Testimony of
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Astronomy and Astrophysics in the FY 2012 Budget
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Thank you for the opportunity to comment on astronomy and astrophysics in the fiscal year 2012 budget from my perspective as President of the American Astronomical Society (AAS). **The AAS supports the NASA budget request of $18,724 million. Within the NASA Science Mission Directorate, the AAS support the Division of Astrophysics request of $683 million, the James Webb Space Telescope request of $374 million, the Division of Heliophysics request of $622 million, the Division of Planetary Science request of $1,541 million, and the Division of Planetary Science Technology Program request of $133.9 million that includes support for the critical restart of production of plutonium-238, necessary for missions that explore the remote parts of our solar system. The AAS also supports the Astrophysics Explorer Program request of $118.3 million, a highly ranked priority in the Astronomy and Astrophysics Decadal Survey. The AAS supports the NSF request of $7,767 million and the Division of Astronomy requested funding level of $249 million. The AAS supports the Department of Energy Office of Science request for $5,416 million and the Office of Nuclear Energy plutonium-238 production restart for $10 million.**

Representative Wolf, let me begin my testimony by thanking you for your bipartisan leadership in supporting science and advanced research during your time in Congress. Your efforts, along with your colleague Representative Mollohan over the past several years, have significantly benefited science broadly and astronomy in particular. I can think of no more important way to ensure the long-term success of our Nation than to support advanced research in science, engineering and technology, as you have done and I know you will continue to do.

The excitement of scientific discovery is a powerful force among our Nation's youth, and leads directly to an improved standard of living in our Nation by attracting talented young people to pursue STEM careers. Astronomy has a role to play in this regard, not just in uncovering the mysteries of the Universe, but by drawing young people to the worlds of science, technology and engineering. Nearly everyone I have met involved in the pursuit of science, from student to professor, is amazed by discoveries about the Universe revealed by NSF-supported telescopes like the VLA and NASA missions like the Hubble Space Telescope and the Kepler mission. The "Rising Above the Gathering Storm" report warns that our younger generation is less educated than its parents, and that the nation is not adequately training the next generation of engineers and scientists; this failure directly impacts our economy. The public science literacy rate is less than 30%, and the US must improve to remain competitive. Astronomy offers one way to help because it is a mind-opening field that engages the public and schoolchildren in science; 60 million people go to museums and planetariums every year, 15% of all future K-12 teachers take astronomy as their only college science course, and 250,000 college students are enrolled in astronomy courses annually.

The American Astronomical Society is the pre-eminent membership organization for research astronomers in North America. With nearly 7,500 members overall, and more than 6,500 in the United States, the AAS serves its community by publishing the most important research journals in our field, organizing the largest astronomy meetings in the world, and providing career development, education and outreach activities. I am honored to serve the Society as its President and grateful to be able to provide testimony to the Commerce, Justice and Science Appropriations Subcommittee on behalf of the American Astronomical Society and the community it represents.

The astronomy and astrophysics community in the United States undertakes a survey every decade of the current state of our understanding of the Universe to determine the areas most ripe for discovery in the coming decade and to prioritize the projects, programs, and missions that are necessary to make progress in these important research areas. As a community, we have been executing these decadal surveys since the 1950s. The report is produced by the National Academy of Sciences, with the support and encouragement of the American Astronomical Society and the entire astrophysics community, and is funded by the primary research agencies that support our area of research: NASA, NSF and the Department of Energy. Practically, these reports provide policy makers with a community-prioritized set of initiatives for federal support chosen from a very much larger group of exciting proposals.

The AAS fully endorses the recommendations of the most recent decadal survey, completed in August 2010: the "New Worlds, New Horizons" (NWNH) report. The recommendations of NWNH represent the consensus of the astronomical community on our priorities for research and activities in astronomy and astrophysics in the decade between 2012 and 2021.

The recommendations are based on a 2-year effort, starting with several hundred white paper submissions and dozens of Town Halls from all over the nation, filtered through nine panels and six study groups to the main Astro2010 committee to come up with a plan that fits the budget guidelines we were originally given by the federal agencies. The process involved a careful assessment of cost evaluation and technical readiness by an independent contractor so that the projects and activities should not suffer cost overruns. The NWNH report acknowledges the challenges of maintaining and developing a national astronomy and astrophysics program during a time of budget constraints. The report states, "The committee's proposed program is recommended on the basis of four general criteria—maximizing scientific contribution, building on the current astronomy and astrophysics enterprise, balancing this decade's programs against investing in the next decade's, and optimizing the science return given the highly constrained budget."

