The MACRO Consortium Newsletter

Volume 3
Fall 2025

The 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.

Robert L. Mutel Telescope image of the NGC 4485/4490 galaxy pair.

Image credit: Philip Griffin (University of Iowa).

Another Stellar Year for MACRO

The MACRO Consortium enjoyed a truly spectacular 2024-2025 observing season. Since Volume 2 of the newsletter was published in September of 2024, students, staff, faculty, alums, and friends have been engaged in a variety of unique endeavors that will be described throughout this newsletter. The Robert L. Mutel Telescope (**RLMT**) is delivering unique datasets for two major research programs, which in turn are the centerpieces of novel student experiences.

Members of the MACRO Consortium in front of the Robert L. Mutel Telescope at the Winer Observatory in Sonoita, Arizona, October 2024.

Image credit: Philip Griffin (University of Iowa).

Knox College Becomes Full Member

We are delighted to welcome Knox College as a full member of the MACRO Consortium! As of January 1, 2025, Knox College is on an equal footing with Augustana, Coe, and Macalester. Professor Nathalie Haurberg joins John Cannon, William Peterson, and James Wetzel on the MACRO Consortium Board of Directors. Knox College students can now benefit from the RLMT being the cornerstone of the astronomy curriculum.

Professor Haurberg, J. Alex Fluegel, and Knox College students in front of the RLMT, March 2025.

Image credit: Philip Griffin (University of Iowa).

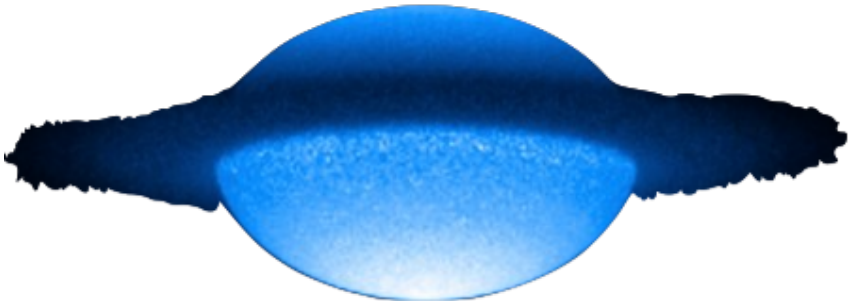
Knox College Becomes Full Member

The Knox College community brings deep and multi-faceted expertise to the MACRO Consortium. Science Technician **J. Alex Fluegel** is the Director of the Knox College Makerspace. Alex is a master machinist who has played a leadership role in MACRO's instrumentation development endeavors. Knox College astronomy and engineering students, and members of the MACRO Consortium in general, have the opportunity to gain hands-on training in astronomical instrumentation.

J. Alex Fluegel (left) and Theo Darci-Maher (Macalester 2027) mill a component for the RLMT at the Winer Observatory, August 2024

In the spring semester class CS322, "Software Engineering", Knox College computer science students worked with Visiting Instructor **Michael Gerten** on various projects related to the RLMT and its data stream. This group made important strides in improving the database system that MACRO will deploy. When completed, this database will streamline the process of requesting, acquiring, and retrieving RLMT data. It will present a public-facing data archive and will document project status for student classroom projects as well as for the Consortium's flagship research programs.

Flagship Science Program: Be Stars



Model of a Be star and disk (image credit Daniel Moser Faes).

As was described in Volume 2 of the Newsletter, 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 it. This disk can produce emission lines in spectra - opposite to what is seen in most normal stellar spectra (e.g., in the Sun), where effectively all spectral lines are absorption. The H-alpha grism on the RLMT is a powerful tool with which to investigate the properties of Be stars, as described in detail below.

Flagship Science Program: Be Stars

One of the many fascinating aspects of Be stars is their notorious variability. The emission line features in the spectrum of an individual star can change their shapes and strengths on a range of timescales (from days to years). Remarkably, some Be stars have transitioned from emission to absorption and back again.

The primary goal of the MACRO Be stars campaign is to quantify the variability properties of a robust sample of Be stars on a range of timescales.

Such an observing program is perfectly suited to the RLMT, since the Consortium has the flexibility to schedule the observations on the cadence that is most scientifically useful.

Observational strategy

- Monitor hundreds of Be stars using the H-alpha grism
- Determine timescales of spectral changes
- Inform upon the complex physics of these systems
- Serve as the centerpiece of the "Be A Star!" topics class

Research to Curriculum: "Be A Star!"

- The Be Star science campaign was the centerpiece of a novel inter-institutional research topics class in the spring of 2025
- Open to any interested student with no pre-requisites
- 49 students enrolled in the course, from all five MACRO institutions
- Multiple "alum educators" were embedded as research group leaders - called "Trailblazers"
- 14 recent alums visited the class in the "Be Inspired!" series
- More than 70 total participants in the experience, including faculty, staff, students, alums, and guests

"Be A Star!" - Trailblazers

Alexis Riggs
(Knox 2024)

Joshua Marine
(Macalester 2023)

Audrey Fisher
(Knox 2020)

Elliott Lewis
(Macalester 2027)

Jackson Codd
(Macalester 2023)

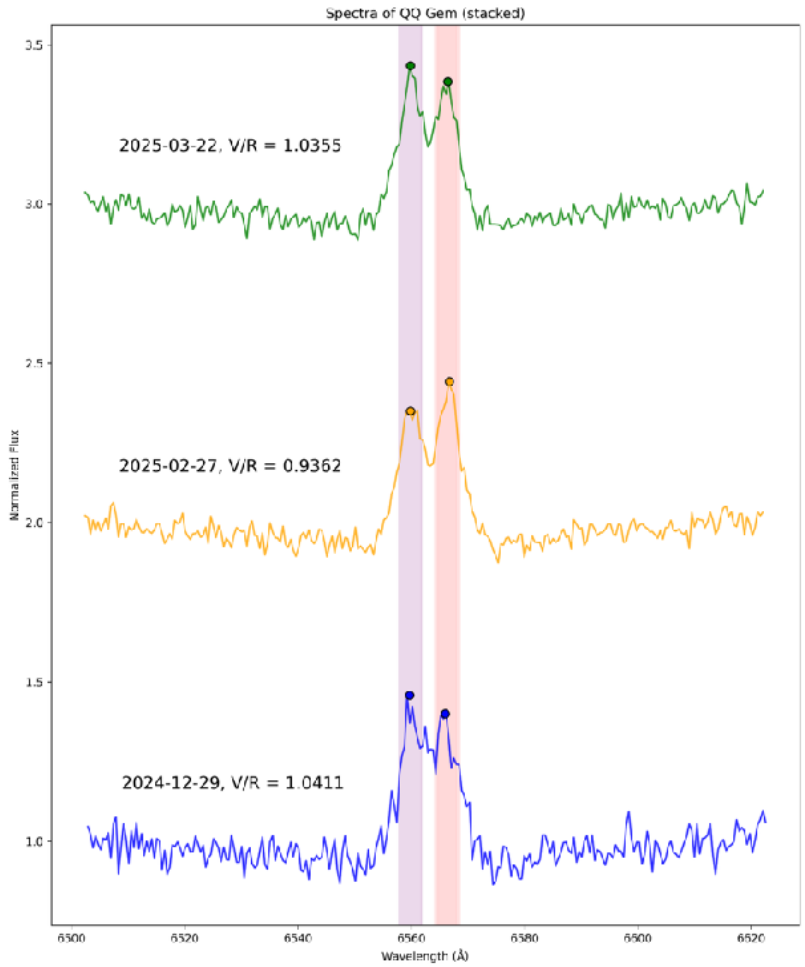
Lila Schisgal
(Macalester 2025)

