20 June 2019

40th Anniversary of NASA's Infrared Telescope Facility (IRTF)

July 2019 marks the 40th year of operations for the 3.0-meter NASA Infrared Telescope Facility (IRTF), managed and operated by the University of Hawai'i Institute for Astronomy for NASA. Located at the 13,800-foot summit of Maunakea on the Big Island of Hawai'i, one of the best sites in the world for infrared astronomy, the IRTF was built to support the Voyager missions to the outer planets and to provide mission support. Initial images of Jupiter at 5 microns were made in May 1979 to support the Voyager 2 flyby which occurred two months later. The images showed the thermal emission from the lower atmosphere that could be seen through the less cloudy regions of the Jovian atmosphere and this allowed Voyager 2 to point to these regions and to probe the lower atmosphere of Jupiter. Additional observations were made later to study the power output of the newly discovered volcanos on Jupiter's moon Io and the composition of the Jovian ring.

The IRTF was dedicated on July 6, 1979, and at the time of the dedication it was the 10th largest telescope in the world and the second largest infrared telescope after the 3.8-m United Kingdom Infrared Telescope, also located at the summit of Maunakea. In the early days of the planetary exploration program it was relatively difficult to obtain telescope time for observing solar system objects. Thus, having a dedicated telescope for solar system observations with a large aperture for that time period was a great benefit for the planetary community. The IRTF offered infrared instrumentation for 1-25 microns that was not generally available in 1979 as well as providing a platform for new kinds of infrared instrumentation especially at submillimeter wavelengths. This allowed solar system researchers to exploit the strong infrared molecular and solid state bands to be fully explored for the first time as well as to study the total power emitted by solar system bodies. The latter allows understanding the internal heat sources of the outer planets, the albedos of the terrestrial planets and asteroids, and estimates of asteroid diameters by remote sensing. These observations allowed the completion of the reconnaissance of the solar system and provided basic information for mission planning and support.

The early observations with the IRTF yielded pioneering data on the colors and composition of the icy satellites of the outer planets, Pluto, and asteroids; the thermal properties asteroids and Saturn's rings; the discovery of the infrared aurora of Jupiter; heterodyne spectroscopy of planetary atmospheres at mid-infrared and submillimeter wavelengths; measurements of asteroid albedos and diameters; infrared spectroscopy of planetary atmospheres probing composition and dynamics; and near-infrared and mid-infrared spectrophotometry of comets. These observations help lay the foundation for the exploration of the solar system at what was then a new spectral domain, the formulation of scientific objectives for space missions, and testing of novel instruments and detectors.

In contrast to the relatively short observing period of a flyby mission, one of the strenghts of a dedicated planetary telescope is to be able to observe an object or phenomena over a long period of time. Such long-term observations allowed the average power output of Io to be precisely measured, the characterization of seasonal changes in the atmospheres of Jupiter and Saturn over several decades, and the measurement of changes in the surface composition of Pluto and Triton as a function of longitude and time. The spectral variations of the surface of Pluto measured by IRTF was a key factor in choosing which hemisphere the New Horizons spacecraft would observe during its flyby.

Another strength of a dedicated planetary telescope is that it can be committed to an observing campaign in which an entire month or more of guaranteed time can be allocated and competed. Such observing campaigns were set up for the comet Shoemaker-Levy 9 impacts with Jupiter, comet Hyakutake, comet C/2012 S1 (ISON), comet 103P/Hartley 2 (to support EPOXI), comet Wirtanen, Io service observing, Venus, and Mars. Both facility instruments and unique visitor instruments are used for such campaigns.

The IRTF is the only telescope that routinely allows daytime observing that are critical for observing solar system objects that are near the sun, such as comets near perihelion and the planets Mercury and Venus. The IRTF has contributed significantly to infrared spectroscopy of comets and in most cases daytime observing is required to observe the comet when it is brightest. Observations of Mars, Jupiter, and Saturn that are connected to missions are often needed to get time-critical observations during the daytime. Long-term observations of Venus, Mars, and Jupiter with a visiting mid-infrared heterodyne spectrometer are often done during the day time to increase the observing time on the target.

The IRTF has provided a rich database of infrared spectra of asteroids. This is significant because the near-infrared spectral region provides critical surface composition information. The flexible scheduling of the IRTF allows the telescope to be used efficiently for observing near-Earth objects (NEOs) on very short notice in support of NASA's Planetary Defense Program. The closest approaching NEOs must be observed within a few days before they become too faint.

