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Stars

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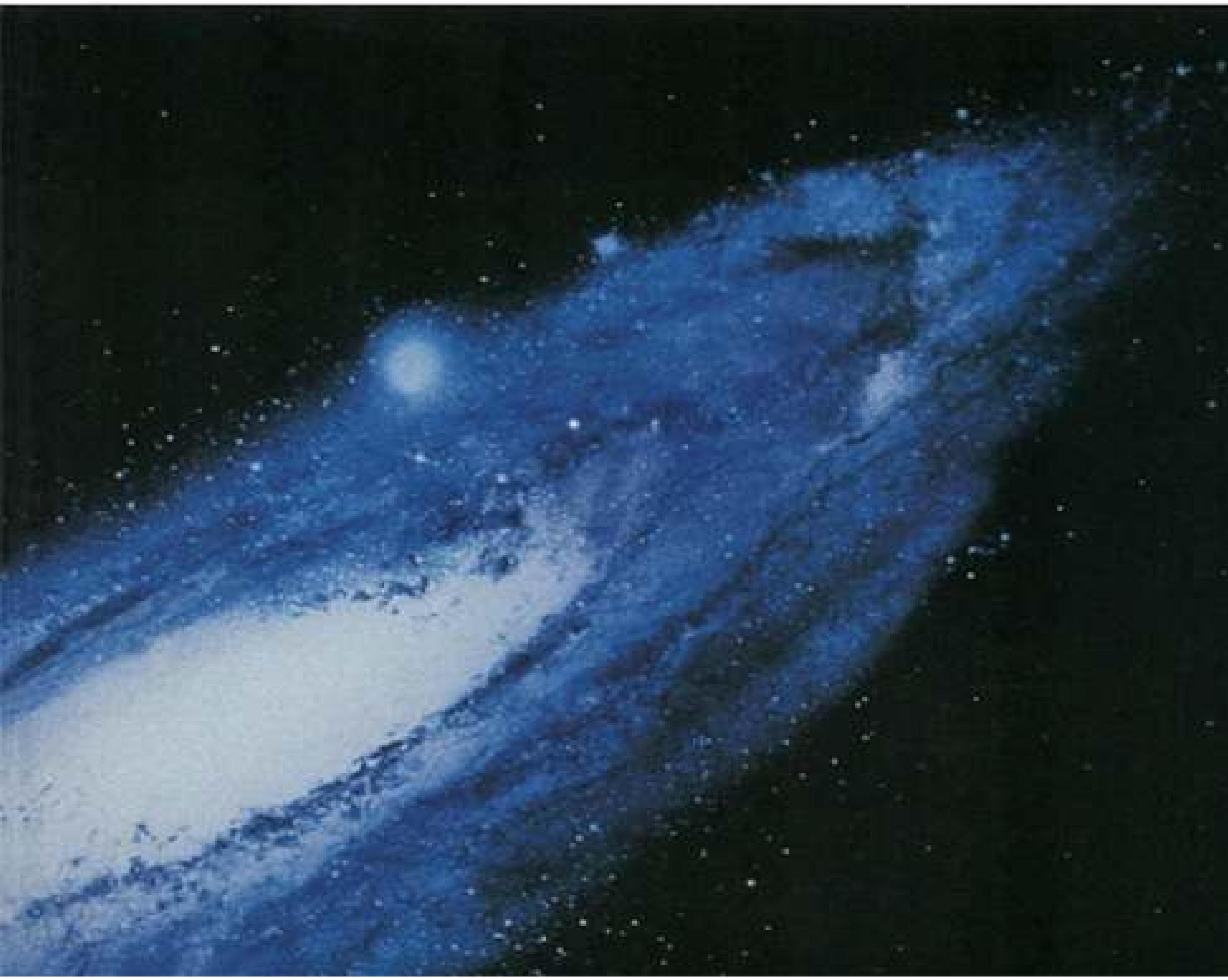

STARS

A GUIDE TO THE CONSTELLATIONS, SUN, MOON, PLANETS, AND OTHER FEATURES OF THE HEAVENS

a Golden Guide® from St. Martin's Press

by
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St. Martin's Press New York

FOREWORD

The artist, James Gordon Irving, worked with skill and imagination. His wife, Grace Crow Irving, assisted in research. David H. Heeschen of the Harvard Observatory and Ivan King o the University of Illinois Observatory helped with data and tables. Paul Lehr, of the Nation Oceanic and Atmospheric Administration, checked text involving meteorology. Hugh Rice o the Hayden Planetarium gave helpful advice, and our seasonal constellation charts owe muc to his projections. Dorothy Bennett, for many years a member of the Hayden Planetarium staff, contributed greatly to our editorial planning. Isaac Asimov, Joe and Simone Gosner ar to be credited for intermediate revisions; Mark R. Chartrand prepared the latest revisio Twelve new illustrations by Howard Friedman have been added for this edition.

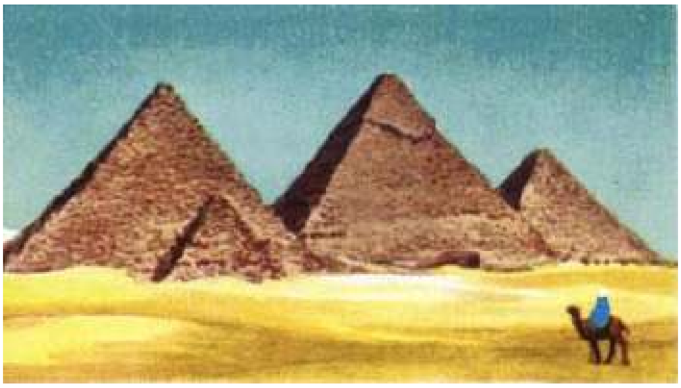
Thanks are due the Lowell, Hale (Mt. Wilson and Mt. Palomar), Lick, Yerkes, and Nation Optical Astronomy observatories and NASA for the use of images.

eISBN 978-1-4668-6244-9

CONTENTS

This is a book for the novice, the amateur, or anyone who wants to enjoy the wonders the heavens. It is a field guide, with information to help you understand more fully what yo see. Use this book when you are watching the stars, constellations, and planets. Thum through it at odd moments to become familiar with sights you may see; carry it along on tri or vacations.

