The MACRO Consortium Newsletter
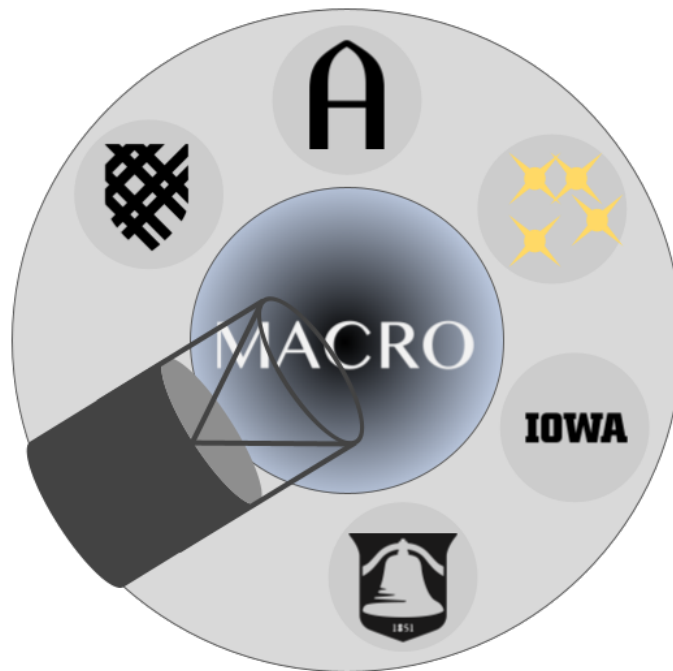
Volume 1
September 2023

The Macalester-Augustana-Coe Remote Observatory (MACRO) Consortium

In the spirit of discovery and with mutual interest in cooperation, friendship, and education, Macalester College, Augustana College, and Coe College have established a Consortium whose guiding principle is to operate a robotic telescope that is used primarily by students at small liberal arts colleges for education and research.

A New Era for the University of Iowa's Historic Remote Observatory

IOWA ⟹ MACRO
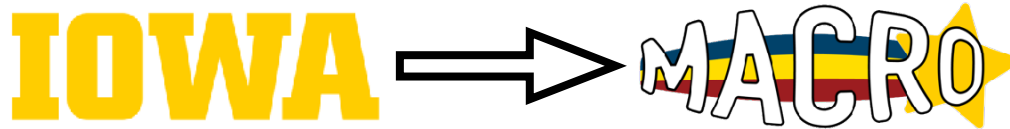
2023 has been a year of excitement and change. On January 1, the newly-formed MACRO Consortium took over stewardship of the Gemini Telescope, located at the Winer Observatory in southern Arizona. Gemini is a fully robotic optical observatory that represents the culmination of more than 25 years of work by Professor Emeritus Robert Mutel and dozens of students, staff, and faculty from the University of Iowa.

The first action of the MACRO Consortium was to change the name of the facility to the Robert L. Mutel Telescope (RLMT). This recognizes and pays tribute to the remarkable vision and tireless effort of Professor Mutel, who has been a pioneer in the field of robotic observatory design and operation. This technology allows students to use cutting edge astronomical data from telescopes that are located far away, enabling transformational classroom experiences and rigorous research projects.

The MACRO Consortium at the RLMT in February 2023. Left to right: John M. Cannon (Macalester College), William Peterson (Augustana College), Jack Kelley (University of Iowa), Will Golay (Univ. of Iowa), Robert Mutel (Univ. of Iowa), and Caroline Roberts (Univ. of Iowa).

Professor Mutel indicates the upward trajectory of the MACRO Consortium at the beginning of a hike through the Arizona grasslands. James Wetzel (Coe College) in foreground.

MACRO

Congratulations to Professor Mutel

After 45 years on the faculty at the University of Iowa, Robert Mutel began the transition into Emeritus status in 2020. Originally hired by Professor James Van Allen to establish a radio astronomy program at the University, Robert has enjoyed an illustrious career as a world-renowned scholar and a leader in the global astronomical community. His infectious curiosity has been a source of inspiration for the nearly 6,000 students who enrolled in his courses and for the dozens of graduate students and professional collaborators with whom he has worked.

Career highlights include the authorship of nearly 200 refereed scholarly manuscripts, the supervision of 14 PhD and 8 Masters theses, and the receipt of numerous teaching and innovation awards from the University of Iowa. Mutel Peak in Antarctica is named in his honor.

Retirement will allow Professor Mutel to focus on his passion for ultra cycling. Here he rides through Monument Valley in Arizona.

Meet the Institutional Leads
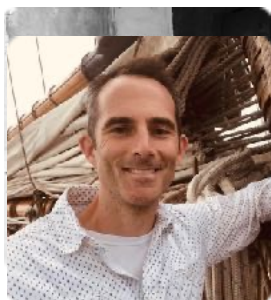
John M. Cannon
Professor of Astronomy
Macalester College
B.S. Univ. of Iowa 1999
PhD University of Minnesota 2004

After finishing his graduate studies, John worked as a postdoctoral researcher at the Max Planck Institute for Astronomy, as a postdoctoral researcher at Wesleyan University, and then moved to a faculty position at Macalester College. John collaborates with Macalester students on projects related to the physical properties of low-mass galaxies.

