

Wes Lockwood Saves the Universe

David S.F. Portree
Flagstaff, Arizona

HONORABLE MENTION

BOEING *GRIFFITH OBSERVER* SCIENCE WRITING CONTEST

Now that we know we can't see most of the matter in the universe, it may seem astronomically indulgent to fret over light pollution and campaign for more darkness than all of that dark matter already proliferates. We wouldn't, however, even know it is a dark universe if we could not see the distant galaxies that betray its presence.

Astronomers are still looking for the light, and that requires dark skies. When the nights at Flagstaff's Lowell Observatory started losing astronomy's high ground to the invading lumens of commerce and recreation, the astronomers and their allies in the army of darkness worked with government and business to protect access to the stars and made Flagstaff, Arizona, the "World's First International Dark Sky City."

David S.F. Portree, an author and educator, detailed the mobilizations and skirmishes that led to Flagstaff's celestial distinction in the October, 2002, issue of the *Griffith Observer*. His award-winning article, "Flagstaff's Battle for Dark Skies," reported the history of keeping Flagstaff in the dark. He returns now with more Boeing Science Writing Contest distinction but this time puts dark-sky advocate Dr. G.W. "Wes" Lockwood into the limelight. Wes Lockwood saved Flagstaff...and the universe...from falling into the light.

David Portree has written several histories for NASA, including *Mir Hardware Heritage* (1995), *Walking to Olympus: an EVA Chronology* (1997), and *Humans to Mars: Fifty Years of Mission Planning, 1950-2000* (2001). The International Academy of Astronautics added some thrust to *Walking to Olympus* by conferring on it the Napolitano Book Award in 1998. Mr. Portree is now working on books about the history of planning moon and Mars exploration for NASA, the University Press of Florida, and Springer Praxis.

Astronomy magazine, *Air & Space Smithsonian*, and other general-audience publications have carried David Portree's byline, and he has contributed more than 400 scripts to the *Earth & Sky* and *Star Date* radio series (1992-present). Encyclopedias contain more than 200 articles by him. He has also written extensive exhibit text for the Astronaut Hall of Fame (1997), the Kansas Cosmosphere (2005), and other museums.

Involved in astronomy education since 1986, David Portree has worked at planetaria. In 2002, he joined the Lowell Observatory Navajo-Hopi Astronomy Outreach Program, which works with individual teachers and their classes for an entire school year. In 2006-2007, he worked with teachers in Window Rock and Pinon on the Navajo Reservation and at Jeddito on the Hopi Reservation.

Environmental history is a relatively new area of interest for Portree. Much of his research in the field is activated by his enthusiasm for astronomy. He spotlights light pollution.

David Portree and his daughter Samantha lost Martha Portree, wife and mother, in a recent automobile accident, and he dedicates this article to her.

ASTRONOMER WES LOCKWOOD doesn't know why he enlisted to defend the night sky of Flagstaff, Arizona, the largest city on the Colorado Plateau. It wasn't out of self-interest, for the light from Flagstaff homes, businesses, and parks barely affects his research at Lowell Observatory, overlooking the west side of town. "I must have been going through some do-gooder stage in my life," he explains, smiling.

That do-gooder stage has continued through many battles over nearly two decades. Though he can't recall what got him started, he is very clear about why he fights for the night now. "Everyone likes to look at the night sky," he says. "Adults who've lived in a dark place want their children to see dark skies... And since the population of the country is growing and growing, the places where you can see the stars are getting fewer and fewer."

The diffuse silver ribbon of the Milky Way, our home galaxy; the seasonal parade of constellations; and the planets wandering against a backdrop of gleaming star clusters: These are the things for which Lockwood fights. To this list might be added something ineffable: a sense of connection with infinite possibilities.

Astronomy Comes to Town

Lowell Observatory was founded to explore just one cosmic possibility—that intelligent life might exist on Mars. Wealthy Bostonian Percival Lowell set up his first telescope on the mesa overlooking Flagstaff in 1894. He was drawn to the mountain town by its clear skies and high

altitude (about 7000 feet). His goal: To study hair-thin straight lines observers around the world had glimpsed on the planet's ochre disk. Lowell became convinced that they were canals dug by a powerful Martian civilization.

At the time, Flagstaff was an overgrown lumber camp with a population of about 1000. The town gave Lowell a warm welcome. To keep his observatory (and his pocketbook) near at hand, its leading citizens deeded to him his ponderosa pine-covered observatory site for one dollar. Visible from all over town, the site became known as Mars Hill.

Lowell soon began to explore other astronomical possibilities—for example, that a planet might exist beyond Neptune. In 1930, 14 years after its founder's death, Lowell Observatory discovered Pluto. The discovery put Flagstaff (population 2500) on newspaper front pages around the world.

The U.S. Naval Observatory established its Flagstaff Station two miles west of town in 1955, just in time for *Sputnik I* in 1957 and an explosion in federal funding for space science. By then, Flagstaff was home to 8000 people. In 1959, eager to position itself to expand its programs, Lowell established a dark-sky site for its biggest telescopes on Anderson Mesa, about ten miles out of town. Helped along by government funding, the observatory's research diversified, and its staff grew.

