The MACRO Consortium Newsletter

Volume 2
September 2024

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, Coe College, Knox College, and the University of Iowa 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.

MACRO

A Stellar Year for the MACRO Consortium

The 2023-2024 observing season was an enormous success for everyone in the MACRO Consortium. Since Volume 1 of the newsletter was published in September 2023, students, staff and faculty have been engaged in a wide variety of projects which will be described throughout this newsletter. The Robert L. Mutel Telescope (RLMT) underwent major upgrades during this time period, including a new camera, a new telescope backend, and a new observing capability. The RLMT is operating smoothly and enabling cutting-edge educational and research opportunities for students at each of the member institutions.

Color image of NGC2903 taken with the newly upgraded RLMT.

Image credit: Alexis Riggs (Knox College).

Please read on to learn about the transformative experiences that MACRO is providing to students at each institution!

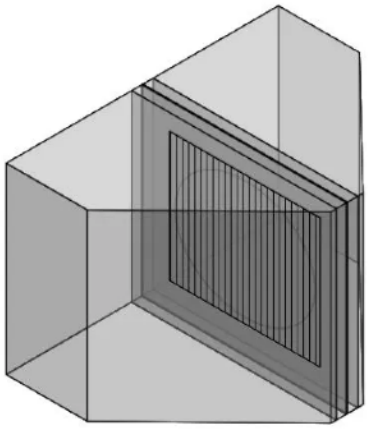
With gratitude,
John M. Cannon
Director, MACRO Consortium
September 2024

A Unique Observing Capability: The H-alpha Grism

One of the distinguishing strengths of the RLMT is its unique suite of instrumentation. Foremost among these is the ability to switch the observing mode from imaging to spectroscopy quickly. This procedure is usually time consuming, often requiring human intervention to move components or similar. Thanks to the vision of Professor Mutel and Dr. Dominic Ludovici, the RLMT can make this change with the click of a button. Professor Mutel and Dr. Ludovici patented the "compact grism spectrometer" (hereafter, "grism"), in which a dispersive element is housed within a conventional filter wheel (see U.S. patent number 10345496 and this journal article).

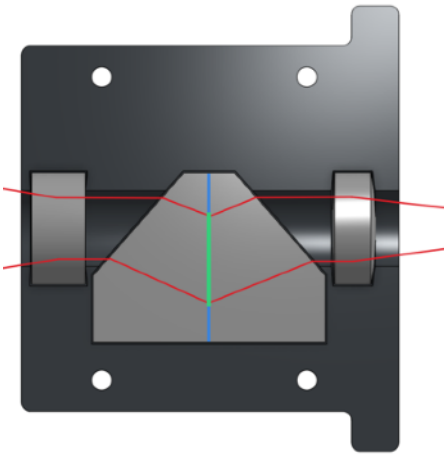
The RLMT already has a "low resolution" grism observing mode. As showcased in the first volume of the MACRO Newsletter, the low-resolution grism delivers sensitive spectral capabilities in the wavelength range of 400 to 650 nanometers. With a spectral resolution of ~400, low-resolution grism data enables students to study stars and galaxies.

Building on the success of the low-resolution grism, the MACRO Consortium envisioned a "high-resolution" version that disperses the light more than the low resolution version, albeit over a more narrow wavelength range. This "H-alpha grism" is designed to observe the Balmer alpha line ("H-alpha") of neutral hydrogen - one of the most powerful spectral lines in the optical regime and a critical spectral transition for studying a wide variety of astrophysical phenomena. Importantly, the high spectral resolution (~3000) allows us to extract kinematic information from the shape of the H-alpha spectral line.



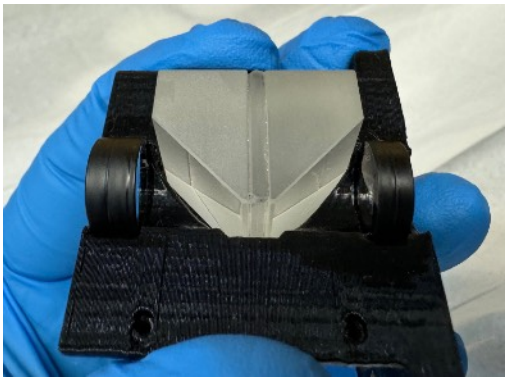
Left: Isometric drawing of the H-alpha grism.

Right: Schematic view of the H-alpha grism. Red lines indicate two optical paths for light at 656 nanometers.



A Unique Observing Capability: The H-alpha Grism

It is important to stress that the H-alpha grism was designed by members of the MACRO Consortium. The dispersive element was commissioned and fabricated by Wastach Photonics using a detailed proposal created by our team. Once received, the dispersive element was placed into its housing, which was designed and then 3-D printed by the MACRO Consortium.



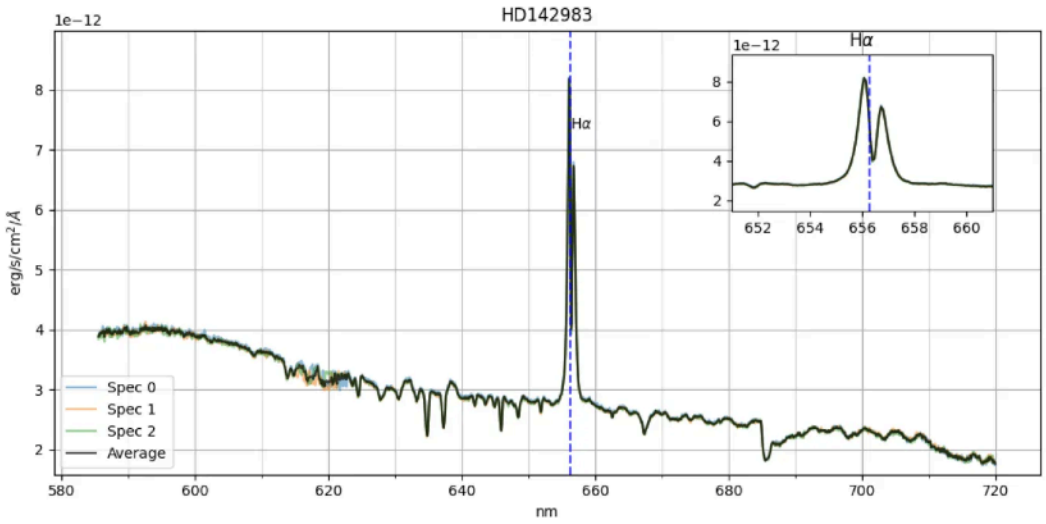
A MACRO team member holds the H-alpha grism during the installation process. The H-alpha grism consists of a 2000 line per mm grating sandwiched between two 44.2 degree prisms. By refracting light back onto an optical path that is parallel to the axis of the telescope after passing through the grating, the wavelength range of interest (around the H-alpha spectral line) lands on the detector with minimal aberration.

The primary RLMT filter wheel, which holds both the imaging filters and the two grisms (indicated by arrows). With the click of a button, the RLMT can switch between imaging and either of tow spectroscopic modes.

With two powerful grism observing modes, the *RLMT* is a highly versatile discovery engine.