Will St John
(Macalester 2026)

Cain Rinkoski
(Macalester 2025)

Henri Reno
(Knox 2025)

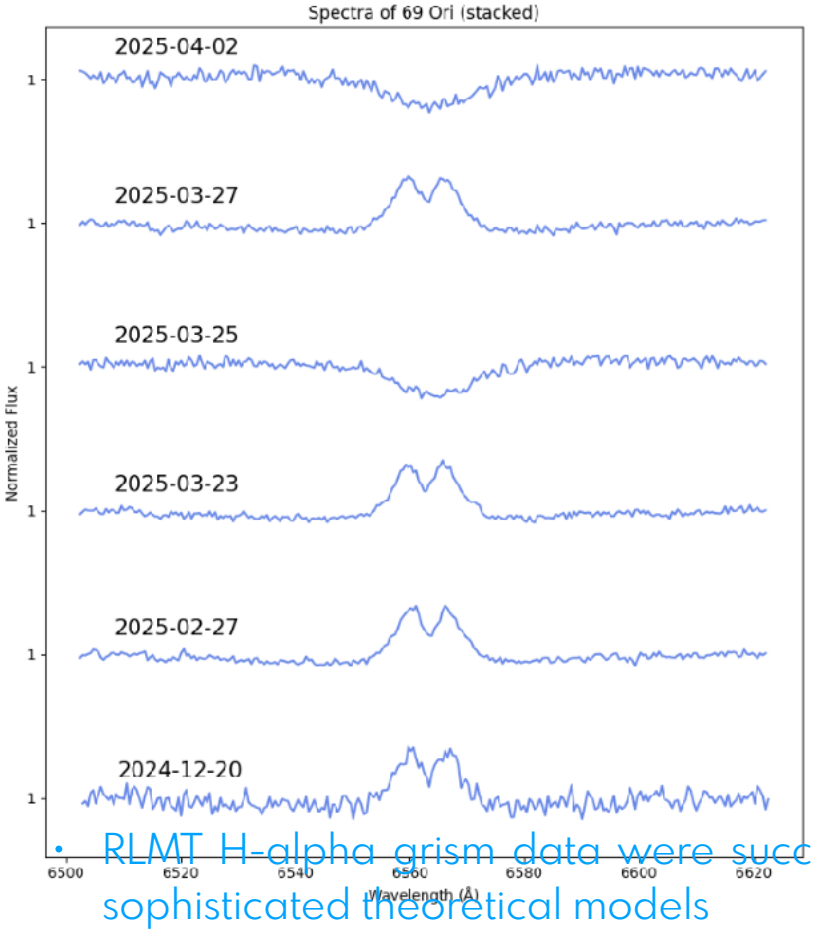
"Be A Star!" - Results



Variability in the RLMT spectra of the Be star QQ Gem. Three normalized spectra, taken over the course of approximately three months, suggest changes in the relative heights of the red and blue peaks of the H-alpha emission line. Further investigation with higher S/N spectra will be undertaken in fall 2025. Image credit: Joshua Marine.

- Acquired more than 6000 individual RLMT spectra on more than 120 unique Be stars
- Read dozens of manuscripts in the primary astrophysical literature
- Undertook variability analyses for all stars with multiple observing epochs
- Variability was detected and quantified in multiple Be stars

"Be A Star!" - Results



Variability in the RLMT spectra of the Be star 69 Ori. Six normalized spectra, spanning more than three months, reveal dramatic changes in the H-alpha profile - including two transitions from double-peaked emission to absorption. After identifying sources of interest like 69 Ori in the first season of observing, we will undertake high time-cadence observations in season two.

Image credit: Cain Rinkoski and Joshua Marine.

- RLMT H-alpha grism data were successfully fit with sophisticated theoretical models
- Provided many important lessons that will carry forward into season two of the Be stars campaign (2025 - 2026)
- Spawned multiple spin-off projects, including new radio observations with the National Radio Astronomy Observatory's Very Large Array

"Be Inspired!"

Catie Ball

Macalester 2018

Cornell University

Karen Perez Sarmiento

Macalester 2019

University of Pennsylvania

Sarah Taft

Macalester 2019

University of Minnesota

Alyssa Bulatek

Macalester 2020

University of Florida

A major goal of the "Be A Star!" course was to allow students at all levels (from 1st and 2nd years who may not have taken any physics or astronomy classes, through advanced juniors and seniors who plan to pursue graduate studies in STEM) the opportunity to learn about physics, astronomy, and mathematics in a project based and cooperative research environment.

Dr. Riley McGlasson

Macalester 2020

PhD Purdue University 2024

Alison Molinari

Knox 2021

University of Maine

Kayla Schang

Macalester 2021

University of Central Florida

"Be Inspired!"

Susie Paine

Macalester 2022

West Virginia University

Aurora Hiveley

Macalester 2023

Rutgers University

Morgan Hopkins

Knox 2023

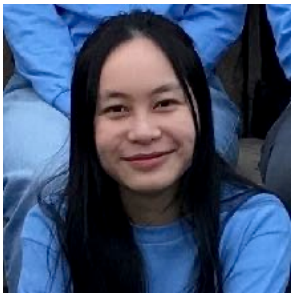
Washington University in Saint Louis

Margaret Shepherd

Macalester 2023

University of Illinois

An important component of this learning is enabled by confidence, a sense of belonging, and the opportunity to "Be Inspired!" by talking with alums about their experiences. Students enjoyed rich conversation with these role models, each of whom is enrolled in (or has recently completed) a PhD program in astronomy, physics, mathematics, or engineering.



