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During this period the operation of the University of Hawaii's 2.2M telescope was partially funded by this grant. The original term of this grant was one year. Most of the grant funds were expended during this year. Subsequently a one year extension was approved. Over the resulting 2 year period, this grant provided approximately 6% of the operating budget of the telescope. The fraction of observing time devoted to studies of solar system objects (e.g., planets, planetary satellites, asteroids, and comets) was approximately 26%.

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NASA GRANT NAG 5-4355

OPERATION OF THE UNIVERSITY OF HAWAII 2.2M TELESCOPE ON MAUNA KEA

Robert A. McLaren, Principal Investigator

FINAL REPORT

March 1, 1997–February 28, 1999

Technical Officers
Jay Bergstralh and Thomas Morgan

During the period March 1, 1997–February 28, 1999, operation of the University of Hawaii's 2.2-meter telescope was partially funded by grant NAG 5-4355, in the amount of $110,000, from the NASA Planetary Astronomy Program.

The original term of this grant was one year March 1, 1997 through February 28, 1998. Most of the money was spent during this first year. Subsequently a one-year no-cost extension) through February 28, 1999) was approved. Over the resulting two-year period, NAG 5-4355 provided approximately 6% of the operating budget of the telescope. The remainder of the operating budget for the telescope was funded by the State of Hawaii, through the University of Hawaii. During the grant period, the fraction of observing time devoted to studies of solar system objects (e.g., planets, planetary satellites, asteroids, and comets) was approximately 26% (i.e., it substantially exceeded the fractional funding provided by this NASA grant). The number of nights allocated to planetary astronomy is summarized below:

Period	Planetary	Other science	Engineering	Planetary fraction
Mar 1997–Feb 1998	92.5	249.5	23	27.0%
Mar 1998–Feb 1999	89	269	7	24.9%

Proposals for use of the solar system observing time coming from within and outside the University of Hawaii competed for this observing time on an equal basis until July 1998. Applications were judged on scientific merit by a time allocation committee at the University of Hawaii.

After July 1998 (five months after the original termination date of the grant) external proposals for observations of solar system objects were not accepted, because of the termination of operational support for the 2.2-meter telescope from the NASA Planetary Astronomy program.

TELESCOPE AND INSTRUMENTATION

During the grant period, the telescope and its instrumentation remained relatively stable. The fraction of nights devoted to engineering tasks was remarkably low (30 nights in 2 years). The Tektronix 2048×2048 CCD was used for a large fraction of the dark time (mostly as an imager, but also with spectrographs), and QUIRC (a 1024×1024 infrared camera) was used for a large fraction of the bright time. The infrared spectrometer KSPEC was decommissioned because superior instruments with similar capabilities (e.g., SpeX on IRTF) will soon be available on other Mauna Kea telescopes.

The Orbit 2048×2048 CCD was brought into operation during the grant period. This CCD is especially useful for imaging in the 310–400 nm region where it has high quantum efficiency (the Tektronix 2048 CCD has very low QE in this region of the spectrum).

A program for the replacement of the aging Telescope Control System (TCS) was commenced during the last months of the grant period. The TCS will be replaced with a modern servo-controlled system operated by a new computer.

NEWSLETTER AND DOCUMENTATION

A newsletter was distributed to all planetary astronomers in the United States who had expressed an interest in receiving it. It was distributed in both electronic form (for speed) and through hardcopy (regular mail). The newsletter contained information about instruments, including their sensitivities, and discussed recent changes and developments at the telescope. The newsletter was distributed three times per year, before each proposal deadline.

Documentation relating to the 2.2-meter telescope is available on the World Wide Web at `http://www.ifa.hawaii.edu/88inch/`.

