

**Office of the President**

**TO MEMBERS OF THE ACADEMIC AND STUDENT AFFAIRS COMMITTEE:**

**DISCUSSION ITEM**

*For Meeting of May 15, 2024*

**ASTRONOMY AT THE UNIVERSITY OF CALIFORNIA**

**EXECUTIVE SUMMARY**

The University of California has been a national leader in astronomy and astrophysics since the founding of Lick Observatory in the 1880s. Enabled by sustained investments in shared research facilities, the number of astronomers serving on the faculty have grown and are now located at all nine of UC's undergraduate campuses. UC astronomers have made amazing discoveries, such as proving the existence of a supermassive black hole in the center of the Milky Way galaxy, measuring the atmospheres of planets orbiting other stars, and illuminating how galaxies have formed since the Big Bang. Collectively, this work has led to numerous important prizes, including the Nobel Prize in Physics in 2020. Astronomy engages and inspires the public and serves as a gateway into science for K–12 students. Today, UC's world-class facilities include laboratories at UC Santa Cruz and UCLA, as well as serving as managing partner of the W.M. Keck Observatory in Hawai'i. UC remains at the forefront of both national and international developments in this pathbreaking field, requiring sustained investments in the programs, faculty, and facilities that enable this excellence. Astronomy is a crown jewel of UC due to excellence in research, education, and outreach.

**BACKGROUND**

**Astronomy at UC**

UC's preeminence in astronomy began with Lick Observatory on Mount Hamilton near San Jose, California. Inspired by meetings with astronomers, James Lick, the wealthiest man in California at the time of his death, decided that his legacy would be the construction of a telescope "superior and more powerful" than any other. This led to the construction of the first true mountaintop observatory, above the turbulent air and (at the time) away from the lights of cities. The 36-inch great refractor at Mount Hamilton fulfilled that vision when it saw "first light" in 1888.

Over the next 80 years, Lick remained a leading facility, and new technologies enabled more powerful telescopes, culminating in the 120-inch Shane Reflector in 1959. Lick became a shared facility for all campuses, and in 1966 the headquarters and most of the staff of the Observatory moved from the mountain to the new campus of UC Santa Cruz. The scientists and engineers

continued to pioneer new technologies. Digital detectors—the predecessors of the sensors in modern smartphone cameras—replaced photographic film and human eyes. UC’s Lawrence Livermore National Laboratory developed the first effective astronomical adaptive optics system that used lasers and deformable mirrors to correct for the blurring of the Earth’s atmosphere and produce images as sharp as the Hubble Space Telescope. The UC Santa Cruz Center for Adaptive Optics, funded by the National Science Foundation (NSF) in 2000, continues to showcase UC’s research excellence in optics.

In the 1980s and 1990s, UC, in collaboration with the California Institute of Technology (Caltech), built the next great telescope, the twin ten-meter (400-inch) telescopes of the W.M. Keck Observatory. Computer-controlled and incorporating new manufacturing techniques, the Keck telescopes were revolutionary at their first light in 1993 and 30 years later remain the largest and most scientifically productive telescopes on the Earth. Keck’s list of transformative discoveries include Professor Andrea Ghez’s Nobel Prize-winning studies of the supermassive black hole in the center of the Milky Way galaxy; the first images of planets orbiting other stars; and detailed studies of distant galaxies billions of years into the past.

UC also plays a major role in astronomy using space telescopes. The James Webb Space Telescope (JWST) became operational in 2021 after twenty years of development by NASA, and it is producing incredible science results almost daily. UC scientists lead many of the key projects for the JWST, including studies of the first galaxies in the universe, measurements of the atmosphere of planets orbiting other stars (“extrasolar planets”), and images of planets in the solar system.

Today there are astronomy faculty at all nine undergraduate campuses, as well as strong astrophysics and related technology groups at all three UC National Laboratories. Access to shared facilities allows even the newest faculty at all campuses to carry out cutting-edge research from the moment of their arrival. More than 350 scientists use UC facilities in some way, and astronomy brought in more than \$30 million in outside research funding in fiscal year 2023 alone. More than 30 percent of all National Academy of Science members in Astronomy are in the UC system. Astronomy and astrophysics in the UC system support STEM pipelines, through an increasing number of astronomy degree programs and campuses, through outreach, and through bridge and student research programs such as Cal-Bridge and the Lamat Institute.

