEE Design Institute in Santa Cruz

In Support of Teaching at the University of Toronto

The Centre for Teaching Support & Innovation, U of T

The Centre for Teaching Support & Innovation of the University of Toronto provides leadership, support and training for teaching staff throughout the entire university. In 2011, the Dunlap Institute contributed to the CTSI's efforts in support of pedagogy and pedagogy-driven instructional technology. Dunlap Institute Director of Education & Public Outreach Michael Reid led a workshop entitled "How to Keep Your Students Engaged", with a CTSI co-presenter. Reid led the same workshop for the Teaching Assistants' Training Program, a teaching certificate program for graduate students.

Faculty of Arts & Science Mentorship Program, U of T

One of the many ways in which the Dunlap Institute supports the broader educational goals of the University of Toronto is through initiatives like the Faculty of Arts & Science high school mentorship program. The program is one of the faculty's Pre-University Academic Enrichment programs. It is designed for grade 11 and 12 students who show exceptional academic potential and are interested in learning more about research being conducted at the university.

In 2011, Michael Reid, along with other Dunlap Institute and DAA astronomers introduced students to a wide range of topics through lectures, informal discussions and planetarium programming. Students also used the institute's telescope to photograph a supernova that had been recently discovered in the galaxy M95.

In Support of Teaching Across the Province

Higher Education Quality Council of Ontario – HEQCO

The Dunlap Institute's support for teaching extends beyond the campus of the University of Toronto to the Higher Education Quality Council of Ontario, an agency whose mandate is to improve the system of postsecondary education in the province. HEQCO achieves its goals by conducting research, evaluating the province's postsecondary system, and providing policy recommendations.

The DAA's John Percy and Michael Williams and the DI's Michael Reid received HEQCO funding for a project through which the Dunlap Institute and DAA can uniquely support the council's mandate. The project, titled "Increasing Engagement and Understanding Using Interactive Planetarium Shows," will study the effectiveness of interactive planetarium shows as teaching tools in large, first-year astronomy classes.

This innovative program is designed to fill a gap that exists in the pedagogical literature regarding the use of modern, digital planetariums as teaching tools. It is representative of the Dunlap Institute's commitment not only to offer educational programs of the highest quality, but also to assess those programs to ensure their efficacy.

EUREKA! Conference

The goal of the Toronto District School Board's annual EUREKA! conference for secondary school science teachers is to improve science education throughout the board and to ensure that students are engaged in their science studies.

At the December 2011 conference, the DAA's John Percy and Mubdi Rahman, along with Michael Reid, presented workshops on the transit of Venus, which will be occurring on June 5, 2012. The workshops were designed to help high school teachers provide astronomy education to their students, a particular challenge as most instructors have little or no astronomy background.

DISCOVERING THE UNIVERSE

OUTREACH AT THE DUNLAP INSTITUTE

For decades, the David Dunlap Observatory shared the thrill of discovering the Universe with the public. Today, the Dunlap Institute is bringing this tradition into the twenty-first century. Through social media, video chats, a web portal and interactive planetarium shows, we are helping people around the world discover more about the universe they live in. And we continue the long tradition of offering public events and lectures featuring some of the world's most fascinating astronomers—not unlike the lecture David Dunlap attended in 1921.

Numbers of undergraduate students who attended classes and seminars in the planetarium in 2011/2012 academic year:

AST101 – The Sun and its Neighbours: **1,000**

AST121 – Origin and Evolution of the Universe: **50**

AST201 – Stars and Galaxies: **1,000**

AST251 – Life on Other Worlds: **25**

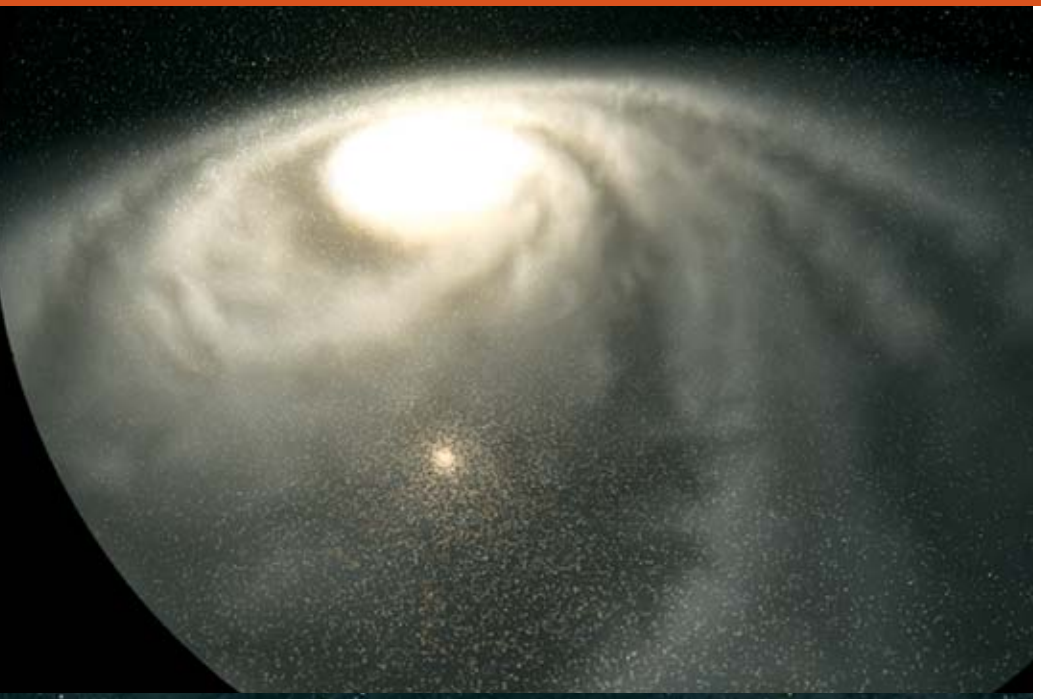
AST325/326 – Introduction to Practical Astronomy/ Practical Astronomy: **20**

PMU199 – First Year Seminar: **45**

A Focused Vision for Dunlap Institute Outreach

In May 2011, staff from the Dunlap Institute and the Department of Astronomy & Astrophysics gathered at a retreat outside of Toronto to decide how best to carry out their mandates for public education and outreach. They brought together University of Toronto astronomers, as well as special guests from scientific institutions across North America where public education and outreach are priorities. The retreat resulted in a vision for the near future that included new initiatives for bringing the Universe into the classroom, and connecting astronomers with students—no matter where they are.