William Peterson
Professional Faculty Instructor of Physics
Augustana College
B.S. University of Iowa 2000
PhD University of Iowa 2011

Bill earned his doctorate from the University of Iowa in 2011, where he subsequently worked as an adjunct professor and astronomy lab coordinator for two years before taking his current position at Augustana College in the department of Physics, Engineering, and Astronomy. He has involved many students in his research of active binary stars and magnetic fields, and in his spare time plays keyboards in bands and builds synthesizers.

James Wetzel
Adjunct Assistant Professor of Physics
Coe College
B.S. University of Iowa 2008
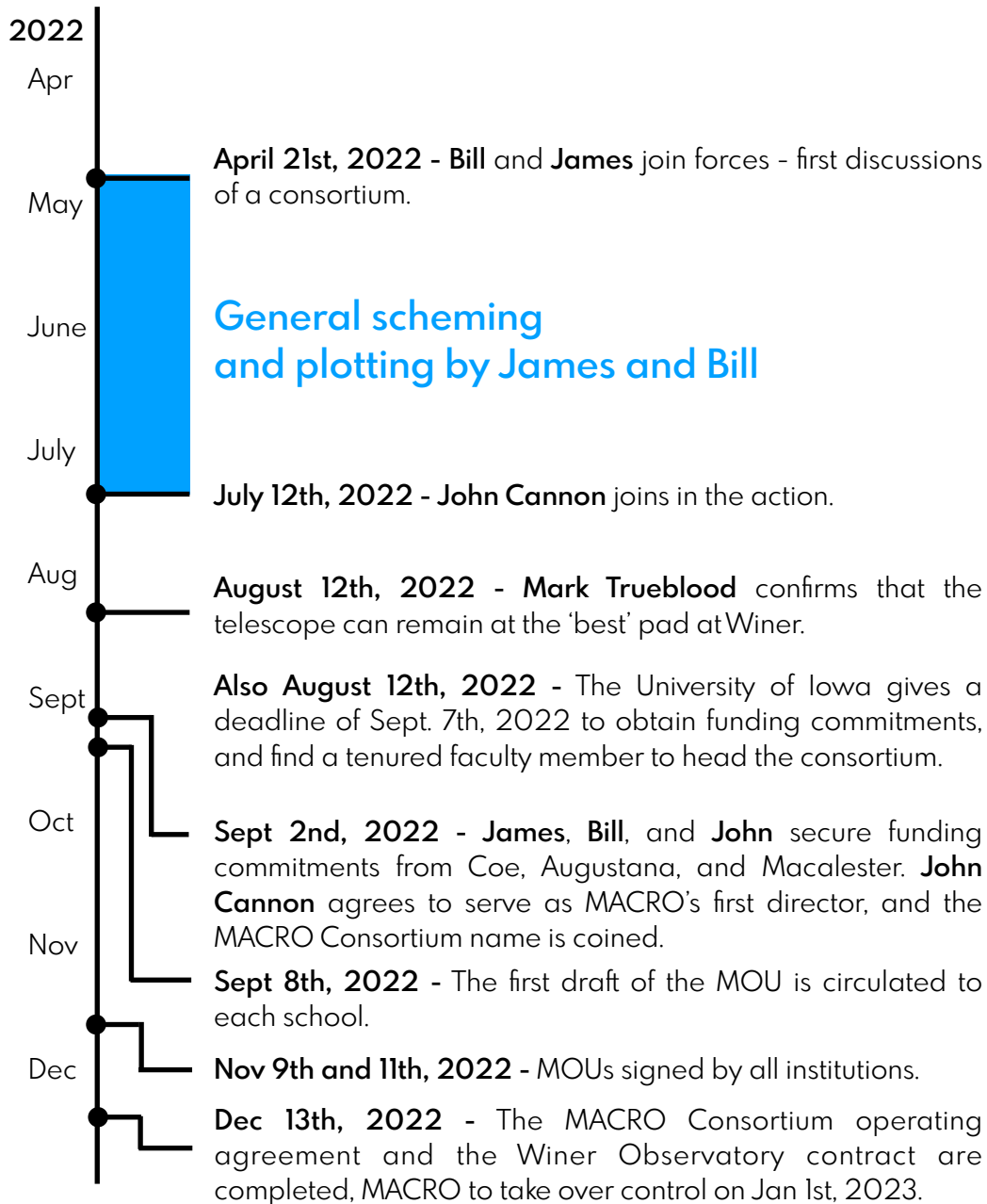PhD University of Iowa 2014

James is a scientist, professor, and entrepreneur, currently affiliated with both CERN and Fermi National Accelerator Laboratory where he is actively involved in the field of experimental particle physics. His main interest is in the design and testing of detectors, in particular hadronic and electromagnetic calorimeters. James has a passion for space and astronomy that he has brought to Coe by designing a general education astronomy course with lab component, which he loves to teach, and by helping to bring life to the MACRO Consortium!

