FALL **2020**

DEPARTMENT OF

ASTRONOMY

Dedication of the James B. Kaler Astronomy Classroom

Thanks to all of our alumni and friends, the department is proud to announce that we have raised enough funds to dedicate our classroom as the James B. Kaler Astronomy Classroom.

Professor Emeritus **Jim Kaler** is one of our most beloved faculty members. Jim has been the face of astronomy at Illinois since 1964, and he personifies our tradition of excellence in research, teaching, and outreach. He is renowned for his research on stars and stellar evolution, specializing in the planetary nebula phase that represents the death throes of intermediate-mass stars (those with one-half to eight times the mass of the Sun). Jim's pioneering work harnessed spectroscopy to unveil the physical conditions of planetary nebulae, to probe stellar evolution, and to trace the synthesis of the elements in stars. His PhD students have gone on to prominent careers in astronomy and in industry. Jim's research was recognized in national awards including a Guggenheim Fellowship, and he served as president of the Astronomical Society of the Pacific.

Jim was not only a prominent researcher, but also an international leader in astronomy education and outreach. Jim works tirelessly to spread his knowledge of and love for astronomy to anyone, with curiosity the only prerequisite. He has a particular genius for teaching introductory astronomy to non-majors, and he has taught thousands of students at Illinois over four decades, winning numerous awards along the way, including American Astronomical Society's 2008 Education Prize.

Not satisfied to merely teach much of the Illinois student body, Jim's lifelong outreach effort spanned the globe. He is a renowned planetarium speaker, and the 2002 planetarium show "The Stargazer" was devoted to him. Jim has also written nearly 20 books, including two textbooks, and his popular STARS website has recorded nearly 4 million visitors! At this time, he is writing another book about astronomy history during his career.

In honor of his commitment to teaching and astronomy, we dedicated the classroom as the James B. Kaler Classroom on August 21 with a virtual ceremony. Details were announced on our department website and Facebook pages.

Donations to continue to support the Kaler Classroom in our ever-changing educational landscape can be made at **astro.illinois.edu/kaler-classroom**.

From the department chair

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I am happy to present the Department of Astronomy's third newsletter as we begin our 99th year as a department (almost to 100!) and my fourth year as chair of the department. However, astronomy, as everything else, has been deeply affected by the terrestrial pandemic and social awakening.

The COVID-19 pandemic has majorly impacted our students and faculty with a quick pivot to online instruction in the spring semester and a still mostly online fall semester. We appreciate how everyone in our department rose to the challenge with amazing flexibility and extreme concern for students, faculty, staff, campus, and our communities. The full consequences of COVID-19 are not yet fully known, but the pandemic will leave a large impact on all of our lives and on astronomical research as well. Many observatories were shut down for the safety of the operators. For example, observations with the large interferometer array in Chile, ALMA, will likely be delayed nearly a year, observations with the airborne telescope SOFIA was delayed over three months, and observations with balloon launches from Antarctica were also delayed a year. On the other hand, some ground-based and most space-based observatories were able to run remotely, making sacrifices to stay open with limited support. Astronomers are very lucky for the most part in that most of our observations or simulations today can be done from home with data streaming in from distant locales. We hope you and your families were able to stay safe too.

Black Lives Matter. We affirm this truth and acknowledge that our department has significant work to do in order to live up to this truth. We must increase diversity at all levels and address systemic racism and deep-rooted social injustice, and its impact on astronomy and Illinois. We examined ourselves as part of a departmental discussion following the call for a strike on June 10, 2020 by Particles for Justice and Shutdown STEM in response to the unjustifiable killings of Breonna Taylor, George Floyd, Ahmaud Arbery, and many others. The faculty, staff, and students at the Department of Astronomy are committed to working to shape our public university to serve the diverse people of the state of Illinois and our nation as a whole. On our webpage, we have created a diversity menu with many action items. Although in the past, we have failed some students, today's students have a warmer and more welcoming arrival in the department than ever before. Our academic advising is now handled by a dedicated and professionally trained advisor. In addition to this, we have started an 8-week introduction course called "Careers in Astronomy" that provides students with the context of astronomy and a place to get additional support and interact with other majors, as well as provide a pathway for concerns to be expressed. We will continually strive to do better.