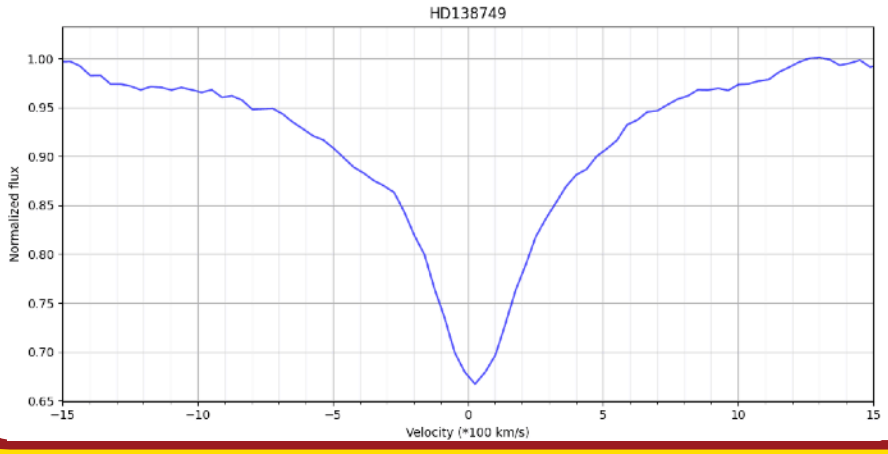
H-alpha Grism Science Demonstration: Emission Line Stars

One of the primary science drivers for the H-alpha grism is to probe the complicated physics of "Be stars". These stars are hotter and more massive than our Sun. Their distinguishing characteristic is very rapid rotation, which causes material to be ejected from the star and subsequently to establish a disk of hot material around the star. This disk can appear in spectra as an emission feature. This is opposite to what is seen in most stellar spectra (e.g., the Sun), where effectively all spectral lines are in absorption. The H-alpha grism on the RLMT is a powerful new tool with which to investigate the properties of Be stars.



H-alpha grism spectrum of emission-line star HD 142883. The zoomed inset shows a double-peaked H-alpha emission line from material being ejected from the rapidly-rotating star.

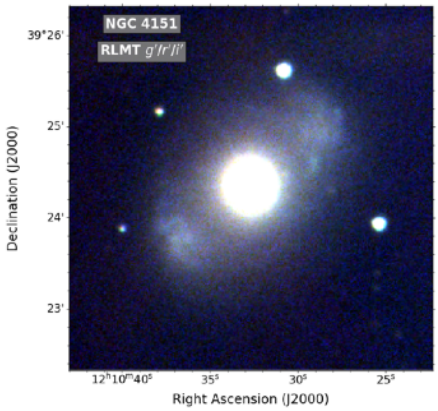
A major observing program is now underway to monitor ~100 Be stars for variability. Preliminary results already show that individual sources have dynamic H-alpha profiles.



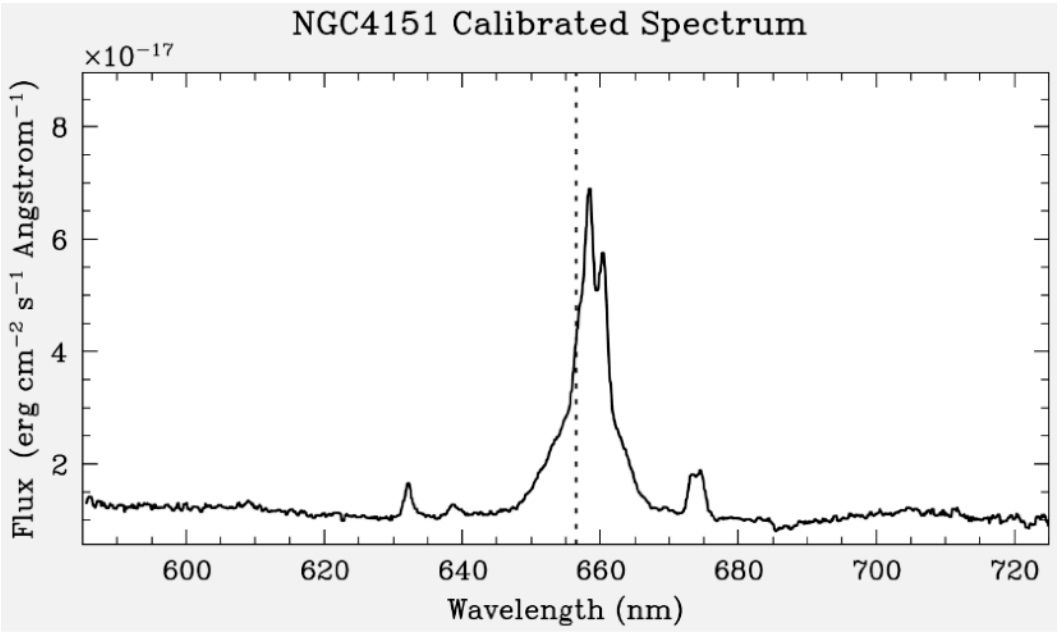
Normalized H-alpha grism spectrum of emission-line star HD 138749 (note the x-axis shows velocity). This star has transitioned from emission to absorption over a ~10 year timescale (Catanzaro et al. 2013).

H-alpha Grism Science Demonstration: Active Galactic Nuclei ("Quasars")

The sensitivity and spectral resolution of the H-alpha grism make it an ideal tool with which to explore "active galactic nuclei". These are galaxies whose central supermassive black holes host disks of material that rapidly rotate about the black hole and that launch powerful "jets" - beamed emission that allows the objects act as beacons from the distant universe. The H-alpha grism allows us to explore the composition and kinematics of the gas in these accretion disks in detail.



RLMT color image of NGC4151, an active galaxy located approximately 52 million light years away. The very bright nuclear region resides within an extended spiral disk.



H-alpha grism spectrum of NGC4151. The H-alpha line is multi-peaked, indicating rapidly rotating gas in close proximity to the supermassive black hole. Various emission lines are detected, including species of nitrogen, iron, sulfur, and oxygen.

MACRO

MACRO in the Classroom

"Observational Astronomy" at Macalester, Spring 2024
Professors Williams and Cannon co-taught a group of six students. A long-term RLMT observing project was completed by each individual. The range of topics was impressive: cataclysmic variable stars, exoplanets, globular clusters, and supernovae. The Macalester group visited the RLMT over spring break; during this visit they performed various maintenance and upgrade tasks, observed targets for projects, toured facilities at Kitt Peak National Observatory and the University of Arizona's Richard F. Caris Mirror Lab, and enjoyed the surreal beauty of southern Arizona.

Each of the enrolled students presented the results of their class research project at the 244th Meeting of the American Astronomical Society in June 2024 (see section below).

Macalester College group at the RLMT, March 2024. Back row (left to right): Brian Adams (staff), Nick Cebula (course preceptor), Matthew Brodsky (enrolled student), and Will St John (enrolled student). Front row (left to right): John Cannon (faculty), Edward Wallace (enrolled student), Anna Williams (faculty), Kalev Murray-Rouse (enrolled student), Cain Rinkoski (enrolled student), Caedan Miller (enrolled student), and Olivia Laske (course preceptor).

MACRO in the Classroom

"Observational Astronomy" at Knox, Spring 2024

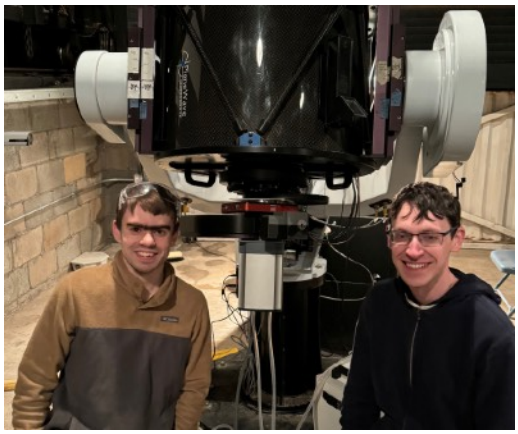
Professor Haurberg taught an Observational Astronomy course of 7 students in the Spring term of 2024. The class relied heavily on observational data collected from the RLMT and the local Knox Observatory. As part of a lab, RLMT images of the open cluster NGC 6694 were used by the entire class to create color magnitude diagrams. In addition, all students completed individual observing projects using data collected from either the Knox Observatory or the RLMT. Projects utilizing RLMT data included determining asteroid rotation periods, measuring galaxy surface brightness profiles, and calculating the light curves for eclipsing binary stars. Some of this work was presented at the 244th American Astronomical Society meeting in June (see below).