John, Bill, and James are each very lucky to have worked with early versions of the robotic telescope systems at the University of Iowa. Bill and John accompanied Professor Mutel on the very first student trip to the Winer Observatory in early 1998.
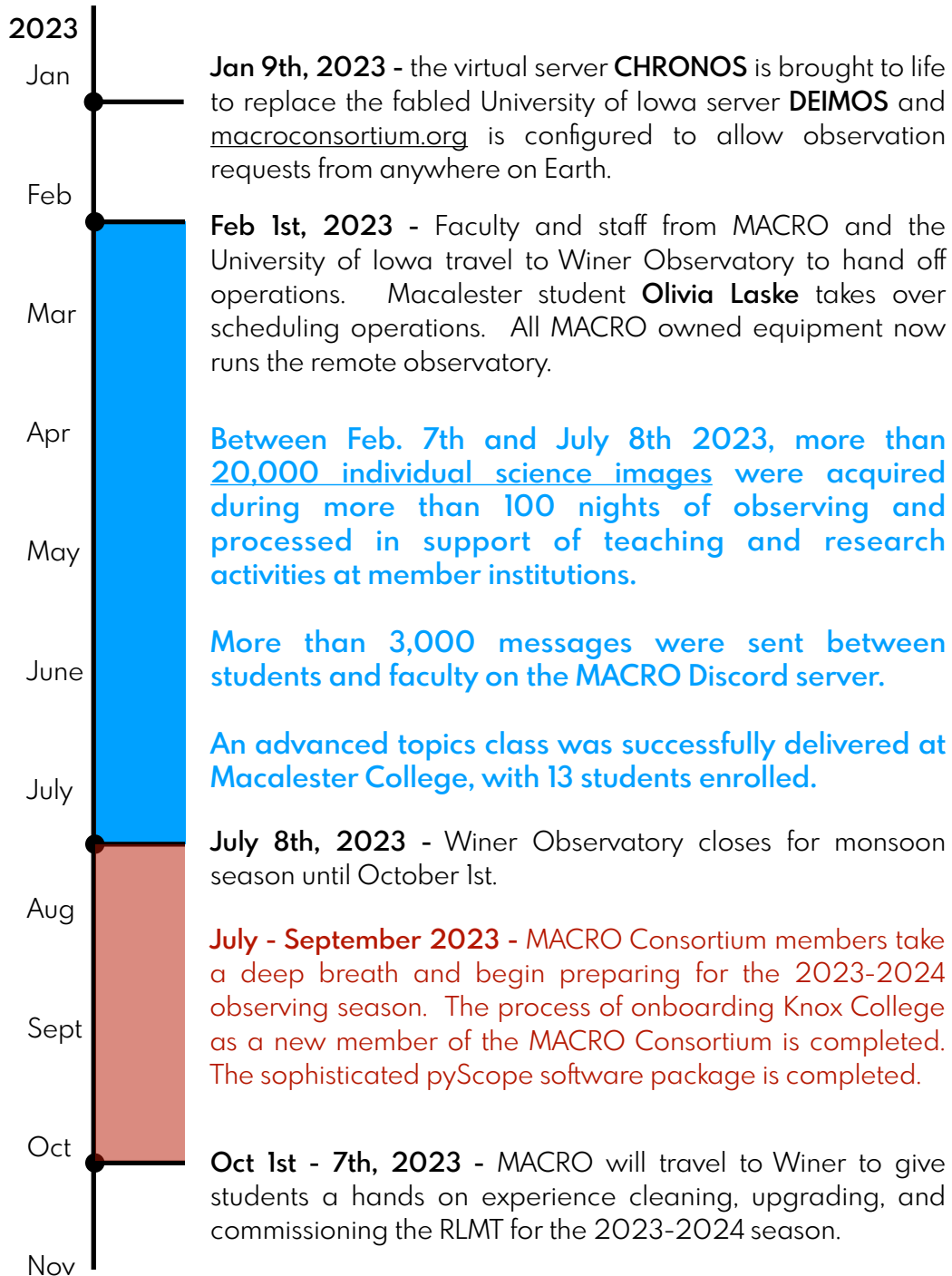
Bringing MACRO to Life

The first observing season of the RLMT was enormously successful. Starting in the spring of 2022, hard work by dozens of students, faculty, and staff at each of the member institutions allowed us to reach multiple milestones in a very short amount of time. Highlights include:

2022

Apr

April 21st, 2022 - Bill and **James** join forces - first discussions of a consortium.

May

General scheming and plotting by James and Bill

June

July

July 12th, 2022 - John Cannon joins in the action.

Aug

August 12th, 2022 - Mark Trueblood confirms that the telescope can remain at the 'best' pad at Winer.

Sept

Also August 12th, 2022 - The University of Iowa gives a deadline of Sept. 7th, 2022 to obtain funding commitments, and find a tenured faculty member to head the consortium.

Oct

Sept 2nd, 2022 - James, **Bill**, and **John** secure funding commitments from Coe, Augustana, and Macalester. **John Cannon** agrees to serve as MACRO's first director, and the MACRO Consortium name is coined.

Nov

Sept 8th, 2022 - The first draft of the MOU is circulated to each school.

Nov 9th and 11th, 2022 - MOUs signed by all institutions.