Even with a pandemic and social awakening, our faculty, research staff, graduate students, and many of our undergraduate students continue to produce amazing lines of research. Inside this newsletter, we focus on some stunning results from our graduate students. I am always impressed when talking to them with their mixture of drive, curiosity, and wide interests. Their work highlighted in this newsletter shows a mix of fundamental research from the origin of the Moon to distant galaxies with strong public engagement.

Although the pandemic has curtailed many or our usual activities, our online 2020 convocation was a success, and we were able to hold numerous, productive online department-wide discussions, Astronomy on Tap, journal clubs, etc. I am proud of how our department continued to strive under such difficult circumstances.

Thank you for your support. It is needed more than ever.

I'm honored to have the opportunity to be the chair of the department during the next year to pursue our shared goals of Illinois astronomy excellence and impact all aspects of our land grant mission.

Sincerely,
Leslie Looney

OUTREACH SPOTLIGHT

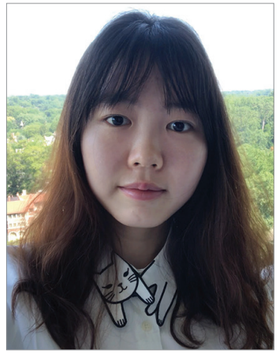
Bringing Astronomy to the Danville Correctional Center

From 2013 to 2015, professor **Brian Fields** taught astronomy workshops at Danville Correctional Center (DCC), a nearby medium security men's prison, as part of the Education Justice Project (EJP) at the University of Illinois. There was a revival of the visits when numerous Illinois astronomers did a tour of southern Illinois correctional facilities to inform them about the 2017 solar eclipse, led by professor **Leslie Looney.** Since then, graduate students **Adrienne Ertel** and **Samantha Thrush** have regularly taught workshops to incarcerated students, and recently began developing materials for an astronomy curriculum in addition to the self-contained workshops already being given. "The idea is to develop a bunch of little physics modules and examples to insert more physics/math into the conceptual astronomy talks we've been giving so far," Ertel said, "also possibly develop a series of accessible python labs that can be put on the computer in the prison and give the students access to real astronomy data to work with." Given the security restrictions of the prison, it is difficult for teachers of other STEM subjects to have "wet" labs, but astronomers sidestep this hurdle by bringing in images, numerical data, and computational exercises. Because STEM overall is underrepresented among teaching prison initiatives, one project goal is to make materials widely accessible and reusable by departments outside of the University of Illinois.

There is high interest among the Illinois Outreach group, their incarcerated students, and EJP to have a sustained, in-depth astronomy curriculum at DCC. Though COVID has made teaching in prison impossible for the foreseeable future, Thrush and Ertel's lecture materials will be accessible for future graduate students to continue their effort.

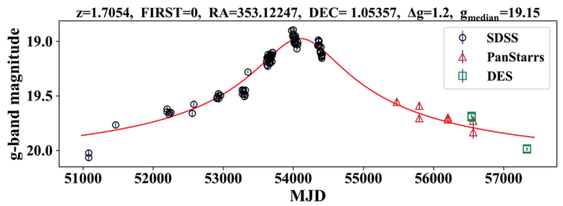
ALUMNI SPOTLIGHT

Observing Supermassive Black Holes Variations Over 16 Years



Alumna **Yuanze Luo,** left, (astronomy 2019 and now a graduate student in the Department of Physics and Astronomy at Johns Hopkins University), in collaboration with associate professor **Yue Shen** and postdoc **Qian Yang** (both Illinois astronomy), led a study of a mysterious population of supermassive black holes that varied their light to an extreme extent over the past two decades.