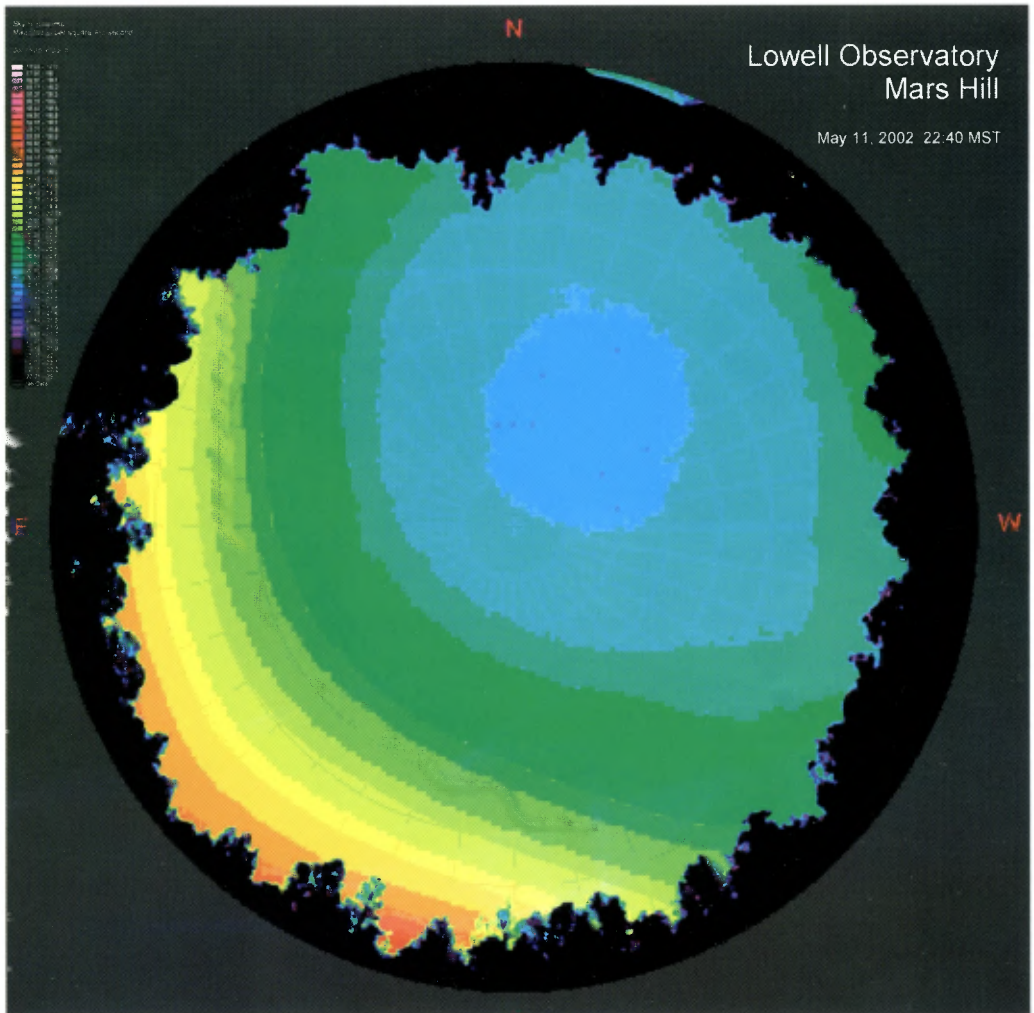
The Making of a Dark Sky Activist

Lockwood came to Lowell Observatory in 1973, when Flagstaff's population was about

FRONT COVER

When Outer Space Went to the Dogs

The modern Space Age began 50 years ago last month, on 4 October 1957, when the U.S.S.R. put the first artificial satellite, *Sputnik 1*, into orbit. The world did not have much time to acknowledge the accomplishment before the Soviet Union launched a second satellite, *Sputnik 2*, a month later, on 3 November 1957. Even more remarkable, *Sputnik 2* had a passenger, Laika, a dog. Laika lived ten days in space, before her oxygen supply was depleted. *Sputnik 2* reentered the atmosphere on 14 April 1958 and burned up in descent. Decades later, the Republic of Congo, in west central Africa, issued this stamp to commemorate Laika's sacrificial ride. (collection E.C. Krupp)



The dark isn't what it used to be at Lowell Observatory. This fish-eye profile of the sky's brightness around Mars Hill, measured on 11 May 2002, rims the horizon with the dark silhouettes of pine trees, but above them, the night sky is artificially bright, with the brightest zone toward the south-southeast, in the direction of the I-17/I-40 highway interchange. The darkest sky is a confined cap offset a little to the northwest from the zenith. (courtesy David S.F. Portree)

25,000. Twenty years earlier, at age 12, he had discovered the night sky at a Boy Scout meeting in his home town of Hampton, Virginia. "I remember the evening that I walked home from a Scout meeting, having heard some guys talking about this constellation called Orion. And... there it was, right in front of me. I said, 'Hey, that's cool!'"