OBSERVING THE SKY



Egyptian Pyramids

Stars and planets have attracted man's attention since earliest times. Ancient tablets ar carvings show that movements of planets were understood before 3000 B.C. Legend says tw Chinese astronomers who failed to predict an eclipse correctly in 2136 B.C. were put death. The Egyptians placed their pyramids with reference to the stars. The circles of stone Stonehenge may have been used to keep track of lunar eclipses. Astronomy is indeed th oldest science, yet its importance increases as scientists turn to the stars to study problems physics which they cannot tackle directly in the laboratory.

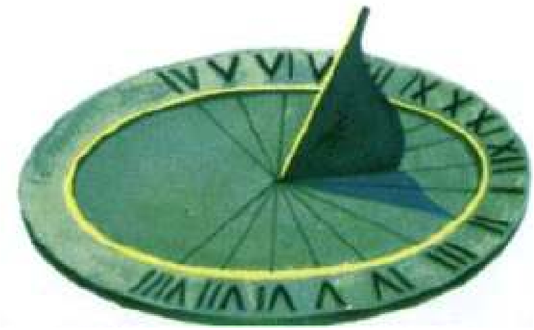
As far back as history records, there were professional astronomers — long before the were professional zoologists and botanists. The Egyptians, Chinese, and Europeans had cou astronomers. Their work often involved trying to predict future events, but their syster though considered unscientific today, involved observation and recording of facts about sta and planets. These early astronomers, as well as those of today, made remarkable discoveri that changed man's outlook on the world and himself.

There has always been, too, an army of amateurs studying and enjoying the stars. Som make practical use of their knowledge — sailors, pilots, surveyors — but most study th heavens out of sheer interest and curiosity.

WHY LOOK? The stars can tell you time, direction, and position. These are about their on practical use to an amateur. More important is the satisfaction one finds in recognizing th brightest stars and planets. To see and to recognize Leo in the eastern sky is akin to seein the first robin. And, as you learn more about the stars and the variety of other celesti objects, the more the wonder of the heavens grows.

WHERE TO LOOK Star-gazing has no geographic limits. Some stars can even be seen fro brightly lit, smoky city streets, but the less interference from lights or haze the better. A ideal location is an open field, hill, or housetop where the horizon is not obscured by trees buildings. However, buildings or a hill may also be used to screen off interfering lights, ar although you may see less of the sky this way, you will be able to see that part of it better.

WHEN TO LOOK Only the brighter stars and planets are visible in full moonlight or soo after sunset. At these times the beginner can spot them and learn the major constellation without being confused by myriads of fainter stars. On darker nights, without moonlight, or may observe minor constellations, fainter stars, nebulae, and planets. Stars and plane visible at any given hour depend on time of night and season of the year. As the earth rotate new stars come into view in the eastern sky as the evening progresses. Late at night one ca see stars not visible in the evening sky until several months later. The seasonal star char here, here, here, and here and planet tables show the location of major celestial objects various times of the year. See check list.



Sundial

HOW TO LOOK First, be comfortable. Looking at stars high above the horizon may cause stiff neck and an aching back; so use a reclining chair, a couch, or a blanket spread on th ground. Remember — ground and air may be unexpectedly cold at night; warm clothin even in summer, may be needed. How to look also involves a method of looking. The sectio on constellations here gives suggestions. Many observations require knowing a little abo angles in the sky; After you have become familiar with the more common star constellations, and planets, a systematic study may be in order — perhaps with field glasse By that time your interest may lead you to some of the activities suggested on the followi pages.

EQUIPMENT You need no equipment, except your eyes, to see thousands of stars. This boo will point the way to hours of interesting observation with your eyes alone. Later you wi find your enjoyment greatly enhanced by the use of field glasses (6- to 8-power) such as thos used in bird study. With these you can see vastly more — details on the moon, moons o Jupiter, many thousands of stars, star clusters, double stars, and nebulae. Larger field glass (12-, 15-, or 18-power mounted on a tripod) will reveal finer lunar details and more hundre of exciting stellar objects. Some day you may buy or make your own telescope.

ACTIVITIES FOR THE AMATEUR

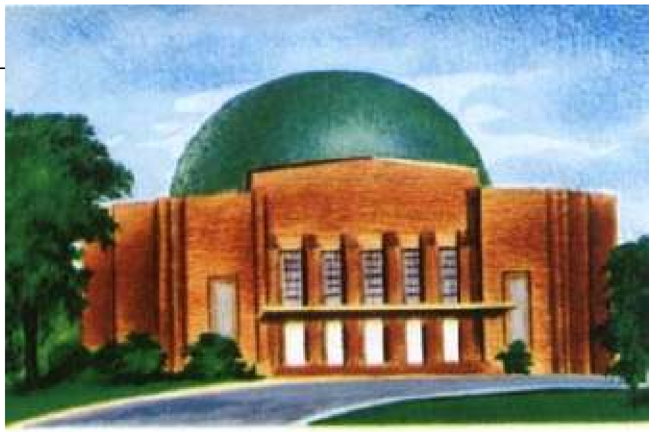
ENJOYING THE STARS It is worth repeating that night-by-night observing, studying, ar enjoying the stars is the activity that can mean the most to most people. No equipment ar little preparation are needed. This book and sources of information suggested will help.

