Colliers
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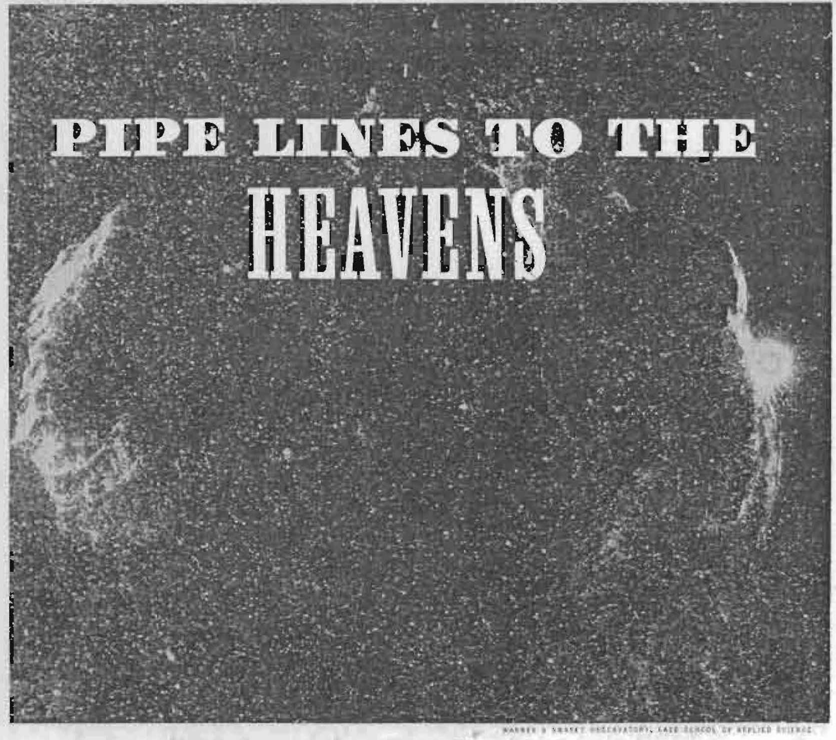
PIPE LINES TO THE HEAVENS



WARNER & SWASEY OBSERVATORY, CASE SCHOOL OF APPLIED SCIENCE

Millions of suns provide a brilliant background for the nebula in the constellation Cygnus in this Schmidt telescope photograph

BY G. EDWARD PENDRAY

The Schmidt telescope uses both mirror and lens. This one, the biggest ever built, is in use at the Warner & Swasey Observatory

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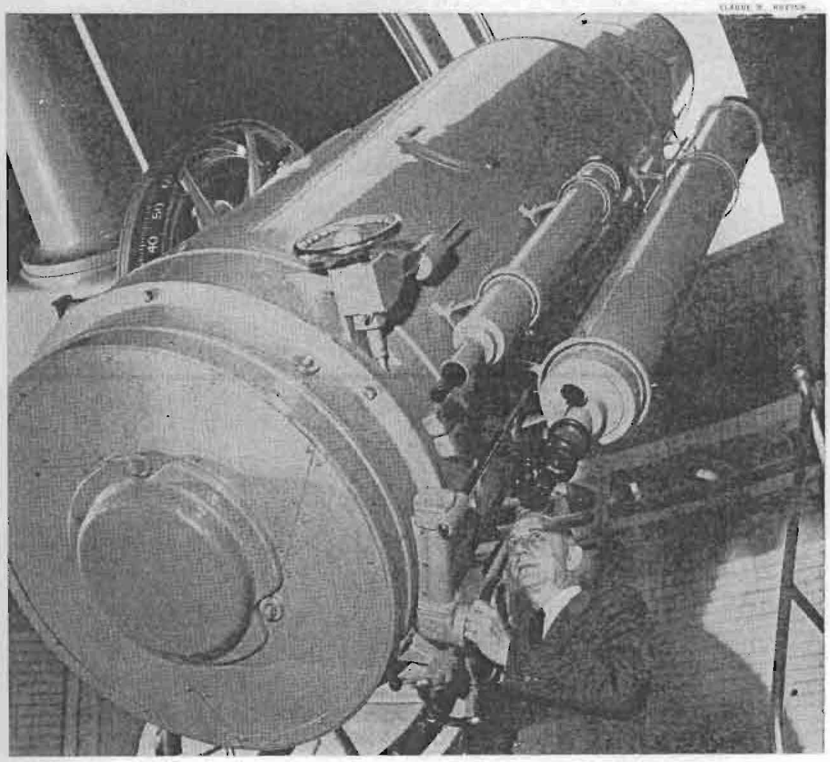