In high school Lockwood built a reflecting telescope with an eight-inch mirror. "My buddy and I would prowl the junkyards looking for pipe fittings and stuff we could use for telescope mount parts," he recalls. "I had a tube made at the metal shop and bought a mirror, some eye-pieces, an eyepiece holder, and a diagonal... I had that telescope through high school."

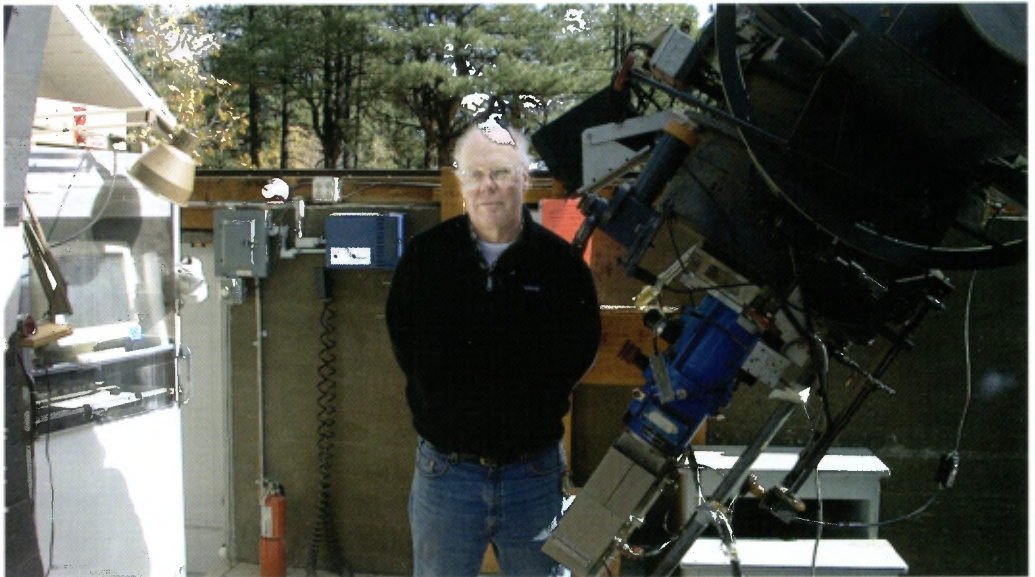
As an undergraduate, Lockwood abandoned the night sky—he sold his telescope and majored in physics—but he returned to astronomy in graduate school. His advisor at the University of Virginia, ex-Lowell astronomer Larry Fredrick, helped Lockwood get to Arizona. He recommended Lockwood to his friend Art Hoag at the National Optical Astronomy Observatory on Kitt Peak, near Tucson. Hoag had directed the Naval Observatory Flagstaff Station from 1955 to 1965 and so was well known on Mars Hill. Hoag hired Lockwood onto the Kitt Peak staff in 1968 and five years later helped Lockwood move to a job at Lowell.

Using a '50s-vintage 21-inch reflector among the pines on Mars Hill—a telescope tiny by professional astronomy standards—Lockwood began a long-term program of monitoring the fluctuating brightness of Uranus, Neptune, and Saturn's moon Titan. His observations give insights into how their weather changes with their seasons. His research continues to this day because the distant cold

worlds he studies have long years. Austere blue Neptune, for example, needs 164 earth years to go around the sun once, and so its four seasons each last 41 earth years.

Lockwood paid little attention to Flagstaff lighting during his first 13 years on Mars Hill, in part because he studied relatively bright objects that could punch through Flagstaff's steadily increasing sky glow. "It didn't affect me at all," he says. "Even though we were less than a mile from City Hall, it was suitable for my work then, and it still is."

Art Hoag returned to Flagstaff in 1977 as Lowell Observatory director. He was an early dark-sky activist. "He had a great interest in it that started in Flagstaff and went to Tucson and came back to Flagstaff," Lockwood says. "He... carried this idea around with him and worked on it wherever he was." Lockwood felt no urge to aid Hoag in his defense of the night. "Art was the kind of guy that didn't ask for help... So I was quite comfortable with [saying], 'Gosh, Art's taking care of it, the rest of us can relax.'"



Superheroes often save the planet, but not many save the universe. Dr. G.W. "Wes" Lockwood, disguised as a mild-mannered astronomer for a great Southwest observatory, appears less concerned about light pollution in full daylight, but when the sky goes dark, he and his sidekick, the 21-inch reflector he has used for three decades, goes to work on behalf of astronomical truth, photometric justice, and the Milky Way. (photograph courtesy Lowell Observatory)



Dr. Art Hoag, a veteran of Kitt Peak National Observatory near Tucson and of the U.S. Naval Observatory Flagstaff Station, understood the need to defend dark skies, and when he became Director of Lowell Observatory, he continued to think cosmically and act locally. He helped engineer Flagstaff's use of low-pressure sodium streetlights. (photograph Lowell Observatory)

Interlude: The Night Sky in Summer

Stop among the piñons and junipers along U.S. 89 north of Flagstaff on a moonless night and look up at the wonders a truly dark sky reveals. Images of the earth at night taken by orbiting satellites show that the highway passes through some of the darkest areas remaining in the United States.

