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Office of the President

TO MEMBERS OF THE ACADEMIC AND STUDENT AFFAIRS COMMITTEE:

DISCUSSION ITEM

For Meeting of March 20, 2024

ASTRONOMY AT THE UNIVERSITY OF CALIFORNIA

EXECUTIVE SUMMARY

The University of California (UC) 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 (UCSC) and UC Los Angeles (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 more "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 (UCSC). 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 UCSC Center for Adaptive Optics, funded by the National Science Foundation in 2000, continues to showcase UC's research excellence in optics.

In the 1980s and 1990s, UC, in collaboration with 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 20 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 bridge and Research Experiences for Undergraduates (REU) 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 with expansion planned 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 Hamilton and at UCSC, 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 UCSC 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 the National Science Foundation to 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 telescopes. The latter is particularly critical in the case of Hawai'i.

The Thirty Meter Telescope (TMT) is a next-generation, ground-based telescope, capable of transformative science, from 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 the California Institute of Technology and the national science foundations of Canada, India, and Japan. The U.S. National Academies 2020 Decadal Survey recommended a major federal government role in the two U.S. ELT projects as its highest priority for the U.S. National Science Foundation (NSF). The other ELT project is the Giant Magellan Telescope, to be sited in the southern hemisphere, led by the Carnegie Institution for Science, Harvard University, and the University of Arizona, along with other partners. TMT has formally been proposed to the NSF, passed successfully through preliminary design review, and received design development funding. As of March 26, 2023, the National Science Board—the governing body of NSF—recommended that NSF support one project, requesting NSF to develop a selection process. TMT and UC are monitoring these activities and planning a response when the selection process is developed.

Construction of TMT was halted in 2019 by large-scale protests by the people of Hawai'i, unhappy with the impact of astronomy on Maunakea, a mountain that is sacred to many. Construction remains paused. TMT, with support from UC, has been working to build true 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. UC's partners at the Keck Observatory have been pioneers in Hawaiian community relations. The Legislature of Hawai'i passed a law giving governance of Maunakea to a new Mauna Kea Stewardship and Oversight Authority (MKSOA) which incorporates all voices into its leadership and will have authority over existing leases (such as the Keck Observatory) and future projects. MKSOA is an extremely positive development and creates hope for a just and shared solution to the role of astronomy in Hawai'i.

Lick Observatory is both a challenge and opportunity. The Lick facilities are outsized by Keck and other telescopes, surrounded by bright city lights, and impacted 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 Pulsed All-sky Near-infrared Optical Search for Extraterrestrial Intelligence (PANOSETI) project, which will be capable of surveying the entire northern hemisphere with an increase in observable wavelengths, stellar systems, and monitored time. 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 system-wide

roles to ensure UC will continue to be a leader in astronomy and poised to make future discoveries that extend beyond current imagination.

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
JWST	James Webb Space Telescope
MKSOA	Mauna Kea Stewardship and Oversight Authority
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
TMT	Thirty Meter Telescope
UC	University of California
UCLA	University of California Los Angeles
UCO	University of California Observatories
UCSC	University of California Santa Cruz