New knowledge, new instruments, new methods—these are the spearheads of a concerted attack by astronomers on the ages-old mysteries of the universe

MOST of us have been occupied lately with troubles here on earth, and may have forgotten the relative unimportance of human trivia in the bigness of the universe.

But the astronomers, now returning from numerous war duties all over the world, have not forgotten. They are preparing a co-ordinated drive on the secrets of the cosmos, which may be the biggest and most ambitious campaign for information since the beginnings of astronomy, oldest of the sciences.

In this effort they have a lot of recently won knowledge of physics and other sciences to help them. They will also have a new and larger assortment of instruments, including conventional telescopes, spectrographs and other standard paraphernalia; as well as electric eyes, infrared photography, television, radar, high-altitude rockets, new types of photographic telescopes and possibly even space ships.

The astronomy of the past has answered many questions on the makeup and behavior of the universe and raised many more. These are today the subject of dramatic speculation and of many controversial theories. Never before was there such a mass of sharply defined questions, and never before such power to answer them.

Our tiny earth is revolving in an orbit around one of the stars, our sun, which in turn is revolving around the nucleus of a galaxy or swirl of stars so big it takes light, at 186,000 miles a second, 100,000 years to cross it.

The sun's speed in its course around this galaxy is about 150 miles a second. Nevertheless, it requires about 200 million years to make the complete circuit.

Our Galaxy, which forms the Milky Way, is one of countless millions of galaxies, each consisting of some billions of stars. Most of the galaxies are rotating like pin wheels, showering their light through the vastness of space. And space itself is so enormous that these millions or billions of galaxies are quite lost in it.

So much seems clear. But there is an array of evidence for forming insights far beyond this. One interpretation of the spectra of far-distant star groups is that they are rushing outward from our part of space in all directions. The farther they are, the faster they seem to move. If this be true, the stellar groups at the outer limit of visibility of today's telescopes must be traveling at 60,000 miles a second, or about a third of the velocity of light. In short, our whole universe seems to be expanding with explosive violence.

Are we really a part of an "expanding universe?" Many, but far from all, astronomers take this view on present evidence. And if the universe is expanding, how and when did it start? Tantalizing opportunity for further speculation is given by our knowledge of the radioactive elements, the composition of the stars, star clusters and galaxies and many other things.

This knowledge indicates that in the beginning all of the material of the universe may have been gathered together in one giant sphere. It was possibly ten times the present size of the solar system, was several times as dense as water, a billion times hotter than the sun, and it probably contained a very high percentage of uranium and other heavy elements.

It may have been the first atomic bomb. It was shot off about three billion years ago, by Forces Unknown.

The blast it started apparently is still in progress. Consuming part of their original substance like burning shreds of an exploded firecracker, the fragments of the "Universe-bomb" are still scattering far and wide through space. They are what we know as the stars, planets, comets and meteorites, the misty veils of interstellar dust, the novae, the Milky Way, the extragalactic nebulae and the rest of the universe.

To that explosion we owe our earth, our sun and our lives. It set in motion the chain of events that made us what we are. But in the gigantic continuing expansion our own *(Continued on page 89)*

PIPE LINES TO THE HEAVENS

Continued from page 32

precarious position resembles that of a colony of bacteria, perched on one of the smaller motes of dust from a fragment of the atomic bomb, during the height of the blast of Hiroshima.