From a site near Wupatki National Monument's ancient pueblo ruins the San Francisco Peaks loom black in the southwest, faintly outlined by the lights of Flagstaff beyond. In August, the fishhook shape of Scorpius the Scorpion stands above the mountains soon after sunset. East of Scorpius, due south on the horizon, stands Sagittarius the Archer. The constellation is known for something invisible even in this dark spot: The ovoid hub of our whirlpool-shaped Milky Way Galaxy is that way, 33,000 light-years beyond the horizon.

At this time of year, the Milky Way's hazy band spans the sky from south to north.

The home galaxy arches past the zenith, turning patchy between Vega, Deneb, and Altair, bright stars marking the corners of the Summer Triangle. Dark rifts in this part of the Milky Way are dust clouds blocking the light of billions of stars. Clouds in Sagittarius hide light from the galactic center.

Jostled by gravity and star explosions as they make their 200-million-year circuit of the Galaxy, the clouds eventually will collapse to form new generations of stars. The most massive of these will glare brilliantly for mere millions of years, frantically fusing light chemical elements into heavy ones, and die in supernova explosions that will briefly outshine the combined light of the Milky Way's 300 billion stars. The least massive will calmly conserve their fuel, glowing gently for a trillion years.

An Updated Code

Art Hoag retired in July, 1986, at about the time Flagstaff's population reached 40,000. One of his last acts as a dark-sky defender was to negotiate with the city and Arizona Public Service (APS), its electricity provider, to replace outdated mercury-vapor streetlights on Santa Fe Avenue with astronomy-friendly low-pressure sodium (LPS). To test public acceptance, APS put up 30 amber-colored LPS lights in February, 1986.

Lockwood resolved to pick up Hoag's lighting negotiations where they left off. At about the same time, Naval Observatory astronomer Christian Luginbuhl began working lighting issues. Luginbuhl found Lockwood to be "a get-along kind of guy," while Lockwood says Luginbuhl is "relentless" in negotiations. He says also that "90 percent of the progress in this work has been due to Chris... goading me from time to time." Despite differences in their personalities and approaches to the problem, they soon became close friends.

Inspired by a new lighting code adopted in Tucson to protect Kitt Peak, the two astronomers agreed to enter together into the prosaic world of city and county governance. In a May,

1987, letter to Flagstaff Planning Director Jack Cunning, Lockwood explained that “with the rapid growth of population in Flagstaff... we believe that now is a good time to consider a variety of revisions” to the city lighting code in place since 1973. The 1986 Tucson code, he wrote, could “serve as a good model statewide, and in particular for Flagstaff.” He wrote a similar letter to Bill Towler, Coconino County’s development director.

An APS survey in September, 1987, found that nine in ten people familiar with the Santa Fe test lights wanted LPS all over Flagstaff. “The observatory is a pillar of the community, and it’s important to us,” one respondent explained. Replacing mercury-vapor with LPS was the central tenet of Lockwood and Luginbuhl’s campaign, and so public acceptance of the Santa Fe lights helped their case. The future looked bright for the updated code.

Yellow Freight

In May, 1988, one year after Lockwood’s letters to city and county planners, Coconino County wrote to the Naval Observatory to solicit comment on the Yellow Freight trucking company’s application for a permit to build a truck yard in the Flagstaff Ranch industrial park, less than two miles from Lowell and the Naval Observatory.

The battle with Yellow Freight and Flagstaff Ranch developers still gets Lockwood’s blood up. He says that the Kansas-based truckers “wanted a brightly lit, 24-hour-a-day operation... They wanted unlimited lighting, and they didn’t want low-pressure sodium. They came in pretty heavy-handed... They didn’t want to play ball at all.”

The observatories and people living near Flagstaff Ranch urged the County Planning & Zoning Commission to deny the permit, and on May 31, 1988, it did just that. But Yellow Freight and the developers appealed the decision to the County Board of Supervisors, and Lockwood and Luginbuhl soon realized that Flagstaff’s dark skies faced their greatest challenge ever.

On September 14, after a summer of sparring, the Naval Observatory and the truckers reached a compromise. It revolved around the lumen, the international unit of light quantity. A 60-watt bulb emits about 800 lumens.

Luginbuhl told Yellow Freight that the Naval Observatory could accept a 30-percent increase in sky brightness. To meet this requirement, the truckers could use no more than 200,000 lumens on their 12.33-acre property. Yellow Freight’s original application had called for 650,000 lumens on 11.25 acres; a subsequent revision proposed LPS lights producing 309,000 lumens over 12.33 acres. Yellow Freight insisted on 309,000 lumens but agreed to buy six extra acres and leave them dark to compensate for the extra light. In exchange, the Naval Observatory agreed to end its challenge. Lockwood was not bound by the agreement; he told Flagstaff’s *Daily Sun* newspaper that “putting a major source of light... pollution near an existing astronomical observatory cannot be viewed as a positive development for astronomy in the Flagstaff area.”