(Below) An instructor inside the DI/DAA portable planetarium



Universe in a Classroom

A Teaching Planetarium on Campus

Since 2010, a portable planetarium has been operating in the Astronomy building on the St. George campus. The inflatable GeoDome planetarium theatre holds 25 people. A projector equipped with a fish-eye lens projects the NASA and Hayden Planetarium Digital Universe on the dome—a scientifically accurate model of the entire cosmos, from the surface of the Earth to the edge of the observable universe. The digital model of the Universe is updated regularly to reflect recent discoveries, including those by Dunlap Institute astronomers.

The purchase of the dome and projection equipment, and infrastructure improvements were financed with funding from the Dean's Office of the university, the Astronomical Society of the Pacific, the DAA and the Dunlap Institute.

For public tour audiences, school groups, and scouts and guides, the planetarium experience is one of discovery and delight. Over 500 grade six to 12 students, scouts, guides and others attended planetarium shows from April 2011 to March 2012. As well, approximately 950 public visitors attended presentations that followed monthly astronomy talks put on by the DAA and Dunlap Institute.

For U of T students who attended astronomy classes and seminars during the 2011/2012 academic year, the planetarium is a powerful, digital, interactive teaching tool. The digital technology allows students to move throughout the Universe to see—up close—objects of current research interest. It also allows them to program data into the digital model and see the results on the dome.

(Top, Left) A globular cluster and the Milky Way Galaxy

(Bottom, Left) Planetarium visualization showing habitable zone relative to planetary system discovered by Kepler spacecraft

The Universe Online

universe.utoronto.ca

In partnership with the DAA and CITA, the Dunlap Institute is reaching out to the public through an online portal—universe.utoronto.ca—that connects the three institutions with non-scientists anywhere. Launched in the fall of 2011, the portal is more than a website; it gives the public access to activities, resources, and astronomical and educational expertise.

Anyone can submit a question to an astronomer via the portal, then see their question and the answer posted online. In 2011, the Dunlap Institute and DAA answered such questions as: What is at the centre of the Milky Way Galaxy? How can amateur astronomers contribute to astronomy? And, can the force of gravity become repulsive?

Also, schools can book planetarium visits, and larger groups from schools, libraries or museums can request a scientist to deliver a public talk.

Small groups can set up a live video chat via universe.utoronto.ca and ask questions to an expert. In 2011, several chats took place, giving students a chance to talk live to an individual from one of the three institutions, or from the Ontario Science Centre.

universe.utoronto.ca

(This page and opposite) Dunlap Institute 2012 Summer Student Program participants are ready for the June 5, 2012, transit of Venus

PUBLIC LECTURES AND TALKS

In 2011 and 2012, audiences discovered the Universe through public talks on an array of topics:

- **March 15, 2012:** "The Cosmic Gift of Pulsars" by Helen Sawyer Hogg Distinguished Visitor, Prof. Victoria Kaspi, on recent discoveries related to pulsars. (In collaboration with the DAA.)
- **February 2, 2012:** "The Lives of Galaxies" by Anne-Marie Weijmans, on the nature and evolution of galaxies.
- **October 18, 2011:** "The Sky's Dark Labyrinth", by Stuart Clark, author, astronomy journalist, Fellow of the Royal Astronomical Society, senior editor for space science for European Space Agency, on the first of his Copernicum Trilogy novels.
- **October 11, 2011:** "Copernicus' Search for a More Perfect Heaven", by Dava Sobel, author of *The Planets, Galileo's Daughter and Longitude*, on her latest book about Nicolaus Copernicus.
- **September 1, 2011:** "Chasing Stardust with Cool Technology", by Suresh Sivinandam, on how infrared technology is changing astronomy.
- **August 4, 2011:** "Taking the Twinkle out of the Stars", by Nicholas Law, on laser-guide-star adaptive optics.
- **July 7, 2011:** "Imaging Planets Beyond Our Solar System", by James Graham, on direct observation of exoplanets.
- **Throughout 2011:** University of Toronto Ph.D. candidate Kelly Lepo gave a series of popular, well-attended talks at various Toronto Public Libraries. Her talk, "2012: From Garbled Science to Death from the Skies", debunked the notion that the world is coming to an end in December 2012.

Once-in-a-Lifetime Public Outreach

June 5, 2012 Transit of Venus

While Dunlap Institute astronomers search the skies for evidence of distant planetary transits, the world gets to see a transit up close in the summer of 2012. In 2011 and early 2012, outreach staff at the Dunlap Institute and Department of Astronomy & Astrophysics, in collaboration with the Royal Astronomical Society of Canada and the Quebec Federation of Amateur Astronomers, began planning for what will be a once-in-a-lifetime event for most: the June 5, 2012, transit of Venus. The last transit of Venus was in 2004; after the 2012 event, the next won't occur until 2117.

Plans included an April 2012 symposium for media and educators, a transit-viewing event on the university campus, and support of a similar event in Ottawa. A transit webpage on the universe.utoronto.ca public portal included transit information, and brochures were produced in multiple languages. Also, 43,000 transit glasses for viewing the event safely were distributed to the RASC, the Quebec Federation of Amateur Astronomers and universities across Canada.