Zeiss Projection Planetarium

IDENTIFICATION The enjoyment of stars involves some practice in identification. Knowir two dozen constellations and a dozen of the brightest stars is often enough. A systemat study of stars, the identification of lesser constellations, and the location and study of cluste and nebulae demand more intensive efforts. A serious amateur will benefit by knowir nearly all the constellations and bright stars before going deeper into any phase astronomy.

FOLLOWING THE PLANETS The planets, moving along in their orbits, are constant changing their positions. Even the beginner can become familiar with the movements planets — can recognize them, and predict which way they will travel. Knowing the planets as important and as enjoyable as knowing the stars.

MUSEUMS Many museums have astronomical exhibits worth seeing. These may incluc meteorites, photographs of stars and planets, and sometimes working models of the sola system. Museums may be found at universities, observatories, planetariums, or government institutions. Inquire locally or when traveling concerning museums in the area that may offe astronomical exhibits.



Hayden Planetarium

OBSERVATORIES These are the sites of the great optical and radio telescopes whe professional astronomers work. When work is going on, astronomers cannot be disturbe However, many observatories are open for tours at specified hours, and some offer schedule of public lectures. Some of the major places you can visit are listed here, and othe are given in references on here.

Kitt Peak National Observatory, Tucson, AZ

National Radio Astronomy Observatory, Greenbank, WV

Mt. Wilson Observatory, Los Angeles, CA

U.S. Naval Observatory, Washington, DC

Allegheny Observatory, Pittsburgh, PA

PLANETARIUMS These “indoor universes” offer the chance to see and learn the sky unde the instruction of experts. Sky shows also explain astronomical concepts. In addition hundreds of small planetariums in schools and smaller museums, among the maj planetariums are:

Hayden Planetarium, New York, NY

Adler Planetarium, Chicago, IL

Fels Planetarium, Philadelphia, PA

Griffith Planetarium, Los Angeles, CA

Fernbank Planetarium, Atlanta, GA

Charles Hayden Planetarium, Boston, MA

Morrison Planetarium, San Francisco, CA

Davis Planetarium, Baltimore, MD

Buhl Planetarium, Pittsburgh, PA

CLUBS AND ASSOCIATIONS Amateur astronomers often band together to share the experiences and interests. Clubs are found in most large cities and many smaller ones. meetings, a lecture or discussion is usually followed by a period of observing throu telescopes. Some clubs work on cooperative projects in which the members share som scientific investigation. Visitors are usually welcome, and membership is commonly open anyone who is interested.

Through such activities anyone from a youth in high school to a retired couple can becon serious amateurs. Such amateurs spend much of their time working on an astronomic hobby. They often become experts; some have made important discoveries. Profession astronomers are glad to have the help of trained amateurs, and several fields of astronomic research are manned largely by them. Amateur activities that demand greater skill ar experience offer greater rewards in the satisfaction they provide.

Grinding a Mirror

TELESCOPE MAKING Making a telescope requires time and patience. But in the end yo have an instrument costing only a small fraction of its worth, plus the fun of having made i The telescopes made by amateurs are usually of the reflecting type, with a concave mirro instead of a lens for gathering light. Telescope-making kits, including a roughly finished gla "blank" for the mirror, other telescope parts, and complete instructions, are available fro some optical-supply firms.

OBSERVING METEORS Meteors or shooting stars often occur in well-defined shower Careful observation and plotting of the paths of meteors yield information of scientific valu A number of groups of amateurs are engaged in observing meteors, and any intereste amateur or group of amateurs can join. Contact the American Meteor Society, Dept. Physics and Astronomy, State University, Geneseo, NY 14454.

Armillary Sphere Once Used to Demonstrate Celestial Motions

OBSERVING VARIABLE STARS Amateurs with telescopes have done unusual work in th advanced field. Studies of these stars are coordinated by the American Association of Variab

Star Observers, 187 Concord Ave., Cambridge, Massachusetts 02138. The director of th
Association will be glad to furnish qualified amateurs with details about this work.

STELLAR PHOTOGRAPHY Photographing the stars and other heavenly bodies is not difficul Excellent pictures have been taken with box cameras set firmly on a table. But pictures o faint objects must be taken with a telescope or with a special camera adjusted to compensa for earth's motion. Photography is an important tool of astronomers — one which th amateur can use to good advantage.

MORE INFORMATION This book is a primer to the sky and can only introduce a story whic is more fully told in many texts and popular books on astronomy.

BOOKS:

Abell, George O., *Exploration of the Universe*, 3rd ed., Holt, Rinehart, and Winston, New York, 1975. One of the best colle level textbooks.

Bok, Bart J. and Priscilla E., *The Milky Way*, 4th ed., Harvard University Press, Cambridge, 1974. An engaging introduction our own galaxy by two renowned experts.

Chartrand, Mark R., *Skyguide*, Golden Press, New York, 1982. This excellent introduction to the sky and to astronomy general bridges the gap between books such as this one and textbooks. It contains seasonal sky maps and detailed charts all the constellations.

Kirby-Smith, H.T., *U.S. Observatories: A Directory and Travel Guide*, Van Nostrand Reinhold, New York, 1976. Information visiting observatories and other astronomical sites.

Lum, Peter, *The Stars in Our Heavens*, Pantheon Books, New York, 1948. A delightful recounting of sky mythology fro around the world.

Mayall, Mayall, and Wyckoff, *The Sky Observer's Guide*, Golden Press, New York, 1965. An introductory book for the laym with maps of the heavens.

Norton, Arthur P., *Norton's Star Atlas*, Sky Publishing Corp., Cambridge, 1978. An excellent first sky atlas useful wi binoculars or a small telescope.