A New Code

Soon after the Yellow Freight fight began, Lockwood and Luginbuhl recognized that the truck yard presaged new challenges in years to come. Perhaps their awareness of the infinite possibilities revealed in a dark night sky inspired them to think beyond established ways of regulating lighting, for they soon saw in the threat from Yellow Freight an opportunity to work with city and county staffers to craft innovative, wholly new lighting codes for Flagstaff and Coconino County.

The new county code was the first in the world to govern both type of light and amount of light per acre. It divided Coconino County into four zones. Shielded LPS lights were required in all four. Zone I included all county land within 2.5 miles of the Naval Observatory and Anderson Mesa. The code set a cap of 25,000 lumens per acre in Zone I, 50,000 lumens per acre in Zone II (2.5 to 7 miles from

the observatories), and 100,000 lumens per acre in Zone III (7 to 35 miles out). Zone IV, beyond 35 miles, had no lumens per acre limits. Coconino County passed the code in March, 1989, and the Flagstaff City Council passed a similar code in November.

The new codes weren't the only benefit of the Yellow Freight battle. "Overall, I think it was good for us," Lockwood says. "For one thing, we learned how to fight."

Yellow Freight had promised about 50 truck-driving jobs with a \$6-million payroll, numbers that dazzled its supporters (though observatories and other science institutions contribute more to the Flagstaff economy). Yellow Freight delivered as promised. In 1992, however, the company revised its nationwide route network. Lockwood smiles when he describes what happened next: "they walked away from the property... all those jobs and all those payrolls... [they] went out the door so fast it was just amazing." The observatories, meanwhile, never ceased exploring the night sky.

Interlude: The Night Sky in Autumn

On its way from Wupatki to Flagstaff, U.S. 89 passes between Doney Park and Black Bill Park, horse-friendly residential outliers of Flagstaff on Coconino County land. Black Bill is west of the highway, toward the San Francisco Peaks, and Doney is on the cinder cone side, to the east.

Turn west onto Timberline Trail on a clear November evening and look up. The pale Milky Way bridges the sky from east to west. Directly overhead, Pegasus the Flying Horse is a square of stars. North of that, set against the Milky Way, Cassiopeia the Queen sits on her M-shaped throne. The points of the M aim at the Andromeda galaxy, which looks like an outlier of the Milky Way's hazy band.

Andromeda is actually a spiral galaxy half again as massive as our Milky Way, and the farthest object one can readily observe without a telescope. Though divided by two million light-years of emptiness, the Milky Way and Andromeda feel a mutual attraction. Soon, as

the universe reckons time, they will fall together. Their dark dust clouds will collide in a frenzy of star birth, and their classic spiral forms will rupture, spilling their stars across intergalactic space. The collision might cast our sun and earth into the starless void for the rest of time.

Dark Skies versus Bureaucracy

Threats to Flagstaff's night sky have often originated from outside, with entities that seem to lack appreciation for its unique environment and long astronomical heritage. They see Flagstaff as one small part of their statewide, regional, national, or international plans and so they come to town and insist on doing things as they do them elsewhere. The Yellow Freight battle showed that companies and developers have been guilty of this. So have Arizona state institutions.

Northern Arizona University (NAU) isn't really from outside Flagstaff—it came to town in 1899, and so has been part of the community for almost as long as Lowell Observatory. But it's a state property. "As a state property, it is not subject to any local regulation whatsoever," Lockwood explains. "They could do anything they want down there."

NAU established its own observatory in 1952. By the early 1980s, however, the university had grown up around it, making astronomical research and training there all but impossible. The mercury-vapor streetlight NAU put up—and left up, for years—outside its beleaguered observatory is notorious in Flagstaff astronomy circles.

For a time in the early 1990s, buoyed by city and county acceptance of the 1989 codes, Lockwood, Luginbuhl, and other Flagstaff dark-sky defenders had hopes that NAU would do more to save the night. After a cordial exchange of views, NAU president Eugene Hughes wrote to Robert Millis, Lowell Observatory director, promising that the university would try to conform to the 1989 Flagstaff code. "That letter went into a file cabinet and has never been seen since," Lockwood says. He offers an explanation:



Not every unnecessary light is successfully snuffed on behalf of darkness, but Wes Lockwood and the Flagstaff Dark Skies Coalition were able to influence lighting on new public buildings. The fixtures that illuminate the parking lot of the Flagstaff/Coconino County Jail are shielded and incorporate low-pressure sodium lighting. This building was completed in 2001, and the International Dark-Sky Association awarded it high marks for outstanding lighting. (photograph Christian B. Luginbuhl)

“Like many large bureaucracies, one hand at the university doesn’t always know what the other hand is doing, so things happen, and once they happen, it’s difficult to make them un-happen.”

Still, Lockwood remains hopeful. The university now consults with the astronomers, he says, and recently hired a lighting designer to develop a new campus-wide lighting plan. He smiles. “We have a toehold... Used to be, we were locked out of the process. Now we’re on a first-name basis.”