SCHEDULING PERIODS

Beginning August 1997, the telescope scheduling period was changed from four-month trimesters to six-month semesters. This change was made to coordinate the scheduling period with the scheduling periods of all the other telescopes on Mauna Kea. Associated with this change, about 10–15 nights per semester were held back for allocation later in the semester. Some preference in the allocation of these additional nights is being given to target of opportunity observations, and to observers who lose all or a large part of their observing time to weather or instrument failures.

SCIENTIFIC HIGHLIGHTS

A sample of the many scientific programs performed on the 2.2-meter telescope during the grant period are described below.

THE OUTER SOLAR SYSTEM—TRANS-NEPTUNIAN OBJECTS AND THE KUIPER BELT

Undoubtedly the major contribution to planetary science coming from the UH 2.2-meter telescope during the last decade has been the exploration of the outer solar system by Jewitt, Luu and collaborators. This work continued during the grant period with a total of 38.5 nights scheduled on the telescope during the grant period. During the first part of the grant period, Jewitt and collaborators used the 8192×8192 CCD camera to discover KBOs on the 2.2-meter telescope, and the Tektronix 2048×2048 CCD for subsequent astrometric measurements to determine orbits. They later used the 8192×8192 CCD camera and a 12288×8192 CCD camera on the Canada-France-Hawaii Telescope for discovery of KBOs and the Tektronix 2048×2048 CCD on the 2.2-meter telescope for subsequent astrometric followup measurements to determine the orbits of the newly discovered KBOs.

COMET HALE-BOPP

Extensive observations of comet C/1995 O1 Hale-Bopp by Meech and collaborators, highlighted the development of intricate structures in the inner coma of the comet, starting in about 8/96. In addition, extensive data were obtained during 6/96 to look at the rotation of the nucleus, and more subsequently, narrow-band data were obtained during 4/97 (using the NASA Hale-Bopp filter set) to investigate the production of CN to see if it was correlated with the dust jets as was the case with P/Halley.

NEAR-EARTH ASTEROIDS

Tholen performed physical studies of near-Earth asteroids. His observations included photometry and astrometric followup. We attempted to provide flexible scheduling for these observations—there is often very little time between discovery and closest approach, so these observations cannot easily be accommodated in the conventional semester proposal system. We have been able to support some observations of newly discovered near-Earth asteroids by giving access to engineering nights.

Tholen also commenced a search for near-Earth asteroids at low solar elongation. Such objects will not be found by opposition searches, and the asteroids found likely represent a greater impact hazard.

Graduate student R. Whiteley made heavy use of the 2.2-meter telescope for work on asteroid compositions, and has performed searches for asteroids in dynamically new locations (e.g., Earth, Venus and Mars Trojans, Atens). He used the 2k CCDs for colorimetry and the 8k CCD for searches.

ASTEROID FAMILIES

M. Gaffey and M. Kelley (Rensselaer Polytechnic Institute) have obtained low-resolution optical spectra of asteroids, and conducted a parallel program with the NASA IRTF to obtain near-infrared spectra. They will use their spectra to reconstruct the internal structure and constrain the thermal evolution of their parent bodies, and to investigate collisional evolution in the asteroid belt.

GALILEO MISSION SUPPORT

Orton and collaborators from JPL conducted an extensive imaging campaign in support of the Galileo mission, using the University of Hawaii 2.2-meter telescope. Their observations consisted of mapping Jupiter's cloud albedo fields at different wavelengths and at gaseous CH_4 absorptions. The most important mission critical function of this work was to provide direct real-time support for the Galileo atmospheric investigation, particularly for the Solid State Imager (SSI) and Near-Infrared Mapping Spectrometer (NIMS) experiments, verifying their photometric calibration, and characterizing the time history of atmospheric features targeted for intense study. This provided SSI and NIMS comparisons with other regions during spacecraft encounters, and the broader coverage characterized processes outside the very limited fields of view of these instruments for phenomena, such as injection of energy or momentum into the area being observed.

