2,713 Nights and Counting

By Wes Lockwood

Off the beaten path several hundred yards west of the main complex of Mars Hill observatory buildings, an antiquated manually operated 21-inch reflecting telescope continues to produce precise stellar and planetary brightness measurements as it has done since 1953.

It was Harold L. Johnson – brilliant, mercurial, and outspoken – who ushered in the modern era of electronic measurements of starlight at Lowell Observatory using the 21-inch telescope. Johnson was a pioneer in the development of the photoelectric photometer, an instrument that measures light through colored glass filters. Johnson's classic *Astrophysical Journal* paper, written shortly after he arrived at Lowell in 1952, described the "UBV system" (Ultraviolet, Blue, Visual) of star colors still used today. When he came to Lowell he found the 42-inch reflector on Mars Hill (now on display as an outdoor exhibit) unsuitable for his work, and that is how the 21-inch telescope came to be.

The heart of a photoelectric photometer is its electronic detector, a photomultiplier tube resembling an old-fashioned radio tube. Photomultipliers produce an electrical current when exposed to starlight. Johnson built several photometers while at Lowell as well as the electronic amplifiers needed to record data as a squiggly trace on a moving strip of chart paper. Nowadays, we record data directly onto a computer disk, but otherwise, the techniques of photoelectric photometry have remained unchanged for decades.

The Lowell "Solar Variations" program was one component of the Observatory's first externally funded research, "The Project for the Study of Planetary Atmospheres," supported by the Air Force Cambridge Research Laboratories. A 1950 annual report included observations of Uranus and Neptune made by Henry Giclas. The possibility of solar variability had been of urgent interest to meteorologists for some time because of suspected consequences for Earth's weather and climate. The basic idea of measuring sunlight indirectly is conceptually simple – if the Sun varies, then so will the amount of sunlight scattered from the atmospheres of the planets. Careful measurements could, in principle, detect solar variations larger than a few percent if they occur. The planets Uranus and Neptune were thought to be ideal targets because they appear starlike in small telescopes. It is relatively straightforward to compare their brightness with stars lying along their path in the sky using a technique called differential photometry.

By the time Johnson left Lowell in 1959, the solar variations project was a routine, funded program. Early results, dutifully reported in scientific journals, showed no clear evidence for solar variability but initiated a half-century record of intrinsic and seasonal planetary brightness variations. The Air Force continued to support the effort through 1965, and Lowell's new director, John S. Hall, hired a young Polish astronomer, Krzysztof Serkowski, to pick up where Johnson had left off. Serkowski, starting afresh, analyzed the accumulated data from scratch using an electronic computer at Northern Arizona University. After Serkowski returned to Poland in 1963, he recommended a graduate student, Mikolaj Jerzykiewicz, to replace him.

Photo of Brian Skiff at the 21" telescope showing the photoelectric photometer. This particular photometer was built in 1971 and is still in use today.

Two papers on "The Sun as a Variable Star" (Lowell Bulletins 116 in 1961 and 137 in 1966) presented the key findings. What they reported is that the Sun, if it varied at all, changed by, at most, a couple of percent over a decade. We now recognize that this was a quixotic quest from the beginning – satellite measurements after 1980 found that the Sun varies by less than 0.1% over the 11-year solar cycle, a level of fluctuation impossible to measure from the ground, then or now.

Wrapping up what had been a very long and essentially futile effort to detect actual solar variability, Serkowski and Jerzykiewicz presented their results at a 1965 climate change conference, now recognized as a watershed event. Here, many of the major players in climate research were present, including such luminaries as Edward Lorenz, Reid Bryson, Paul Damon, Maurice Ewing, Wallace Broecker, and NOAA climatologist J. Murray Mitchell, Jr.

Had the Lowell project indeed been useless? Hardly. Paralleling the series of planetary measurements, the stellar photometry needed to calibrate planetary data produced a 12-year series of measurements of 16 sunlike stars noteworthy both for duration and unprecedented precision. In typical understated fashion the authors concluded, "In our opinion, this long series of photoelectric observations has taught us more about the variations of solar-type stars than about the Sun itself." Therein was planted the seed for much future productive work with the 21-inch telescope.

The study of solar variability might well have reached an ignominious end in 1966 except for unrelieved angst in the climate community about whether the Sun varied or not. Definitive satellite measurements of total solar irradiance were still far in the future. Murray Mitchell had not forgotten the Lowell contribution to this subject and in a 1970 letter to John S. Hall wrote, "I am distressed by the fact that we are already into the year 1970, four years after the Lowell program was discontinued, and not only do we not yet have the satellite measurements in question but the latest NASA schedules do not show them beginning until at least 1972…" (Nimbus 7, the first earth orbiting satellite to make measurements of the total solar output, was not launched until 1978.)