### **UC Observatories**

The UC Observatories (UCO) Multi-Campus Research Unit (MRU) has several critical missions. First, it continues to operate Lick Observatory, maintaining it as a resource for students and faculty. Second, it represents UC in the Keck collaboration and leads the development of new instruments for use with the Keck telescopes. Developing a modern astronomical instrument costs \$10 million to \$40 million (or more) and requires extremely specialized technical expertise. UCO serves as the home for that expertise and supports seed funding for initial design stages so that instrument designs are complete enough to propose to federal and private funding opportunities. Third, UCO supports education: telescopes are used for undergraduate and graduate classes and workshops, and new programs are building

partnerships with community colleges and the California State University system. Fourth, UCO brings science to a broad California audience, primarily through visitor programs at Lick but expanding over the next few years. A recent highlight is the *La Noche de las Estrellas* program, a Spanish-language event for high school students at Lick Observatory. In all, the UCO MRU successfully develops new technologies and instruments that have allowed continuous paradigm-breaking discoveries for UC astronomers and offers meaningful engagements with astronomy to the public.

Prior to 1990, UCO's technical staff were almost exclusively at Mount and at UC Santa Cruz, while the scientific users were at all campuses. Beginning in 1990, UCLA launched a laboratory for infrared instrumentation that has developed state-of-the-art Keck instruments. UCO supports core technical staff at both UCLA and UC Santa Cruz and fosters multi-campus collaborations. UCO underwent significant restructuring and funding cuts ten years ago; successive directors, National Medal of Science winner Professor Sandra Faber and National Academy member Claire Max, have worked to produce a stable long-term operations level. In 2022, UCO appointed Bruce Macintosh as its new Director after a national search and is beginning a broad strategic planning process with support from the Office of Research and Innovation at the Office of the President.

A major grant to UCO from the Gordon and Betty Moore Foundation (GBMF) is allowing a large expansion of education and outreach at Lick Observatory. A new Scientific Teaching through Astronomical Research (STARS) program will bring students from Bay Area community colleges and California State University campuses to Lick, allowing a diverse population of students to experience moments of discovery and inspiration.

### **Opportunities for the Future**

The astronomy landscape continues to change rapidly. The National Academy of Sciences released the Decadal Survey of Astronomy and Astrophysics (Astro2020) in 2021. It highlighted three scientific areas: the study of extrasolar planets and the search for potentially life-bearing, Earth-like worlds; the evolution of galaxies and how matter flows through them to make stars and planets; and the search for new laws of physics, such as the nature of the dark matter and dark energy that dominate the universe. All of these align with areas of strength for UC and the UC-affiliated National Laboratories. Astro2020 also set priority investments for federal funding, recommending that the NSF invest in Extremely Large Telescopes (ELTs) as well as a NASA mission—now called the Habitable Worlds Observatory (HWO)—that will be able to detect Earth-twin planets orbiting nearby stars. UC scientists have leadership roles in many of the recommended projects.

Astro2020 also highlighted the state of the astronomy profession, the importance of diversifying STEM and supporting astronomers in a healthy scientific environment, free of harassment and prejudice. The Survey also considered the societal impacts of astronomy, and the need for a community-based astronomy model in which astronomers meaningfully partner with the communities that host their telescopes.

The most significant example of this is Hawai'i, where historically astronomy did not sufficiently consult or benefit the local community. The Keck Observatory has been implementing a community-based astronomy model consistent with Astro2020 and connecting with the community in Hawai'i. UC supports this and also directly operates the Akamai internship program, a STEM research program connecting Hawaiian students with observatories and other science and engineering opportunities. The legal structure for managing Maunakea lands where Keck located is also evolving. The Legislature of Hawai'i passed a law shifting stewardship responsibilities for Maunakea to a new Mauna Kea Stewardship and Oversight Authority (MKSOA) which vests decision-making in community stakeholders and will have authority over leases (such as the Keck Observatory) and permitting of future projects.