Dec

Dec 13th, 2022 - The MACRO Consortium operating agreement and the Winer Observatory contract are completed, MACRO to take over control on Jan 1st, 2023.

MACRO

Bringing MACRO to Life

2023

Jan

Jan 9th, 2023 - the virtual server **CHRONOS** is brought to life to replace the fabled University of Iowa server **DEIMOS** and macroconsortium.org is configured to allow observation requests from anywhere on Earth.

Feb

Feb 1st, 2023 - Faculty and staff from MACRO and the University of Iowa travel to Winer Observatory to hand off operations. Macalester student **Olivia Laske** takes over scheduling operations. All MACRO owned equipment now runs the remote observatory.

Mar

Apr

Between Feb. 7th and July 8th 2023, more than 20,000 individual science images were acquired during more than 100 nights of observing and processed in support of teaching and research activities at member institutions.

May

June

More than 3,000 messages were sent between students and faculty on the MACRO Discord server.

July

An advanced topics class was successfully delivered at Macalester College, with 13 students enrolled.

July 8th, 2023 - Winer Observatory closes for monsoon season until October 1st.

Aug

July - September 2023 - MACRO Consortium members take a deep breath and begin preparing for the 2023-2024 observing season. The process of onboarding Knox College as a new member of the MACRO Consortium is completed. The sophisticated pyScope software package is completed.

Sept

Oct

Oct 1st - 7th, 2023 - MACRO will travel to Winer to give students a hands on experience cleaning, upgrading, and commissioning the RLMT for the 2023-2024 season.

Nov

MACRO

Expanding the Footprint of MACRO

We are delighted to welcome **Knox College** into the MACRO Consortium! Located in Galesburg, IL, Knox is a prestigious private liberal arts college that enrolls more than 1,200 students from 45 states and 49 countries. The astronomy program thrives under the guidance of Professor Nathalie Haurberg, who has led the effort to install and commission a new 17-inch PlaneWave Astrograph telescope on the roof of the Umbeck Science-Mathematics Center on the Knox College campus. The MACRO Consortium will benefit from Professor Haurberg's extensive experience with telescope operations, observation planning, data analysis and interpretation, and student mentorship.

On September 1, 2023, Knox College joins the MACRO Consortium with "user" status. This entitles Professor Haurberg and members of the Knox community to a fixed fractional percentage of the observing time on the RLMT.

Nathalie Haurberg
Associate Professor of Physics
Knox College

Nathalie graduated from Knox College in 2006, and then completed her PhD in astronomy at Indiana University in 2013.

Professor Haurberg's research focuses on dwarf galaxies, which provide unique insights into understanding the earliest galaxies in the Universe, as well as crucial insights into how galaxies have evolved over time.

MACRO

MACRO Anchors Curricula at Member Institutions

In addition to facilitating research experiences, the RLMT allows instructors at each member institution to infuse cutting-edge astronomical data into their classes, at all levels of the curriculum. The examples that follow showcase the creativity of the MACRO Consortium faculty and the fidelity of the imaging and spectroscopic data that the RLMT provides.

Augustana College: The RLMT will be used for group projects by introductory astronomy students in the "Planets" and "Stars and Galaxies" courses this Fall and Spring, and by students following the Astronomy track in the upper-level "Advanced Numerical Techniques" course in the Spring. The RLMT is central to the new Astronomy minor at Augustana, which should be approved and added to the curriculum in Fall of 2024.

Coe College: James Wetzel and Coe College Assistant Professor Firdevs Duru will use RLMT data in the introductory class "Modern Astronomy" and in the advanced class "Introduction to Astrophysics".

Knox College: Professor Nathalie Haurberg will teach "Stellar Astrophysics" in the winter term and then "Observational Astronomy" in the spring term. RLMT data will be used in the former and will be a centerpiece of the latter.

Macalester College: Professor Anna Williams will teach a first year seminar in the fall of 2023 called "Our Solar System and Beyond". In their first semester on campus, fifteen students will use RLMT data to observe planets transit across other stars and to measure the rotation periods of small Solar System objects (asteroids). In the spring semester of 2024, Professor Williams and Professor Cannon will co-teach an advanced observational techniques class in which student research projects will be based on RLMT data.

The University of Iowa: Data from the RLMT will be used in the laboratory sections of introductory class "Stars, Galaxies, and the Universe" and also extensively for group projects in an advanced class "Observational Techniques in Astronomy" being taught in the fall semester.

The Consortium fosters inter-institutional interaction and collaboration. An upcoming example will occur in the spring semester of 2024, when an advanced observational techniques class is offered at both Macalester and Knox. Students from both institutions will work on collaborative projects that involve individuals from both communities.

Transformational Student Opportunities

One of the primary goals of the MACRO Consortium is to facilitate transformative research experiences for undergraduate students using the RLMT. This initiative hit the ground running in the spring semester of 2023, when the advanced topics class "Remote Observatory Operations" was offered at Macalester College. Thirteen astronomy emphasis majors worked alongside four Macalester College astronomy faculty members to undertake advanced research projects using RLMT data. The projects showcased the remarkable capabilities of the RLMT system; topics included transiting extrasolar planets, variable stars, active galaxies ("quasars"), and nearby star-forming galaxies. Results from selected projects are showcased later in this newsletter. One student wrote in the final course evaluation, "This class is pushing Macalester [and the other Consortium schools] a step ahead of other colleges in its capability for interesting astronomical science with high-quality data, and it was a real treat to be a part of."