APPENDIX 1: Partial list of recent publications resulting from observations on the 2.2-meter telescope

J.K. Davies, S. Green, N. McBride, E. Muzzerall, D.J. Tholen, R.J. Whiteley, M.J. Foster, and J.K. Hillier (2000), Visible and infrared photometry of fourteen Kuiper Belt Objects, Icarus (submitted).

C. Dumas, T. Owen, M.A. Barucci (1998), "Near infrared spectroscopy of low-albedo surfaces of the solar system: Search for the spectral signature of dark material," Icarus, 133, 221.

O. Hainaut, K.J. Meech, H. Boenhardt, and R. West (1998), "Early recovery of Comet 55P/Tempel-Tuttle," A& A, 333, 746.

O. Hainaut et al. (2000), "Physical properties of TNO 1996 TO_{66}," A& A, submitted.

D. Jewitt and J. Luu (1997), "Kuiper Belt: The Solar System Beyond Neptune," invited review at Asteroids, Comets, Meteors '96, Versailles, France, July 8-12 1996, in press.

D. Jewitt and J. Luu (1997), "The Kuiper Belt," in Stardust to Planetesimals. ASP Conf. Ser., 122, 335–345.

D. Jewitt, J. Luu, and C. Trujillo (1998), "Large Kuiper Belt Objects: The Mauna Kea 8k CCD survey," AJ, 115, 2125.

D. Jewitt (1999), "The Kuiper Belt," Annual Reviews of Earth and Planetary Science, 27, 287.

D. Jewitt (1999), "The Kuiper Belt," Physics World, 12, 7, 37.

D. Jewitt and J. Luu (2000), "Physical nature of the Kuiper Belt," Protostars and Planets IV (in press).

D. Jewitt (2000), "Cometary rotation," Invited review, Earth Moon and Planets (in press).

P. Kalas and D. Jewitt (1997), "A candidate dust disk surrounding the binary stellar system BD+31°643," Nature, 386, 52–54.

J. Luu, B. Marsden, D. Jewitt, C. Trujillo, C. Hergenrother, J. Chen and W. Offutt (1997), "A new dynamical class in the outer solar system," Nature, 387, 573–575.

K. J. Meech, J. M. Bauer, and O. R. Hainaut (1997), "Rotation of Comet 46P/Wirtanen," A& A, 326, 1268.

K. J. Meech, M. W. Buie, N. H. Samarasinha, B. E. A. Mueller, M. J. S. Belton (1997), "Observations of structures in the inner coma of Chiron with the *HST* Planetary Camera," AJ, 113, 844–862.

K. J. Meech (1999), "Physical Properties of Cometary Nuclei," invited review at Asteroids, Comets and Meteors '96 in Versailles, France, Advances in Space Research, in press.

K.J. Meech and R.L. Newburn (2000), "Observations and modeling of 81P/Wild 2," Icarus, submitted.

K.J. Meech (2000), "What we have learned from the apparition of C/1995 O1 Hale-Bopp," Nature, submitted.

S. Mottola, et al. (1997), "Physical model of near-Earth asteroid 6489 Golevka (1991 JX) from optical and infrared observations," AJ, 114, 1234–1245.

T. B. Spahr, C. W. Hergenrother, S. M. Larson, M. Hicks, B. G. Marsden, G. V. Williams, D. J. Tholen, R. J. Whiteley, D. J. Osip (1997), "The discovery and physical characteristics of 1996 JA_1," Icarus, 129, 415–420.

C. Trujillo, and D. Jewitt (1998), "A semi-automated sky survey for slow-moving objects suitable for a Pluto-Express mission encounter," AJ, 115, 1680.

R.J. Whiteley, and D.J. Tholen (1998), "CCD search for Lagrangian asteroids of the Earth-Sun system," Icarus, 136, 154.

E.F. Young, K. Galdamez, M.W. Buie, R.P. Binzel, and D.J. Tholen (1999), "Mapping the variegated surface of Pluto," AJ, 117, 1063.