Chloe Zheng

Macalester 2023

Ohio State University

Temazulu Zulu

Macalester 2023

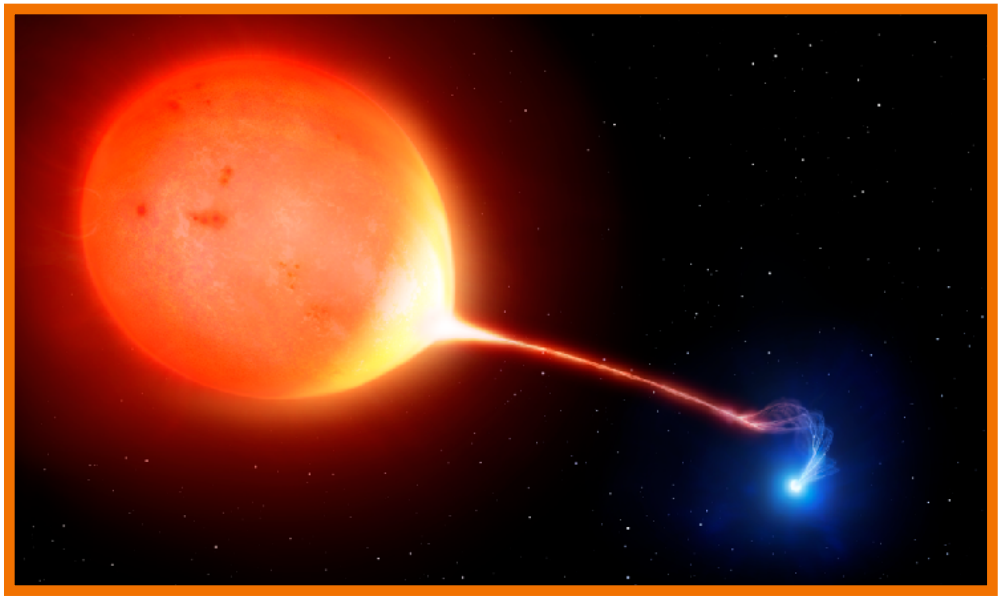
Harvard University

Olivia Laske

Macalester 2024

Pennsylvania State University

Flagship Science Program: MCVs

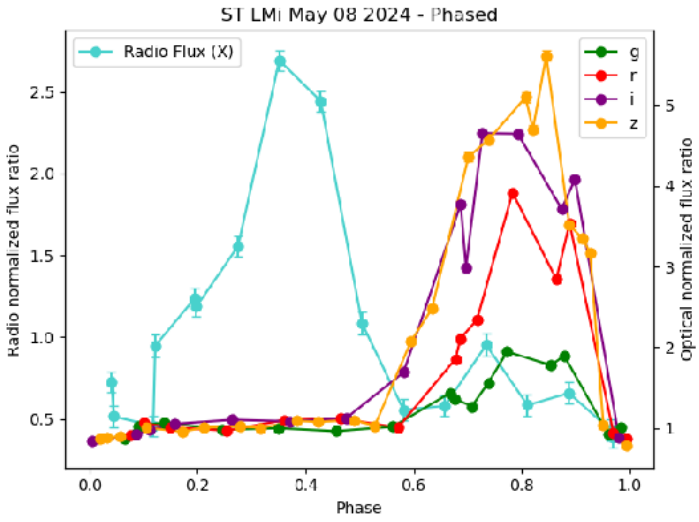


Artist's representation of a "polar" (which is short for optically polarized star), a magnetic cataclysmic variable ("MCV") where mass is being exchanged between a white dwarf (right) and a low-mass donor star (left). The strong magnetic field of the white dwarf governs the motion of the exchanged material, causing it to fall directly onto its surface. The two stars orbit their common center of mass every few hours (!!), causing their x-ray, optical, and radio brightnesses to change dramatically.
Image used with permission of the author (Dr. Mark Garlick).

observations of the polar ST LMi. Based on the success of those observations and of the first MACRO Summer Program (summer of 2024), we have expanded this endeavor to include seven more polars. **Each of these systems was observed simultaneously with the RLMT and with the VLA.**

Flagship Science Program: MCVs

In the first MACRO Summer Program (2024), students from across the Consortium confirmed that the optical and radio "pulses" (i.e., increases in brightness) of ST LMi are offset in time.