The astronomy and astrophysics divisions of NASA and NSF have designed FY2012 budgets to align with the recommendations of NWNH. The NWNH report is a balanced set of recommendations, with small, medium, and large projects and missions, for ground and for space, and also includes core research activities such as technology development, laboratory astrophysics, theory and computation, and data analysis and archiving. The top two large-scale ground-based initiatives are the Large Synoptic Survey Telescope (LSST) and the Mid-Scale Innovations Program. The top two large-scale space-based initiatives are the Wide-Field Infrared Survey Telescope (WFIRST) and the Explorer Program.

The LSST is a large field-of-view 8-meter class telescope. It will revolutionize our exploration of the sky by opening the time domain window, with a survey of half the sky every few days. The rapid response system will alert astronomers to transient events within 1 minute for quick follow-up observations, and the tens of terabytes of data acquired each night will require development of a very accessible database. LSST will be applied to everything from Near-Earth asteroids (a Congressionally mandated study) to observations of billions of galaxies and a mapping of our Galaxy's stars, to supernovae and mapping of large-scale matter distributions that will help our understanding of cosmic acceleration and put constraints on dark energy and dark matter. It will be a facility that is unique in the world, and the US leadership in this endeavor will emphasize some of the US optical astronomy technical strengths.

LSST is technically ready to go and under development, with many private and international investors, and NSF and DOE would share the federal cost (NSF through the Major Research Equipment and Facilities Construction [MREFC] line and later AST for the federal share of operations costs, and DOE for the camera). The data system development fits in well with Presidential cross-cutting areas of data archiving capabilities (also tying in to NSF's CIF21 line in the FY2012 budget for cyber infrastructure).

The Mid-Scale Innovations Program was the second-ranked large-scale project, allowing a competed program for projects between the $4M Major Research Instrumentation (MRI) line and the $135M MREFC line. There were more than two dozen worthy projects in this category proposed to the decadal survey. Among them are CCAT, a 25-meter sub-millimeter and millimeter telescope that will complement ALMA (Atacama Large Millimeter Array) by providing large-scale surveys, as well as a solar radio telescope with high resolution, a gravity-wave detector, a Cerenkov detector to study high energy events, advanced adaptive optics, and a radio array to probe the epoch of recombination when the first stars formed. NSF is now considering a Foundation-wide mid-scale line, because other disciplines also have a need for this level of funding, and it makes sense to provide funding through competed programs.

WFIRST is a wide-field infrared telescope with three goals: it will accomplish exoplanet space studies through microlensing, to complement the discoveries of Kepler by doing a census of planets in the outer parts of solar systems, it will provide insight on dark energy through three techniques (baryon acoustic oscillations, supernovae, and weak lensing), which will complement the ground-based LSST optical results, and it will have a survey mode for galactic and general guest investigator studies. NASA may pursue a possible collaboration with ESA on a joint WFIRST/Euclid mission if it could do all the science NWNH proposed for WFIRST; such a joint project would build on the strengths of international collaborations for large projects. Meanwhile, NASA has selected the Science Definition Team for WFIRST, which is necessary for helping to specify the mission details.

For the FY2012 budget, NASA has included a separate line in the Astrophysics Division for an Explorer program as a response to the second-ranked large-scale recommendation in NWNH. Each Explorer is medium-scale; the funding NWNH recommended was for several Explorers per decade (2 SMEX, 2 MIDEX, and several Missions of Opportunity) to restore the program to its previous level of activity. These missions provide rapid turnaround, have led to Nobel prize-

winning results such as with COBE (Cosmic Background Explorer), and enable crucial training for young astronomers to learn how to build instruments for later larger missions.

The James Webb Space Telescope (JWST) is the successor to the Hubble Space Telescope, which has brought astronomy and astrophysics to the next level and inspired many Americans to study astronomy. The potential of JWST to transform astronomy underlies many of the activities recommended in the NWNH decadal report. It is designed to observe beyond Hubble's capabilities to the earliest observable epoch of the universe. It is expected to serve thousands of astronomers over the next decade.

JWST's primary scientific mission has four main components: to search for light from the first stars and galaxies which formed in the Universe after the Big Bang, to study the formation and evolution of galaxies, to understand the formation of stars and planetary systems, and to study planetary systems and the origins of life. JWST will have a 6.5-meter (21.3 ft) primary mirror, about three times the size of Hubble's 2.4-meter mirror. The sunshield is the size of a tennis court. In order for it to fit in a rocket for launch, the sunshield will be folded up like origami. JWST will orbit 1 million miles away from Earth, four times any distance humankind has traveled. (For comparison, Hubble orbits 300 miles above Earth, and the International Space Station orbits at about 220 miles. The Moon is 250,000 miles away from Earth.) JWST will be at the L2 Lagrange point, where it is not serviceable but can maintain the same orientation with respect to the Sun and Earth, making shielding and calibration much simpler.