Knox College group at the AAS, June 2024. Left to right: Naysha Jain (enrolled student), Nathalie Haurberg (faculty), J. Alex Fluegel (staff), Alexis Riggs (enrolled student), and Lauren Wittry (enrolled student).

New Camera and Backend

During the spring 2024 semester, the members of the MACRO Consortium upgraded the camera on the RLMT. The previous "CMOS" camera was replaced by a high-performance "CCD" camera. This CCD camera (a science grade Andor iKon-L 936) was previously acquired by the University of Iowa, but its use was precluded by hardware limitations. Specifically, the weight of the camera made it difficult for the telescope "backend" (everything after the mirrors) to be able to focus. With the arrival of a more robust focuser on the market, the possibility of deploying the Andor CCD became viable.

MACRO Consortium members Philip Griffin and Alex Fluegel led the Herculean effort to design a new backend system that would allow the RLMT to use the new focuser and camera. As part of the redesign, Philip and Alex also implemented multiple versatile new capabilities. These included the addition of a second filter wheel (to enable broad-band color imaging) and a pick-off system that will be used by the future "Integral Field Spectrograph" (see section below).



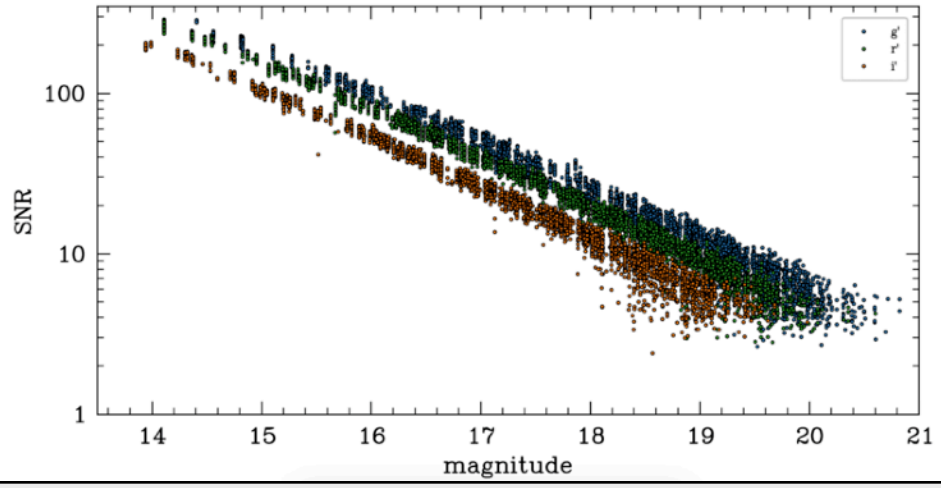
Alex Fluegel (left) and Philip Griffin (right) in front of the newly-redesigned telescope backed.

The camera upgrade was made possible by generous support from Dr. David Fowler (Macalester College class of 1975).

The installation of the new RLMT backend at Winer Observatory (April 2024). Left to right: John Cannon (Macalester), Dr. David Fowler (Macalester Class of 1975), Alex Fluegel (Knox), Philip Griffin (University of Iowa), Robert Mutel (University of Iowa), and Will Golay (Harvard University).

New Camera and Backend: Performance

The new camera and backend are performing well. An ethylene glycol chiller system enables the camera to hold a constant operating temperature of -80 degrees C. At this temperature the system performance is limited by source or sky Poisson noise.



Plot of signal-to-noise ratio as a function of stellar magnitude in 60-second integration images in the Sloan g', r', and i' filters using the new Andor CCD camera. In most cases we are dominated by a source's Poisson noise or by the sky's Poisson noise at faint magnitudes. The detector-generated noise makes only a negligible contribution.

RLMT image of the aptly chosen Hercules galaxy cluster using the newly upgraded Andor camera and the backend. Many dozens of individual galaxies are visible in this image.

MACRO

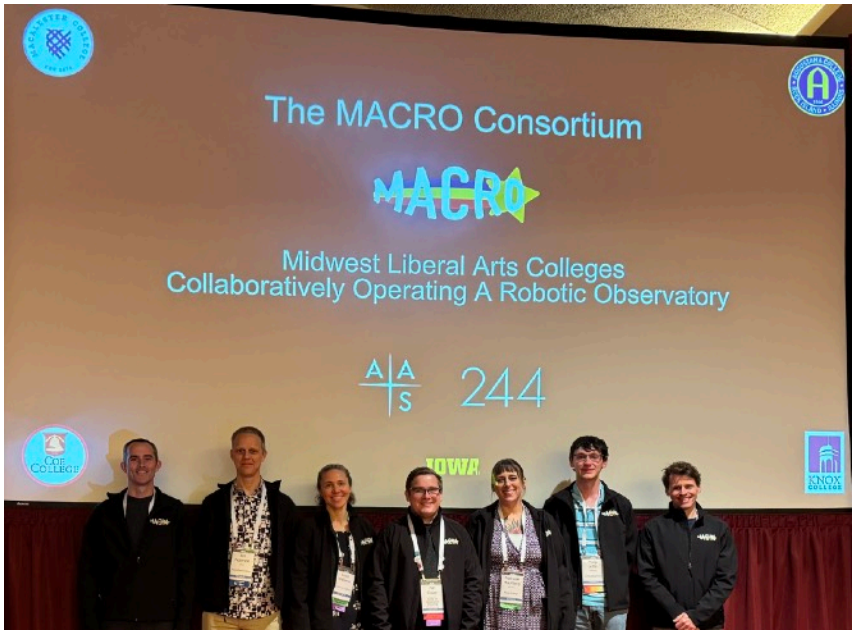
The 244th Meeting of the American Astronomical Society

The MACRO Consortium was selected by the Vice Presidents of the American Astronomical Society ("AAS") to host a "special session" at its 244th meeting ("AAS244"), which was held in Madison, WI, in June 2024. The "special session" consisted of a dedicated 90-minute oral presentation and a supporting poster session.

MACRO seized this opportunity to showcase the educational and research endeavors which define our collaboration to the many hundreds of professional astronomers in attendance. It was an important milestone that brought the majority of the members of our consortium together to celebrate a successful year of operations.

The MACRO Consortium at AAS244.

The 244th Meeting of the American Astronomical Society: Oral Presentations



MACRO speakers at AAS244. Left to right: John Cannon (Macaletser), William Peterson (Augustana), Anna Williams (Macalester), Will Golay (Harvard), Nathalie Haurberg (Knox), Philip Griffin (Iowa), James Wetzel (Coe).

John M. Cannon: "The MACRO Consortium And The Robert L. Mutel Telescope"

Walter W. Golay: "Robotic Telescope Software Development With The Consortium's Robert L. Mutel Telescope: Pyscope"

William L. Peterson: "Tools For Optical Path Spectroscopy On MACRO's Robert L. Mutel Telescope"

James Wetzel: "Imaging Capabilities Of The MACRO Consortium's Robert L. Mutel Telescope"

Philip Griffin: "MACRO's Next Generation Capabilities: An Integral Field Spectrometer For The Robert L. Mutel Telescope"

Nathalie Haurberg: "The Diversity Of Research At MACRO: Scientific Highlights"

Anna L. Williams: "RLMT In The Classroom: Integrating Robotic Observations Into Undergraduate Curricula"

The 244th Meeting of the American Astronomical Society: Student Posters

The AAS special session featured **twenty** research posters, fourteen of which were led by undergraduate students as the first author.