To view this spectacle, astronomers have only some relatively tiny and inadequate instruments, but in spite of everything, they have been able to learn a great deal with them.

Until very recently there were two principal kinds of telescopes: the *refractors*, which make use of lenses to focus the images of the stars, and the *reflectors*, which do the same job with convex mirrors. Both kinds of telescopes have important advantages as well as limitations —and both have probably now reached their maximum size and effectiveness.

The World's Largest Refractor

The biggest refractor is the 40-inch telescope at the Yerkes Observatory of the University of Chicago. It was completed in the last years of the 19th century. The giant mounting which holds the optical parts was first exhibited in 1893 at the Columbian Exposition in Chicago. It has held its place as the biggest refractor ever since. The likelihood that a larger one will ever be made is remote.

The biggest reflecting telescope is the 100-inch at Mt. Wilson Observatory, Pasadena, California. It was finished in 1917. It weighs 100 tons, and cost $600,000. It can "see" 600,000,000 light years, or about 36,000,000,000,000,000,000,000 (21 ciphers) miles, into space; but what lies beyond?

As everybody knows, the biggest telescope venture of all time—and possibly the biggest glass-mirror instrument that will ever be built—is the 200-inch Mt. Palomar Observatory reflector, now approaching completion. It has been promised for some time in 1947. It will weigh about as much as a locomotive. Together with its auxiliary equipment and buildings it will cost $6,000,000, or ten times as much as the 100-inch. Its huge mirror will be able to catch 800,000 times as much light as the human eye.

With such an optical system it will be capable of seeing into space about 1,200,000,000 light years, so it will be able to double the radius of the present visible universe.

In addition to these instruments, the astronomers now have a brand-new type of telescope, invented about 1930 by Bernhard Schmidt, an obscure optician of the Hamburg Observatory in Bergedorf, Germany.

Schmidt developed his new instrument to overcome some of the difficulties astronomers were having with the big reflectors which, for all their penetrating power, have only a relatively small field of view, because they suffer from optical distortions, the principal one being "coma," which makes the star images teardrop-shaped when they are a little off the main axis of the instrument.

These troubles limit reflector users to the study of only a small portion of the sky at one exposure. Even the biggest reflectors bring into sharp focus only about one tenth of a square degree of sky. Since in the whole sky there are 41,253 square degrees, it is obvious that surveying the heavens with a reflector is a long, tedious business.

The new Schmidt telescope goes a big way toward solving that problem. A good Schmidt has a field of about 25 square degrees—or 250 times that of a reflector. It speeds up the task of studying the sky by 250 times and more; making it possible to scan the sky rapidly, looking for objects of interest or mapping large portions of it—work that was almost beyond doing in the pre-Schmidt days.

The Schmidt is neither a refracting telescope nor a reflector, but is a combination of the two. It has a lens at the forward end, and a mirror at the back. In operation, light coming from the stars first passes through the lens (or "correcting plate") where the rays are slightly bent, or refracted. The amount of refraction is just enough to provide a good, sharp focus from the spherically curved convex mirror, which the rays strike next. From the mirror they are reflected to a point about midway between the lens and the mirror, and there the high-speed camera, with a photographic plate which is also slightly curved, is waiting to capture them.

The Schmidt may be said to be able to "see out of the corner of its eye." Light coming from oblique angles through the lens is focused on the plate, as well as that coming straight in, provided the rays strike the mirror. For this reason, many Schmidt telescopes have mirrors which are larger than their lenses.

"I'm your neighbor. I was wondering if I could borrow . . ."

COLLIER'S LEO GAREL

Bernhard Schmidt was virtually an unknown worker in the Hamburg Observatory at the time of his invention. In the summer of 1930 he amused himself and some of his friends by reading the epitaphs on tombstones in a near-by cemetery with his first small model of the new telescope. He died four years later, but already the fame of his new instrument had begun to spread.