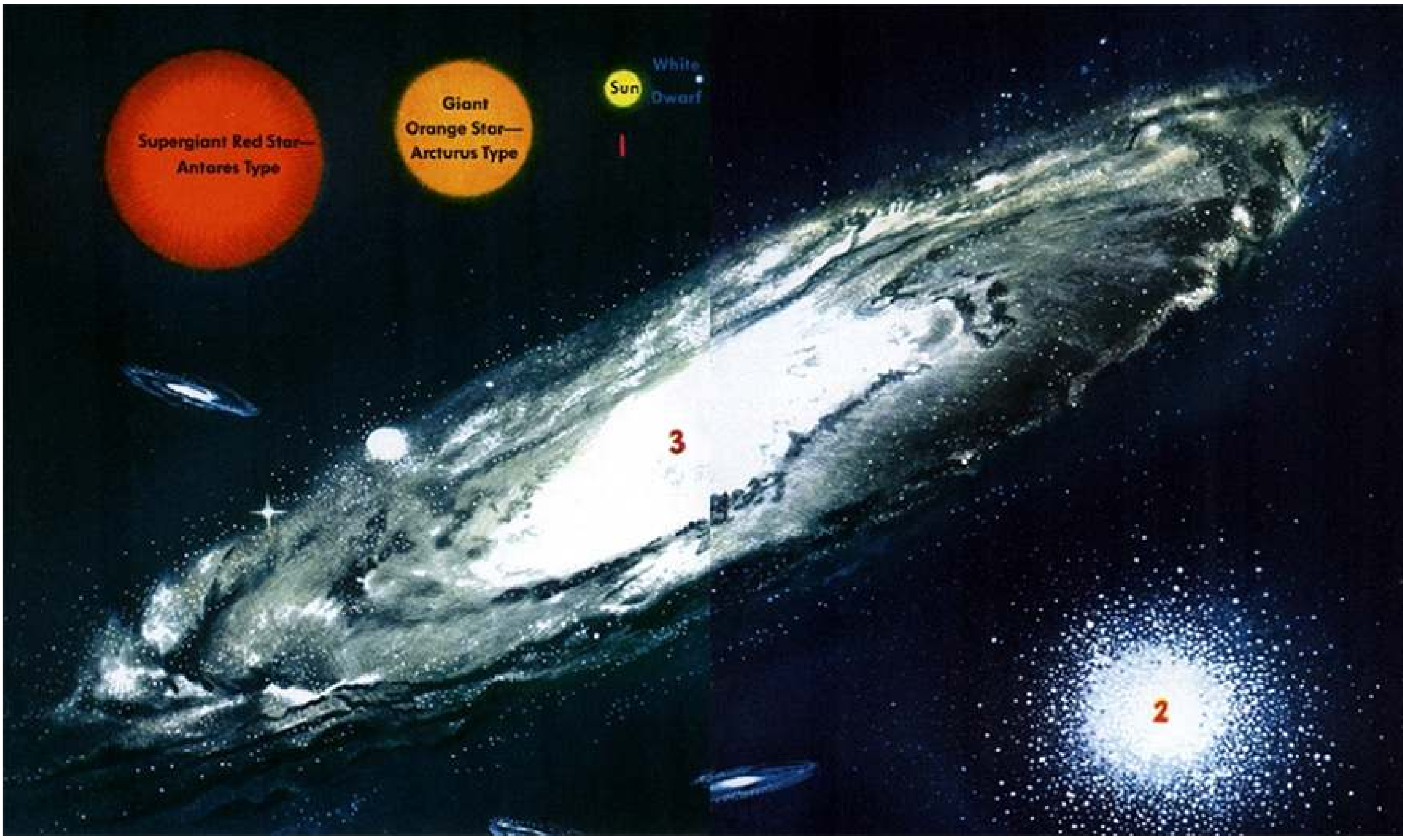
Shipman, Harry L., *Black Holes, Quasars, and the Universe*, 2nd ed., Houghton Mifflin Co., Boston, 1980. An exciti introduction to recent astronomical discoveries.

MAGAZINES:

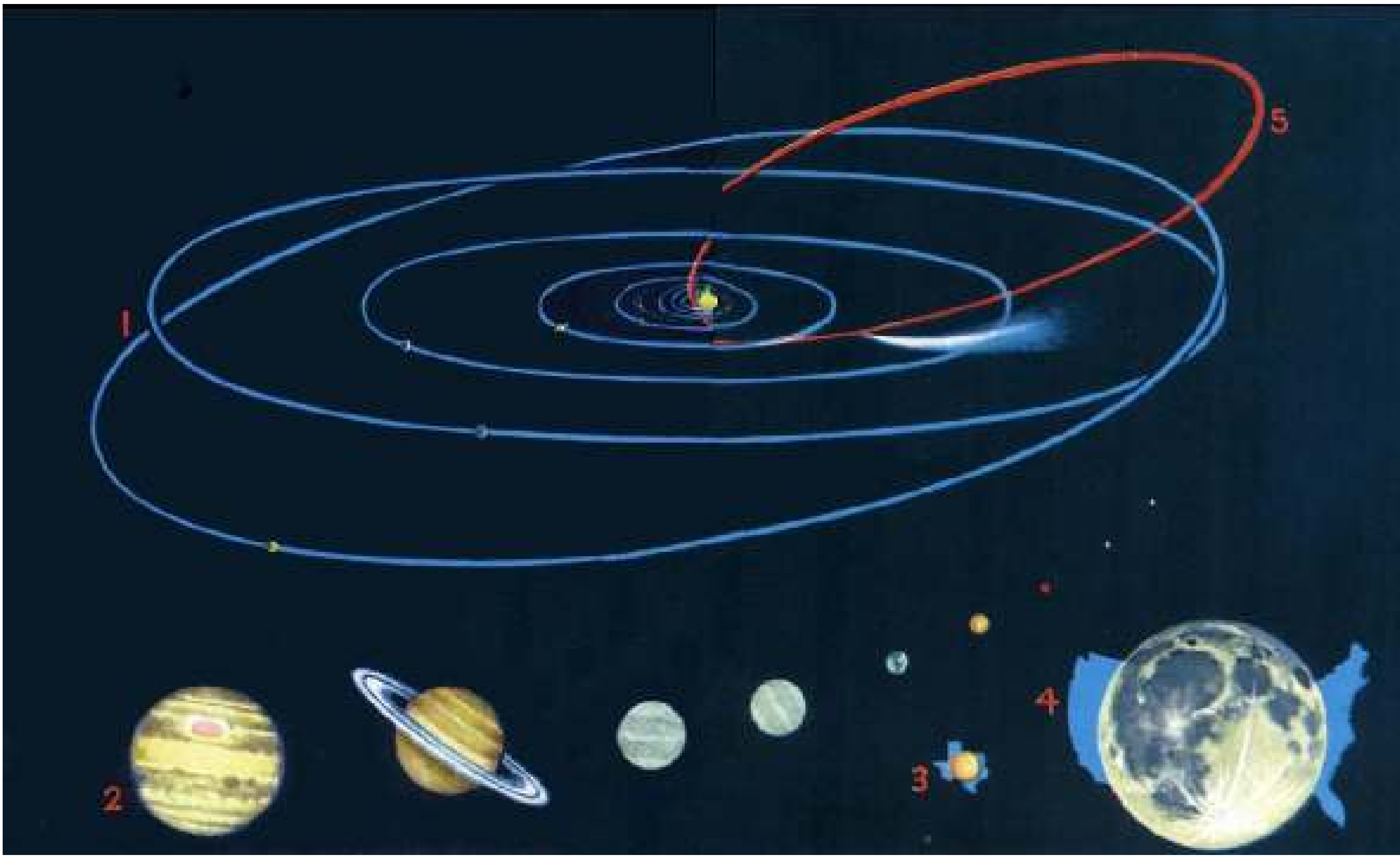
Astronomy, AstroMedia Corp., P.O. Box 92788, Milwaukee, Wl 53202.

Mercury, Astronomical Society of the Pacific, 1290 24th Ave., San Francisco, CA 94122.

Sky and Telescope, Sky Publishing Corp., 49 Bay State Rd., Cambridge, MA 02138.



OUR UNIVERSE is so vast that its limits are unknown. Through it are scattered millions o galaxies of various sizes and shapes. In a galaxy like one shown here (3), our sun and th earth are located here. Galaxies contain hundreds of millions, even hundreds of billions, o stars of many types (1), ranging from red supergiants less dense than the earth's atmosphe to white dwarfs hundreds of times denser than lead. Stars on the average are spaced sever light-years apart, but may be closer in some clusters (2). Planets may revolve around many o the stars.



OUR SOLAR SYSTEM is located halfway from the center of our galaxy — the Milky Wa Around the sun revolve the nine major planets with more than four dozen satellites; als hundreds of thousands of asteroids and swarms of meteors. Here we see the planets (1) their orbits around the sun (see here) and (2) in the order of their size. The asteroid Ceres compared (3) to Texas for size, and the moon is compared (4) to the United States. A comet orbit (5) appears in red. Our solar system may be only one of billions in the universe. So fa life is known to exist only on earth.


Solar Prominences Compared to Size of Earth

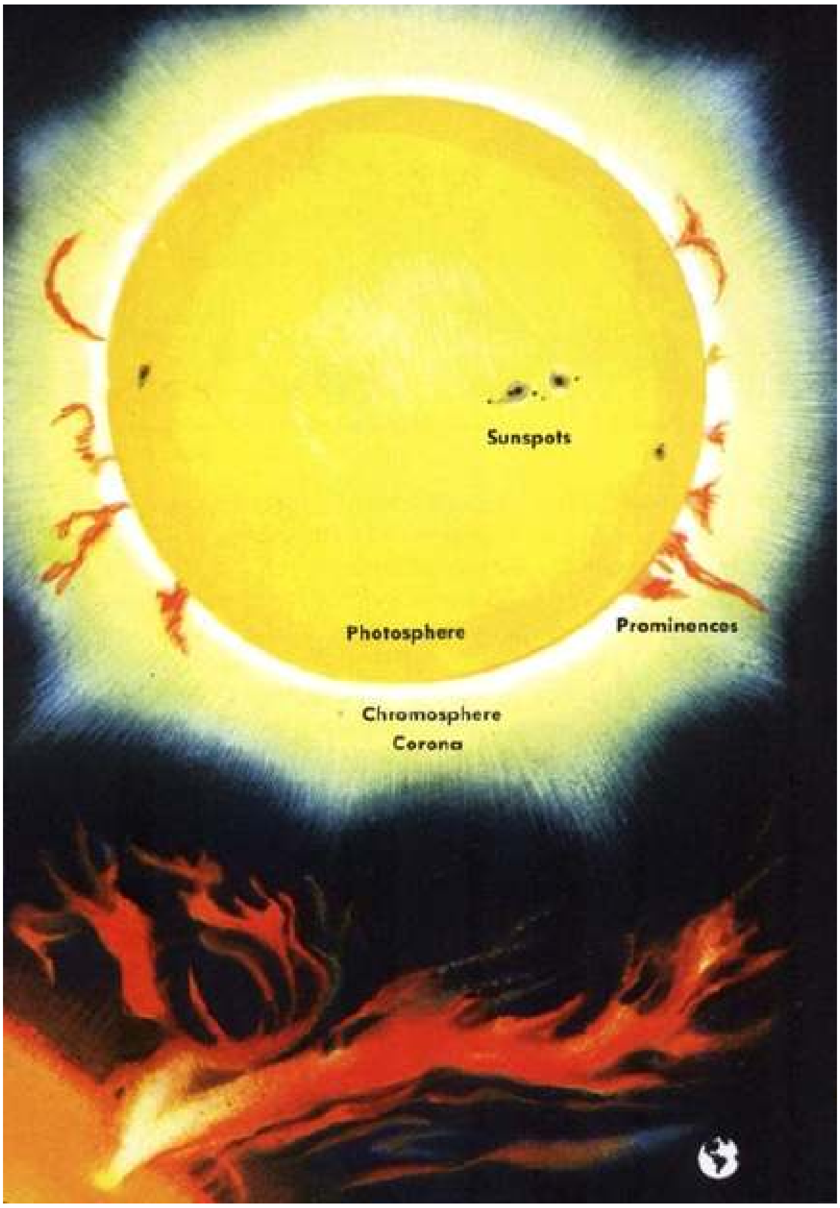
THE SUN is the nearest star. Compared to other stars it is of just average size; yet if it we hollow, over a million earths would easily fit inside. The sun's diameter is 860,000 miles.