The advanced topics class "Remote Observatory Operations", held at Macalester College in the spring semester of 2023. Top row, left to right: faculty (John Cannon, Anna Williams, Jay Gallagher, Brian Adams). **Middle row**, left to right: Joshua Marine '23, Ezra Wolf '23, Jackson Codd '23, Karlee Taylor '23, Margaret Shepherd '23, Ross Ferguson '23. **Bottom row**, left to right: Nick Cebula '24, Charlie Burton '24, Olivia Laske '24, Chloe Zheng '23, Aurora Hively '23, Bill Chen '23, Frank Sun '23.

Science Highlights

In the "Remote Observatory Operations" class offered at Macalester in the spring of 2023, one research group used the grism observing mode to acquire spectra of nearby active galaxies. These are systems that host an accreting supermassive black hole in the central region, resulting in extreme physical conditions where highly excited material orbits at thousand of kilometers per second. These objects serve as luminous beacons that allow us to study the distant universe.
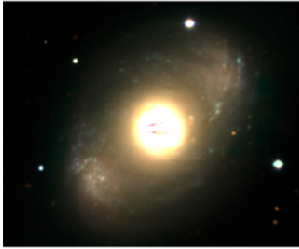
This color image of the active galaxy NGC4151 was obtained from the Sloan Digitized Sky survey (sdss.org). The very bright region at the center of the system is a "quasar" – an accreting supermassive black hole. Very energetic material orbits this object at high velocities, producing strong and broad emission lines.
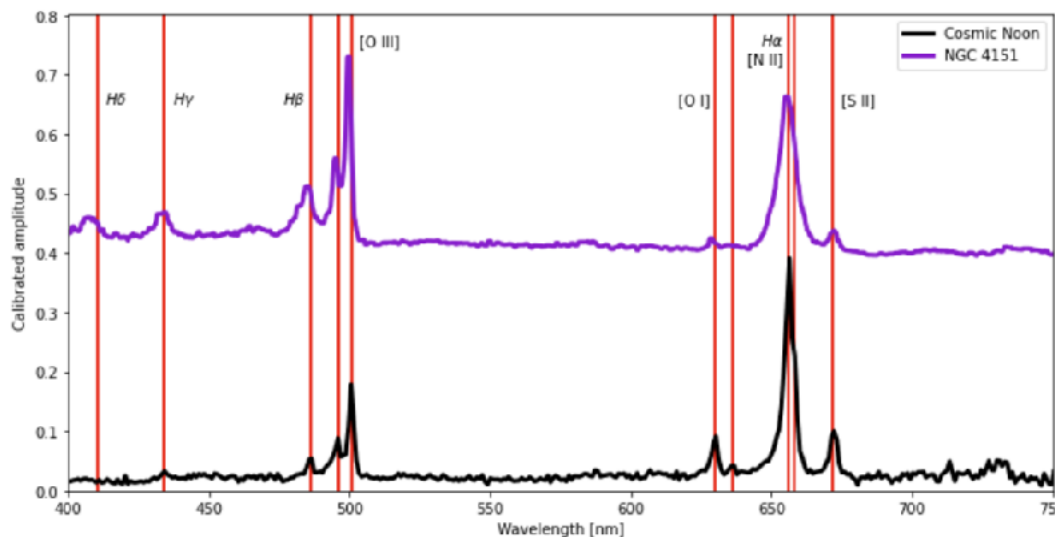
RLMT grism spectrum of NGC4151 (purple line), compared with a composite spectrum of a high-redshift galaxy using data from the James Webb Space Telescope (JWST - bottom panel; McKinney et al. 2023, Astrophysical Journal, 946, L39). Prominent emission lines are highlighted by the vertical red lines. Note the remarkable agreement between the RLMT spectrum and the JWST spectrum. The RLMT spectrum allows us to accurately measure the profiles of the broad emission lines, which reveal the physical conditions within the material in the central regions of this extreme object.

Grism spectroscopy is a unique capability of the RLMT system. Here, a low resolution spectrometer is housed in the filter wheel, using a design that was patented by Professor Mutel and Dr. Dominic Ludovici (PhD, University of Iowa, 2017; U.S. patent #62349200).

Science Highlights

Another group in the "Remote Observatory Operations" class used RLMT images to measure the transit of an extrasolar planet across the surface of its parent star. In this situation, the planet blocks a small fraction of the light from the star, thus decreasing its brightness for a period of time.
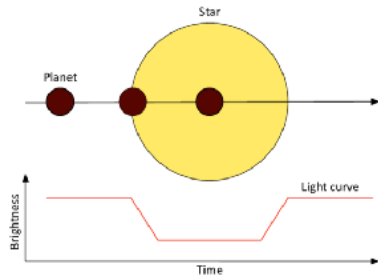
Pictorial representation of an extrasolar planet transit. The planet orbits the star; this motion is depicted as the planet being in three different positions from left to right. As the planet moves in front of the star, it blocks a fraction of its light, thus causing the observed brightness to fall during the event and then rise again after the transit ends.