By 1940 astronomers practically everywhere were making and using Schmidt telescopes. One of the first in this country was constructed for Mt. Palomar Observatory: an 18-inch Schmidt with a 26-inch mirror. Promptly on completion it began finding exploding stars and similar phenomena that other telescopes had missed.

A very fine Schmidt was installed at the Harvard College Observatory. The Harvard Schmidt has a 24-inch lens and a 33-inch mirror and was specially designed for use in the Harvard surveys of the disposition of the stars and galaxies. Another excellent Schmidt now in operation is in Mexico. It has a 26-inch lens and a mirror 33 inches in diameter.

The biggest Schmidt to date was completed just before the war for the Warner & Swasey Observatory of the Case School of Applied Science at Cleveland. It has a lens 24 inches in diameter and a mirror 36 inches across.

A number of even larger Schmidts are now under construction. The California Institute of Technology is constructing one with a 72-inch mirror, to serve as a companion for its 200-inch reflector in surveys of the distant galaxies. Another —to be known as the Armagh-Dunsink-Harvard telescope—is in the works for the Boyden Station of the Harvard College Observatory at Bloemfontein, South Africa, where it will be operated jointly by the governments of Northern Ireland and Eire, and Harvard University. This project, a triumph for political as well as astronomical collaboration, resulted from a chance meeting last spring in Dublin between Eamon de Valera, who has taken a personal interest in it, and Dr. Harlow Shapley, the enthusiastic director of Harvard Observatory.

Between forty and fifty Schmidt telescopes of various sizes are in operation at present, and a kind of "Schmidt fever" has sprung up among astronomers. For the Schmidts have a number of decided advantages. Being essentially short-focus telescopes, they are fast. The Schmidt at Harvard takes only twenty minutes to photograph faint galaxies that require a three-hour exposure with the Metcalf reflector at the same observatory.

Schmidts are relatively inexpensive, too. A good one costs only about a third as much as a reflector of the same diameter—though this advantage may disappear with increasing size.

With the aid of a big "objective prism" covering the whole of the front of the lens, the Schmidt can photograph the spectra of a large number of stars all at once. The spectrum of a star is a thread-like picture of its "rainbow," showing its various characteristic wave lengths of radiation lying side by side in a tiny band. The arrangement of dark and light bands in the spectrum discloses not only what the star is made of chemically, but can also be made to tell how hot it is, how big it is, how fast it is going toward or away from the earth.

Sometimes it also discloses whether the star is single or has a companion, and makes it possible to measure, weigh and analyze the accompanying star, even though it may be too small, too dark or too distant to study by other means.

The kind of spectroscope generally used for getting this information is a large, delicate piece of optical apparatus. It consists of a narrow slit through which the light enters after passing through the telescope, a series of lenses, a prism or diffraction grating for separating the rays of light into a spectrum, another set of focusing lenses, and a photographic plate. Such an instrument can often provide a fine, clear spectrum, but by necessity it must look at the stars one by one.

A Schmidt telescope with a prism big enough to cover the entire lens can cast the spectra of all sufficiently bright stars in its field automatically at one time on a single photographic plate. For comparing stars, this arrangement is about perfect, since all the spectra on the plate have the same exposure. The reason the system works with the Schmidt and not so well with ordinary reflecting telescopes is the wide, clear field of view.

As cast on the plate, these spectra are extremely narrow bands of colored light, interspersed with bright and dark lines. To make the bands a little easier to see, the telescope is simply moved a little during exposure, to make a widened image. Photographed with color-sensitive plates, the brilliant banded star rainbows make a very pretty picture.

The Schmidt telescope and its appurtenances represent one of the greatest strides in astronomical instruments in many years. But a host of other instruments and methods, including some that have still to prove their reliability, are also making a bid for attention.

An Observatory on the Moon?