Cain Rinkoski (Macalester '25): "A Detailed Photometric And Spectroscopic Study Of Cataclysmic Variable ST LMi"

Alexis Riggs (Knox '24): "Composite Color Imaging From The Robert L. Mutel Telescope"

Lila Schisgal (Macalester '25): "Star Formation In The Dwarf Irregular Galaxy Cassiopeia 1: Comparing VLA AND RLMT Imaging"

Emma Motley (Augustana '27): "H-Alpha Observations Of The Long Decay Nova V1405 Cas"

Will St John (Macalester '26): "King-Fitted Structural Parameters Of ~10 Globular Clusters Observed With The RLMT"

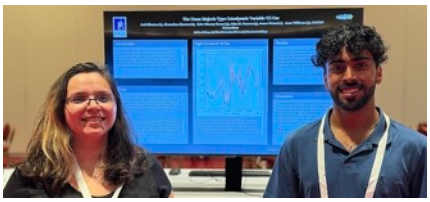
Abigail Kimber (Augustana '26): "A High-Resolution H-Alpha Prism-Grating Spectrometer For A Small Telecope"

Caedan Miller (Macalester '25): "Exoplanet Transits With The RLMT"

The 244th Meeting of the American Astronomical Society: Student Posters

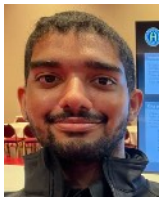
A truly remarkable breadth of science presented in the student posters!

Olivia Laske (Macalester '24): "The First Spectroscopic Results Of Extragalactic Objects With The RLMT High Resolution H-Alpha Grism"



Alexandrea Moreno (Iowa '27, Coe REU '24) and Amit Sharma (Coe '25): "The Ursae Majoris Type Cataclysmic Variable YZ Cnc"

Naysha Jain (Knox '26) and Edward Wallace (Macalester '25): "Eclipsing Binaries: Insights Into Stellar Properties"



Emma Biskie (Augustana '27): "Paradigm Shifting Observations Using A Small Student Telescope"

Nick Cebula (Macalester '24): "An Intriguing Candidate Double Star Observed With The Robert L. Mutel Telescope"

Matthew Brodsky (Macalester '26): "Photometric Monitoring Of Optical Transients With The Robert L. Mutel Telescope"

Abigale Gentry (Augustana '26): "Measuring The Mass Of Giant Planets Using A Small Telescope As An Educational Tool"

MACRO

The 244th Meeting of the American Astronomical Society: Additional Posters

Additional posters contributed by other MACRO Consortium members:

Will Golay (Harvard): "Characterizing And Commissioning The Robert L. Mutel Telescope At Winer Observatory"

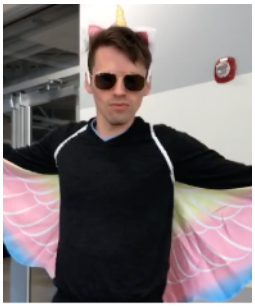
"Pyscope: An Open-Source Python Package For Robotic Operation Of Meter-Class Telescopes"

William Peterson (Augustana): "A Cloud Server As A Platform For A Multi-Institution Astronomical Observatory Collaboration"

J. Alex Fleugel (Knox): "Empowering Educational Collaboration: Advancing Technical Capabilities Through Integration High-Resolution Imaging Spectroscopy At The MACRO Consortium's Robert L. Mutel Telescope"

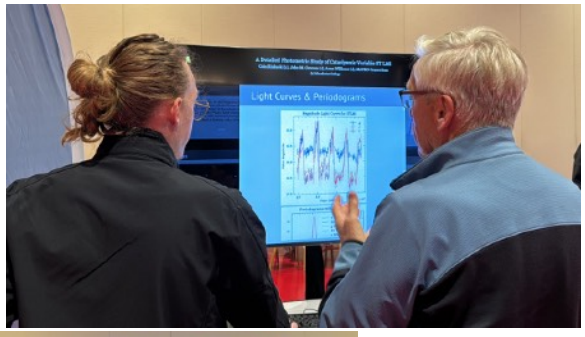
Brian Adams (Macalester): "Asteroid Photometry And Light Curves With The Robert L. Mutel Telescope"

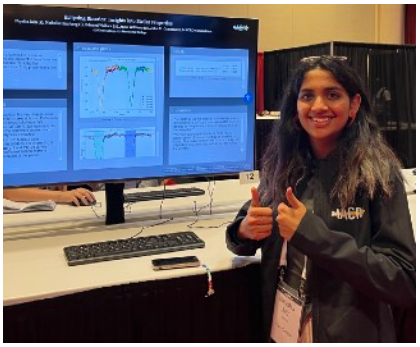
Anna L. Williams (Macalester): "The First Spectroscopic Results Of Stellar Objects With The RLMT High Resolution H-Alpha Grism"

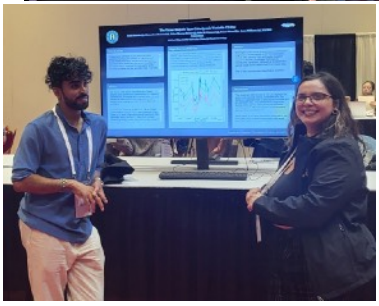


James Wetzel (Coe College): "Measuring the Mass of Giant Planets using a Small Telescope as an Educational Tool"

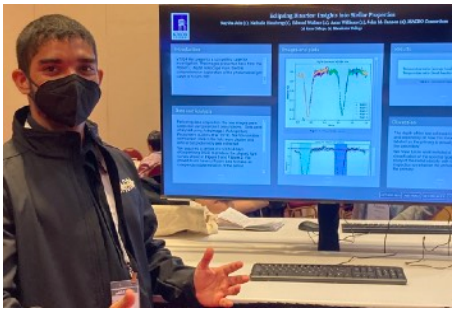
The 244th Meeting of the American Astronomical Society

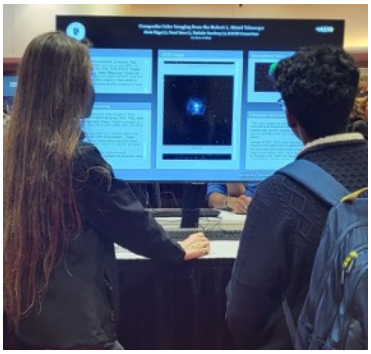


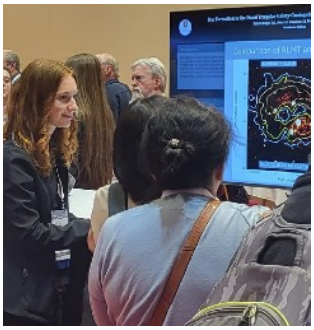


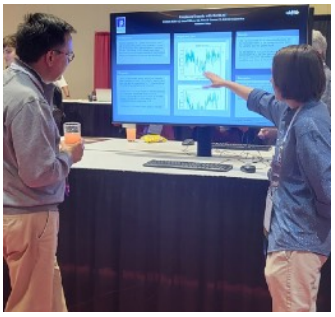


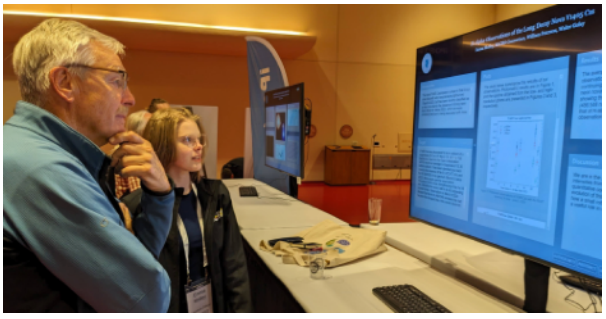
MACRO students present posters at the 244th Meeting of the American Astronomical Society.