RLMT transit observation of the extrasolar planet WASP-43b. The brightness of WASP-43 (the parent star; vertical axis) is plotted versus time (horizontal axis). The data clearly and unambiguously demonstrate a decrease in the brightness of WASP-43 over an interval of approximately 60 minutes. This timescale is in good agreement with published values of the transit duration of WASP-43b (e.g., Murphy et al. 2023, Astronomical Journal, 165, 107).
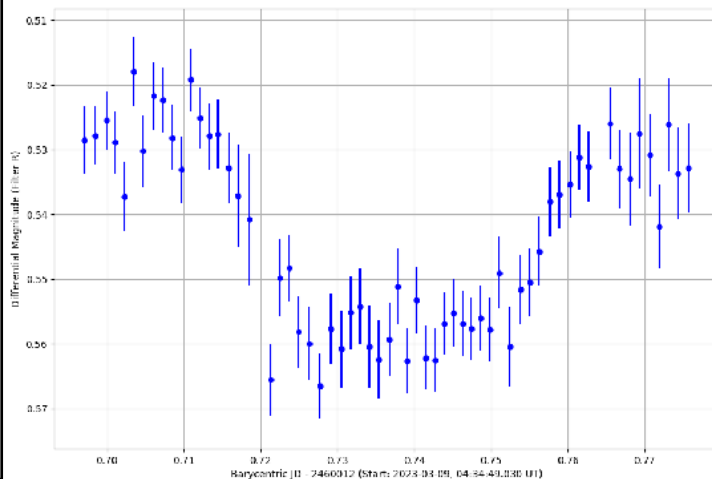
WASP-43b is a gas giant planet with a mass approximately two times larger than that of Jupiter. The parent star is cooler and less massive than our Sun. A "year" on WASP-43b is a remarkably short 19.5 hours – the planet is very close to its parent star and thus completes its orbit very quickly. The physical parameters of the WASP-43 system are taken from the Extrasolar Planet Encyclopedia (exoplanet.eu/catalog/WASP-43_b/).

Extrasolar planet transit science is a promising future area of exploration.

Imaging Highlights

The Coe College group, led by **James Wetzel**, combined RLMT images of famous objects to create majestic color mosaics. This image was produced by High School student Jaklyn Cook while working at Coe over the summer.

IC1396 - Elephant's Trunk Nebula

Cepheus Constellation

Stunning emission nebula IC 1396 mixes glowing cosmic gas and dark dust clouds in the high and far off constellation of Cepheus. Energized by the bright central star seen here, this star forming region sprawls across hundreds of light-years, spanning over three degrees on the sky while nearly 3,000 light-years from planet Earth. Among the intriguing dark shapes within IC 1396, the winding Elephant's Trunk nebula lies just below center. Stars could still be forming inside the dark shapes by gravitational collapse. -nasa.gov. This image comprises 25 images, totaling 3.5 hours, taken with the RLM Telescope at Winer Observatory in 2023.

Imaging Highlights

Coe College student **Amit Sharma** led the effort to learn the sophisticated image processing software that was used to create these mosaics.

B33 - Horsehead Nebula

Orion Constellation

The Horsehead Nebula in Orion is part of a large, dark, molecular cloud. Also known as Barnard 33, this nebula was first discovered in the late 1800s. The red glow originates from hydrogen gas behind the nebula ionized by the nearby bright star Sigma Orionis. The darkness is caused by thick dust. Streams of gas leaving the nebula are funneled by a strong magnetic field. The bright spots in the Horsehead Nebula's base are young stars just in the process of forming. - nasa.gov. The above image was produced by stacking 20 separate images totaling 8 hours taken with the RLM Telescope at Winer Observatory in 2023.

Imaging Highlights

High resolution versions of these posters are available for free download from the macroconsortium.org website.

## M42 - Orion Nebula

Orion Constellation

Believed to be the cosmic fire of creation by the Maya of Mesoamerica, M42 blazes brightly in the constellation Orion. Popularly called the Orion Nebula, this stellar nursery has been known to many different cultures throughout human history. The nebula is only 1,500 light-years away, making it the closest large star-forming region to Earth and giving it a relatively bright apparent magnitude of 4. M42 can be spotted with the naked eye, while offering an excellent peek at stellar birth for those with telescopes. - nasa.gov. The above image was produced by stacking 10 separate images totaling 4 hours taken with the RLM Telescope at Winer Observatory in 2023.