Some of these luminosity variations well exceed a factor of ten, which is highly unusual among the more common supermassive black holes that linger at the center of distant and massive galaxies. The team used a large collection of astronomical data from different telescopes that spanned more than 15 years to perform a detailed study of how these black holes varied their light, and if the pattern of variations depends on the physical properties of these supermassive black holes. While the reasons behind these extreme luminosity variations remain elusive, this study ruled out a few proposed ideas, and suggested that the dramatic change is due to the stochastic accretion process that powers these supermassive black holes. This is the first detailed study of the long-term behaviors of supermassive black holes showing extreme variability.

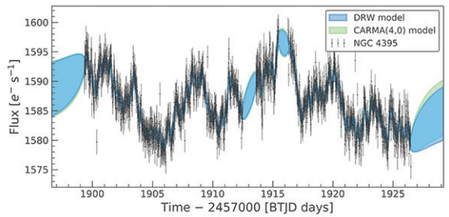


Brightness of a distant supermassive black hole with extreme variability plotted as a function of time (Modified Julian Days) over 16 years: the point colors represent different telescopes. The rise and fall for this particular object can be well fit by a microlensing model (red line), where the light from this active supermassive black hole is amplified for a period of a few years by a gravitational lens (most likely a star) in a foreground galaxy.

GRADUATE STUDENT SPOTLIGHTS

The Flickering Signal from a Baby Supermassive Black Hole

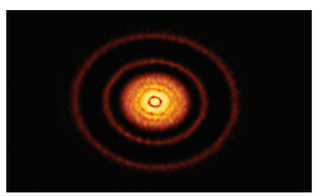
Supermassive black holes in the centers of galaxies are amongst the most violent and energetic phenomena in the universe. Using the TESS satellite, which was built for exoplanet discoveries, third-year graduate student **Colin Burke,** below, along with associate professor **Yue Shen,** assistant professor **Xin Liu,** and collaborators, detected the flickering of light from one of the smallest known supermassive black holes. This famous galaxy, NGC 4395, has a supermassive black hole mass of "only" a hundred thousand solar masses. Using the unprecedented precision of the TESS instrument, Burke and his team studied the statistical properties of the flickering. This flickering, or the variability of light at different times, is a smoking gun signature of these so-called active galactic nuclei. They found that the flickering from NGC 4395 behaves almost exactly as expected given its lightweight black hole. This result implies there may be a global relationship that governs the variability of active galactic nuclei across vastly different scales and masses. With additional observations, they hope to better understand the physical processes governing how the accretion of material onto supermassive black holes of all sizes drives this variability.



Flickering signal of NGC 4395 from the TESS satellite. This plot shows the light output (flux) versus time (days) and two models that can describe the variability.

Probing Young Solar Systems for Magnetic Fields

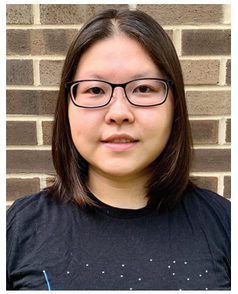
Protoplanetary disks are rotating disks of gas and dust that surround young stars as they form. Magnetic fields likely play a key role in the accretion of material from the disk onto the young star; however, finding direct observational evidence of magnetic fields in protoplanetary disks has proven difficult. Fourth-year graduate student **Rachel Harrison,** left, (and professor **Leslie Looney**) used observations of circularly polarized light produced by the Zeeman effect, a phenomenon where a single spectral emission line splits into several components in the presence of a magnetic field, to directly measure or set upper limits on magnetic field strengths. By observing the total intensity and circular polarization of nine spectral lines of the cyano radical (CN), the team was able to set an upper limit on the magnetic field strength in the protoplanetary disk AS 209 of about 8 mG (comparable to the magnetic field 1 foot away from a blender). From this limit, they derived an upper limit of the magnetically-driven accretion rate at a radius of 50 au from the central protostar of 10^{-8} solar masses per year, which is about 10 times lower than the accretion rate inferred by previous observations for regions close to the protostar. The difference in accretion rates, if confirmed, could mean that material close to the protostar is depleted at a higher rate than material farther out in the disk. Measuring magnetic field strengths in protoplanetary disks gives researchers insight into the formation of young solar systems, and this team plans to expand their study to include more sources in the future.