AWARDS & HONOURS

James Graham
Senior Fellow, Massey College, May 2011

MEETINGS, TALKS, CONFERENCES, OBSERVING TRIP & SCIENTIFIC ACTIVITIES

MEETINGS ORGANIZED

James Graham
Jun 2011: MaNGA Meeting, Toronto, ON - DI/MaNGA Collaboration
Oct 2011: DEBRIS Meeting, Toronto, ON - DI/NRC-HIA
Feb 2011: Submm Meeting, Toronto, ON - DI/NRC-HIA

Nicholas Law
May 2011: PTF Collaboration Meeting, Santa Barbara, CA, USA - KITP
Aug 2011:IUCAA AO Science and Engineering Workshop, Pune, India - IUCAA
Mar 2012: Robo-AO Science Meeting, Pasadena, CA, USA - California Institute of Technology

Suresh Sivanandam
Ongoing: Astro-ph Coffee Discussion, Toronto, ON - DAA/DI
Ongoing: Astronomical Instrumentation Discussion, Toronto, ON - DI

Anne-Marie Weijmans
Jun 2011: MaNGA Meeting, Toronto, ON - DI/ MaNGA Collaboration

MEETINGS ATTENDED

James Graham
Sep 2011: Extreme Solar Systems II, Jackson, WY, USA - Scientific Organizing Committee doe ESSII

David Law
Mar 2012: MaNGA Planning Meeting, Princeton, NJ, USA; New York, NY, USA - MaNGA Collaboration
Mar 2012: After-Sloan 3 (AS3) Planning Meeting, Baltimore, MD, USA - AS3 Collaboration

Nicholas Law
May 2011: PTF Collaboration Meeting, Santa Barbara, CA, USA - Palomar Transient Factory

Jérome Maire
Oct 2011: GPI Science Meeting, San Jose, CA, USA - SETI

Anne-Marie Weijmans
Sep 2011: Atlas3D Meeting, Paris, France - IAP
Mar 2012: MaNGA Planning Meeting, Princeton, NJ, USA; New York, NY, USA - MaNGA Collaboration
Mar 2012: After-Sloan 3 (AS3) Planning Meeting, Baltimore, MD, USA - AS3 Collaboration

TALKS GIVEN

James Graham
Apr 2012: TMT SAC: *High Contrast Imaging for TMT, Pasadena*, CA, USA (remotely given) - TMT
Apr 2012: Canadian Perspectives Lecture Series: *Imaging of Planets Outside our Solar System*, Toronto, ON - Senior Alumni Association, UofT
Apr 2012: Invited Colloquium: *Direct Detection of Exoplanets*, Victoria, BC - NRC-HIA
Apr 2012: A Transit of Venus Symposium: *Transits in the Modern Era*, Toronto, ON - DI

David Law
Nov 2011: Waterloo Lunch Talk: *The Rest-Optical Morphological Properties of Star-Forming Galaxies in the Young Universe*, Waterloo, ON - University Waterloo
Mar 2012: After-Sloan 3 (AS3) Meeting: *Bundle Design and Dithering with MaNGA*, Baltimore, MD, USA - AS3 Collaboration

Nicholas Law
2012: Invited Talk: *Astronomy in the Canadian Arctic* - Waterloo, ON
Mar 2012: Invited Colloquium: *Cool Stars, Cool Planets and Very Cold Astronomy,* New York, NY, USA - Columbia University
Apr 2012: Invited Colloquium: *Cool Stars, Cool Planets and Very Cold Astronomy*, Vancouver, BC - University of British Columbia

Jérome Maire
Jan 2012: Seminaire: *Vers l'avènement de l'imagerie dans l'étude des planètes extrasolaires*, Nice, France - Laboratoire Lagrange, Université de Nice

María Montero-Castaño
Mar 2012: G2000: *Butcher-Oemler Effect on Clusters of Galaxies at z~2*, Toronto, ON - Graduate Astronomy Student Association (DAA, UofT)

Anne-Marie Weijmans
Nov 2011: Seminar at UWO: *Mapping the Dark and Stellar Haloes of Early-type Galaxies with Integral-field Spectrography*, London, ON - University of Western Ontario

Shelley Wright
Mar 2012: G2000: *Extending Optical SETI into the Near-Infrared*, Toronto, ON - Graduate Astronomy Student Association (DAA, UofT)
Apr 2011: TMT SAC: *IRIS Science & Requirements for High Contrast and NGS-AO*, Pasadena, CA, USA (remotely given) - TMT
Apr 2012: Colloquium: *Discovering Galactic Disks, Mergers, Weak AGN in High-Redshift Star Forming Galaxies*, London, ON - University of Western Ontario

MEETINGS, TALKS, CONFERENCES, OBSERVING TRIP & SCIENTIFIC ACTIVITIES

CONFERENCE PRESENTATION

James Graham

Sep 2011: Extreme Solar Systems II: *Direct Detection of Extra-solar Planets Using High Contrast Imaging and the Gemini Planet Imager*, Jackson, WY, USA - Scientific Organizing Committee doe ESSII

Nicholas Law

May 2011: PTF Meeting: *PTF Survey Status, Spring 2011 (Keynote)*, Santa Barbara, CA, USA - Palomar Transient Factory
May 2011: PTF Meeting: *PTF/M-dwarfs: Searching for Planets Around 100,000 M-dwarfs*, Santa Barbara, US, USA - Palomar Transient Factory
May 2011: AAS Summer Conference: *Low-mass-star Surveys with PTF*, Boston, MA, USA - AAS
Jun 2011: CASCA Conference: *A New Planet-finding Telescope in the Canadian Arctic*, London, ON - CASCA
Jan 2012: AAS Winter Conference: *New Exoplanet Surveys in the High Canadian Arctic*, Austin, TX, USA - AAS

Suresh Sivanandam

Jun 2011: CASCA Conference: *A New View Of Ram-Pressure Stripping*, London, ON - CASCA