Imaging Highlights

High resolution versions of these posters are available for free download from the macroconsortium.org website.
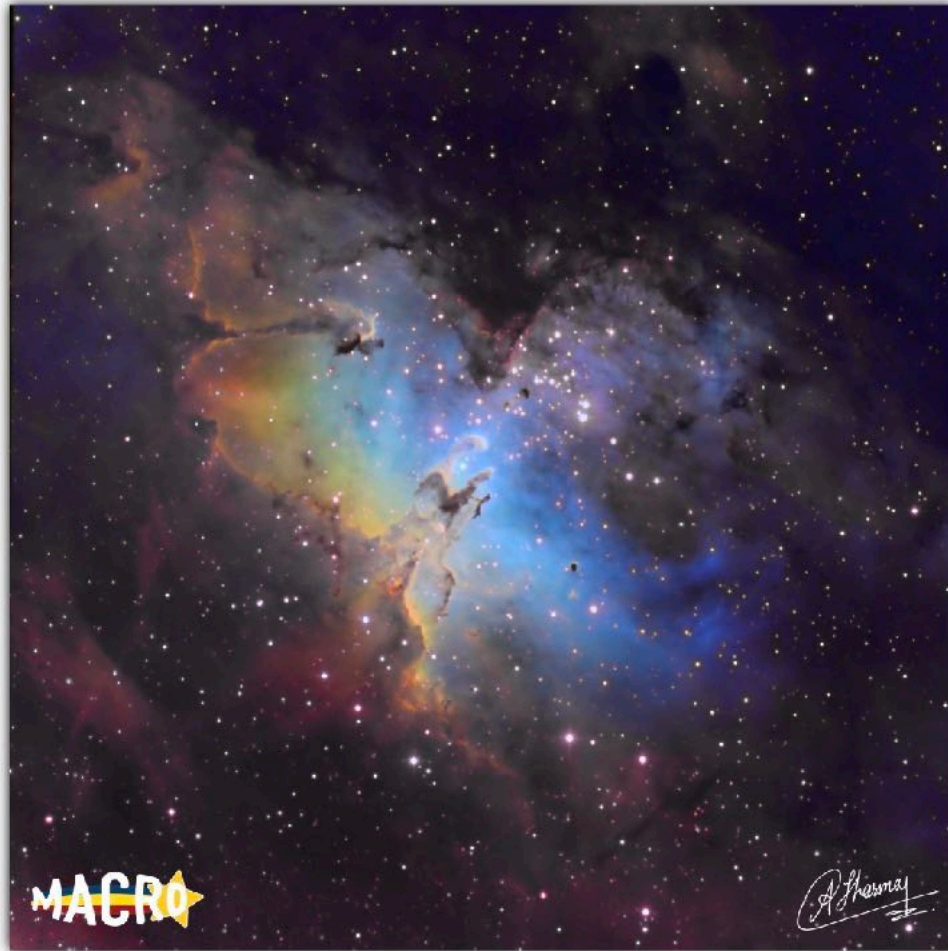
M16 - The Eagle Nebula

Serpens Constellation

Towering tendrils of cosmic dust and gas sit at the heart of the Eagle Nebula. The aptly named Pillars of Creation at the center of this picture are part of an active star-forming region within the nebula and hide newborn stars in their wispy columns. The blue colors in the image represent oxygen, red is sulfur, and green represents both nitrogen and hydrogen. The pillars are bathed in the scorching ultraviolet light from a cluster of young stars located just outside the frame.The winds from these stars are slowly eroding the towers of gas and dust. -nasa.gov. The above image was produced by stacking 30 separate images totaling 8.5 hours taken with the RLM Telescope at Winer Observatory in 2023.

New Observing Capabilities

During the 2023-2024 academic year, the observational capabilities of the RLMT will be expanded by the addition of two new pieces of instrumentation. These modes bring a level of sophistication to the RLMT that makes it truly unique.
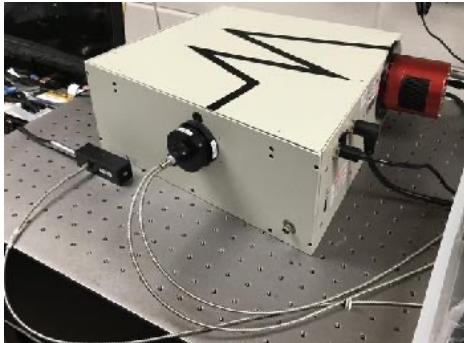
Fiber spectrometer: This Integral Field Spectrograph will allow the RLMT to acquire optical spectra of 19 regions of the sky simultaneously. This will enable detailed studies of spatially resolved objects, such as nebulae and galaxies. Multiple members of the Consortium are actively involved in the commissioning of this instrument.
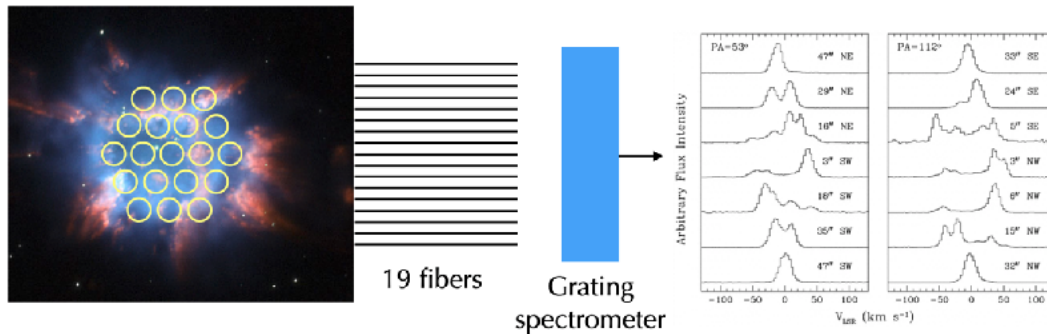
Demonstration of how the Integral Field Spectrograph will operate once on the RLMT. Light from each of 19 different regions (shown by the yellow circles) is directed by fiber optics (the silver cables in the top image) to the grating, which separates the light by wavelength and produces spatially resolved spectra as shown at the right.