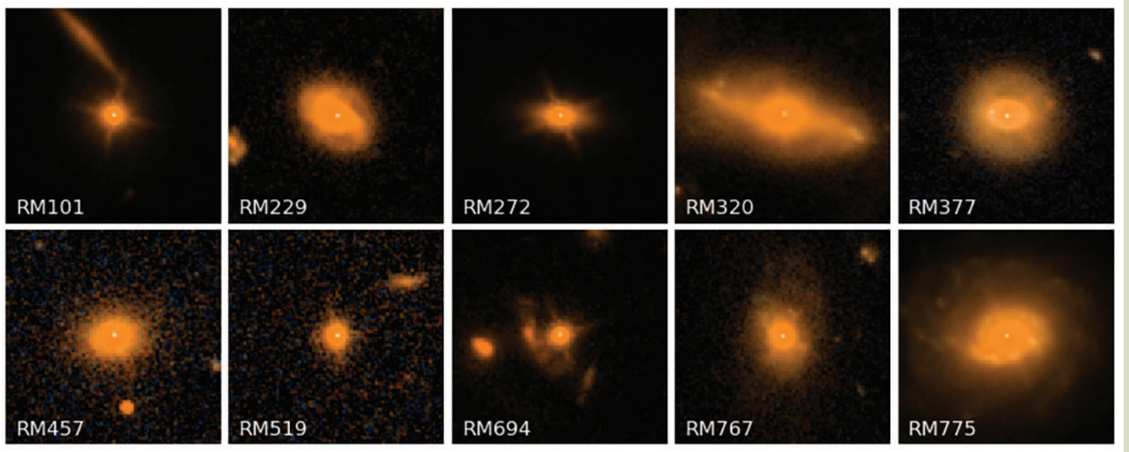


A higher resolution dust image of AS 209. Image Credit: ALMA (ESO/NAOJ/NRAO), S. Andrews et al.; NRAO/AUI/NSF, S. Dagnello

Supermassive Black Hole Scaling Relations Over Cosmic Time

Black hole scaling relations are the key observational evidence that links the growth and evolution of galaxies to their central supermassive black holes. Studying the redshift evolution of black hole scaling relations will allow us to understand how supermassive black holes regulate their galaxy's evolution over cosmic time. Graduate student **Jennifer Li,** left, and professor **Yue Shen** are part of the Sloan Digital Sky Survey Reverberation Mapping (SDSS-RM) collaboration (see last year's newsletter), which is simultaneously monitoring 849 quasars (the most luminous active galactic nuclei, AGN) out to a redshift of 4.5 (about 12 billion light years away). Reverberation mapping is the primary technique to measure directly black hole masses beyond the local universe by monitoring the delay in light variability from different structures of the AGN. In a sample of 10 quasars followed up using the Hubble Space Telescope (HST), they found that the black hole-host galaxy mass relation at a redshift of 0.5 (about 5 billion light years away) is consistent with local galaxy samples, showing that galaxies and supermassive black holes have been growing together for at least the last 5 billion years. Li and her team are currently observing 28 additional quasars from the SDSS-RM project with HST, which will yield the largest sample with accurate supermassive black hole masses for studying their evolution out to redshifts of 1 (about 8 billion light years away).

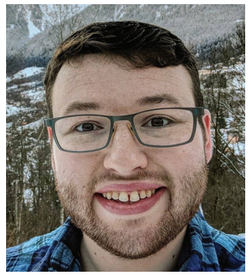




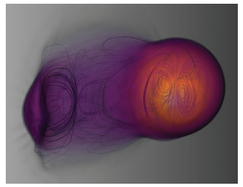
HST composite images of the 10 SDSS-RM quasars and their host galaxies.