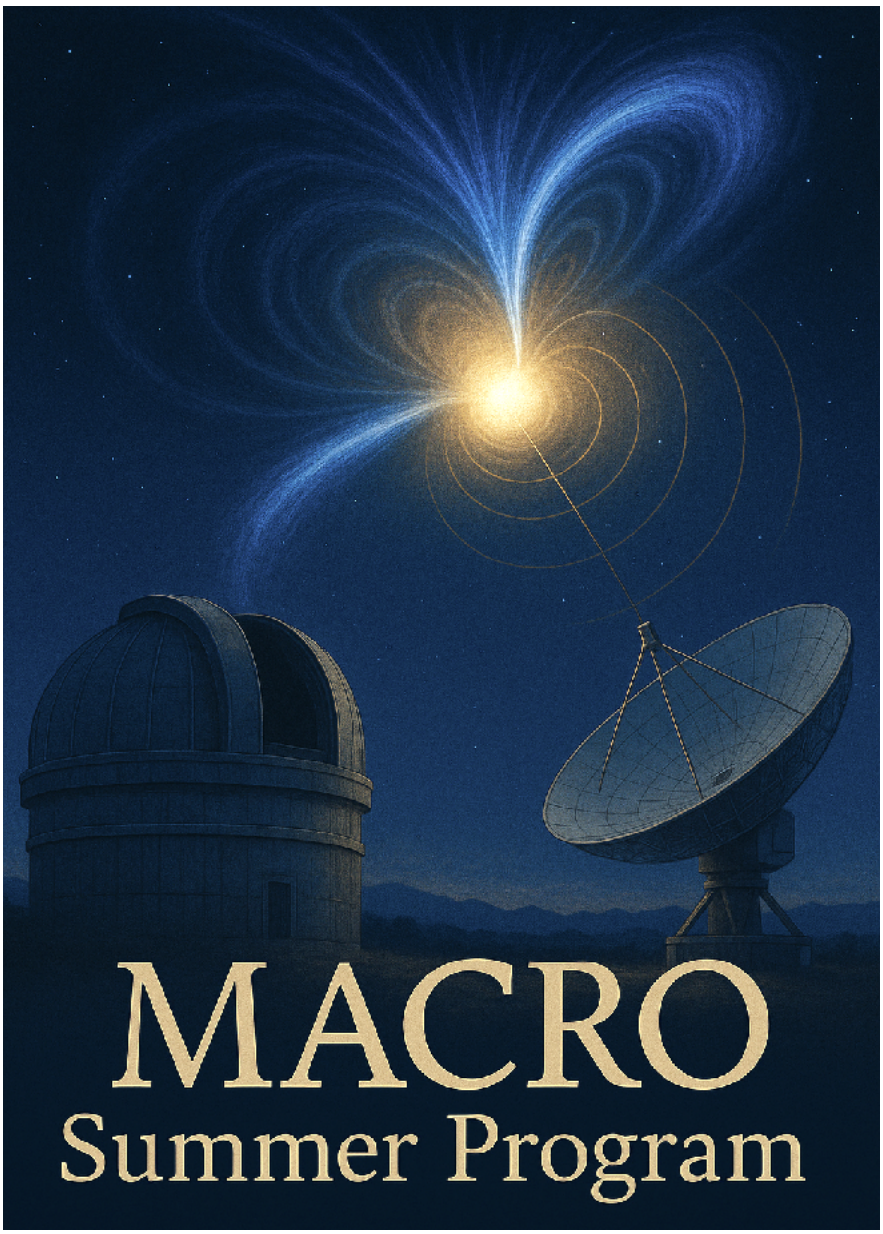


The optical (RLMT) and radio (VLA) brightness of ST LMi versus orbital phase for the pilot observation in May 2024. The increases in brightness are not simultaneous - a result that was not known prior to the first MACRO Summer Program.

e physical properties of eight different polar systems. Specifically, a new VLA observing program collected data throughout 2025. Various members of the MACRO Consortium perfected methods with which to ensure that the RLMT was able to observe the sources simultaneously, thereby creating a truly unique and powerful dataset on polars.

Research to Curriculum:
The MACRO Summer Program

The VLA+RLMT data suite on polars was the centerpiece of the second annual MACRO Summer Program. This was an inter-institutional research experience in which individuals from all five MACRO campuses worked together on various aspects of the MCV science program.



Research to Curriculum:
The MACRO Summer Program

An immersive, six-week summer research program that was open to any interested students.

Fifteen students participated, under the guidance of a faculty lead at each of the Colleges.

A comprehensive pedagogical program: research methods; fundamentals of optical, radio, and x-ray observations and data; astrophysical background; image and data analysis; and interpretation of results.

The optical group processed thousands of images from the RLMT and other telescopes.

The radio group processed ten new VLA datasets on polars and also a dataset on the exotic cataclysmic variable star LX Serpens (see below for more details).

New territory was explored as the x-ray group (led by Dr. Sean Gunderson, see below) processed data from the Chandra, XMM-Newton, and other x-ray observatories.

Approximately 30 total participants were involved, including staff, faculty, students, and guest lecturers.

MACRO Summer Program: Results

The simultaneous VLA and RLMT datasets are unlike any others in existence.

We have discovered ubiquitous periodic coherent radio emission in all polars observed to date (four more systems have VLA datasets in progress).

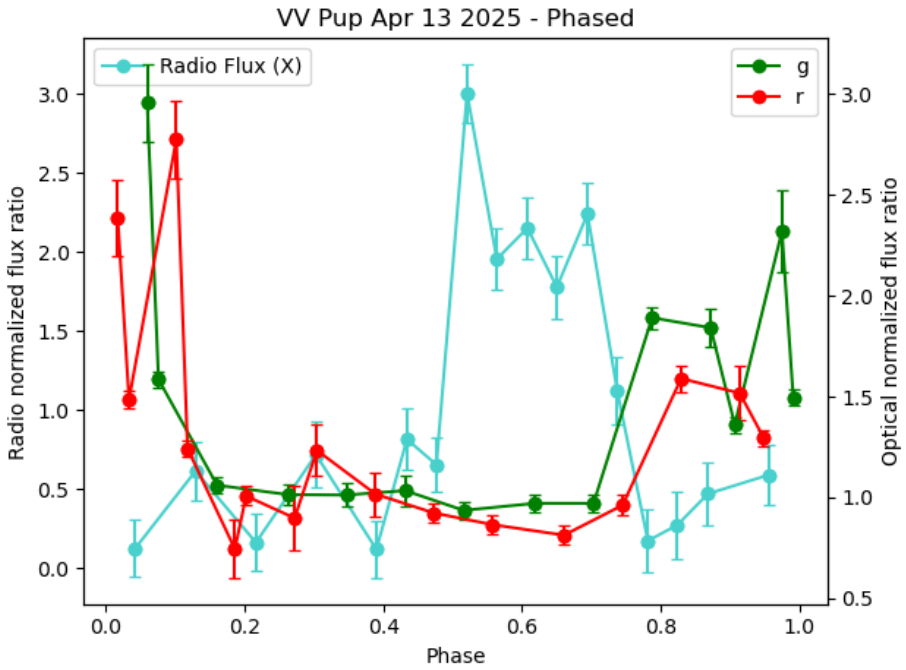
The broadband pulses are similarly phased in all systems. The interpretation of the radio emission is ongoing as of this writing. Results forthcoming in Golay et al. (in preparation).

The broadband pulses are approximately spectrally flat and ~ 100% circularly polarized.