Dark Skies versus Megabureaucracy

The universe is hierarchical—galaxy clusters have more mass and gravitational pull than galaxies, galaxies more than stars, and stars more than planets. Bureaucracies follow a similar pattern. “If the university is a bureaucracy, then the [Arizona] Department of Transportation is a megabureaucracy,” Lockwood says. He looks pained as he recalls the 1998-2000 fight over lighting for the new I-40/I-17 interchange at Flagstaff’s southern edge. “That’s another one we lost,” he says ruefully.

The interchange is where I-17, the main route north from Phoenix, crosses I-40, which links Los Angeles with Albuquerque and points east. After calculating that the high-mast high-pressure sodium (HPS) lights planned for the

interchange would brighten Flagstaff’s night skies by about 10 percent, Lockwood and Luginbuhl called on Phoenix-based ADOT to use LPS on short poles. The town rallied to the astronomers—the *Daily Sun* newspaper featured the fight at the top of its front page and published an editorial urging ADOT to change its ways, and Flagstaff mayor Joe Donaldson and Coconino County Supervisor Paul Babbitt negotiated with the department. But it was like a planet pulling on a galaxy cluster—the megabureaucracy went ahead with its original lighting plan.

Lockwood, the get-along guy, says that the engineers and bureaucrats at ADOT have reasonable arguments in favor of high-mast HPS—at least from their earthbound perspective. “For example, they want to use the same hardware everywhere. Simplifies their inventory and their maintenance. Secondly, they want high-mast lighting, which is a central pole that has a bunch of lights on top. The reason for that is, they can get very uniform illumination over a large area with one pole... Low-pressure sodium has a disadvantage that they would have to have had a pole every couple hundred feet on all arms of the interchange, which makes them difficult to service.”

Lockwood looks resigned. “Well, we have to

realize that there are certain places where we're not going to get our way."

Flagstaff Dark Skies Coalition

Though unsuccessful, the battle with ADOT helped galvanize a new phenomenon in Flagstaff—a citizen's group dedicated to dark skies. The Flagstaff Dark Skies Coalition (FDSC) formally announced its existence by marching in the city's Fourth of July parade in 1998. Its founding members wore t-shirts that read "Flagstaff—we'll leave the light out for you."

"We're very pleased to have an organization that is not primarily made up of astronomers," Lockwood says. "They want to help the observatories, and they want to be able to look at the stars from their backyards... And they tend to show up at council hearings on things like the Thorpe Park redevelopment, and things of that sort. So they're around when we need them."

Art Hoag's efforts in the 1980s, the innovative 1989 codes, the 1999 loophole-closing code revision, and FDSC's formation led the Tucson-based International Dark-Sky Association (IDA) to declare Flagstaff the world's first International Dark Sky City in October, 2001. IDA director David Crawford told a crowd at NAU that "no other city or town has shown such an overall commitment to protecting the quality of its dark skies, not only for the observatories, but for all the citizens of northern Arizona."

Interlude: The Night Sky in Winter

Thorpe Park, located just below Mars Hill, is a favorite venue for Flagstaff's summer softball league games. This frigid February evening, however, the park is deserted and snowy. The Milky Way is visible through Flagstaff's sky glow as a narrow band arcing from north to south across the zenith. It's hard to see and not only because of city lights. These winter nights earth looks away from the home galaxy's dense hub and out toward its thinly populated rim.

That's not to say that the winter sky lacks wonders—in fact, it has more bright stars and constellations than any other season. In the



Unwanted light from the Thorpe Park ball fields blankets the dome and open shutters of the historic Clark 24-inch refractor telescope at Lowell Observatory. Closer to the ground, subdued, red light allows visitors to find their way without compromising night vision. (photograph John Spencer)

southwest, just above the snow-cloaked pines, stands Orion the Hunter, probably the most distinctive constellation of any season. Three bright stars in a straight line form his belt. Two bright stars mark his shoulders and two his knees. Fainter stars trace out a sword hanging from his belt; midway along the blade, like a sword-maker's mark, there's a hazy patch with a hint of sparkle.

The maker's mark is the Orion nebula, a collapsing dust cloud where thousands of stars are birthing. The Hubble Space Telescope revealed dark disks around many of these infant stars—the makings of the next generation of planets. It's possible that life will form on some of Orion's new-born worlds and that some of that life will evolve into complex forms. It's also possible that, billions of years in the future, some of that complex life will play an equivalent of summer softball.

The View from Mars Hill

Lockwood lives on Mars Hill's brow, about 1500 feet from the 21-inch telescope he uses for research and about 900 feet from his office.



The lights of downtown Flagstaff don't really interfere with Wes Lockwood's astronomical research. The planets of the outer solar system are bright compared with distant galaxies and quasars. This view from near Dr. Lockwood's house on the grounds of Lowell Observatory is nonetheless discouraging. Faint and distant objects are at the mercy of our artificial lighting. To address all of the questions the universe throws at us, we need dark sky, and to feel at home in the universe, we ought to be able to see it. (courtesy David S.F. Portree)

His Lowell Observatory-owned house, which he shares with his wife Susan and several cats, commands an impressive view of world's first International Dark Sky City.

