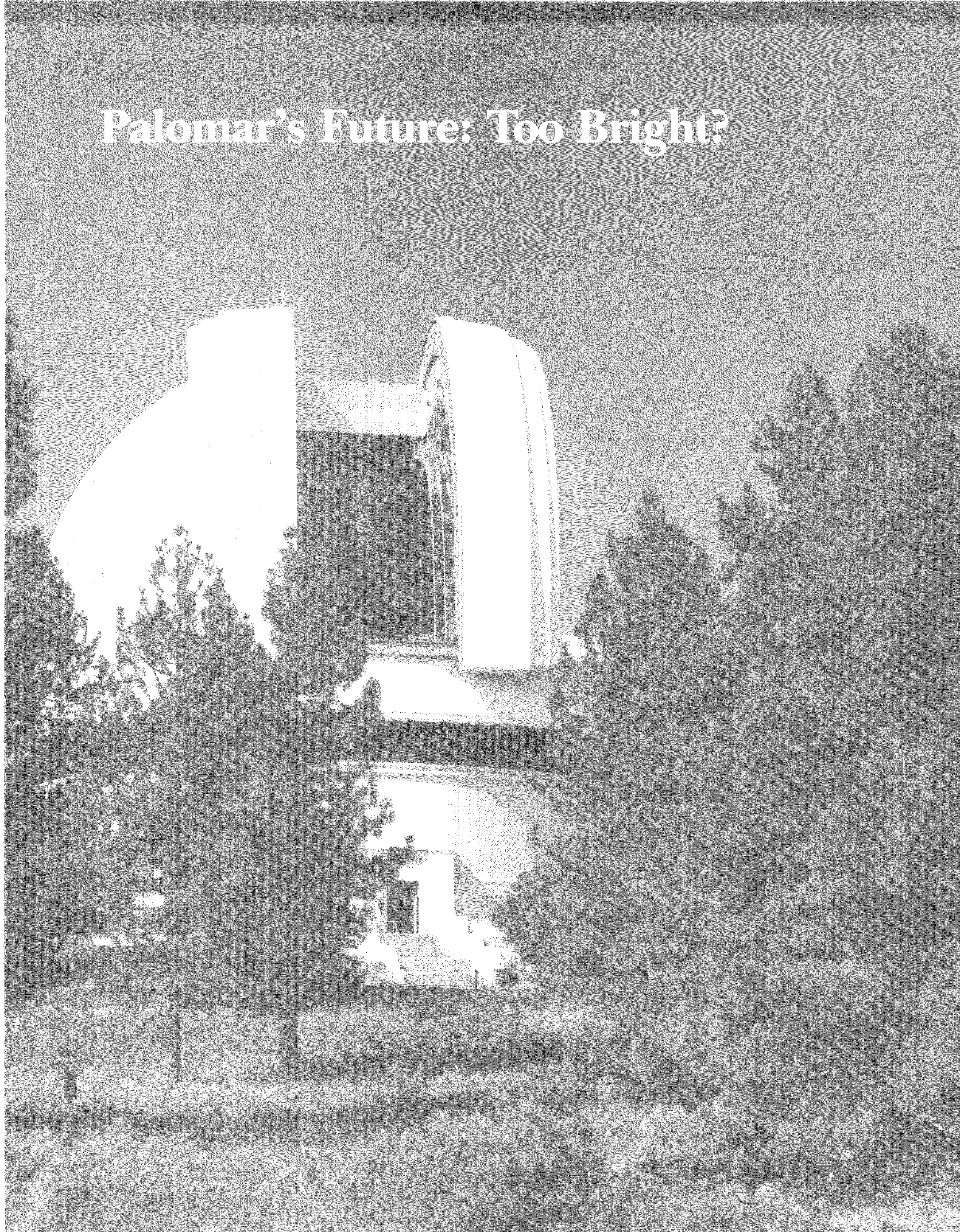
Palomar's Future: Too Bright?