rotates on its axis about once a month. The sun is gaseous; parts of the surface move different speeds. The sun's density is a little under 1½ times that of water.

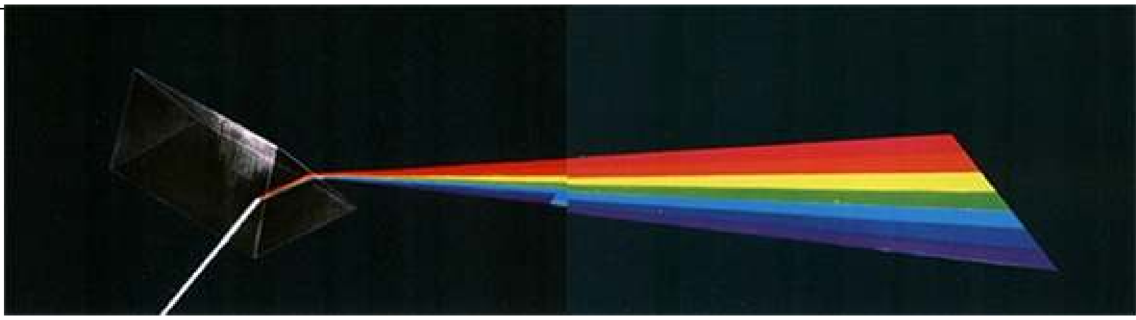
The sun is a mass of incandescent gas: its core is a gigantic nuclear furnace where hydroge is built into helium at a temperature of millions of degrees. Four million tons of the sun matter is changed into energy every second. This process has been going on for billions years, and will continue for billions more.

The sun's dazzling surface, the photosphere, is speckled with bright patches and with dar sunspots. Rising through and beyond the chromosphere, great prominences or streamers glowing gases shoot out or rain down. The corona, which is the outermost envelope of gase forms a filmy halo around the sun.

It is unsafe to observe the sun directly with the naked eye or binoculars. Use special filter, a dark glass, or a film negative to protect your eyes. When a telescope is use project the sun's image on a sheet of paper.

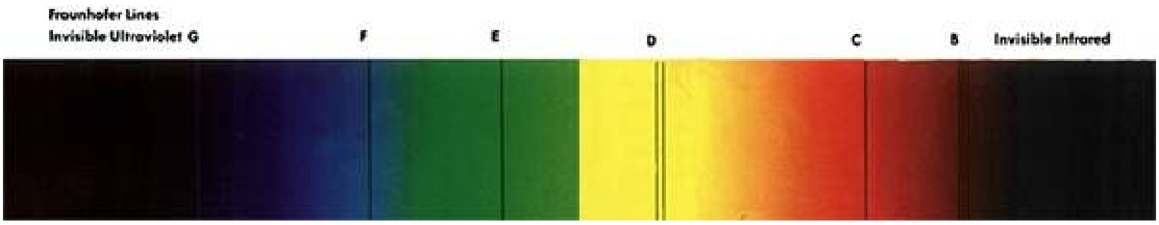


How a Prism Breaks Up a Beam of Sunlight into Its Component Colors



SUNLIGHT Every square yard of the sun's surface is constantly sending out energy equal t the power of 700 automobiles. About one two-billionth of this, in the form of sunligh reaches us. Sunlight is a mixture of colors. When it passes through a glass prism, some of th light is bent or refracted more than other portions. Light leaving the prism spreads out into continuous band of colors called a spectrum. Colors grade from red, which is bent leas through orange, yellow, green, and blue to violet, which is bent most.

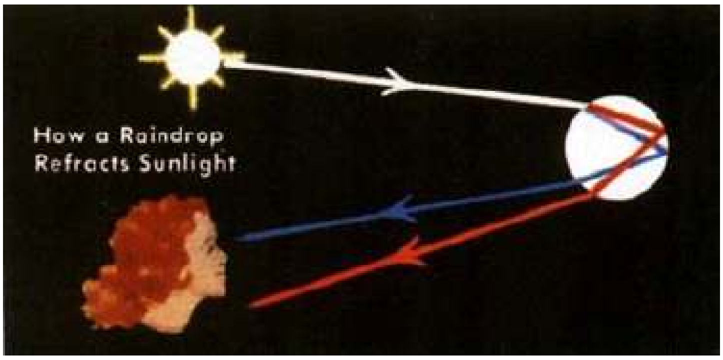
The spectrum is crossed by thousands of sharp dark lines. These indicate that some lig was absorbed as it passed through the cooler gases above the sun's surface. These gase absorb that part of the sunlight which they would produce if they were glowing at a hig enough temperature. Thus a study of the dark lines in the solar spectrum (called Fraunhofe lines, after their discoverer) gives a clue to the materials of which the sun is made. Of the 9 "natural" elements on the earth, ⅔ have been found on the sun. The rest are probably prese also. From the shifting of spectral lines, astronomers can measure the rotation of the sun an the motions of stars. They can detect magnetic fields from spectral lines and can determine star's temperature and its physical state. Although astronomers can only see the surface of star, they can calculate what it must be like deep inside.