Anne-Marie Weijmans

May & Jun 2011: CASCA Conference: *Mapping Dark and Stellar Haloes With Integral-Field Spectrography*, London, ON - University of Western Ontario
Jul 2011: Galaxy Formation: *Mapping Dark and Stellar Haloes With Integral-Field Spectrography*, Durham, UK - Durham University

OBSERVING TRIP

David Law

Aug 2011: 3 nights, Keck Observatory - OSIRIS LGSAO

Nicholas Law

TBD: Many hours on robotic telescopes, New Mexico & Hawaii, USA; Australia
2011 & 2012: 6 nights (using a Keck I telescope), Hawaii, USA - Caltech
2011: 5 nights (using a Palomar 60-inch telescope with Robo-AO), California, USA - Caltech
2011: 5 night trip (for robotic telescope installation), New Mexico, USA - DI

Suresh Sivanandam

Jun 2012: 2 days (for DIT Testing), Victoria, BC - HIA-NRC
Oct 2012: 5 days (for DIT Testing), Mayhill, NM, USA - New Mexico Skies
2011-2012: 10.4 hours (Herschel OT1 Observations) - Herschel Space Telescope

Shelley Wright

Mar 2012: 2 nights (for optical SETI), Lick Observatory, CA, USA - University of California

OTHER SCIENTIFIC ACTIVITIES

David Law

Sep 2011: GMTIFS CoDR Panelist, Lick Observatory, CA, USA

Suresh Sivanandam

Jun 2011: Test DIT, Victoria, BC
Sep 2011: Cold-testing of DIT, Victoria, BC
Oct 2011: Meeting with collaborators at University of Arizona, Tucson, AZ, USA

Anne-Marie Weijmans

Sep 2011: Working visit ESO, Garching, Germany
Mar 2012: Working visit NYU (MaNGA), New York, USA
Apr 2012: Working visit Gemini, Hilo, USA

Shelley Wright

Jan 2012: IRIS Team Meeting, Teleconference
Jan 2012: IRIS Management Meeting, Teleconference
Feb 2012: IRIS Exoplanet Meeting, Teleconference
Feb 2012: Optical SETI Meeting, Teleconference
Mar 2012: IRIS Team Meeting, Teleconference
Apr 2012: IRIS Astrometry Meeting, Teleconference

TELESCOPE TIME & GRANT PROPOSALS

TELESCOPE TIME

David Law

Telescope Proposal: The Dynamics of Merging Pairs at z~2-3
Status: Co-I; Telescope: Keck/NIRSPEC; Outcome: Successful

Telescope Proposal: Dissecting Stellar Populations within a Grand Design Spiral Galaxy at z=2.18
Status: PI; Telescope: HST; Outcome: Pending

Telescope Proposal: Exploring the Evolution of Stellar Structure in the z=2-3 Protocluster Environment
Status: PI; Telescope: HST; Outcome: Pending

Telescope Proposal: The Stellar Populations and Physical Orientation of the Sagittarius dSph and M54
Status:Co-I; Telescope: HST; Outcome: Pending

Nicholas Law

Telescope Proposal: Searching 100,000 M-dwarfs for Planet Transits
Status: PI; Telescope: Palomar 48"; Outcome: 11 nights

Telescope Proposal: Radial Velocities of Eclipsing Binaries
Status: Co-I; Telescope: Keck; Outcome: 3 nights

Telescope Proposal: Extremely-wide binaries
Status: Co-I; Telescope: Gemini; Outcome: Not granted

Telescope Proposal: Searching 100,000 M-dwarfs for Planet Transits
Status: PI; Telescope: Palomar 48"; Outcome: 11 nights

Telescope Proposal: Radial Velocities of Eclipsing Binaries
Status: Co-I; Telescope: Keck; Outcome: 2 nights

Telescope Proposal: Followup of M-dwarf Planets and EBs
Status: PI; Telescope: FTN & FTS; Outcome: 50 hours

Telescope Proposal: Searching 100,000 M-dwarfs for Planet Transits
Status: PI; Telescope: Palomar 48"; Outcome: 10 nights

Suresh Sivanandam

Telescope Proposal: Dust in the Wind – Ram-pressure Stripping of Galaxies
Status: PI; Telescope: Herschel OT2; Outcome: Approved 12.6 hours

Telescope Proposal: The First Spatially Resolved Study of Stellar Populations in z~0 Massive Compact Galaxies
Status: Co-I; Telescope: Gemini 2012B; Outcome: Submitted

TELESCOPE TIME

Anne-Marie Weijmans

Telescope Proposal: The First Spatially Resolved Study of Stellar Populations in z~0 Massive Compact Galaxies
Status: Telescope: Co-I; Outcome: Gemini 2012B; Submitted

Telescope Proposal: MATLAS – Mass Assembly of Early-Type Galaxies with Their Fine Structures
Status: Co-PI; Telescope: CFHT (large program); Outcome: Submitted

Telescope Proposal: Resolving the Mystery of the Assembly History of Early-Type Galaxies with Intermediate Angular Momentum
Status: Co-PI; Telescope: HST; Outcome: Submitted

Telescope Proposal: Identifying Old Tidal Dwarf Galaxies Around Nearby Disturbed Early-Type Galaxies
Status: Co-PI; Telescope: Gemini-North; Outcome: Submitted & accepted; data in hand

Telescope Proposal: MATLAS: Investigating the Origin of the Molecular Gas in Atlas3D Early-type Galaxies with Extremely Deep Imaging
Status: Co-PI; Telescope: CFHT; Outcome: Submitted & accepted; observations currently on-going

Shelley Wright

Telescope Proposal: OSIRIS LGS-AO, z~1 galaxies
Status: Co-I; Telescope: Keck (UC); Outcome: In review

Telescope Proposal: OSIRIS LGS-AO, z~1 galaxies
Status: Co-I; Telescope: Keck (NASA); Outcome: In review