The 200-inch Hale Telescope at the Palomar Observatory of the California Institute of Technology is one of the most important scientific instruments ever built. For over 30 years, astronomers have been using it and its companion telescopes at the observatory to increase our understanding of the universe. In that period, astronomy has advanced enormously, with other fine conventional telescopes being built, and both advanced orbiting and ground-based telescopes planned or under construction. But now civilization is encroaching on the observatory, as developments spring up around it. In this interview, Gerry Neugebauer, professor of physics at Caltech and director of the observatory, discusses the current value to astronomy of Palomar's telescopes and the threat of light pollution to their effectiveness. The interview was conducted by Dennis Meredith, director of the Caltech News Bureau.

Dennis Meredith: Could you start by describing the relationship the Palomar telescopes have to other instruments today?

Gerry Neugebauer: In astronomy today, there are on the order of 20 telescopes that are bigger than 100 inches in diameter, and of these the Hale is one of the half dozen bigger than about 150 inches. The Soviets have a bigger telescope, but the Hale Telescope remains the biggest in this country. It dominated astronomy in the fifties and sixties because of both its size and its achievements. When it was built, it was twice as large as any previous telescopes, and all the others of comparable size have been built only recently.

DM: Is it still useful in astronomy?

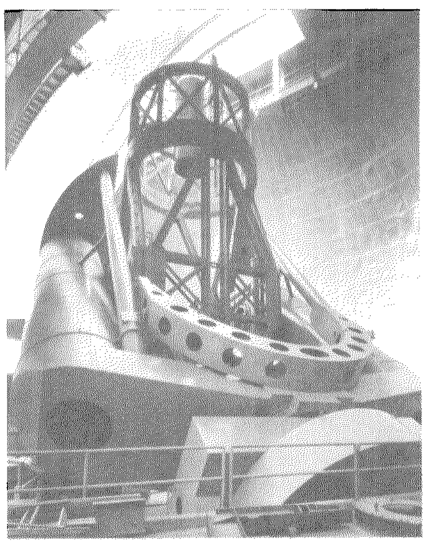
GN: Most certainly. It's a highly valuable instrument that is at the forefront of astronomical research. The telescope itself is a light-gathering device for the detectors that are placed on it, so it doesn't go out of style. And the instrumentation developed for the 200-inch Palomar telescope has always been at the front of the line. Things such as multi-channel analyzers and spectrographs that more effectively analyze the gathered light have long been used. And we were among the first, if not *the* first, to use charge-coupled devices, which are arrays of electronic elements that are far more sensitive light detectors than traditional photographic plates. Because the new detectors are more sensitive than the old photographic plates, the 200-inch can now see objects a hundred times fainter than it could when it was built. In addition, in just the last few years we have upgraded such things as control systems to point the telescope.

DM: Could you outline a few of the discoveries that have been made with the telescope over the last few years?

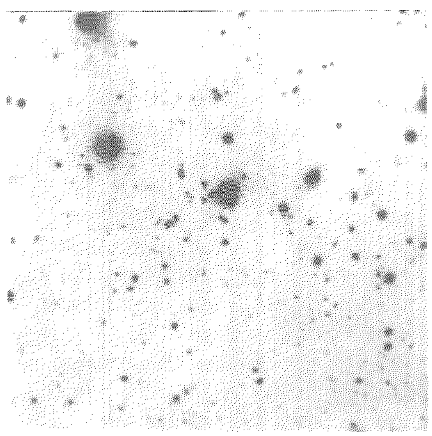
GN: The most recent has to do with quasistellar objects, or quasars, which are incredibly bright objects at the edge of the observable universe. Astronomers believed that quasars were the nuclei of galaxies of stars, but until the recent detection at Palomar of starlight around a quasar, they had no solid evidence. Now we have proof that quasars are, indeed, at the centers of galaxies.

Another fascinating study now being done at Palomar involves studying the spectrum of light from quasars to detect absorption by material in clouds between the quasars and earth. The quasars, in effect, backlight the clouds, which have been found to be perhaps the most pristine material in the universe, unchanged since its beginning.