A Rainbow Is a Spectrum

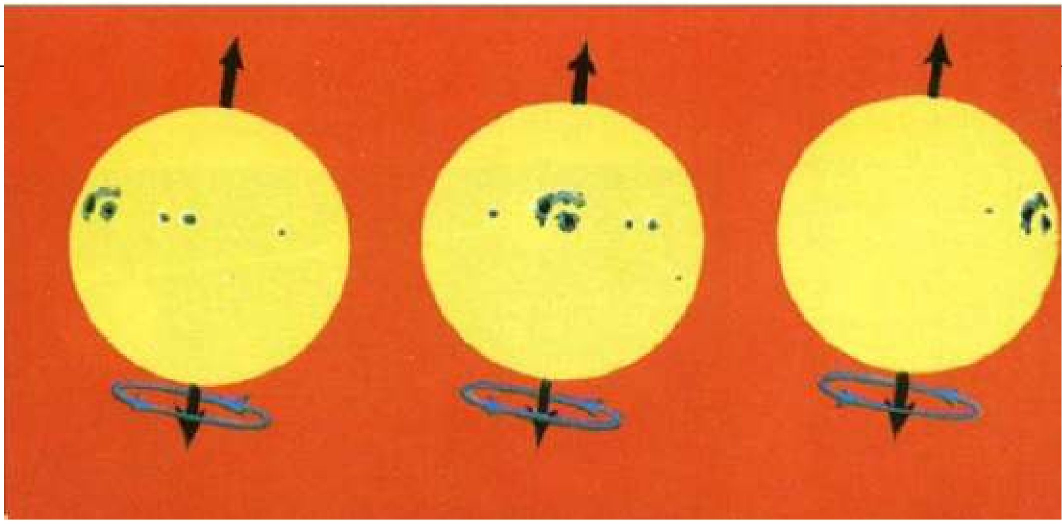
RAINBOWS are solar spectra formed as sunlight passes through drops of water. Rainbow may be seen when a hose is adjusted to a fine spray. The drops act like prisms, refractin sunlight to produce the spectrum.

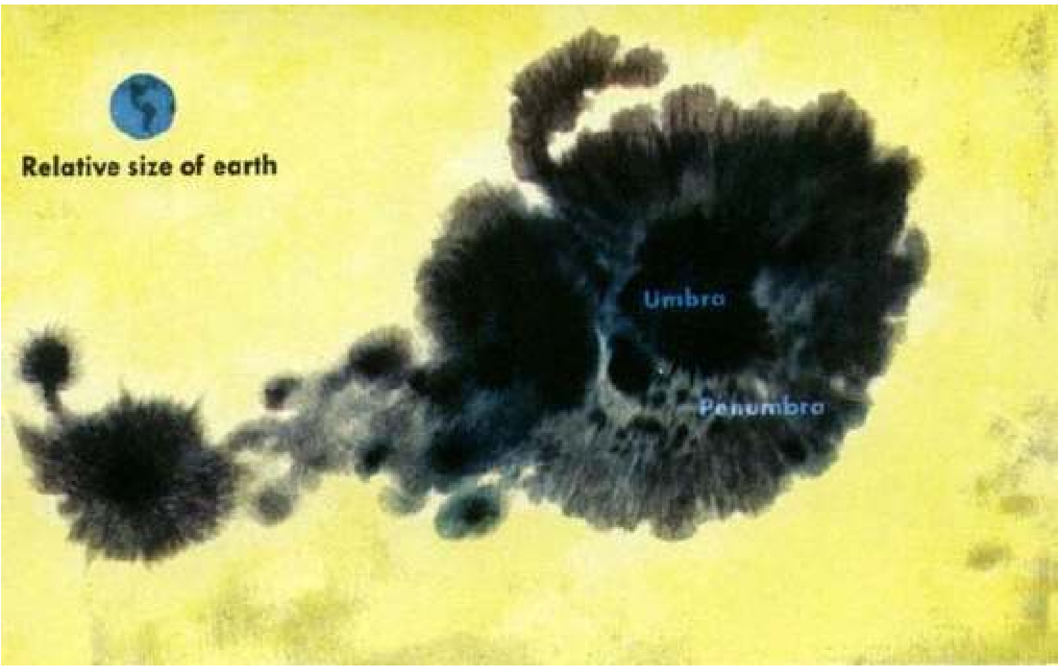
A single, or primary, rainbow has red on the outside, violet inside. The arc is 40 degrees radius. The center of the arc is always opposite the sun. When you see a bow, the sun behind you. Sometimes a secondary rainbow forms outside the primary. It is fainter, wi colors reversed — red inside, violet outside. The secondary bow forms from light reflecte twice within drops. Light may be reflected more than twice, so occasionally up to fiv rainbows are seen. Another type of bow — red, or red and green — may appear with primar and secondary bows.



SUNSPOTS often appear on the sun's photosphere — appearing as dark, sculptured "holes" contrast to the bright white surface. These sunspots are sometimes so large they can be see with the unaided eye (through a dark glass for protection, of course), and are most easi observed when the sun is low on the horizon. The use of field glasses or a small telescop helps, but the safest method of observation is to study photographs. The dark center, umbra, of a sunspot varies from a few hundred to over 50,000 miles across. This surrounded by a less dark area, a penumbra, that often doubles the size of the sunspot. As th sun rotates, new sunspots come into view. Most persist for a week or so, but the maximu duration is from three to four months.