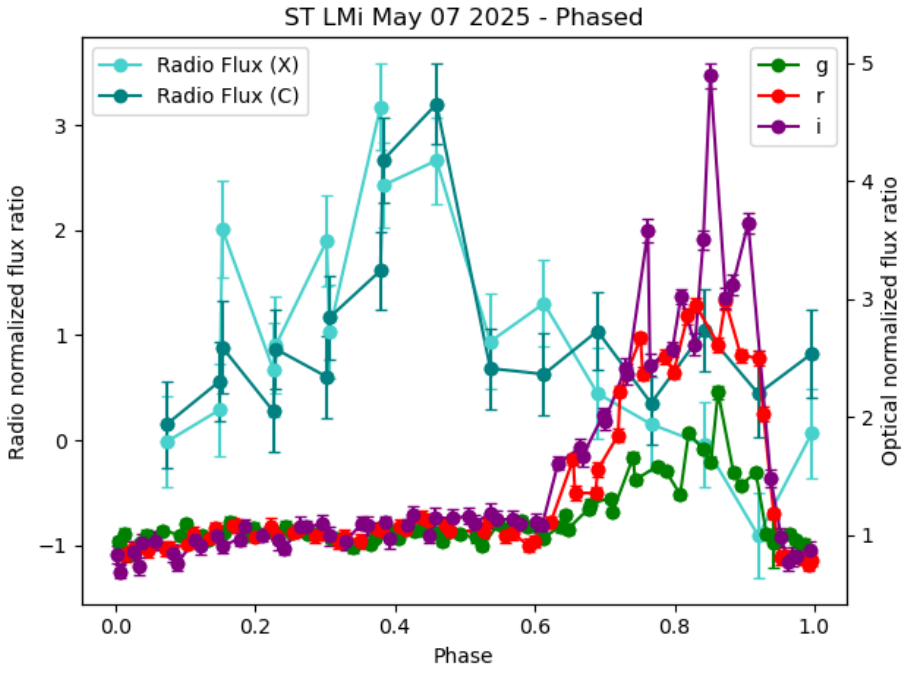
The minutes-long pulses are periodically stable with lifetimes of at least months, and sometimes superimposed on detectable quiescent broadband radio emission.

This program has spawned multiple observing proposals spanning the electromagnetic spectrum.

MACRO Summer Program: Results

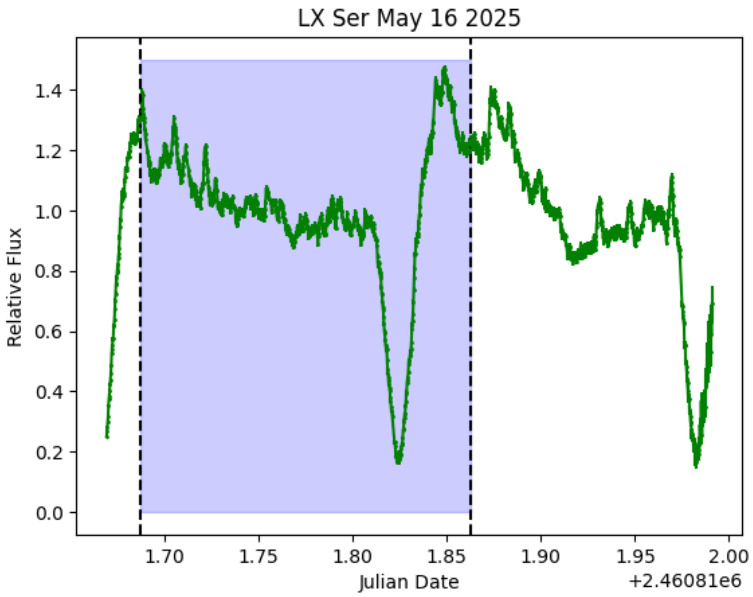


Simultaneous RLMT and VLA light curves for the polar VV Pup (top) and ST LMi (bottom), produced by students in the MACRO Summer Program. Note the dramatic offsets between the radio and the optical pulses. The lower panel confirms that the radio pulses are stable over timescales of years (c.f. the light curve from 2024 shown above).



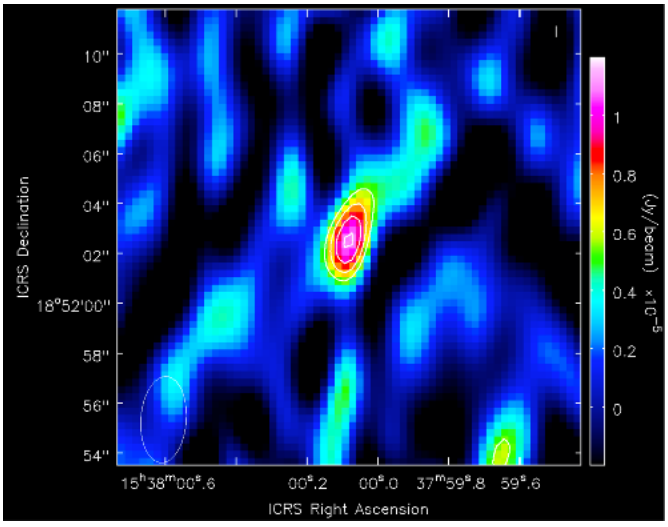
MACRO Summer Program: Results

On May 16, 2025, the MACRO Summer Program acquired a very sensitive VLA observation via the National Radio Astronomy Observatory's "Observing for University Classes" program. The target was the eclipsing cataclysmic variable LX Serpens. This source was observed simultaneously with the RLMT, the VLA, the Knox College Observatory, the University of Iowa's Van Allen Observatory, and Dick Bernstein's telescope (which, like the RLMT, is located at the Winer Observatory).



The spectacular RLMT light curve of LX Ser, spanning ~8 hours. The blue shaded region denotes the time interval during which the VLA was also observing the source. Note the dramatic drops in brightness as one star eclipses the other.

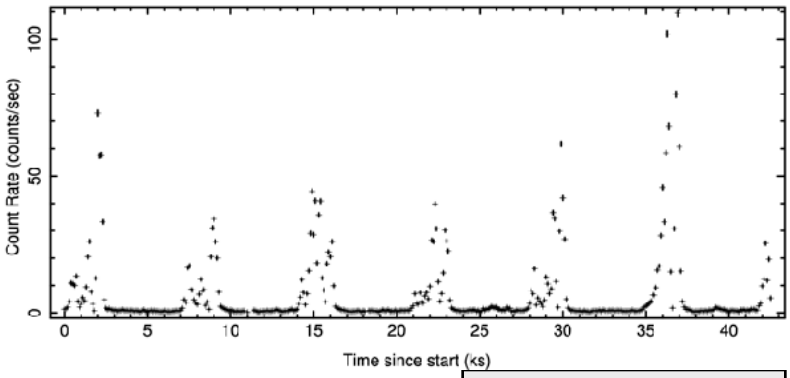
The VLA X-band image of LX Ser, produced by students in the MACRO Summer Program. The sensitivity of this observation is exquisitely low, enabling a robust detection of the comparatively faint eclipsing cataclysmic variable star. These data are under active analysis as of this writing.