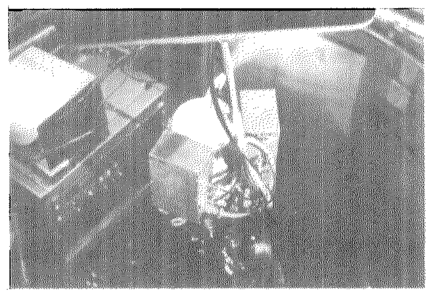
Also, very significant studies of the gravitational lens effect were done in 1979 with the 200-inch. In this effect, the light from quasars is warped by the gravity of galaxies between the quasar and earth, creating multiple images of the quasar.



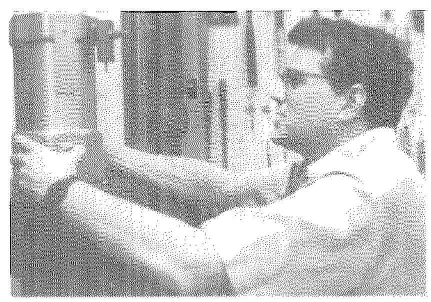
The 200-inch Hale Telescope points toward the zenith. The solid tube at the top is where the prime-focus observing cage is located.



This 6,000-second exposure of the first gravitational lens taken by a detector on the 200-inch telescope is one of the deepest pictorial looks into the universe ever taken. The field size is 12 square arc-minutes (compared to the moon's 700), and the faintest visible objects are of a magnitude fainter than 25, which is 100 million times fainter than anything visible to the naked eye. The photo was obtained by Jerome Kristian of the Mount Wilson and Las Campanas observatories and the late Peter Young of Caltech.



The PFUEI/CCD system that made possible the picture at the left is mounted in the prime-focus cage of the 200-inch. The PFUEI (Prime Focus Universal Extragalactic Instrument) was designed by James Gunn, formerly of Caltech, and James Westphal, professor of planetary science. CCD stands for charge-coupled device. The photo is courtesy of graduate student David Jewitt.



Gerry Neugebauer, professor of physics and director of the Palomar Observatory, with the infrared detector he uses in astrophysical research.

Astronomers can study the differences among these images to learn about the stars in the distant galaxies the light has traveled through and also about the precise distances to the edge of the universe.

Other discoveries farther back in time include the first measurement of the diameter of Pluto, the establishment of the distance scale of the universe, and the first discovery of quasars. All of these represent some of the most exciting astronomy ever done.

DM: Of course, the 200-inch is not the only telescope on the mountain.

GN: No, and that's important to stress. Because it's the telescope that looks at the faintest objects the farthest out in space, it's been preeminent. On the other hand, the 48-inch Schmidt telescope, which is basically a large camera, can't see as far. It has, however, a much larger field of view, so it's used for mapping big areas of the sky. There's an exact twin of it in Australia. Immediately after the Schmidt was installed at Palomar in 1949, astronomers used it to survey the entire sky, and the result has been called the Bible of astronomy. We're going to repeat that survey maybe two years from now, using the Schmidt to map the entire sky at several different wavelengths. The project will take about five years, but if the survey was done with the 200-inch, it would take about 200 years.

DM: Will this new survey be an improvement over the previous sky surveys?

GN: It's an important improvement in two ways: It will be at different wavelengths and with improved, more sensitive film, so it will show more objects; and it will show how the stars have moved in the sky over the years. Knowing such motions is very important for astronomers.

DM: How does the work at Palomar relate to studies done with such space probes as the Space Telescope, which will be launched in 1985?

GN: Well, first of all, Palomar is significantly aiding such efforts. For instance, right now we are using the 48-inch to make a survey of the sky to establish the guide stars for the Space Telescope.

More importantly, though, ground-based telescopes like the 200-inch and the 48-inch are complementary to such instruments as the Space Telescope. It's certainly not that one kind of instrument will put the other out of business. While the Space Telescope will not have to deal with atmospheric interference, ground-based telescopes are larger and we have the flexibility to change our instrumentation more often. What I think will happen is that once we have the Space Telescope, it will open up more, different kinds of problems that can be attacked with the 200-inch.