GRADUATE STUDENT SPOTLIGHTS CONTINUED

Forming the Moon



The Moon is thought to have formed in the aftermath of a violent collision between a planetary mass impactor and the young Earth during the final stages of planet formation in the Solar System. This "giant impact" produces a disk of debris that orbits the Earth, which later condenses to form the Moon. Fifth year graduate student **Patrick Mullen,** above, and professor **Charles Gammie** use some of the world's most powerful supercomputers to simulate this Moon-forming giant impact scenario. In particular, their 3-D numerical models address the role of magnetic fields during the collision and in the evolution of the post-impact debris disk. Mullen and Gammie find that the Moon-forming giant impact stretches and winds any magnetic field the impactor and/or Earth may have possessed, hence amplifying their strength(s). In some regions of the post-impact system, they find that the magnetic field can be amplified to strengths comparable to those found in a medical magnetic resonance imaging (MRI) machine! Furthermore, their numerical models demonstrate that the debris disk ultimately succumbs to vigorous magnetized turbulence. This turbulence governs the post-impact evolution of the debris field, and, as Mullen and Gammie argue, may influence when, where, and how the Moon actually formed.



Snapshot from a 3-D numerical simulation of a magnetized, Moon-forming giant impact.

Graduate Student News

Graduate students play a critical and important role in our department. They are students, researchers, teachers, mentors, and leaders, and we acknowledge their achievements in all of these areas. This year with the pandemic, their efforts are even more distinguished. In the last year, their research interests spanned topics in all of astronomy. Attending talks of our students, we expect some more great results this upcoming year in spite of all the difficulties.

One of the first steps for our graduate students is the preliminary exam in which they outline their PhD research. The graduate students who have passed their prelims this academic year are (ordered by date): **Samantha Thrush** and **Sunny Tang.**

We are happy to announce our graduate students who have graduated with a PhD this academic year (ordered by date): **Taylor Tobin, Andrew Nadolski, Miguel Holgado,** and **Celeste Lü.**

The Mr. and Mrs. Hsiang-Pai and Wen-Hua Chu Department of Astronomy Excellence in Research Graduate Student Award was founded by Professor Emeritus and former Department of Astronomy chair **You-Hua Chu,** named in honor of her parents. The 2020 winner of the award is **Jennifer Li.** Li uses a wide array of imaging, spectroscopic, and time-domain data from ground- and space-based facilities to study the evolution of supermassive black holes and their host galaxies.

In addition to these departmental awards and milestones, our students are winning university-wide and external recognition. Some selected highlights: **Patrick Aleo** (CAPS Fellowship), **Melanie Archipley** (Excellent Teacher List, Sp19, CAPS Fellowship), **Colin Burke** (Excellent Teacher List, Sp19, CAPS Fellowship), **Tony Chen** (Taiwanese Government Scholarship to Study Abroad 2019-2021, CAPS Fellowship), **Alex Gagliano** (National Science Foundation Graduate Research Fellowship), **Di Wen** (Excellent Teacher List, Sp19), and **Xinyang Lu** (Excellent Teacher List, F19).

Undergraduate Student News

Our majors are still increasing, which is great. This year, we have had some truly amazing students, doing classwork, getting involved in research, and making a difference. With the pandemic, we had a very successful online convocation. We are proud of our 2020 graduates! Congratulations to the Department of Astronomy Class of 2020, our biggest graduating class to date: **Nirali Bhatt, Vivek Bhookya, Barry Chiang, Tori Colthurst, Elizabeth De Sa E Silva, Devanshi Pratap, Keslie Elketroussi, Lina Florez, Lauren Gregory, Andrew Groesch, Anushri Gupta, Lily Ho, Jacob Hogan, Yuxuan Hu, Angela Iwanicki, Logan Kimball, Yujie Liang, Yufeng Luo, Nikhil Makhijani, Jason Meier, Alexander Moore, Chauncey Murphey, Kyle Nelli, Charmi Patel, Vivian Perez, Sonny Podlesnik, Aisyah Rafique Ali, Ethan Rane, Alexander Rudd, Richard Scherrer, Robert Sells, Charmi Shah, Alexander Shepard, Danylo Sovgut, Pengyue Sun, Nathan Turcich, Hailin Wang, Charles Young, Emily Zhang, Zitao Zhu,** and **Yi Zhuang.**