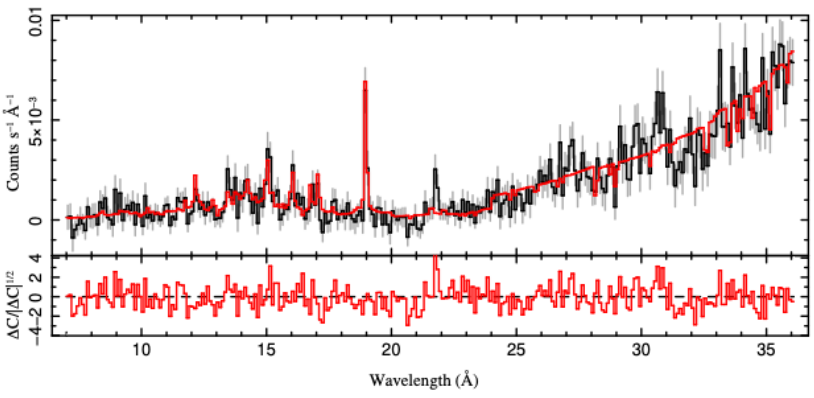
MACRO Summer Program: X-rays

As a part of the MACRO Summer Program, participants had the opportunity to learn how to work with X-ray data. While X-ray astronomy has parallels to optical, the number of events is usually so low that the participants had to learn to do detailed statistics.

Participants worked on archival XMM-Newton data of AR UMa, the polar with the strongest known magnetic field. This proved to be a challenge because AR UMa was so bright that it saturated the instrument!



The X-ray light curve of AR UMa showing the exceptional brightness of the system. The gaps in the peaks are due to the orbital motion of the system. The variations in the peaks is an on-going investigation by the Summer Program Participants.



The X-ray spectrum of AR Uma in black shows the complex emission of polars. Prominent oxygen, neon, and iron lines are easily identified in the spectrum.
In red is the best fit model from the participants, but work is ongoing since it doesn't replicate everything.

Unique Student Experiences: REU at Coe

Isaac Groene (Knox, Left) and Joshua Reardon (U. Iowa. Right) visiting the Antimatter Factory at CERN in Geneva, Switzerland.

This summer, two undergraduates, Isaac Groene from Knox College and Joshua Reardon from the University of Iowa, were selected by Professor James Wetzel at Coe College to participate in the Coe College REU program, funded by the NSF. As part of their REU experience, they joined the MACRO Summer Program and contributed to active astrophysics projects, with Joshua exploring techniques for analyzing radio data and Isaac working with X-ray observations.

Both students also had the rare opportunity to accompany their mentor to CERN in Geneva, Switzerland. There, they participated in a beam test of the qCal high-resolution calorimeter prototype — a cutting-edge detector concept for next-generation high-energy physics experiments. For Joshua and Isaac, the summer offered not only technical training but also the chance to see firsthand how local research connects to international discovery.

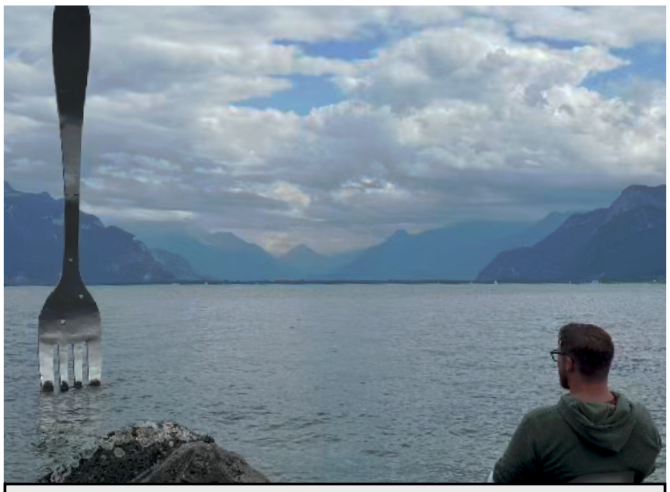
And they also got to tour an 11th century castle!

Unique Student Experiences: The Integrative Power of MACRO

This experience is a testament to the integrative power of MACRO. By linking together the resources, faculty, and students of its member institutions, the Consortium creates opportunities no single college could provide on its own.

Isaac and Joshua, coming from Knox College and the University of Iowa, benefitted from the Coe REU program, gaining hands-on training in both astrophysics and high-energy physics. At the same time, MACRO benefits from having an REU site embedded within its member colleges, strengthening the pipeline of talented undergraduates who contribute to the Consortium's research and carry its collaborative spirit forward.

Experiences like these prepare students for a lifetime of success and excellence in science and beyond.



Joshua observing the Fork outside the Alimentarium, Vevey, Switzerland.

If you look closely you can see Isaac and Josh looking down at one of the beam lines at the CERN Test Beam Facility.

Image Credits: J. Wetzel

Unique Student Experiences:
The MACRO Postbac Program

The successful operation of any observatory requires the "unseen heroes" who, behind the scenes, ensure that high quality data is being delivered to students, faculty, and collaborators. MACRO's "unseen heroes" are the post-baccalaureate ("postbac") researchers. In this role, recent graduates from a MACRO member institution (and, for the first time this year, beyond) play leadership roles during their transition from undergraduate to graduate study.

Working as a postbac offers individuals the unique opportunity to gain leadership experience working in a professional collaboration - an important stepping stone as they pursue an advanced degree. The postbac researcher is a steadfast resource that the Consortium faculty rely upon on a daily basis. They lead the day-by-day operation of the RLMT, schedule observations, check data quality, acquire calibration images, and diagnose operational inefficiencies. They work on the extensive pyScope code base that operates the telescope and actively take part in all Consortium meetings.

Alexis Riggs
Knox College 2024
MACRO Postbac 2024-2025

Alexis (at right) works on the *RLMT* with students. A co-author on multiple scholarly manuscripts from their work as a postbac, Alexis is now a first-year student in the astrophysics PhD program at the University of Minnesota. Congratulations Alexis!

Unique Student Experiences: The MACRO Postbac Program

As the flagship science programs (described above) have grown in complexity and scope, the operational efficiency of the RLMT is now more critical than ever before. During the 2025-2026 observing season we are very fortunate to be able to address this challenge with a group of four postbac researchers. These individuals have stepped into leadership roles in MACRO's flagship science programs.