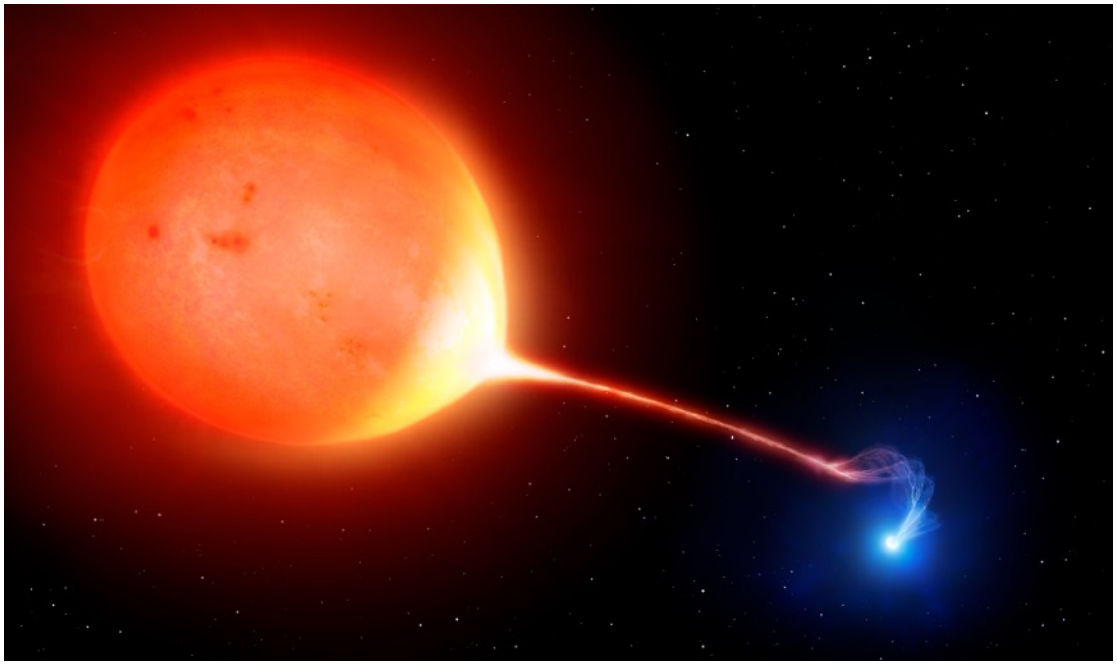
Access to all posters, talks, and more can be found at macroconsortium.org/aas-244

The Inaugural MACRO Summer Program

In the summer of 2024 we launched the inaugural "MACRO Summer Program". The goals of the program are as follows:

- Provide an immersive research experience for any interested student from any institution in the MACRO Consortium
- Showcase the capabilities of the RLMT to enable cutting-edge research programs that result in student-led publications
- Give students the opportunity to be exposed to different areas of observational astrophysics by analyzing RLMT data alongside data from other regions of the electromagnetic spectrum
- Give faculty the opportunity to publish with students using RLMT data

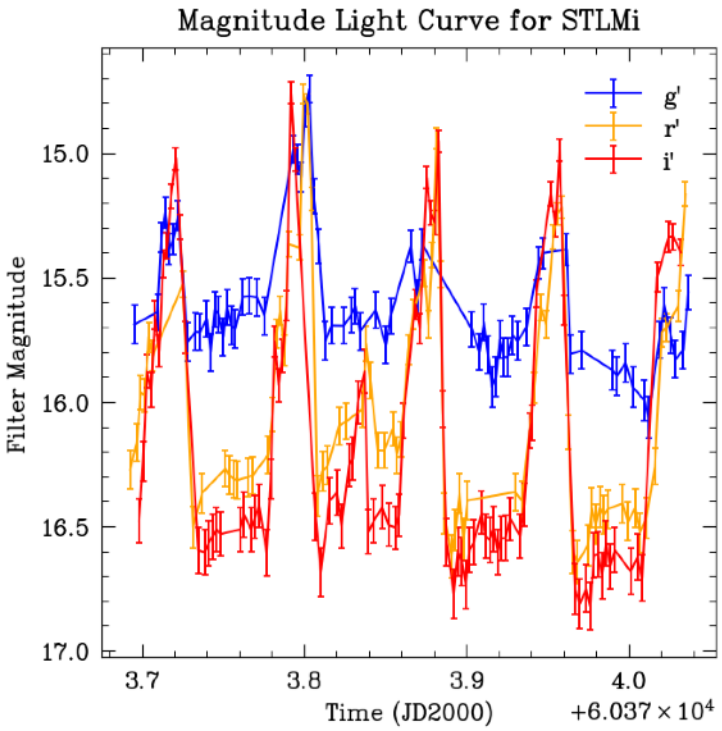
The scientific theme of the 2024 program was "polars". These are magnetically active binary star systems that consist of a compact white dwarf (which will eventually be the final state of our own Sun) and another low-mass star. The white dwarf has a strong magnetic field which results in collimated mass exchange between the two stars and also in strongly polarized emission (hence the moniker "polar"). An artist's rendition of a polar is shown below (image used with permission from the author, Dr. Mark Garlick; https://www.markgarlick.com/).



Artist's representation of a Polar, a type of cataclysmic variable where mass is being exchanged between a white dwarf (right) and a low-mass star (left). The strong magnetic field of the white dwarf channels material and no accretion disk is able to form. The two stars orbit their common center of mass on typical timescales of a few hours, causing their optical, radio, and x-ray brightnesses to change rapidly. Image used with permission from the author (Dr. Mark Garlick; https://www.markgarlick.com).

The Inaugural MACRO Summer Program: "Simultaneous RLMT and VLA Imaging of the Exotic Polar ST LMi"

The specific polar that was studied in this program, ST LMi, was selected based on results from a student class project in Macalester College's "Observational Astronomy" class in the spring 2024 semester. Cain Rinkoski (Macalester '25) acquired time-series imaging of ST LMi throughout the spring semester in order to measure the photometric variability of the system. Cain's analysis revealed dramatic changes in the brightness of the source (see Cain's AAS poster for more details).



RLMT light curves of the exotic polar ST LMi, constructed using imaging in the Sloan filters acquired on March 4, 2024. Periodogram analysis reveals an optical timescale of ~112 minutes. ST LMi shows strongly wavelength dependent brightness variations. Analysis and images created by Cain Rinkoski, Macalester College class of 2025.

The intriguing optical variability of ST LMi strongly motivates a detailed examination of the properties of the source across the electromagnetic spectrum. Radio observations of magnetically active binary star systems are particularly useful for revealing the origin of the emission at wavelengths much longer than those in the optical (which can often originate from different mechanisms).

The Inaugural MACRO Summer Program: "Simultaneous RLMT and VLA Imaging of the Exotic Polar ST LMi"

In order to study the radio properties of ST LMi, in April 2024 we applied for observations with the National Radio Astronomy Observatory's Very Large Array ("VLA" - one of the most powerful radio interferometers in the world) via the "Observing for University Classes" program. The request specified that the VLA dataset would be showcased in the inaugural "MACRO Summer Program". This request was approved, and the 2.5-hour VLA observation was executed on May 8.