It's as if you owned a store in an area and somebody wanted to build more stores nearby. Your business won't be hurt, it will be helped, because the more stores you bring in, the more people will come to buy. In the same way, I think the more we learn about astronomy with the Space Telescope, the more use the 200-inch will see.

DM: Could Palomar then be described as a cheap space probe, because the knowledge it brings is less expensive?

GN: I wouldn't call ground-based astronomy a cheaper version of the space program. What we have learned from the ground undoubtedly cost us less, but I would like to emphasize that space yields different knowledge. That's the real answer. There are wavelengths you can look at from space you simply can't detect from beneath the atmosphere.

DM: What do you consider the major current problem facing Palomar?

GN: Right now, as far as its long-term future, light pollution is the major problem for both telescopes. Without light pollution, we should without a doubt be able to keep on using Palomar far into the next century. The only limit is our imagination in building new instrumentation, and we can keep on doing that. The limit set by light pollution, however, will soon be a fundamental limit; that is, because of it we won't be able to keep on pushing to fainter and fainter objects. We are already looking at objects that are fainter than the sky, but if the sky brightness continues to increase, pretty soon we just won't be able to make measurements.

DM: How can you look at objects that are fainter than the sky?

GN: Even at the darkest of sites on the darkest nights there is a natural glow that comes from a lot of different things. It comes from light pollution from surrounding cities, from material in the upper atmosphere, and from dust in the solar system. With our new electronic instrumentation, we can subtract out that background because it's random noise that cancels itself out. It differs from the light from the object, which builds up as we fix on it with the detector. But this subtraction can only go so far.

DM: How about replacing Palomar with other telescopes at a better site or moving the existing telescopes to a better site?

GN: According to current estimates, it would cost from $50 to $100 million to replace Palomar, which makes that out of the question. We've thought a bit about moving the telescope, but when you look at the numbers, that's impractical, too. Just as important is the fact that there aren't that many good sites left. Among the many excellent qualities that Palomar Mountain has is that the atmospheric turbulence is very low there, so the seeing is very good. We couldn't match that quality by just going out to the desert to look at the stars. So, if we can just keep the lights down, along that ridge near San Diego is a really ideal place for the telescope.

DM: What would you ask of the people who live in communities near the mountain?

GN: Well, first of all, I accept the fact that we can't have an ideal world with no lights around Palomar. And so what we want to try to do is to ask for the kinds of lights we can deal with most effectively. That's why first of all we're recommending low-pressure sodium lights for outdoor use. All the light from low-pressure sodium lamps is emitted in one narrow line of the spectrum. In effect, it's gathered up in one small area of the spectrum, and our instruments can effectively filter it out. On the other hand, incandescent, high-pressure sodium, and mercury vapor lamps emit light that's all over the spectrum, and it literally blinds the instruments. In fact, because low-pressure sodium lights emit all their energy at a usable visible wavelength, they're more efficient and cheaper to use.

The other thing we're asking is that people try to use fewer outdoor lights for less time. We hope that lights for advertising can be shut off after business hours. Beside being bad for us, they're not selling very much during that time anyway, so we're actually only asking the users to save energy and money. When lights such as security lights do have to stay on, besides asking that they be low-pressure sodium lights, we'd like to have them shielded, so they don't shine above the horizon.

DM: Are the low-pressure sodium lamps effective for security use?

GN: In every case in which the effectiveness of the lamps has been studied, there has not been an increase in crime in an area where low-pressure lighting has replaced other forms.

DM: Does the average person who lives around Palomar and has a porch light or other outdoor light really make a difference to the effectiveness of the telescopes?

GN: Absolutely! The average guy clearly does make a difference. If you just look out over the area around Palomar, you can see more than street lights and advertising lights. Street lighting probably contributes something on the order of a third to light pollution, depending on the time of night and the kind of area. But all the rest of the light is made up of little bits and pieces — porch lights, security lights, and such. If we can get people to arrange those so that they're downward-looking, and to perhaps turn them off after midnight, I think it'll be a big step forward.