One of the greatest problems of the astronomer is the fact that he must always function at the bottom of an ocean of air. This absorbs a great deal of starlight, and almost all of some of the more interesting kinds of invisible radiation, such as ultraviolet. For this reason, astronomers have long considered that the airless moon might make an ideal site for an observatory. Lacking means of getting there at present, the next most likely idea seems to be to send astronomical cameras, spectrographs and such up to the edges of the atmosphere by rocket.

It was with this idea in mind, among others, that the late Dr. Robert H. Goddard, who founded the modern science of rocketry, first began his experiments more than thirty years ago. His dream is now beginning to come true. Last autumn at White Sands Proving Ground, in New Mexico, several promising attempts were made to obtain photographs and spectra of the sun and stars by automatic instruments sent up in large rockets of the V-2 type. It is possible that no major observatory in the future will be considered complete if it lacks a rocket launching field.

Another attractive new idea may have been suggested by the Army's successful attempt a year ago to contact the moon by radar. Efforts of this sort fail when they are aimed at getting signals back from such distant objects as the planets and stars, because these objects are relatively so small and so far away.

But the stars and other materials in space nevertheless may help us, for it begins to appear that they emit not only visible light, infrared, ultraviolet, and other radiations, but may be sending out radio signals, too. At recent astronomical meetings, Grote Reber, an astronomical-minded radio engineer of Wheaton, Illinois, has reported some of the results he has obtained with a giant radio receiver, suitable for listening to the programs from some of these celestial broadcasting stations. Aiming it at the heavens, he has received "cosmic static," especially from portions of the Milky Way, which he interprets as originating in the central portion and some of the spiral arms of our Galaxy.

Another interesting idea in astronomical instruments looks toward the use of electronics to brighten the images of stars after they have been focused by the telescope. Bigger telescopes would be even more useful if some practical way were found to amplify such images in the way that radio signals received by an antenna are amplified by the tubes and circuits of a radio receiver.

With all these new—and promised—instruments, the astronomers are now preparing to move particularly on three baffling key problems of the universe.

The first might be called the Mystery of the Invisible Nucleus. Examination of other rotating nebulae, of the kind our own Milky Way is supposed to be, shows that most of them have a dense cluster of stars near the center: the nucleus. A considerable fraction of the mass of the Galaxy is contained in this nucleus; it is the gravitational center around which the other stars whirl.

The behavior of the stars in our part of space, and the general shape and motion of the Galaxy, indicate that the Milky Way must have a massive and brilliant nucleus, too, probably in the direction of the constellation Sagittarius. The mass should be equivalent to many million suns, and ought to be the most spectacular feature of our nighttime sky.

But where is it? A blaze of light coming from so many billions of stars would dim the moon by comparison.

Probably the reason we don't see the nucleus is that clouds of dark obscuring matter are in the way. The existence of such clouds, consisting of dust, gas and possibly minute ice crystals, is pretty well proved. What is now needed is a means of penetrating them with instruments that will let us "see" the galactic center indirectly, by means of infrared and other radiations.

The second big astronomical project now under attack is the Mystery of the Expanding Universe. Learning more about this will depend on being able to see farther into space, so progress will probably have to await completion of the 200-inch telescope. Only this enormous instrument will have enough penetration to give us more of the story.

The third project is the Mystery of Where the Baby Stars Come From: one of the exciting new ventures of astronomy. It may, among other items, involve a study of certain dark, obscuring clumps of matter observed in space—which may be new stars in process of birth.

For years astronomers have speculated as to whether all the stars are the same age. There is some evidence that most are. But some enormously large ones seem to be mere children among the stellar family. Compared with middle-aged characters like our sun, *these* youngsters are pouring out energy at so *prodigious* a rate it is hard to understand how they could keep it up for more than a fraction of the estimated life of the universe. If all stars were born at the same time, how can these spendthrift stellar bodies be accounted for?