Image of the VLA near Socorro, New Mexico. The VLA consists of 27 individual radio telescopes (each of diameter 25 meters) that operate together to simulate one much larger telescope. Image taken by John M. Cannon.

The MACRO Consortium's guaranteed access to the RLMT allowed the necessary scheduling flexibility to be able to begin observing ST LMi while the VLA observation was in progress. This allowed the creation of a truly unique dataset.

The RLMT and the VLA observed ST LMi simultaneously!

With simultaneous optical and radio datasets, we have the opportunity to study the optical and the radio variability timescales in this exotic source without any ambiguity resulting from temporal offsets between the datasets. The stage was set for a unique student research experience!

The Inaugural MACRO Summer Program: "Simultaneous RLMT and VLA Imaging of the Exotic Polar ST LMi"

The inaugural MACRO Summer Program was wildly successful. Students and faculty members from all member institutions met (virtually) every day over the course of multiple weeks during the summer. For multiple students, this was their first formal research experience in astronomy. Faculty members gave lectures about optical and radio astrophysics, including both theoretical and observational concepts. After a few weeks, students and faculty formed "working groups" to focus on analysis of the RLMT and the VLA datasets.

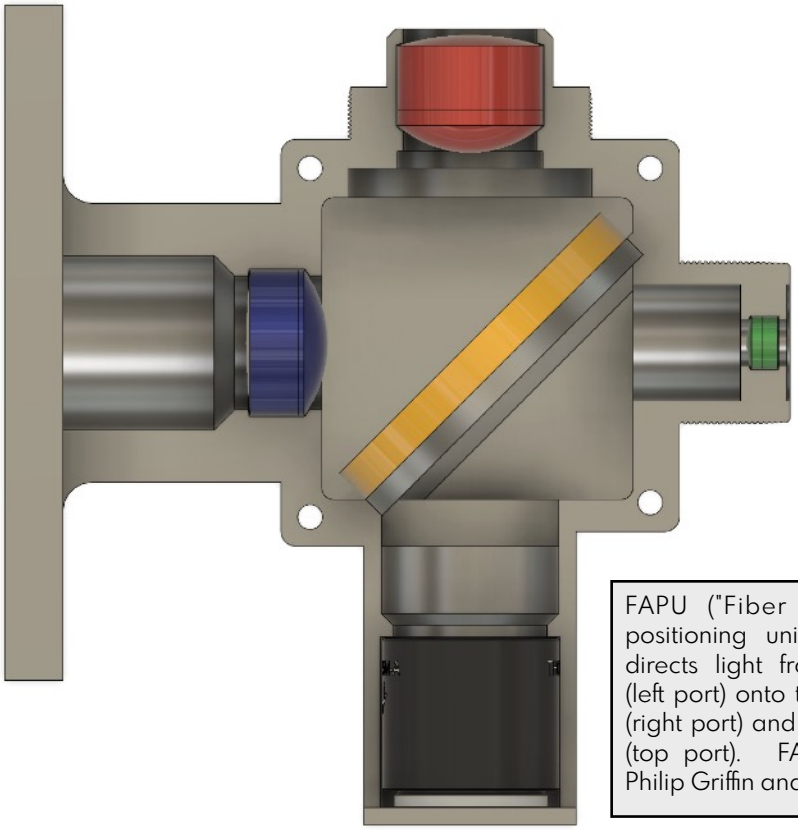
One of the virtual meetings of the MACRO Summer Program.

ST LMi is detected at high significance in the VLA data (which covers the frequency range of 8-12 GHz). The VLA data do not support a "maser" interpretation for the radio flux. Instead, the broad-band brightness variations are suggestive of a "radio hot spot" scenario. We are currently building a three-dimensional model of this scenario.

The work on ST LMi will continue throughout the 2024-2025 academic year. We anticipate that multiple peer-reviewed manuscripts will result from this summer program; all of the participants in the program will appears as co-authors. A comprehensive investigation of magnetically active binary stars will begin in October 2024 (see section below about future projects).

Future Instrumentation:
The Integral Field Spectrograph

The MACRO Consortium's fiber spectrograph is currently at the University of Iowa and is fully functional. With a new plan for the implementation of the integral field spectrograph (see the "MACRO Success Stories" section below), including a "fiber acquisition and pickoff unit" (FAPU), considerable progress has been made in the last year, including real spectra of astrophysical objects taken with the system using the observatory on the Knox College campus.

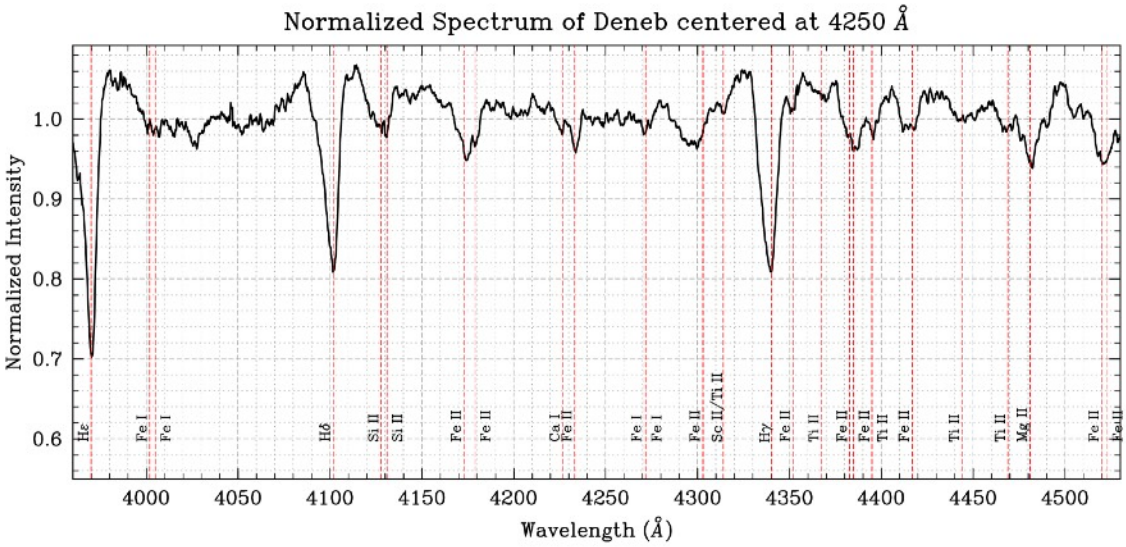


FAPU ("Fiber acquisition and positioning unit"): This assembly directs light from the telescope (left port) onto the 19-fiber bundle (right port) and the guide camera (top port). FAPU design credit: Philip Griffin and J. Alex Fluegel.

The FAPU mounts to the side of the modified extra-height filter wheel used to house our grism spectrometers, where a 90° mirror is housed in a filter slot, sending light into the FAPU. Light is then redirected to the 19-fiber bundle as well as a guiding camera used to help position targets precisely onto the fiber bundle.

Future Instrumentation:
The Integral Field Spectrograph

The integral field spectrograph utilizes 19 optical fibers facing the sky to capture 19 individual spectra simultaneously. This enables the creation of spatially resolved maps of galaxies or nebulae at any visible wavelength of interest. Further, we can extract high resolution spectra of individual point sources (such as stars or quasars). This is similar to the data produced by the H-alpha grism, but covering a wider range of the visible portion of the electromagnetic spectrum. An example spectrum of the blue supergiant star Deneb is shown below.



Continuum normalized spectrum of Deneb (alpha Cyg) around 4250 Angstroms showing many spectral absorption features from hydrogen, calcium, iron, silicon, and more. Spectrum captured using the Knox Observatory in August 2024 using the MACRO Consortium's integral field spectrograph.