Telescope Proposal: OSIRIS LGS-AO, sub-mm galaxies
Status: Co-I; Telescope: Keck (NASA); Outcome: In review

Telescope Proposal: Optical SETI
Status: PI; Telescope: Lick; Outcome: Awarded

Telescope Proposal: NIFS LGS-AO, z~2 Quasars
Status: PI; Telescope: Gemini; Outcome: In review

TELESCOPE TIME & GRANT PROPOSALS

GRANT PROPOSALS

James Graham
Grant Proposal: NSERC: Direct Detection and Characterization of Extrasolar Planets
Status: PI; Grant Received (in CAD): $393K
Grant Proposal: Connaught Summer Institute Award: Extreme Astronomical Instrumentation Summer Institute
Status: PI; Grant Received (in CAD): $50K

Nicholas Law
Grant Proposal: Robo-AO Infrared camera (DURIP)
Status: Project scientist; Grant Received (in CAD): $200K
Grant Proposal: Robo-AO Operations Support (Mt. Cuba foundation)
Status: Project scientist; Grant Received (in CAD): $100K
Grant Proposal: Balloon Imaging Telescope (Canadian Space Agency)
Status: Project scientist; Grant Received (in CAD): $480K

María Montero-Castaño
Grant Proposal: Diagnosis of the Early Stages of Massive Stellar Evolution in Young Stellar Clusters
Status: Co-I; Grant Received (in CAD): In review process, final resolution in June.

Mike Reid
Grant Proposal: Connaught Summer Institute Award: Extreme Astronomical Instrumentation Summer Institute
Status: Co-I; Grant Received(in CAD): $50K

Suresh Sivanandam
Grant Proposal: CFI LEF Technology Innovation
Status: Co-I; Grant Received (in CAD): Passed pre-proposal stage, final stage in progress ($1M)

Shelley Wright
Grant Proposal: Discovery Grant
Status: PI; Grant Received (in CAD): $30K per year
Grant Proposal: Connaught Summer Institute Award: Extreme Astronomical Instrumentation Summer Institute
Status: Grant Received (in CAD): Co-I; $50K

EDUCATION OUTREACH ACTIVITIES

EDUCATION OUTREACH ACTIVITIES ORGANIZED

Johannes Hirn
May 2011: Outreach Retreat, Orangeville, ON - DI
Oct 2011: Public Speaking Training Session, Toronto, ON - DI

Anne-Marie Weijmans
May-Aug 2011: Summer Student Program, Toronto, ON - DI

EDUCATION OUTREACH ACTIVITIES ATTENDED

Johannes Hirn
May 2011: Post-Secondary Education Web 2011, Toronto, ON - Academia Group
June 2011: Worldviews Media and Higher-Ed, Toronto, ON - OCUFA

Quinn Konopacky
Mar 2012: Professional Development Program Inquiry Institute, Maui, HI, USA - ISEE (UC Santa Cruz)
Apr 2012: Professional Development Program Design Institute, Santa Cruz , CA, USA - ISEE (UC Santa Cruz)

Anne-Marie Weijmans
May 2011: Science-Rendezvous (volunteered as planetarium presenter), Toronto, ON - Science-Rendezvous
May 2011: DI Outreach Retreat, Orangeville, ON - DI
Oct 2011: Public speaking workshop, Toronto, ON - DI
Mar 2012: Professional Development Program Inquiry Institute, Maui, HI, USA - ISEE (UC Santa Cruz)
Apr 2012: Professional Development Program Design Institute, Santa Cruz , CA, USA - ISEE (UC Santa Cruz)

TALKS GIVEN

Johannes Hirn
Jan 2012: Public Library Event: *Black Holes are Like Kinder Surprises*, Toronto, ON - Gerrard/Ashdale Library
Jan 2012: Public Library Event: *Black Holes are Like Kinder Surprises*, Toronto, ON Richview Library
Jan 2012: Public Library Event: *Black Holes are Like Kinder Surprises*, Toronto, ON - Don Mills Library
Jan 2012: ASX Annual Symposium: *Finding Your Own Path to SpaceToronto*, ON - ASX

David Law
Feb 2012: NYAA Meeting: Tidal Streams in the Milky Way, Toronto, ON - North York Astronomy Association (NYAA)

Nicholas Law
Mar 2012: RASC Toronto Centre Speakers Night: *Extremely Cool Astronomy: Finding Exoplanets in the High Canadian Arctic*, Toronto, ON - RASC Toronto
Mar 2011: DAA/DI Public Observing Night: *Taking the Twinkle Out of the Stars*, Toronto, ON - DAA

EDUCATION OUTREACH ACTIVITIES

TALKS GIVEN

Michael Reid

Jul 2011: *The 500,000,000 Sisters of Ear,* Toronto, ON - Ontario Science Center
Sep 2011: First-year Students Orientation: *Electives and Extraterrestrials,* Toronto, ON - Victoria College
Oct 2011: *Habitable Worlds: The Search for Another Earth*, Richmond Hill, ON - David Dunlap Observatory
Nov 2011: *Life in the Cosmos*, Toronto, ON - Glendon College, York University

Suresh Sivanandam

Sep 2011: UofT Public Tour: *Chasing Stardust with Cool Technology*, Toronto, ON - UofT GASA
Jan 2012: NYAA Talk: *Arctic Astronomy: A Wild Canadian Venture*, Toronto, ON - NYAA
Feb 2012: RASC Talk: *Seeing Beyond Red with Cool Technology*, Toronto, ON - RASC Toronto
Mar 2012: RASC Talk: *Seeing Beyond Red with Cool Technology*, Mississauga, ON - RASC Mississauga

Anne-Marie Weijmans

Aug 2011: DDO Summer Lectures: *The Quest for Dark Matter,* Richmond Hill, ON - RASC Toronto
Nov 2011: RASC Meeting: *The Quest for Dark Matter*, Mississauga, ON - RASC Mississauga
Feb 2012: Public Tour: *The Lives of Galaxies*, Toronto, ON - GASA, UofT