His home is 800 feet from Mars Hill's oldest telescope, the 24-inch Clark refractor. Handcrafted in 1895-96 by famed Boston instrument maker Alvan Clark, the 13-ton tele-

CENTER

Strung Out in the Shadow

As the moon negotiated the earth's shadow—from after midnight until past dawn—on 28 August 2007, Father Ronald Royer documented its progress step-by-step in a multiple exposure acquired with an old Speed Graphic 4x5 stationary camera with Kodak sheet film (E100VS processed to 200). His 135-mm lens was set at f5.6, and he opened the shutter at 5-minute intervals with 1-second exposures during the partial phases and 5-second exposures during totality. He began at 1:50 a.m., P.D.T., and ended at 5:30 a.m., P.D.T. Clouds created the gap at the beginning of totality. Elsewhere in this issue, please see "Eclipsing 'til Dawn."

scope is one of the largest and best-known of its kind. The Clark and its unique bucket-shaped dome are a national historical site.

These days, the Clark is not used for research—instead, it's the centerpiece of Lowell's public outreach program, which each year shows the sky to some 70,000 people. For children especially, the experience of peering through the massive telescope can be life-changing.

Lockwood says that the view of Flagstaff's lights from his home helps to inspire his efforts to control light pollution—"especially the lights from Thorpe Park, because they shine right on the side of my house." The lights, which illuminate softball fields, were an irritant even before Lockwood arrived at Lowell Observatory in 1973. They shine directly on the Clark telescope.

Recreational lighting was exempted from the 1989 city code's lumens-per-acre limits. If the astronomers had asked for limits on ball-field lighting, an enraged mob carrying torches and softball bats might have marched on Mars Hill. Lowell reached a "gentleman's agreement"—the city's Parks & Recreation Department promised to turn the lights off by 11 p.m.

But by the mid-1990s that wasn't enough. "Ten years ago we didn't have much of a public program up here," Lockwood explains. "We were open Friday night, and that was pretty much it. But now we have a very big public program... open many, many nights per year, including almost every night in the summer-time when the ball fields are illuminated. Folks come to the observatory, and they're standing in line out there, and they're seeing these lights, and they're saying, 'How can this be world's first International Dark Sky City, when you've got a ball field shining lights on the telescope?'"

Delayed Improvement

In 1996, Flagstaff citizens approved a bond issue to fund park improvements, including new fully shielded Thorpe Park lights that would better illuminate the ball fields while saving the night for Lowell visitors. Parks & Recreation

needed considerable time to complete its list of improvements, however. As late as the 2005 softball season light from Thorpe Park still ruined the night for tens of thousands of people on Mars Hill. Finally, in October, 2006, Parks & Recreation installed lights friendly to both softball and dark skies.

Lockwood is in a good position to determine whether the new lights will make a difference. As a byproduct of his astronomical research, detectors on the 21-inch telescope record sky brightness. This means that he has a 30-year record of summer softball lighting and other Flagstaff lighting changes. Lockwood says that when the old lights were on, the sky over the 21-inch brightened by 30 percent. He smiles. "I'm guessing that, next softball season, it'll be 10 percent... I think it's going to be darker on Mars Hill than it has been for decades."

Interlude: The Night Sky in Spring

On evenings in May, the Milky Way sprawls along the horizon, and so it's hard to see even in dark places like Wupatki. Here on Mars Hill, any part of the home galaxy not obscured by sky glow is hidden behind *ponderosas*.

The Big Dipper is high in the north in May. It's a celestial signpost; a line drawn between the two stars in its rectangular bowl farthest from its curved handle points down toward the San Francisco Peaks and faint Polaris, the North Star. Extending the handle's curve south across the sky leads to golden Arcturus and onward to Spica, the only bright star in the large constellation Virgo the Maiden.

Besides Spica, Virgo is best known for something invisible to the unaided eye—the Virgo Cluster of some 3000 galaxies, centered about 50 million light years away. Some of its galaxies, such as the Sombrero, are visible in a small telescope under dark skies. The Milky Way and Andromeda galaxies are the largest of about 30 galaxies in our cozily named Local Group, a mini-cluster fleeing from the Virgo Cluster. Eventually, however, the combined gravity of

the Virgo Cluster's galaxies will halt our escape. The Local Group will then fall into the Virgo Cluster and lose its distinct identity.

The Future Looks Bright

Flagstaff is now home to about 60,000 people. The revised 1989 lighting codes have been successful—satellite images show that the city produces only as much light as a typical city of 45,000. But it could do more to save the night. Chris Luginbuhl estimates that Flagstaff would produce less light than a city of 30,000 if persistent lighting problems could be solved. Solving these problems will become especially critical as Flagstaff grows—some predict a population of 100,000 before 2050.