The next steps in the integral field spectrograph project include determining the total throughput of the system (which will allow us to calculate the faintest detectable objects), writing control software for the spectrograph and the FAPU, and determining the requisite spectral calibration procedures. This work will be part of Philip Griffin's PhD thesis (see discussion in the "MACRO Success Stories" section below).

A New Generation of Robotic Telescope Control

pyscope

Complete Observatory Control

A Brief History — Pier #1 at Winer Observatory in Sonoita, AZ, now occupied by the RLMT, has a long and storied history in the development of computer software that can control a telescope without any intervention from the observer. Driven by the first students to build and operate a telescope on the roof of the astronomy building, Professor Robert Mutel realized that the burgeoning World Wide Web will enable remote control of a telescope at a more optimal site than downtown Iowa City, IA. In the subsequent 25+ years since 1998, Prof. Mutel and many students made major strides in autonomous telescope operation. MACRO has picked up right where Prof. Mutel left off and begun development of a new software package that will support robotic operations of not just the RLMT, but all kinds of small optical telescopes. We anticipate use at all of our institutions campus observatories.

The first telescope built on the roof of Van Allen Hall, circa 1998. Shown: Robert Mutel (bottom right) and John Cannon (bottom left).

Our Work — In April 2024, we successfully transitioned robotic operations of the RLMT from the deprecated Iowa Observatory Telescope Automation (IOTA) software code to complete control using our new Python package Pyscope. Images are automatically collected by the telescope every night using a pre-configured schedule from observer submissions and then transferred back to our institutions and automatically processed. Student contributions were essential every step of the way. Will St. John (Macalester '26) was critical in the development of the automatic image processing algorithm and Lila Schisgal (Macalester '25) built helpful tools for observers to quickly summarize their data. Cain Rinkoski (Macalester '25) developed software tools to process data acquired with the grism spectrometers and Olivia Laske (Macalester '24) served as a regular scheduler. In the coming year, development will continue as we build out new capabilities for more advanced request submission, scheduling, and data management. To learn more, check out Will Golay's poster from AAS244 or reach out directly.

MACRO

The Next Stage:
Major Ongoing Science Programs

As the 2024-2025 observing season begins, the MACRO Consortium will embark upon two new major observing programs. These Consortium-wide endeavors will provide rich datasets that will be used in both classroom and in research settings.

Magnetic Cataclysmic Variables: Inspired by the success of the multi-wavelength observations of ST LMi, MACRO will begin monitoring a sample of over 30 cataclysmic variables with the RLMT. The primary goal of this program is to determine how and why the flow rate of material transferred from the main sequence star onto the white dwarf varies. To investigate these phenomena, the RLMT optical monitoring program allow us to quickly identify when a system changes between high (bright) and low (dim) accretion states. A VLA observing proposal was submitted this summer, and if successful, will provide radio data whenever an accretion state change is detected in one of the systems. These data will be akin to those analyzed during the MACRO Summer Program. The combined optical and radio observations will allow us to probe the varying magnetic field and plasma properties associated with accretion, and to examine the underlying dynamo processes.

Emission Line Stars: As described above, emission line stars (dubbed "Be stars") are rapidly-rotating objects that harbor disks of material around their equatorial regions. The objects are known to be variable; indeed, the exploratory RLMT observations presented in the AAS244 poster by Anna Williams demonstrated that multiple sources had transitioned from having the H-alpha line in emission to being in absorption over an approximately 10 year timeline. Using both grism modes, we plan to monitor dozens of northern Be stars over the course of the entire observing season. We will quantify the variability of these sources using a statistically significant sample on timescales of weeks to years. As progress continues with the Integral Field Spectrograph (see section above), we will also observe sources of interest at high spectral resolution across the optical regime, allowing us to study the variations in other spectral lines aside from H-alpha.

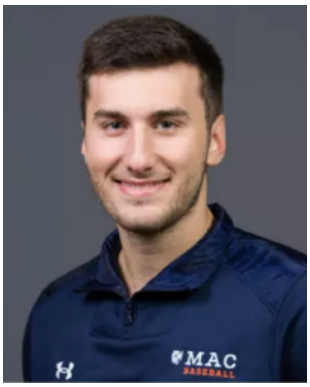
Major research programs will define the 2024-2025 *RLMT* observing season.

MACRO

MACRO Success Stories

In a year as busy as this past one has been, it is difficult to select only a few success stories to highlight. Focusing on the impacts that MACRO has had on students, we congratulate each 2024 graduate who has been involved with MACRO! We also give special recognition to those individuals who are moving directly into graduate school.

Olivia Laske (Macalester College): Olivia has been heavily involved with MACRO since its inception. Olivia has served as the telescope scheduler, worked on the Pyscope software package, taken part in research projects, collaborated with alumni, participated in a MACRO-specific research topics class, and gone on two site visits to the Winer Observatory. Olivia completed an honors thesis in physics based on the work that she did in the CalTech summer REU program. Olivia is now in the PhD program in physics at Penn State University, where she plans to work in the exciting new arena of gravitational waves. Congratulations Olivia!

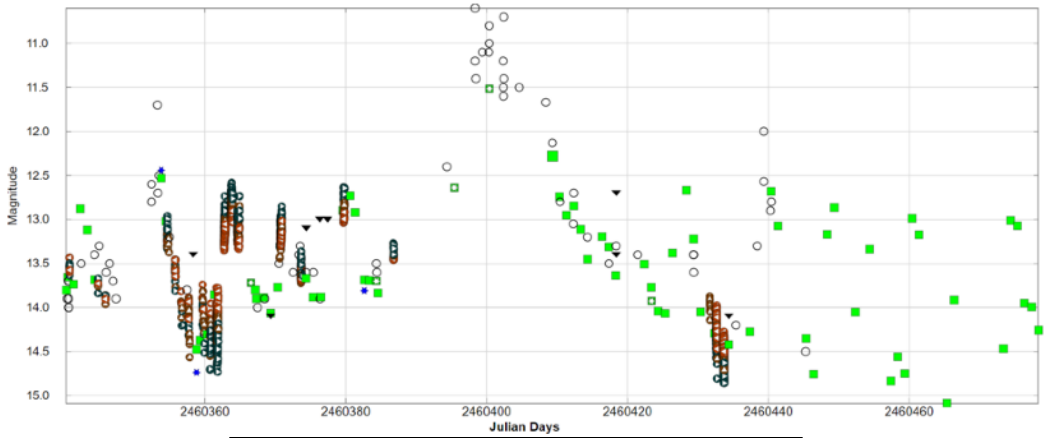


Charlie Burton (Macalester College): Charlie participated in the MACRO-specific Spring 2023 research topics class. Charlie completed an honors thesis in physics based on the work that he did in the NRAO summer REU program. Charlie is now in the PhD program in astronomy at the University of Alberta, where he plans to work on radio and sub-millimeter observations of nearby star-forming galaxies. Congratulations Charlie!

William Murillo (Augustana College): William Murillo put in extensive time designing and printing the housing for the high-resolution H-alpha grism. He has visited Winer Observatory to install the grism, and presented his work at the Spring 2024 APS conference in St. Paul, MN. William is currently working on his Masters in Physics at California State University in Los Angeles, and plans to apply to PhD programs in the future. Congratulations William!