High spectral resolution grism: we are currently in the design phase of a project to install a second grism observing mode on the RLMT. Like the spectra shown in the "Science Highlights" section, this new capability will allow us to study the spectral energy distribution from an object. This new design is an important step forward, as it enables detailed study a of narrow portion of the electromagnetic spectrum around the important $H\alpha$ emission line. This will enable novel investigations of gas kinematics, spectral line profiles, and many other topics.

MACRO Success Stories

The MACRO Consortium has benefitted from the hard work and expertise of many students during its first year. Below we showcase success stories that are representative of the transformative impacts that the RLMT provides.

Will Golay, B.S. University of Iowa 2023, first year graduate student in astrophysics at Harvard University. The MACRO Consortium will owe a permanent debt of gratitude to Will Golay. Having worked with the Iowa Robotic Telescope facilities throughout his undergraduate career, Will has a unique mastery of the RLMT system. He kindly and patiently coached each of the new Consortium members as they learned the intricacies and nuances of the system and grew into their new roles.

Will's undergraduate career is highlighted by many successes, including multiple awards from the Department of Physics and Astronomy and his lead authorship of a scholarly manuscript in a high-impact astrophysics journal (Golay, Mutel, et al. 2023, Monthly Notices of the Royal Astronomical Society, 522, 1394). Of perhaps even greater importance is Will's design and creation of the pyScope software package, which controls the RLMT. With pyScope, Will has created an amazing resource for the astronomical community. This software package (which is "open source", meaning that anyone can use it free of charge) effectively allows any telescope to be controlled robotically — a truly transformative capability that will certainly be implemented at multiple observatories around the world. Indeed, pyScope will be used at the on-campus telescopes of MACRO Consortium schools.

"Remote Observatory Operations":
While the MACRO Consortium is still young, we have already involved numerous students from the member institutions in research and educational projects using RLMT data. Many of these students aspire to continue on in astronomy or related graduate programs, some immediately and some after taking one or more "gap years" following their undergraduate studies. From the class of 2023, we congratulate each student who was involved in the "Remote Observatory Operations" class, and give special recognition to those individuals who are moving directly into graduate school:

Macalester College class of 2023:
Ross Ferguson, graduate program in astronomy, University of Minnesota
Aurora Hiveley, graduate program in mathematics, Rutgers University
Margaret Shepherd, graduate program in astronomy, University of Illinois
Frank Sun, graduate program in astronomy, Brown University
Chloe Zheng, graduate program in physics, the Ohio State University

Acknowledgements

The MACRO Consortium is indebted to many people at each institution for their enthusiastic support. In particular we would like to acknowledge the following individuals who were essential to establishing the Consortium, in order of engagement:

Support MACRO

The educational and research opportunities that the MACRO Consortium provides to undergraduate students are **made possible in large part by support from friends and donors**. More than twenty individual donors have stepped forward to date - thank you!!

Please consider making a contribution to the **MACRO Consortium fund**, which is used exclusively for the operation, maintenance, and improvement of the Robert L. Mutel Telescope, and to **facilitate student experiences that emerge from it**.

Gifts can be made online by visiting this link. Designate the gift to "**Other**", and then enter the **designation** comment "**In support of the MACRO Consortium**".

Alternatively, gifts can be arranged by communication with Theresa Gienapp, Interim Director of Philanthropic Giving at Macalester College, tgienapp@macalester.edu, 651.696.6087.

All gifts made in support of the MACRO Consortium are **tax deductible charitable contributions**.

Please note that Macalester College acts as the fiscal agent for the MACRO Consortium. Upon receipt, all gifts are immediately directed to the MACRO Consortium fund and can be used by all member institutions of the Consortium.

The MACRO Consortium at the RLMT in February 2023.

Further Information

If you would like to learn more about the MACRO Consortium, then please feel free to contact any of us via the methods outlined below. We are excited about MACRO and would be delighted to share this passion with you!

Augustana College:
· William Peterson, Professional Faculty Instructor of Physics, williampeterson@augustana.edu

Coe College:
· James Wetzel, Adjunct Assistant Professor of Physics, jwetzel@coe.edu

Knox College:
· Nathalie Haurberg, Associate Professor of Physics, nhaurberg@knox.edu

Macalester College:
· John M. Cannon, Professor of Astronomy, jcannon@macalester.edu
· Brian Adams, Observatory Manager, adams@macalester.edu
· Anna Williams, Assistant Professor of Astronomy, alwilliams@macalester.edu

University of Iowa:
· Caroline Roberts, Observatory Manager, caroline-roberts@uiowa.edu

The MACRO Consortium at the RLMT in February 2023.

MACRO