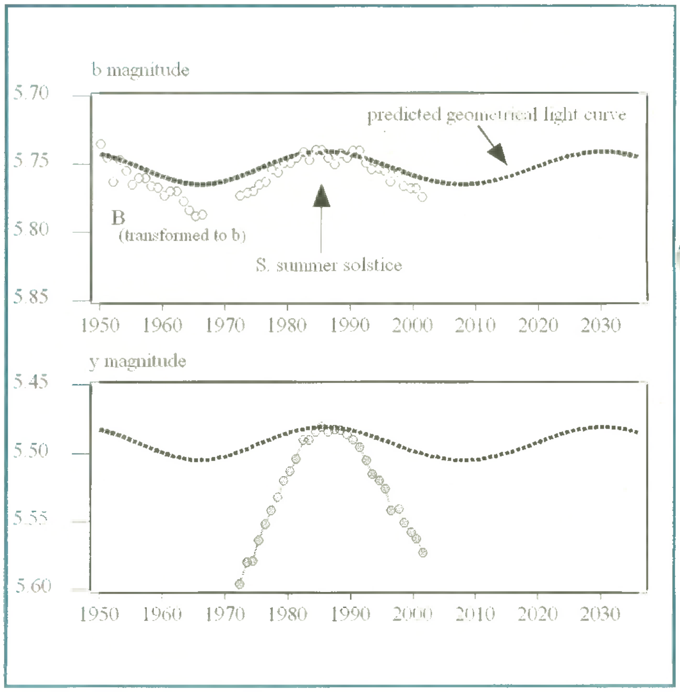
With Mike Jerzykiewicz back at Lowell for a two-year stint, the Solar Variations program restarted in 1971 with National Science Foundation support. There were a few changes: Titan, Saturn's largest moon, was added as a third object. The only satellite in the solar system possessing an atmosphere, Titan was thought to be a better target than Uranus, whose brightness changes associated with its polar flattening and 98° tilt were difficult to interpret. Jerzykiewicz used blue and yellow filters from a new photometric system, the "Strömgren uvby system," because their narrower spectral coverage offered higher precision.

When Jerzykiewicz returned to Poland in late 1973, I got his job. Thirty years, 2,713 nights, 15 grants and more than $2,000,000 later, the planetary and stellar work carried out over three decades in association with Don Thompson (now retired) and Brian Skiff continues as we map out the seasonal variations of Titan, Uranus, and Neptune. We measured the Galilean satellites of Jupiter to determine their orbital and solar phase variations and learned that their brightness is steady to 0.5% or better as they travel around the Sun. We measured the transparency of the sky over Flagstaff in good times when there is no dust in the air at all, and in bad, when global stratospheric haze episodes associated with the eruptions of the El Chichón volcano in 1982 and Mount Pinatubo in 1991 dimmed the stars significantly.

On the stellar front, extending the measurements of Sun-like stars originally studied by Jerzykiewicz and Serkowski, we determined rotation periods for stars in the Hyades open cluster by observing the dimming of starlight as starspots (similar to sunspots) rotate across their disks. In a heroic 15-year effort supported by the Air Force and the NSF, Brian Skiff, observing on over 1,000 nights, obtained data showing that some stars very similar to the Sun vary significantly more than the Sun does. The original theme of solar variability has thus extended to the study of nearby stars.

In 2007, Uranus, on its 84-year long trip around the Sun, will reach equinox as the Sun crosses its equator from South to North. Sunlight is now illuminating northern latitudes for the first time in decades. In collaboration with colleagues Heidi Hammel and Kathy Rages who obtain images of Uranus with the 10-meter Keck telescope on Hawaii, we are beginning to assemble a decades-long seasonal picture of how Uranus varies in brightness and how its clouds and zonal features change from year to year. The illustration below shows its brightness variations since 1950, as measured from 1950 to 1966 by Henry Giclas, Robert Hardie, Harold Johnson, Braulio Iriarte, Richard Mitchell, William Sinton, Wojciech Krzeminski, Krzysztof Serkowski, and from 1972 to the present by Jerzykiewicz, Don Thompson, and me.

For scientific projects requiring decades for completion, Lowell Observatory offers a unique capability with its small readily accessible telescopes. The 21-inch telescope, almost the last of its kind, still plays a useful role in astronomy.★



The brightness variations of the planet Uranus since 1950 as measured by blue and yellow filters (symbols). Uranus is tipped on its side as seen from the Earth, and because it is also slightly flattened (its polar diameter is smaller than its equatorial diameter), as it travels around the Sun, its apparent brightness changes as indicated by the dotted line. The observed variation, especially in yellow light (y), differs from the prediction because of changes in the planet's reflectivity over time, and variations in reflectivity from equator to pole.