Nico Flota Sanchez
Colby College 2025
MACRO Postbac

Nico and Lauren will serve as the co-leads of the *RLMT* MCV science program during the 2025-2026 observing season

Lauren Wittry
Knox College 2025
MACRO Postbac

Jackson Codd
Macalester College 2023
MACRO Postbac

Jackson and Josh will serve as the co-leads of the *RLMT* Be stars science program during the 2025-2026 observing season

Joshua Marine
Macalester College 2023
MACRO Postbac

Unique Student Experiences: MACRO Preceptor Training

Building on the successes of the "Be A Star!" inter-institutional topics class (see above), in the current fall 2025 semester we are piloting a new student experience called "MACRO Preceptor Training" ("MPT25"). Working alongside the MACRO postbacs, the enrolled students are receiving focused and detailed telescope training. MPT25 is a unique educational experience that is not available in any other type of class. Seven students are enrolled in MPT25, which is being offered as a special topics class at Macalester and as an independent study experience at Augustana, Coe, and Knox.

Leadership: p ledge base to become future m
Teamwork: p rative skills as part of a large
Independence: participants will design and lead long-term astrophysics research projects
Longevity: specifically targeted at current sophomores and juniors, in order ensure that they can employ their skills during multiple subsequent semesters

Unique Student Experiences: MACRO Preceptor Training

Suhrid Abrar
Knox College 2028
Preceptor

Prashanna Khatiwada
Knox College 2028
Preceptor

Walker Law
Coe College 2027
Preceptor

Future student leaders of MACRO

Emma Biskie
Augustana College 2027
Preceptor

Marine McKnight
Macalester College 2028
Preceptor

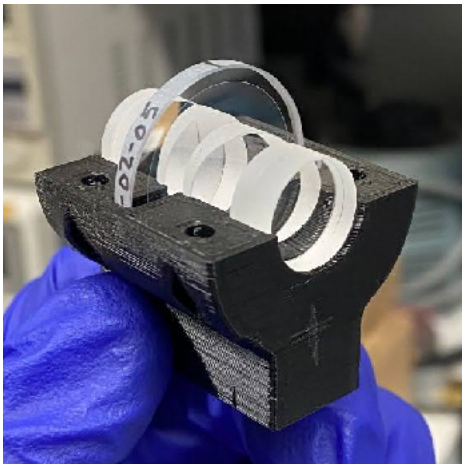
Hayden Arko
Macalester College 2028
Preceptor

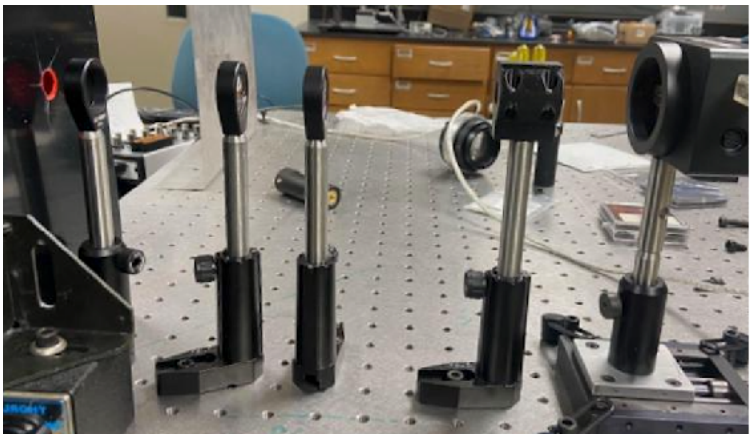
Emma McNellis
Macalester College 2028
Preceptor

Instrumentation and Development

The success of the H-alpha grism (see discussion of the Be stars science program above) has motivated continued study of possible future grism(s) and techniques. An important first step in this journey was taken by **Theo Darci-Maher (Macalester College 2027)** during the spring semester "Optics" class (taught by Professor James Heyman). Working closely with **Philip Griffin (University of Iowa)** and **J. Alex Fluegel (Knox College)**, Theo created a duplicate low-resolution grism and then tested its resolving power on an optics bench. This important work involved the creation of simulations, 3-dimensional housing models, and optical bench layouts that can be used in future grism development work.

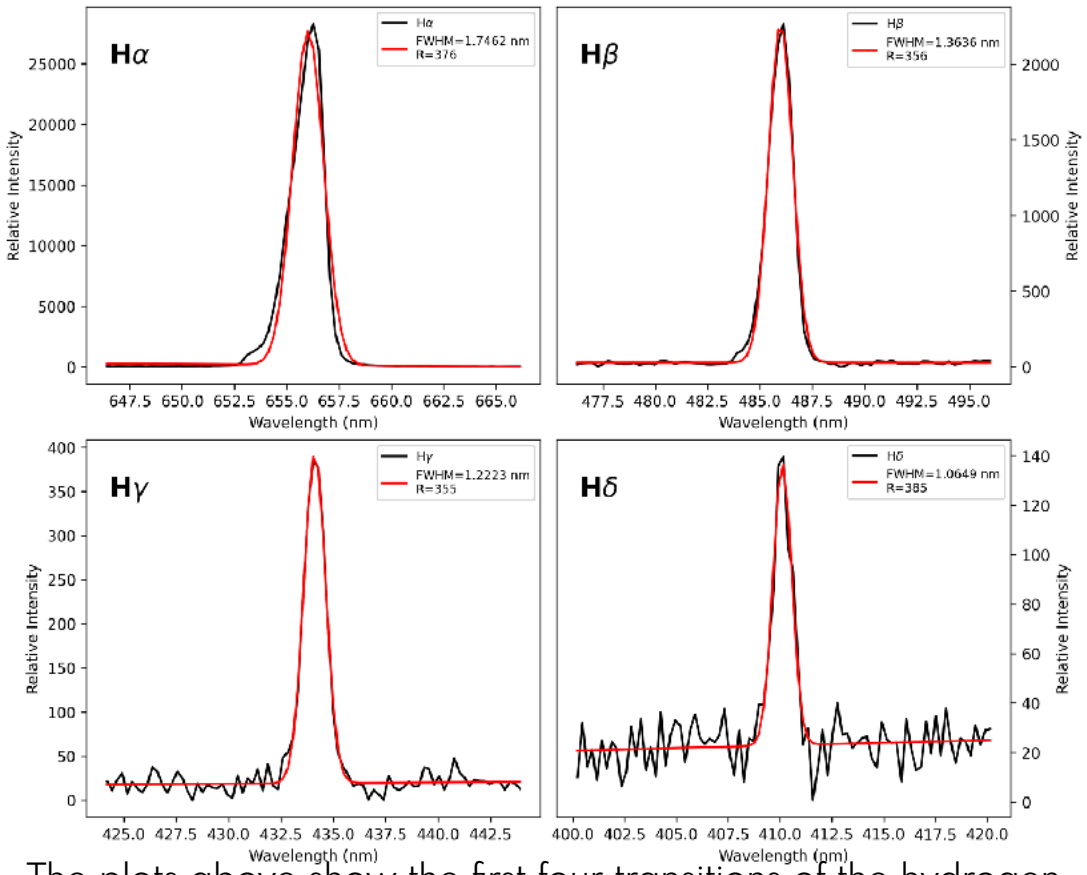
The low-resolution compact grism spectrometer that was constructed by Theo Darci-Maher at Macalester College. The dispersing element is the largest optical component; prisms and lenses are placed on both sides.