TEACHING AND GUEST LECTURE

Anne-Marie Weijmans

Feb 2012: Guest Lecture on Galaxy Modeling Techniques (Graduate Course, AST1420), Toronto, ON
Feb 2012: Two Guest Lectures on Dark Matter (Undergraduate Course, AST 121), Toronto, ON
May & Aug 2011: Two Lectures in the DI Summer Student Lecture Series (Stellar Evolution 101 and Dark Matter 101), Toronto, ON

SCHOOL AND OTHER VISITS

Johannes Hirn

May 2011: Ontario Science Centre, Web Video Q&A, Toronto, ON
May 2011: Ontario Science Centre, Web Video Q&A, Toronto, ON
Oct 2011: Huron Street Public School, Web Video Q&A, Toronto, ON
Mar 2012: Huntsville Public School, Web Video Q&A, Huntsville, ON

Michael Reid

Jun 2011 & Nov 2011: St. Paul's Catholic Secondary School, Mississauga, ON: To make presentations to the grade 9 students about solar activity and to show them our meteorite collection
Mar 2012: Woburn Collegiate Institute, Scarborough, ON: To do an exoplanet transit simulation with each of two classes of gifted grade nine students

MEDIA APPEARANCE

James Graham

Dec 2011: *CBC News*: "Supermassive Black Hole Discovery Shatters Records"
Dec 2011: *Toronto Star*: "UofT Astronomers Discover Two Biggest Black Holes Ever"
Dec 2011: *Postmedia News*: "Scientists Discover Largest Black Holes"
Dec 2011: *Toronto Star*: "Supersized Galactic Mysteries"
Feb 2012: *Al Jazeera TV News*: "Solar Flares and Storms"
Spring 2012: *U of T Magazine*: "Planet Hunters"

Quinn Konopacky

Spring 2012: U of T Magazine: "Planet Hunters"

David Law

Sep 2011: Interviewed by *Scientific American* to comment on a recent paper regarding stellar tidal streams
Apr 2012: Interviewed by *Science News* to comment on a recent paper regarding dark matter in the solar neighborhood.

Nicholas Law

Apr 2011: *Nunatsiaq Online*: "Telescope to be Mounted in Nunavut's High Arctic"
Apr 2011: *Montreal Gazette*: "Arctic Scope Could Make Canada an Astronomy Star"
Apr 2011: *Vancouver Sun*: "Telescope Could Make Canada Astronomy Star"
Jun 2011: *CBC News*: "New Supernova Type Outshines the Rest"
Winter 2012: *U of T Magazine*: "Scanning the Arctic Skies"
Jan 2012: *Science Magazine Now*: "Move Over, Santa, Here Come the Astronomers"
Jan 2012: *Slashdot*: "http://science.slashdot.org/story/12/01/06/0410207/is-the-canadian-arctic-the-future-of-astronomyIs the Canadian Arctic the Future of Astronomy?"

Michael Reid

Summer 2011: *New Road Media*: Did two sessions to film an explanation of how tides work for the show Curious and Unusual Deaths
Jul 2011: *Sun News*: An interview about the end of the shuttle program, along with Sara Poirier of the OSC, Robert Zubrin, and a professor from Guelph
Sep 2011: *Global TV News at 6*: Talked about the de-orbiting of the NASA UARS satellite
Nov 2011: *Sun News*: Talked about the prospects for human exploration of space
Dec 2011: *The Varsity*: Interviewed about his teaching

Anne-Marie Weijmans

July 2011: *Sky and Telescope*: Interviewed after Atlas3D press release on revision of Hubble Tuning Fork

REFEREED PUBLICATIONS

PEER REVIEWED PUBLICATIONS

Discovery of an Active Galactic Nucleus Driven Molecular Outflow in the Local Early-Type Galaxy NGC 1266
Alatalo, K., Blitz, L., Young, L.M., Davis, T.A., Bureau, M., Lopez, L.A., Cappellari, M., Scott, N., Shapiro, K.L., Crocker, A.F., Martín, S., Bois, M., Bournaud, F., Davies, R.L., de Zeeuw, P.T., Duc, P.-A., Emsellem, E., Falcón-Barroso, J., Khochfar, S., Krajnovic, D., Kuntschner, H., Lablanche, P.-Y., McDermid, R.M., Morganti, R., Naab, T., Oosterloo, T.A., Sarzi, M., Serra, P., Weijmans, A. 2011, ApJ, 735, 88

Discovery of a Type IIb Supernova from a Compact Progenitor in the Nearby Galaxy M51
Arcavi, I., Gal-Yam, A., Yaron, O., ..., Law, N., et al. 2011, ApJ, 742, L18

Automating Discovery and Classification of Transients and Variable Stars in the Synoptic Survey Era
Bloom, J., Cenko, S.B., ..., Law, N., et al. 2011, ApJ, in press

The ATLAS3D project – VI. Simulations of binary galaxy mergers and the link with Fast Rotators, Slow Rotators and Kinematically Distinct Cores
Bois, M., Emsellem, E., Bournaud, F., Alatalo, K., Blitz, L., Bureau, M., Cappellari, M., Davies, R.L., Davis, T.A., de Zeeuw, P.T., Duc, P.-A., Khochfar, S., Krajnovic, D., Kuntschner, H., Lablanche, P.-Y., McDermid, R.M., Morganti, R.. Naab, T., Oosterloo, T.A., Sarzi, M., Scott, N., Serra, P., Weijmans, A., Young, L.M. 2011, MNRAS, 416, 1654