Lick Observatory presents both a challenge and opportunity. The Lick facilities are smaller than Keck and other telescopes, surrounded by bright city lights, and affected by wildfire in 2020. However, it remains important for key specialized science programs, for technology development, and as a host to novel experiments from campuses, such as the PANOSSETI project. Lick also plays a large role in education of UC students, and for outreach to the Bay Area community. New partnerships, such as the GBMF STARS program, will help strengthen these missions.

Enabling new discoveries with the Keck Observatory will require UCO to support new faculty with new ideas, and aggressively seek out Federal and private funding for new instruments. There are a broad range of new opportunities in astronomy and astrophysics. New technologies, including artificial intelligence and "optics on a microchip" photonics, will further enhance UC's telescopes. Revolutions in space capabilities can enable new orbiting observatories. Large collaborations will be increasingly important in astronomy, and multi-UC-campus projects could be critically important. As part of the strategic planning process, UCO will explore systemwide roles to ensure UC will continue to be a leader in astronomy and poised to make future discoveries that extend beyond current imagination.

### **The Thirty Meter Telescope**

The Thirty Meter Telescope (TMT) is a next-generation, ground-based telescope that is capable of transformative science, from the study of the origin of the universe to the search for other life-bearing Earths orbiting nearby stars. UC was a founding partner of the project, which now includes Caltech and the national science foundations of Canada, India, and Japan. The US National Academies 2020 Decadal Survey recommended a major federal government role in both of the two ELT projects as its highest priority for the NSF. The other ELT project is the smaller Giant Magellan Telescope to be sited in the southern hemisphere, led by Carnegie, Harvard, the University of Arizona, and other partners. TMT has been formally proposed to the NSF, passed successfully through the NSF's preliminary design review, and received design development funding. Congressional appropriations language encourages the NSF to fund both ELT projects, while a National Science Board recommendation directs the NSF to select between them; the NSF is planning a review to assess the role, readiness, and capabilities of the projects over the next months.

Construction of TMT was halted in 2019 by large-scale protests by the people of Hawai'i who were unhappy with the impact of astronomy on Maunakea, a mountain that is sacred to many. Construction remains paused. TMT has been working to build partnerships in Hawai'i, listening to the concerns of the people, supporting education and workforce development, and developing programs to meaningfully meet the needs of the community. The NSF is also carrying out an environmental and cultural impact survey. The TMT International Observatory (TIO) Board is maintaining the project during NSF consideration and will likely require additional financial commitment from Members. In the near future, Regents may need to take an action to approve additional funding and resources towards the pre-construction and construction of the Project. The University is seeking to obtain a significant portion of such additional funding from philanthropic sources. Approval of this additional funding commitment may be requested in advance of an upcoming TIO Member meeting at the end of May 2024.

### **CONCLUSION**

As a national leader in astronomy and astrophysics, UC makes critical contributions to national and international initiatives through scientific discoveries, technology development, and education and service engagements with the general public. Astronomy engages and inspires the public and serves as a gateway into science for K–12 students. UC is poised to remain at the forefront of this pathbreaking field and will require sustained investments in the programs, faculty, and facilities that enable this excellence.

### **KEY TO ACRONYMS**

ELT	Extremely Large Telescopes
GMBF	Gordon and Betty Moore Foundation
HWO	Habitable Worlds Observatory
JASON	Defense Advisory Group
JWST	James Webb Space Telescope
MRU	Multi-Campus Research Unit
NASA	National Aeronautics and Space Administration
NSF	National Science Foundation
PANOSETI	Pulsed All-sky Near-infrared Optical Search for Extraterrestrial Intelligence
REU	Research Experiences for Undergraduates
STARS	Scientific Teaching through Astronomical Research
STEM	Science, technology, engineering, and math
UC	University of California

UCLA	University of California Los Angeles
UCO	University of California Observatories