Grandfathered lighting is one of two chronic problems that threaten Flagstaff's dark-sky future, Lockwood says. Unless owners of lighting installed before the 1989 code can be compensated for upgrading, it seems unlikely to go away. "The second is bootleg lighting that appears overnight, so to speak, and is not remedied." Bootleg lighting is installed without a permit and is usually not up to code standards. "What percentage that is of the total lighting budget for the city, we don't really know for sure, but it's not insignificant," he adds.

Bootleg lighting persists because the city lacks the resources needed to enforce strictly its ground-breaking lighting codes. "There's a code enforcement officer, just one person, and he has other codes that he has to deal with as well. And in order to get action, assuming that his visit

and verbal contact doesn't do anything, then the paper trail is pretty laborious... Sometimes it takes months before the thing gets resolved. I'm sure he gets discouraged."

Even more discouraging is the threat on Flagstaff's southern horizon. "Light from Phoenix is encroaching on our sky," Lockwood says. Arizona's largest city is about 120 miles away, but it's getting closer. "Phoenix gets bigger every day—an acre an hour is the rate of growth... There are three million people down there, and it's spreading out in this direction, and all other directions as well... It's noticeable on the horizon [and] it's getting brighter all the time."

How much longer can Flagstaff control its own dark sky destiny? Lockwood isn't overly optimistic. "I think that 10 or 20 years is pretty safe—30 years, maybe—50 years, I don't know—unless there's a big change statewide [to] the kind of laws and practices that we have here in Flagstaff."

In hopes of swaying state lawmakers, dark-sky defenders have begun to inventory astronomical activity in Arizona to determine its impact on the state economy. Even in Arizona, however, with more research telescopes per capita than any other U.S. state, the result is likely to be disappointing. Lockwood says that the astronomy contribution is "not going to be 10 percent—probably more like one percent, maybe less." He shakes his head. "I think this one is a hard sell."

Lockwood pauses, considers. "Somebody

BACK COVER

Space Dog

Although the U.S.S.R. released a postage stamp in honor of *Sputnik 2*, it featured a romantic female personification of the spirit of exploration and achievement but no reference to Laika the Space Dog. Dog lovers in Britain criticized the U.S.S.R. for its deliberate sacrifice of Laika to science, but apparently unmoved by the censure, the Russians manufactured a new brand of cigarettes—Laika—and put the dog's picture on the package with images of *Sputnik 1* and *Sputnik 2*. Romania, on the other hand, was the first nation to put Laika on a stamp, which is illustrated on our back cover this month. Laika was accompanied on this stamp by her spacecraft. The stamp was released on 20 December 1957. (collection Dr. Robert W. Rector)

young and energetic's going to have to spend his life working on it," he says. "It's not going to be me."

Infinite Possibilities

The young girl from Phoenix brought her eye up close to the Clark telescope's antique eyepiece. Ringed Saturn swam in the field of view, a sublime work of art wrought by physics. Though the temperature hovered in the upper 20s, she

had stood in line outside with her proud parents for nearly an hour. "She loves math and science," they explained, "and insisted on coming here."

After a long moment, the girl tore herself away from Saturn's majestic geometry and breathed a long gust of fog into the frigid air. Apparently she had held her breath since she found Saturn in the eyepiece. Then quietly she said, "I want to be an astronomer." ■

Eclipsing 'til Dawn

Dr. E.C. Krupp
Griffith Observatory

WITH LITTLE REGARD for the convenience of Los Angeles, the solar system staged an after-midnight total eclipse of the moon on the night of 27-28 August 2007. The moon entered the umbra, or central shadow, at 1:51 a.m., P.D.T., and emerged completely at 5:24 a.m., P.D.T., 28 minutes after dawn began.

Staging a public event in the middle of the night in Griffith Park, which is closed through the night, is complicated. The Observatory has stayed up late, past its usual 10 p.m. closing time, for special astronomical events, but it has rarely remained open through the entire night. We decided Griffith Observatory should sit this one out, and I instead planned to take a look at it from my front porch in Eagle Rock.

Setting my alarm clock for 3:00 a.m., P.D.T., I slept through the penumbral and partial phases and awoke just after the beginning of totality to assess the character of the first total lunar eclipse in southern California since 8 November 2003. When I had said "Goodnight, moon," earlier in the evening, the white full moon was still brilliant. Although I

fully expected to see a moon dimmed in total eclipse when I opened the front door, I was still delighted—not by the transformed appearance of the moon but by the immediate visual confirmation of astronomical expectation.

Neither particularly dark nor particularly bright, last August's totally eclipsed moon wore a dependably copper-red shadow. It seemed dimmer on the lower half, but features on the entire disk could be discerned easily, especially in 7x50 binoculars. In my quiet neighborhood, the eclipsed moon seemed elegant, still, and dignified. Large Griffith Observatory crowds had made public performances out of all of the recent lunar eclipses I'd seen. This one, on the other hand, was private. I was playing eclipse solitaire in the dead of the night.

Although I did not know it at the time, Chris Shelton, my neighbor up the street, was also up at that silent hour and looking at the eclipsed moon. Mr. Shelton is the theatrical director for *Centered in the Universe*, the show presented in the Samuel Oschin Planetarium, and I can only figure that he felt obliged to stage manage the night's performance.