Critical NASA mission support:

- Galileo atmospheric entry probe – Characterization of the entry point on Jupiter
- Cassini - Saturn auroral observations in support of Cassini measurements
- Huygens - Wind observations of Titan in support of the atmospheric probe entry
- LCROSS – Observations of the spacecraft impact with the lunar surface
- Deep Impact – Observations of the impact with the nucleus of comet Tempel 1
- Mars Orbiters - Mid-IR imaging of comet Siding Spring to assess the dust hazard posed to spacecraft at Mars by its close approach to the planet

- New Horizons - Stellar occultation by Pluto (IRTF's location in the middle of the Pacific Ocean provides a critical measurement)
- New Horizons – Measurement of surface composition variation of Pluto, for spacecraft flyby planning. IRTF data was used to select the flyby hemisphere
- Juno – Calibration measurements, and long-term monitoring of Jupiter's atmospheric features for context
- OSIRIS-REx (and other asteroid missions) - Surface composition of asteroids visited by spacecraft, most recently for the OSIRIS-Rex mission.
- SOFIA – Testing of the EXES spectrograph

Current activities

- Critical characterization observations of close-approaching NEOs
- New high resolution facility spectrograph for studies of planetary atmospheres
- Plans for a new broad band facility spectrograph for studies of NEOs and follow up of time domain discoveries

The IRTF and the facility instruments continue to be improved to meet the ever changing needs of NASA's exploration program.

In additional to its pivotal role in planetary science and mission support for NASA, the IRTF has made major contributions to NSF-related astrophysics programs in general. Highlights include the discovery of GD 165B, the first ever L dwarf found, the first new spectral class of star in over 80 years and also probably the first imaged substellar object or Brown Dwarf. With advances in instrumentation the IRTF has now observed and spectrally characterized over 1000 Brown Dwarfs. Brown Dwarfs are an important link between higher mass stars and lower mass planets. The IRTF was a pioneer in the field of high-resolution infrared spectroscopy of young stars, providing some of the first detailed observations of the accretion disks from which stars and planets form. Infrared imaging of optically obscured young star forming regions on the IRTF was also crucial in establishing the lifetime of the accretion disk phase of star formation. Understanding star and planet formation is currently a key activity of the IRTF.

May it live long and prosper.

Some quotes:

John Rayner, seventh Director of IRTF: "At first glance there appears to have been little change to the IRTF since it was commissioned in 1979. However, a look at the telescope focus where instruments are placed shows huge changes. Originally, small (10kg) single-element (one pixel) infrared photometers were used (see Fig. 5). Now, with enormous technological advances in electronic detectors (with millions of pixels), cryogenic optics and computing, instruments are much larger (500kg) and more sophisticated (see Fig. 6). As a result, the IRTF is significantly more sensitive and is orders of magnitude faster at executing observing programs, leading to scientific capabilities that would have been considered fiction when the telescope was built."

Alan Tokunaga, sixth Director of IRTF: "The IRTF was actually designed as a light bucket since there was no prospect of infrared imaging capabilities when the telescope specifications were made. Fortunately the image quality of the mirror was adequate to allow competitive science to be accomplished to the present day. Although the aperture of the telescope is considered small today, the first-rate instrumentation and visitor instruments combined with flexible scheduling have allowed the IRTF to serve the needs of the planetary community. This is a tribute to the dedicated staff who have maintained the high productivity of the observatory."

Figure 1. Dedication in July 1979 with John Jefferies, the founding Director of the Institute for Astronomy. Credit: D.P. Cruikshank

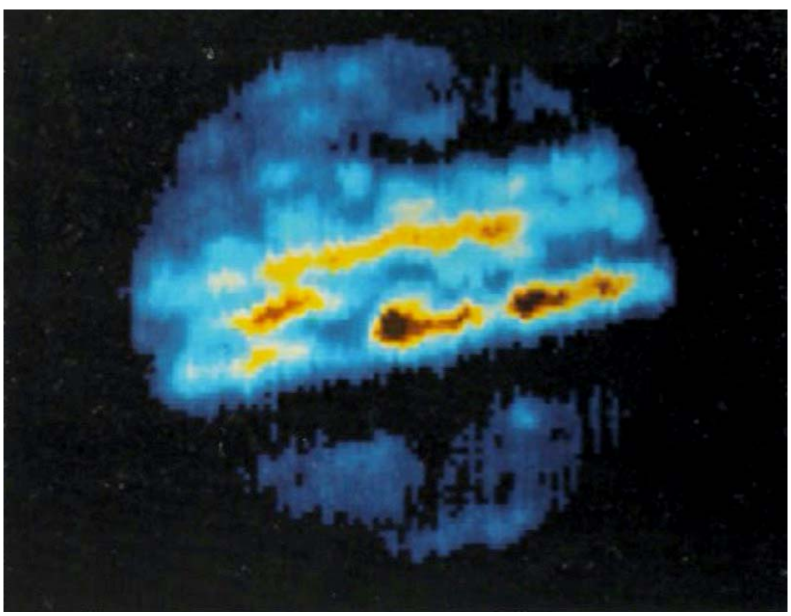

Figure 2. First science with the IRTF: Jupiter at 5 μm, May 1979. Color display of a 5 μm image of Jupiter that was obtained at the IRTF in support of the Voyager encounter with Jupiter. Blue color represents cooler regions of the Jovian atmosphere, while red represents the warmer regions. Picture provided by the Hawaii Institute of Geophysics, Planetary Geosciences Data Processing Facility.