Until recently there was no satisfactory answer. But last September (1946) Dr. Lyman Spitzer, Jr., of the Yale University Observatory, greatly stirred a meeting of the American Astronomical Society with a paper in which he showed how it might be scientifically possible for the thin masses of dust and gases in space gradually to clump together into stars, with the aid of gravitation and light pressure from near-by suns.

Spurred by this work of Dr. Spitzer's, which began about 1941, and by the related studies of Dr. Fred L. Whipple, of Harvard, astronomers immediately began making a serious hunt for condensing clouds of gas and dust—young stars about to be born. The best place to look for them should be in photographs of bright diffuse nebular matter in our own Galaxy. Large, dark embryonic stars should show up clearly against a bright background of this kind.

Sure enough, when the plates were examined, a number of dark gaseous globules did appear. At Harvard Observatory, Miss Edith Reilly, working with Dr. Bart J. Bok, has already located hundreds of them. In an enlargement of a familiar photograph of the nebula Messier 8, taken some time ago at Lick Observatory, at least 25 such dark masses can readily be counted.

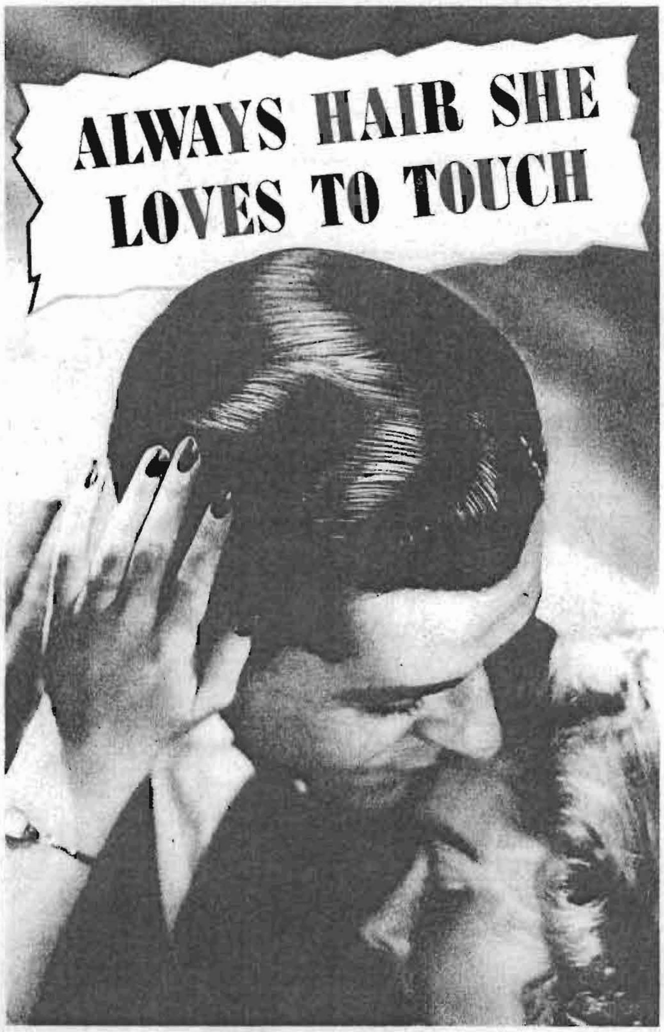
If further research should prove that these masses really are embryo stars, then some of the general theories of the universe will have to be revised—particularly its calculated life expectancy. As things stand, the universe should burn up all its atomic fuels and go out like a dying bonfire in 10 to 20 billion more years. But if new stars are being created, this estimate could prove too short.

It will make little difference to us, of course. Our own sun will burn out even before many of the older stars now visible in the sky—leaving the earth a freezing lump in the darkness of space. But it's a comfort to know that *some* of the universe will continue for a while.

THE END

"How can it make her a glamorous movie star if it's going to make me a big baseball player?"

COLLIER'S JOHN MILLIGAN



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