Our hope is that we can convince the people who live around Palomar that the observatory is a big enough national resource that they will want to help. And so far, everybody that we've talked to has been very cooperative. We've talked to developers, industries, and governmental bodies, and they've all been very understanding. Recently, for instance, TRW agreed to install low-pressure sodium lighting in its new facility near Palomar.

DM: Do you think that light pollution will be the death of Palomar?

GN: If we're not successful in our efforts, it will be. Light pollution is the only factor that is detrimental to Palomar right now. The area right around us is a big national forest, so it won't ever be developed. And we don't see any dust or smoke clouding our images. We had a bit of a problem with airplanes flying over, but the Air Force has been cooperative and rerouted their flights so they no longer interfere with our viewing. And they don't turn on their landing lights right over our telescopes.

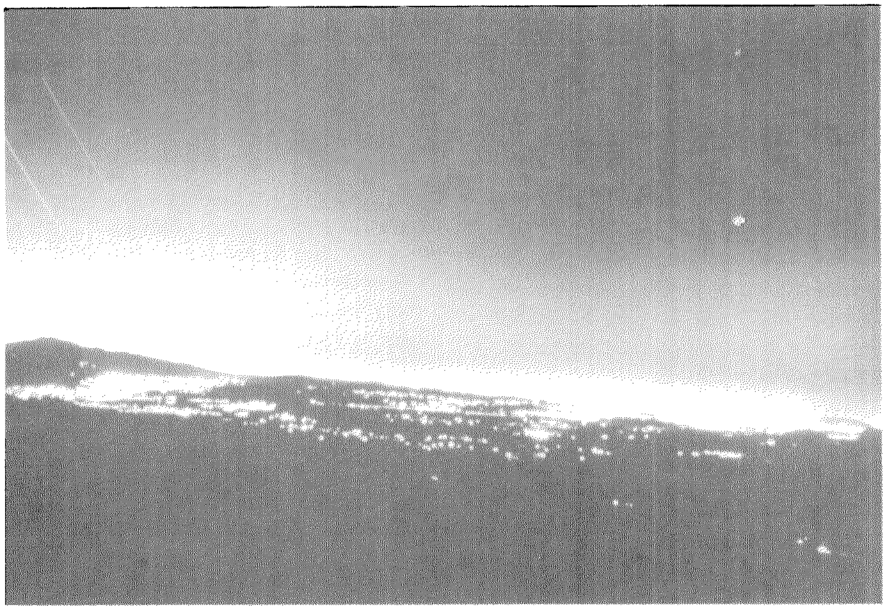
DM: Is there time to reduce light pollution?

GN: There's not as much as we hoped there would be. One reason is that the Public Utilities Commission mandated in 1978 that street and highway lighting be converted to sodium vapor for economic reasons, to save energy. Until now, the conversion has gone largely to high-pressure because the highway agencies thought that the citizens would object to low-pressure because of its yellow color. But it turns out that the people haven't objected to low pressure wherever it has been tried. We've got to try to reverse decisions to go with high-pressure sodium.

Another reason we don't have a lot of years to work on the problem is that the area right around Palomar is the fastest growing in the country. I've seen estimates that say before the year 2000 the population will have increased more than 50 percent. With that increase, unless we can persuade people to install the right kinds of lighting as we go along, it's going to be very hard to reverse the trend. So I don't feel complacent about the problem; I think we have to work with some sense of urgency.

DM: You do feel though that, even given the population increase, if the lighting is done carefully, Palomar can continue to operate?

GN: Yes, I think that it can, or else I wouldn't be investing the effort that I have and am. I think Palomar can continue, and that it will survive as an important contributor to science. □



On a clear night the telescopes at Palomar Observatory would be able to see almost forever if it weren't for the kind of light pollution shown above. This photograph was taken from the mountaintop looking north-northeast, and the glow is largely from Hemet, which is just inside the 30-mile radius around the mountain indicated by the shaded area on the map below. The rest of the lights are shining in Sun City, which is even beyond the 30-mile area.