On November 10, 2010, NASA Administrator Charles Bolden released the findings of the Independent Comprehensive Review Panel on the James Webb Space Telescope (JWST). Senator Barbra Mikulski called for the independent review, which was led by John Casani from NASA's Jet Propulsion Laboratory. The report stated that the mission is technologically sound and the cost growth is a result of mismanagement. The management of JWST has moved to NASA Headquarters. Richard Howard, NASA's deputy chief technologist, will head the new division for JWST. Howard's first order of business will be to make a new budget for JWST. We support the $374 million requested for JWST; however, it is currently going through a bottom-up cost estimate process, and the full cost to launch JWST at the earliest possible date will be known by mid-summer. NASA must be ready to adjust its funding profile at that time in order to optimize the use of federal money.

Let me speak briefly about another important issue, which involves two government agencies, is of low cost, and which has been a shining example of American prowess in scientific and technological achievement: the production of plutoninum-238 (Pu-238) and its integration into power modules that generate electrical power by converting heat into electricity. Pu-238 was produced in parallel with the production of fissile plutonium. With the end of the cold war and reductions in the need for fissile plutonium, the production of Pu-238 was also halted. Through radioactive decay, the stockpile of Pu-238 has dwindled, while also being tapped to power solar system exploration missions like the Cassini mission, which has generated so much new knowledge about Saturn and its rings and moons. For several years, the administration has sought to restart the production by proposing funding of roughly $30M total, while involving both the producer of plutonium (the Department of Energy) and the user (NASA). Only two

nations, the US and Russia, are capable of producing or have stockpiles of this material. It is time again to produce our own.

Restart of Pu-238 production is of critical importance to the development of planetary science missions. There is no viable alternative way to power deep space missions, as solar panels cannot produce enough electricity far from the Sun. If Pu-238 production starts immediately, there will still be a 5-year delay to have enough Pu-238 for a spacecraft. Full scale Pu-238 production is unlikely until 2018, which is too late to meet all of NASA's needs. The delay will push back the 12 proposed planetary space missions that require Pu-238. The delay could cause missions to reach prohibitively high costs, which in turn could bring about job losses, diminish the United States leadership role in planetary science, and prevent us from expanding human knowledge of the universe. Given the magnitude of the funds necessary to regain our production capability, I strongly urge you to fund this request fully at the President's requested level.

As noted in NWNH, for centuries astronomy has contributed to society not only through discoveries about the Universe but also through the advancement of science and technology in general. Technological developments for NASA X-ray astronomy programs have led to today's X-ray inspection systems used by airports, the military, and border patrols. Astronomical image processing techniques are widely used in medical fields, in industry, and even in tracking endangered species. Software developed to schedule observations by the Hubble Space Telescope has now been adapted to optimize semiconductor manufacture, to manage patient flow in hospitals, and to assist in WiFi communications.

We understand the need for fiscal restraint, and we agree that government needs to live within its means. Spending cuts, however, need to be smart and strategic. Cuts to government-sponsored scientific research and critical research facilities are counterproductive at a time when we are seeking to facilitate and spark economic growth. Such cuts would only hurt our long-term competitiveness, especially at a time when emerging economies such as China and India are ramping up their investments in scientific research and education. Europe seems poised to take over the US lead in ground-based optical and space-based astronomy. Cuts to research and facilities would also have a severe impact on cutting-edge research that is critical to our future. At DOE, the cuts would affect high energy and nuclear physics, magnetic fusion, heavy-element chemistry, nanotechnology, high-performance computing, advanced materials, and structural biology. Proposed cuts to NSF would have even broader and more far-reaching impacts in many other important scientific disciplines.

It is time for America to tackle the largest drivers of our debt and deficit, rather than shortchange our future by cutting funding on our most talented students, essential research, and entrepreneurial potential. The Congress instead should look to the bipartisan Senate process that is considering the recommendations of the fiscal responsibility commission. Only reforms of this magnitude can reverse our budget outlook and enable smarter, more strategic decisions about the non-defense discretionary portion of the budget. We know all of our elected representatives seek the long-term success of our nation and the maintenance of leadership in science and technology. The quality of life our children and grandchildren will inherit depends upon the choices you make.