MACRO Success Stories

Alexandrea Moreno (The University of Iowa '26) was MACRO's first REU student. Alex spent the summer working alongside Dr. Wetzel at Coe College as part of Coe's REU (Research Experiences for Undergraduates) program, funded by the National Science Foundation. Alex quickly performed a poster-worthy analysis of the cataclysmic variable star YZ Cnc and presented her work with fellow Coe student Amit Sharma at the AAS Conference (link to AAS244 poster). She then did a more thorough analysis of this object, publishing weeks worth of data to the AAVSO (American Association of Variable Star Observers) website. This data acquired with the RLMT is now the largest single contribution to the repository for this object! She learned the importance of meditation as a practice, contributed to the solution of the fringing problem that affects long-wavelength optical observations, learned how to analyze radio data using the NRAO super cluster, updated the MACRO website, and will continue working with MACRO when she returns to Iowa. Congratulations Alexandrea!



MACRO Data for YZ Cnc among AAVSO data

The first MACRO PhD is now in progress! Given Philip Griffin's heavy investment in MACRO instrumentation, it is fitting that this work becomes part of his in-progress PhD thesis at the University of Iowa. We are pleased to be able to announce that Philip's thesis plan had been modified to include this work. A special acknowledgment is given to Professor Casey DeRoo, Philip's thesis advisor, for his support of MACRO and of this modification.

The theme of Philip's thesis will be astrophysical spectroscopy. This project will include the fabrication of ultraviolet gratings (completed at the University of Iowa in the DeRoo group), the commissioning and installation of the Integral Field Spectrograph on the RLMT, and a project using the SparsePak Integral Field system on the WIYN 3.5m telescope to study nearby star-forming galaxies. These same galaxies will be observed with the RLMT's Integral Fleld Spectrograph once it is operational. Professor Cannon will serve as a co-advisor on Philip's PhD thesis.

Student Voices: Reactions to Visiting the Winer Observatory

"This is one of the best trips I've ever been on, academic or otherwise. The opportunity to observe and handle advanced astronomical equipment myself was exciting, informative, and rewarding. I was able to exercise my problem solving abilities while contributing to something that felt very real and important. I will never forget the time I spent at Winer."

Cain Rinkoski (Macalester '25)

"I am eternally grateful for such an incredible and unique opportunity. I gained deep respect for all of the hard work that goes into ensuring smooth telescope operation. Being in Arizona, physically in front of the telescope, was quite enlightening and insightful. There is something about seeing the images appear - in real time with the camera just a staircase away - that is especially incredible. I am now even more in awe that we are able to observe distant sources with an entirely robotic system."

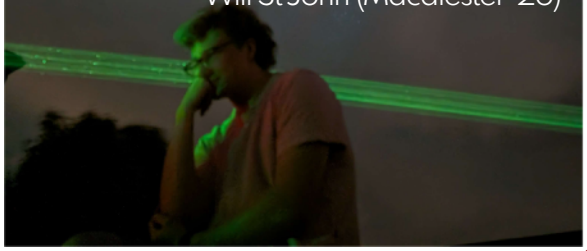
Olivia Laske (Macalester '24)

"I thought the trip was a really special experience because I got to be immersed in physics in a way I haven't been before. Not only did I get hands on experience at Winer but I got to hear about what projects people were currently working on, at the observatory and at their respective colleges, and everyone was more than happy to answer as many questions as I had. It was an experience with a lot of breadth that I'm glad I got to have."

Lila Schisgal (Macalester '25)

"I had a great time on this trip. I learned technical skills related to the functionality of a robotic telescope, gained experience writing scripts to automate the telescope's processes, saw first-hand the methods by which scientific optical images are created, and saw what scholarly work outside of a classroom could look like. Overall I had an amazing time and would love to go back. I feel I gained a more personal connection to the other members on this trip that could not have been accomplished in any other setting."

Will St John (Macalester '26)



Student Voices: Reactions to the American Astronomical Society Meeting

"I thought the AAS was a wonderful experience! I learned a lot from talking to the people there, and from hearing the thoughts and questions they had about my projects. I would definitely recommend it to other undergrads and I hope the consortium is able to keep bringing future students."
"

"It felt special to attend this meeting as an undergraduate. It was fun, educational, and gave a tremendous sense of accomplishment."

"I really enjoyed attending and presenting at the AAS meeting. It was an incredible experience, especially with so many MACRO posters! I also enjoyed seeing all of the professors and grad students present! Everyone had very nice, clear presentations. Thank you for this wonderful opportunity!"

MACRO students at AAS244.

"I had a great time and am very fortunate to be a part of MACRO and all the work it has accomplished this past year! It felt really cool to present at the poster session."

"It was an amazing experience. I was exhilarated when I attended because I got to see so many talented individuals with the same passions as mine. I really liked the community and the platform AAS provided for students and professors to show what they have been working on. I enjoyed every single thing and every single person I met during the AAS conference."

"I really enjoyed presenting and attending the AAS meeting. It was interesting to see what others were researching and be able to talk to them about it so that I could learn more. I also loved connecting with the people who came to ask about my own research because of what we could teach each other about both the data and about the topic in general. I definitely would like to go to another meeting and present again."

Support MACRO

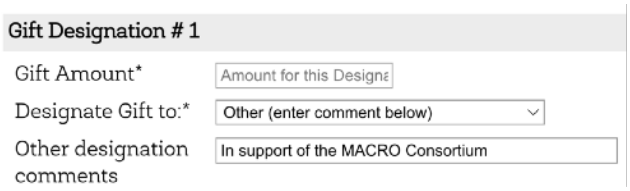
If you believe in the mission of MACRO then please consider providing financial support.

Your **tax deductible charitable contributions** will be used to:

- Maintain and upgrade the operational capabilities of the **RLMT.**
- Provide **student trips to the observatory** to obtain invaluable and irreplaceable hands on experiences with the system.
- Allow students to travel to **professional conferences** to present their work on behalf of the MACRO Consortium.
- Establish a yearly inter-Consortium conference which rotates between MACRO members, providing new educational opportunities to each MACRO community.

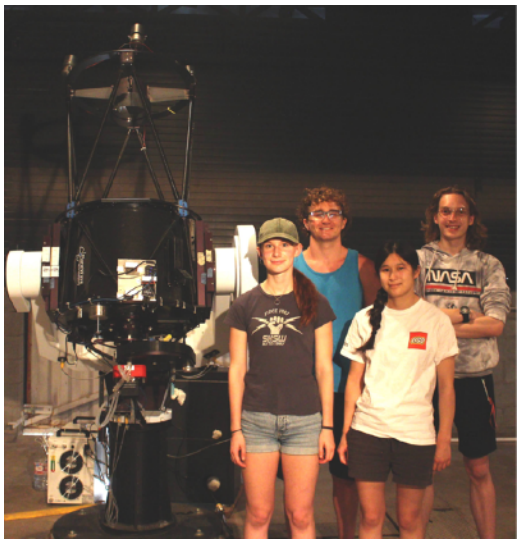
There are two ways to donate:

1. Donate online by visiting this link
   Designate gift to "Other"
   Comment "In Support of the MACRO Consortium "



2. Contact Theresa Gienapp (tgienapp@macalester.edu), 651-696-6087

All gifts are immediately directed to the MACRO Consortium fund and can be used by all member institutions of the Consortium.



Students at the **RLMT** in October 2023. Left to right: Lila Schisgal, Will St John, Olivia Laske, and Cain Rinkoski.

Further Information

If you would like to learn more about MACRO, 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, Associate Professor 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, nhaurber@knox.edu

Macalester College:
- John M. Cannon, Professor of Astronomy, jcannon@macalester.edu
- Anna Williams, Assistant Professor of Astronomy, alwilliams@macalester.edu

University of Iowa:
- Philip Griffin, Graduate Student, philip-griffin@uiowa.edu

MACRO