The Layla Suzanne Ryan Memorial Scholarship was established to recognize outstanding undergraduates who also exhibit community service. The winner of the 2020 award is graduating astronomy major **Lina Florez.** The Stanley Wyatt Memorial Award is awarded annually to the graduating astronomy major or minor with the most outstanding GPA and track record of undergraduate research. The 2020 award co-recipients are graduating astronomy majors **Barry Chiang** and **Kyle Nelli.**

NEW FACULTY:
Decker French

We are happy to welcome our new assistant professor **K. Decker French** to the department this fall. She comes to us from the Carnegie Observatories in Pasadena where she held a prestigious Hubble Fellowship. She received her PhD in astronomy and astrophysics from the University of Arizona in 2017 and two SB degrees in physics and Earth, atmospheric and planetary sciences at M.I.T. Professor French grew up in the suburbs of Chicago, visiting the University of Illinois many times, so we expect that she will fit in quickly to campus. Professor French's research takes advantage of the new and large astronomy surveys of the sky, which allow her to explore new and exciting transient objects. One of the most impressive of these is her study of black holes that have been caught ripping apart stars falling into them, so-called Tidal Disruption Events (TDEs). She has found that TDEs are common in galaxies that have just ended a burst of star formation and are called post-starburst galaxies, which can provide a technique for finding more TDEs and learning the details of their evolution. She is another faculty member that we expect will be taking advantage of the Rubin Observatory Legacy Survey of Space and Time (LSST) opportunities on campus. We look forward to sharing her future research results in future newsletters.

Faculty News

We are excited to announce the following faculty recognitions: Assistant professor **Xin Liu** was recognized as a Lincoln Excellence for Assistant Professors (LEAP) scholar and as a National Center for Supercomputing Applications (NCSA) 2020-2021 Fellow; Professor **Charles Gammie,** as part of the Event Horizon Telescope collaboration (highlighted last year), was awarded the 2020 Einstein Medal and named as one of the Bloomberg top 50; Professor Emeritus **Jim Kaler** was named one of the Legacy AAS (American Astronomical Society) fellows.

The following were recognized on the campus Excellent Teacher List: professors **Bryan Dunne** (F19), **Brian Fields** (Sp19 and F19), **Leslie Looney** (Sp19 and F19), and **Yue Shen** (F19).

Staff News

We are happy to welcome two new astronomy staff members. **Jennifer Dixson** joined astronomy in late fall of 2019 as our new officer manager, and **Susie Zukosky** joined in late spring of 2020 (right before campus was shut down) as our new assistant to the chair.

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We count on the generosity of alumni and friends to support students as they embark on earning a world-class education and to fund faculty members as they conduct world changing research and train students. Your investment makes a big difference!

Yes! I believe in the importance of excellence in astronomy and wish to show my support!

$_____ **Department of Astronomy Annual Fund.** (11334898)
Your gift to our department fund will have the widest impact as it supports the full range of our key missions, including undergraduate and graduate student support, distinguished lecturers, the recruitment of excellent faculty, and alumni and outreach events.

$_____ **James Kaler Astronomy Classroom Fund.** (11341988)
Continue to support our newly dedicated Department classroom, named after one of our most beloved faculty members.

$_____ **Stanley Wyatt Memorial Award Fund.** (11775123)
Support graduating Astronomy majors/minors with outstanding GPAs and track records of undergraduate research. Help us increase the monetary award, which has not increased in the last 10 years.

$_____ **Layla Suzanne Ryan Scholarship Fund.** (11773536)
Support junior or senior majors/minors in Astronomy who exhibit outstanding community service or outreach.

$_____ **Mr. & Mrs. Hsiang Pai & Wen-Hua Chu Department of Astronomy Excellence in Research Graduate Student Award Fund.** (11774227) Support graduate students who exhibit excellence in research. We want to expand this award to have a theory and observational award each year. Your gift can help achieve this.

$_____ **Icko Iben Jr. Distinguished Lectureship Series Fund.** (11772338) Support the Iben Lecture series that brings top researchers to campus to give public talks on their work.

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