The ATLAS3D project – I. A Volume limited sample of 260 nearby early-type galaxies: science goals and selection criteria
Cappellari, M., Emsellem, E., Krajnovic, D., McDermid, R.M., Scott, N., Verdoes-Kleijn, G.A., Young, L.M., Alatalo, K., Bacon, R., Blitz, L., Bois, M., Bournaud, F., Bureau, M., Davies, R.L., Davis, T.A., de Zeeuw, P.T., Duc, P.-A., Khochfar, S., Kuntschner, H., Lablanche, P.-Y., Morganti, R., Naab, T., Oosterloo, T.A., Sarzi, M., Serra, P., Weijmans, A. 2011, MNRAS, 413, 813

The ATLAS3D project – VII. A new look at the morphology of nearby galaxies: the kinematic morphology-density relation
Cappellari, M., Emsellem, E., Krajnovic, D., McDermid, R.M., Serra, P., Alatalo, K., Blitz, L., Bois, M., Bournaud, F., Bureau, M., Davies, R.L., Davis, T.A., de Zeeuw, P.T., Duc, P.-A., Khochfar, S., Kuntschner, H., Lablanche, P.-Y., Morganti, R., Naab, T., Oosterloo, T.A., Sarzi, M., Scott, N., Weijmans, A., Young, L.M. 2011, MNRAS, 416, 1680

Evidence for a compact Wolf-Rayet progenitor for the Type Ic supernova PTF 10vgv
Corsi, A., Ofek, E., Gal-Yam, A., ..., Law, N., et al. 2011 ApJ, 747L, 5C

The Factory and the Beehive: I Rotation Periods for Low-Mass Stars in Praesepe
Covey, K., Lemonias, J., Agueros, M., Law, N., Kraus, A., et al. 2011, ApJ, 740, 110A

The ATLAS3D project – X. On the origin of the molecular and ionised gas in early-type galaxies
Davis, T.A., Alatalo, K., Sarzi, M., Bureau, M., Young, L.M., Blitz, L., Serra, P., Crocker, A.F., Krajnovic, D., McDermid, R.M., Bois, M., Bournaud, F., Cappellari, M., Davies, R.L., de Zeeuw, P.T., Emsellem, E., Duc, P.-A., Khochfar, S., Kuntschner, H., Lablanche, P.-Y., Morganti, R., Naab, T., Oosterloo, T.A., Scott, N., Weijmans, A. 2011, MNRAS, 417, 882

The ATLAS3D project – V. The CO Tully-Fisher relation of early-type galaxies
Davis, T.A., Bureau, M., Young, L.M., Alatalo, K., Blitz, L., Bois, M., Bournaud, F., Cappellari, M., Davies, R.L., de Zeeuw, P.T., Emsellem, E., Duc, P.-A., Khochfar, S., Krajnovic, D., Kuntschner, H., Lablanche, P.-Y., McDermid, R.M., Morganti, R., Naab, T., Oosterloo, T.A., Sarzi, M., Scott, N., Serra, P., Weijmans, A. 2011, MNRAS, 414, 940

The VAST Survey - I. Companions and the unexpected X-ray detection of B6-A7 stars
De Rosa, Robert J., Bulger, Joanna, Patience, Jenny, Leland, Ben, Macintosh, Bruce, Schneider, Adam, Song, Inseok, Marois, Christian, Graham, James R., Bessell, Mike, Doyon, René, 2011, MNRAS, 415, 854

Warm H2O and OH Disk Emission in V1331 Cyg
Doppmann, G. W., Najita, Joan R., Carr, John S., Graham, James R. 2011, ApJ, 738, 112

The ATLAS3D project – IX. The merger origin of a fast and slow rotating Early-Type Galaxy revealed with deep optical imaging: first results
Duc, P.-A., Cuillandre, J.-C., Serra, P., Michel-Dansac, L., Ferriere, E., Alatalo, K., Blitz, L., Bois, M., Bournaud, F., Bureau, M., Cappellari, M., Davies, R.L., Davis, T.A., de Zeeuw, P.T., Emsellem, E., Khochfar, S., Krajnovic, D., Kuntschner, H., Lablanche, P.-Y., McDermid, R.M., Morganti, R., Naab, T., Oosterloo, T.A., Sarzi, M., Scott, N., Weijmans, A., Young, L.M. 2011, MNRAS, 417, 863

The ATLAS3D project – III. A census of the stellar angular momentum within the effective radius of early-type galaxies: unveiling the distribution of fast and slow rotators
Emsellem, E., Cappellari, M., Krajnovic, D., Alatalo, K., Blitz, L., Bois, M., F. Bournaud, Bureau, M., Davies, R.L., Davis, T.A., de Zeeuw, P.T., Duc, P.-A., Khochfar, S., Kuntschner, H., Lablanche, P.-Y., McDermid, R.M., Morganti, R., Naab, T., Oosterloo, T.A., Sarzi, M., Scott, N., Serra, P., van de Ven, G., Weijmans, A., Young, L.M. 2011, MNRAS, 414, 888

Astrometric Microlensing by Local Dark Matter Subhalos
Erickcek, A., & Law, N. 2011, ApJ, 729, 49E

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The SAURON project- XIX. Optical and near-infrared scaling relations of nearby elliptical, lenticular and Sa galaxies
Falcón-Barroso, J., van de Ven, G., Peletier, R.F., Bureau, M., Jeong, H., Bacon, R., Cappellari, M., Davies, R.L., de Zeeuw, P.T., Emsellem, E., Krajnovic, D., Kuntschner, H., McDermid, R. M., Sarzi, R., Shapiro, K.L., van den Bosch, R.C.E., van der Wolk, G., Weijmans, A., Yi, S. 2011, MNRAS, 417, 1787

Two Wide Planetary-Mass Companions to Solar-Type Stars in Upper Scorpius
Ireland, M., Kraus, A., Martinache, F., Law, N., Hillenbrand, L. 2011, ApJ, 726, 113I