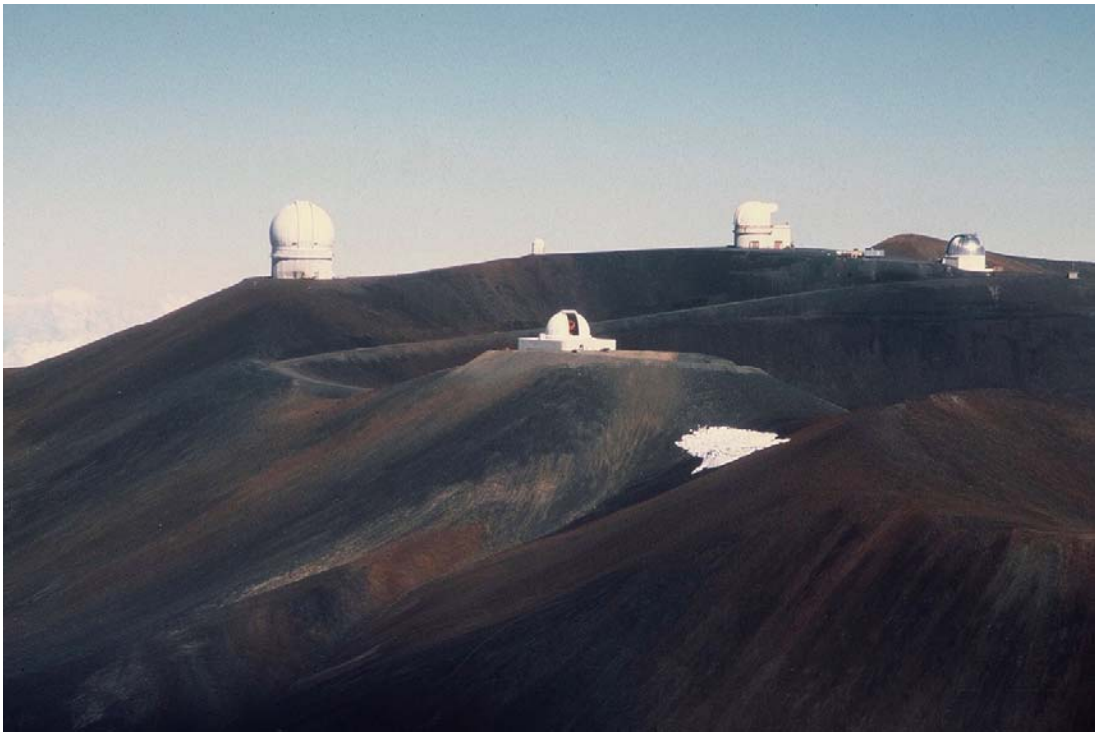

Figure 3. Photo of the summit in 1979. Credit: Duncan Chesley

Figure 4. Photo of the telescope, 1979.
Credit: D.P. Cruikshank

Figure 5. State-of-the-art single-detector infrared photometer (1979).   Credit: C. Telesco