The setup of the experiment on the optical bench. The light-tight box that covers the entire experiment is removed.

Instrumentation and Development



The plots above show the first four transitions of the hydrogen Balmer series as measured by the compact grism spectrometer. A Gaussian with linear continuum is fit to each line, and the full width at half maximum of the resulting best fit gives the dispersion of the grism system. We find consistent measurements for each transition: the resolving power of this low resolution grism system is approximately 370. These bench tests compare favorably with on-sky spectra taken with the low resolution compact grism spectrometer on the RLMT.

Special thanks to James Heyman and David Bailey for generously giving their time and energy in order to make this experiment a success.

Theo Darci-Maher

Macalester College class of 2027

Welcome New Collaborators

As MACRO's flagship science programs have matured, various new collaborators have joined our Consortium. These new faces provide expertise and capabilities that further strengthen our community.

Dr. Paul Barrett (George Washington University) is an expert on cataclysmic variables and a leading developer of scientific programming for astronomy using Python and Julia. Paul is actively analyzing and interpreting the radio datasets for the MCV science program.

Dr. Sean Gunderson (MIT) is an expert X-ray astronomer with a wealth of experience in using these data to probe the physical properties of stars. Working with students, Sean led the X-ray component of the MACRO Summer Program.

Dr. Joe Prendergast (American University) works on cataloging cataclysmic variables and also on interpreting radio and optical observations in order to determine their physical properties. Joe is actively involved in the MCV science program.

Welcome New Collaborators

Dick Bernstein (amateur astronomer) owns and operates a telescope at the Winer Observatory and is currently in the process of building a new telescope system in the mountains of California. Dick has provided exquisite data on the polars that are under investigation in the MCV science program (in fact, many of the datasets are simultaneous between the RLMT, the VLA, and Dick's telescope at Winer).

Walt Cooney (amateur astronomer) is a board member of the American Association of Variable Star Observers (AAVSO) with a wealth of experience in observations of cataclysmic variable stars. Walt is providing optical photometry of targets in MCV science program via his access to telescopes in the AAVSO network.

Ross Ferguson (Macalester 2023) is a third-year graduate student at the University of Minnesota. Ross is contributing to the modeling efforts in the MCV science program.

MACRO's First Publication

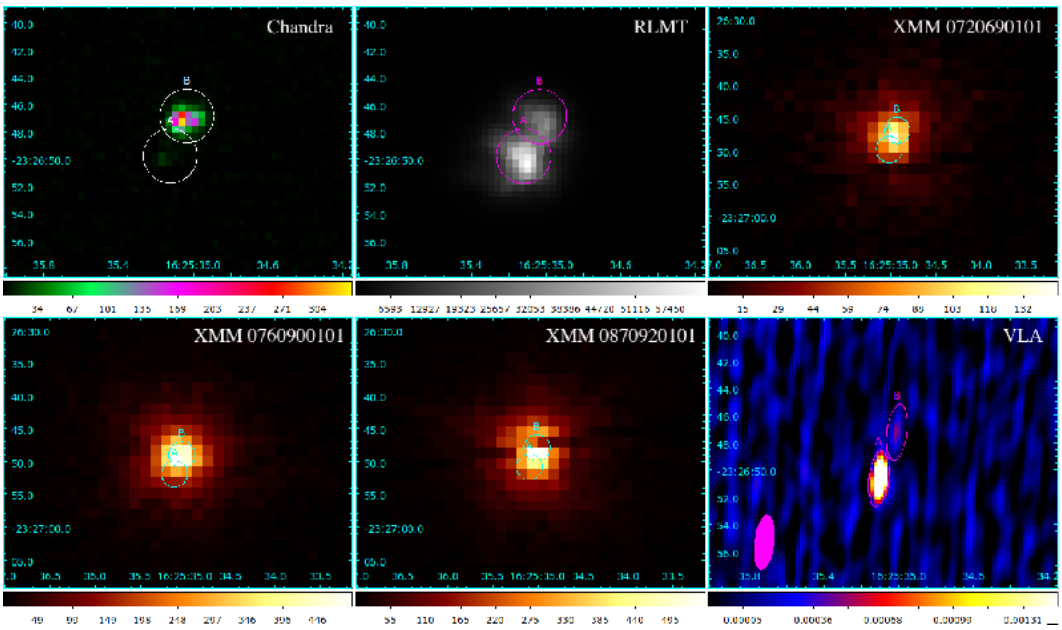
"A Multiwavelength View of ρ Oph I: Resolving the X-ray Source Between A and B"

Gunderson *et al.*, The Astrophysical Journal, in press (ArXiV/2509.26268)

MACRO has its first peer-reviewed scholarly manuscript accepted for publication! The article focuses on the two primary stars of the ρ Ophiuci star forming complex, called ρ Oph A and B. Using archival Chandra X-ray Observatory, XMM-Newton, NuSTAR, and VLA data, along with new RLMT imaging, we have discovered that ρ Oph B is the dominant X-ray source. Previous publications argued that ρ Oph A was the brighter source, but these were based on lower resolution imaging data.

The new Gunderson et al. manuscript has ten co-authors from MACRO, including **current undergraduate student Alexandrea Moreno** and **recent graduates Alexis Riggs** and **Jackson Codd**.

Subsequent publications will focus on ρ Oph C and D. There are also a dozen other stars in the ρ Oph star formation complex, including many young stellar



Images of ρ Oph A and B in the X-ray (Chandra and XMM-Newton), optical (RLMT), and radio (VLA). Figure from Gunderson et al. (in press).

Support MACRO

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

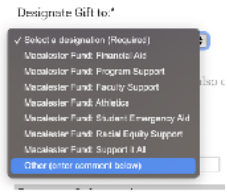
Your **tax deductible charitable contributions** will be used to:

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

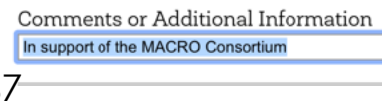
There are two ways to donate:

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

1a.



1b.



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.

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 talk with you!

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MACRO Consortium team members lovingly tend to the RLMT.