The ATLAS3D project – VIII. Modelling the Formation and Evolution of Fast and Slow Rotator Early-Type Galaxies within LCDM
Khochfar, S., Emsellem, E., Serra, P., Bois, M., Alatalo, K., Bacon, R., Blitz, L., Bournaud, F., Bureau, M., Cappellari, M., Davies, R.L., Davis, T.A., de Zeeuw, P.T., Duc, P.-A., Krajnovic, D., Kuntschner, H., Lablanche, P.-Y., McDermid, R.M., Morganti, R., Naab, T., Oosterloo, T.A., Sarzi, M., Scott, N., Weijmans, A., Young, L.M. 2011, MNRAS, 417, 845

The ATLAS3D project – II. Morphologies, kinematic features and alignment between photometric and kinematic axes of early-type galaxies
Krajnovic, D., Emsellem, E., Cappellari, M., Alatalo, K., Blitz, L., Bois, M., Bournaud, F., Bureau, M., Davies, R.L., Davis, T.A., de Zeeuw, P.T., Duc, P.-A., Khochfar, S., Kuntschner, H., Lablanche, P.-Y., McDermid, R.M., Morganti, R., Naab, T., Oosterloo, T.A., Sarzi, M., Scott, N., Serra, P., Weijmans, A., Young, L.M. 2011, MNRAS, 414, 2923

Direct Exclusion of Luminous Progenitor Systems for a Type Ia Supernova
Lei, W., Bloom, J., Podsiadlowski, P., ..., Law, N., et al. 2011, Nature, 480, 348L

Experimental Design for the Gemini Planet Imager
McBride, James, Graham, James R., Macintosh, Bruce, Beckwith, Steven V. W., Marois, Christian, Poyneer, Lisa A., Wiktorowicz, Sloane J. 2011, PASP, 123, 692

Two ten-billion-solar-mass black holes at the centres of giant elliptical galaxies
McConnell, Nicholas J., Ma, Chung-Pei, Gebhardt, Karl, Wright, Shelley A., Murphy, Jeremy D., Lauer, Tod R., Graham, James R., Richstone, Douglas O. 2011, Nature, 480, 215

A Type 1a Supernova within Hours of Explosion in the Pinwheel Galaxy
Nugent, P., Sullivan, M., Cenko, B., ..., Law. N., et al. 2011, Nature, 480, 344N

The ACS Survey of Galactic Globular Clusters XI: The Three-Dimensional Orientation of the Sagittarius Dwarf Spheroidal Galaxy and its Globular Clusters
Siegel, M.H., Majewski, S.R., Law, D.R., et al. 2011, ApJ, 743, 20.

The PTF Orion Project: Eclipsing Binaries and Young Stellar Objects
van Eyken, J., Ciardi, D., Rebull, L., ..., Law, N., et al. 2011, ApJ, in press

The ATLAS3D project – IV. The molecular gas content of early-type galaxies
Young, L.M., Bureau, M., Davis, T.A., Combes, F., McDermid, R.M., Alatalo, K., Blitz, L., Bois, M., Bournaud, F., Cappellari, M., Davies, R.L., de Zeeuw, P.T., Emsellem, E., Duc, P.-A., Khochfar, S., Krajnovic, D., Kuntschner, H., Lablanche, P.-Y., Morganti, R., Naab, T., Oosterloo, T.A., Sarzi, M., Scott, N., Serra, P., Weijmans, A. 2011, MNRAS, 414, 940

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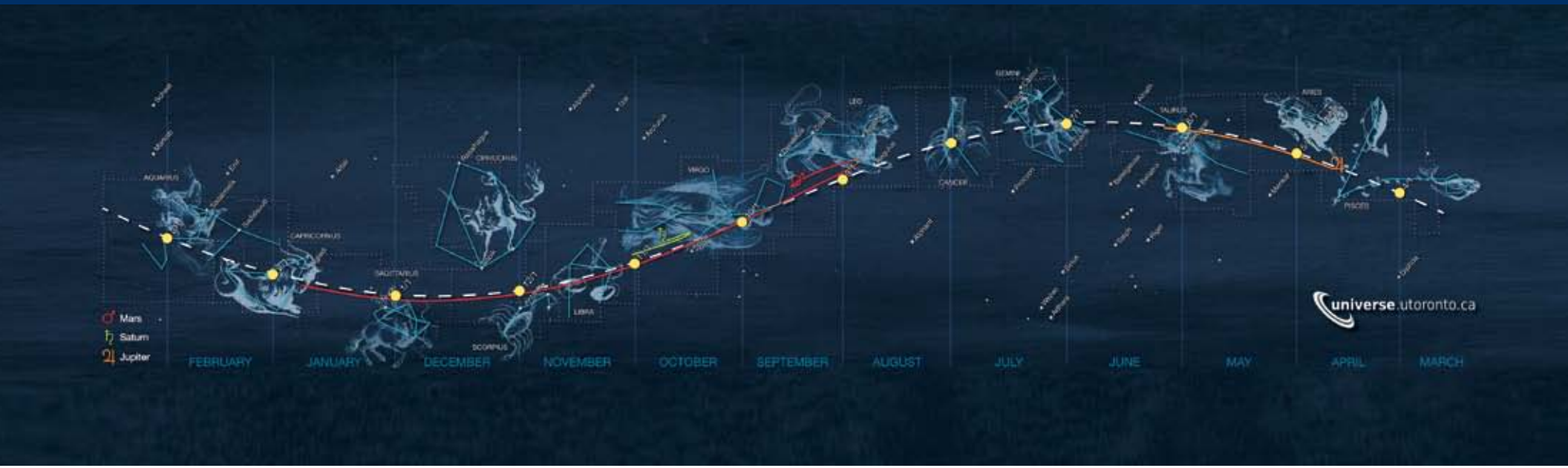

A banner on the side of the Astronomy Building shows passers-by the location of the Sun and planets in 2011 – 2012

Archival photographs of Clarence Chant, David Dunlap, Jessie Dunlap, and David Dunlap Observatory – The University of Toronto Archives: A1965-0004 (6B.27); A1974-0027; A1978-0041; B1994-0002

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