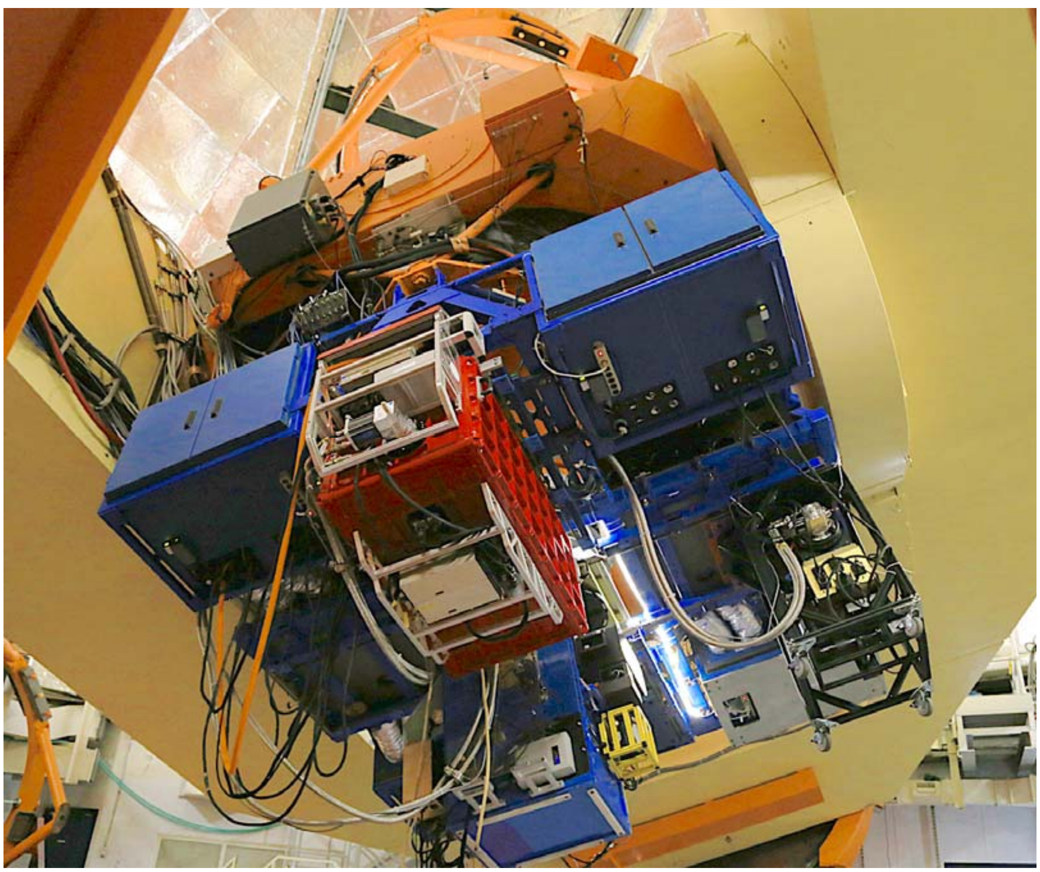

Figure 6. Instrumentation at the Cassegrain focus of the IRTF (2019).   Credit: J. Rayner

Figure 7. Two of the people who got the IRTF working: Jerry Smith (left), project manager, and Eric Becklin (right), first Director of the IRTF (1979). Credit: E. Becklin

Figure 8. Sunset photo. Credit: K. Teramoto

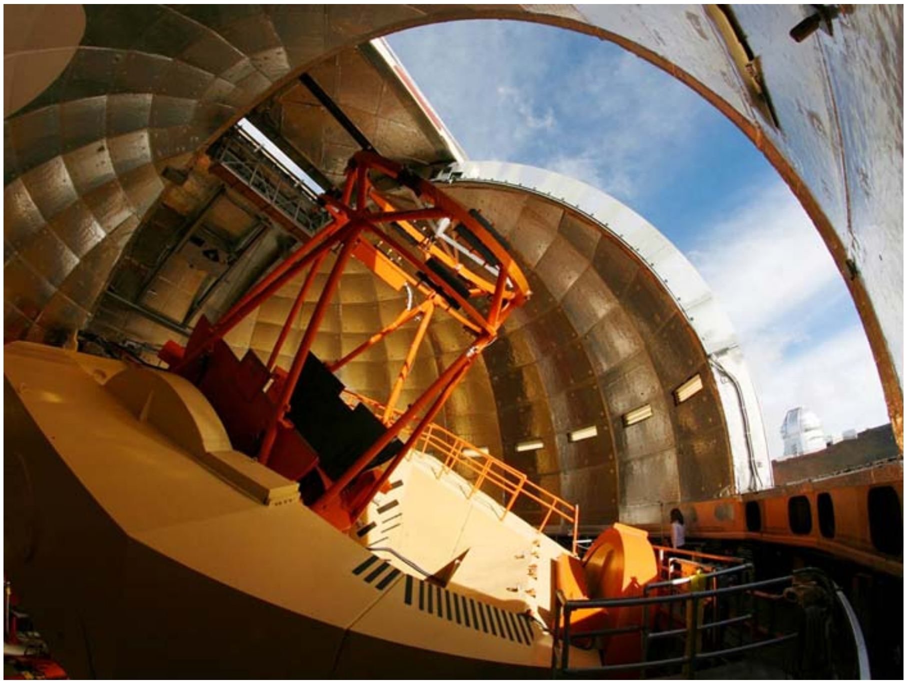

Figure 9. Current photo of the telescope.   Credit: M.C. Connelley

Figure 10. Photo of the January 2019 lunar eclipse.   Credit: M.C. Connelley