The number of sunspots varies in cycles of about 11 years — first increasing steadily unt hundreds of groups are seen annually, then gradually decreasing to a minimum of about 5 groups. At the beginning of a cycle the sunspots appear about 30° north and south of the sun equator. As the cycle progresses, they develop closer to the equator and the zone of activi extends from 10 to 20 degrees on either side of it. The 11 -year cycle is really an averag value. Mysteriously waxing and waning, the exact length of the cycle can be as short as nin years or as long as sixteen. The 11-year cycle is part of a larger 22-year cycle in which th entire magnetic field of the sun may reverse itself.





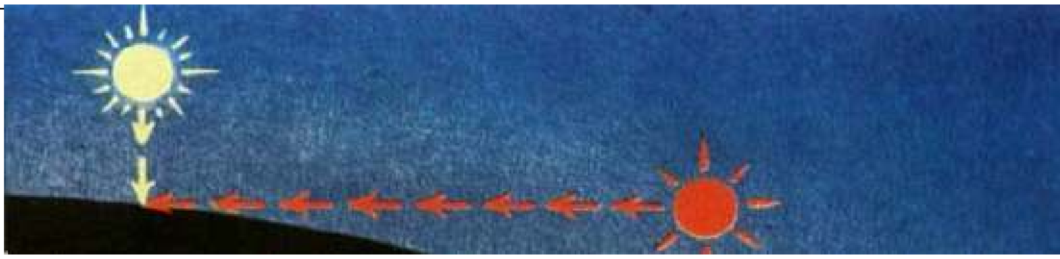
Sunspots seem to be giant magnetic storms on the sun’s surface, which may be caused b deeper, periodic changes. They occur in groups which grow rapidly and then slowly declin The gases in the sunspot (about 8,000°F) are cooler than the rest of the sun’s surface (abo 11,000°F); hence they appear darker. Actually, if a large sunspot could be isolated in anoth part of the sky, it would appear as bright as a hundred full moons. Sunspots have stron magnetic fields. Radiation from “solar flares” near them interacts with the upper levels of th earth’s atmosphere and interrupts shortwave radio transmission; it is also likely to cause a increase in auroras.

AURORAS OR NORTHERN LIGHTS The shifting, glowing, diffuse light of an aurora is har to describe. Yellow, pink, and green lights come and go; arcs of light start at the horizon an spread upward; streamers and rays extend toward the zenith. Auroras last for hours, an often all through the night. They are most often seen in the north and middle norther latitudes and in the arctic. A similar display is seen in the southern latitudes. Auroras occu from about 60 to 600 miles up in the air. At these heights, so little air remains that space almost empty like a vacuum, or the inside of a neon light. The shifting glow of the aurora essentially electrical and somewhat similar to the light from the neon signs along Main Stree

Atomic particles from the sun hitting the thin gases of the upper atmosphere is what caus auroras. The charged particles come from solar flares near sunspots. The fact that auroras ar most frequent near the earth's magnetic poles emphasizes their electrical character. A fe days after a large new sunspot group develops, an auroral display is likely to occur.

THE SKY FROM SUNRISE TO SUNSET As the sun's rays pass through the earth atmosphere, some are scattered, and a play of colors results. Blue rays are scattered mos and therefore a clear sky is typically blue. But just after sunrise and just before sunset the su is reddish. At these times the sharply slanting sun's rays must travel a longer path through th atmosphere, and more of the blue and yellow rays are scattered out of the rays reaching you eye. The red rays, which are scattered least, come through in the largest numbers, giving th sun its reddish hue. If there are clouds and dust in the air, many of the red rays which filt down into the lower atmosphere are reflected, and large areas of the sky may be reddened.

Sunlight Passes Through a Thicker Layer of Air at Sunrise and Sunset



Because of the bending or refraction of light, which is greater when the sun is near th horizon, you can actually see the sun for a few minutes before it rises and after it set Daylight is a bit longer for this reason. The closer to the horizon, the greater the refraction sunrise or sunset. Hence, as refraction elevates the sun's disc, the lower edge is raised mor than the upper. This distorts the sun, just as it is rising or setting, giving it an oval or melo shaped appearance.

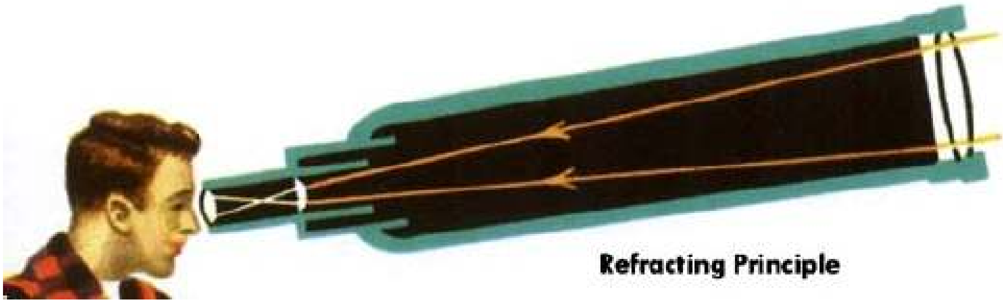
Twilight is sunlight diffused by the air onto a region of the earth's surface where the su has already set or has not risen. Astronomical twilight is defined as the period between suns or sunrise and the time when the sun is 18 degrees below the horizon — that is, a little ove an hour.

THE TELESCOPE was first put to practical use by Galileo in 1609. Since then, it has extende man's horizons farther and has challenged his thinking more than any other scientific devic The telescope used by Galileo, the best-known kind, is the refracting telescope, consisting of series of lenses in a tube. In a simple refractor, two lenses are used, but commonly others a added to correct for the bending of light that produces a colored halo around the image. Th largest refracting telescopes are one with a 40-inch lens at the Yerkes Observatory Wisconsin, and a 36-inch one at Lick Observatory in California.

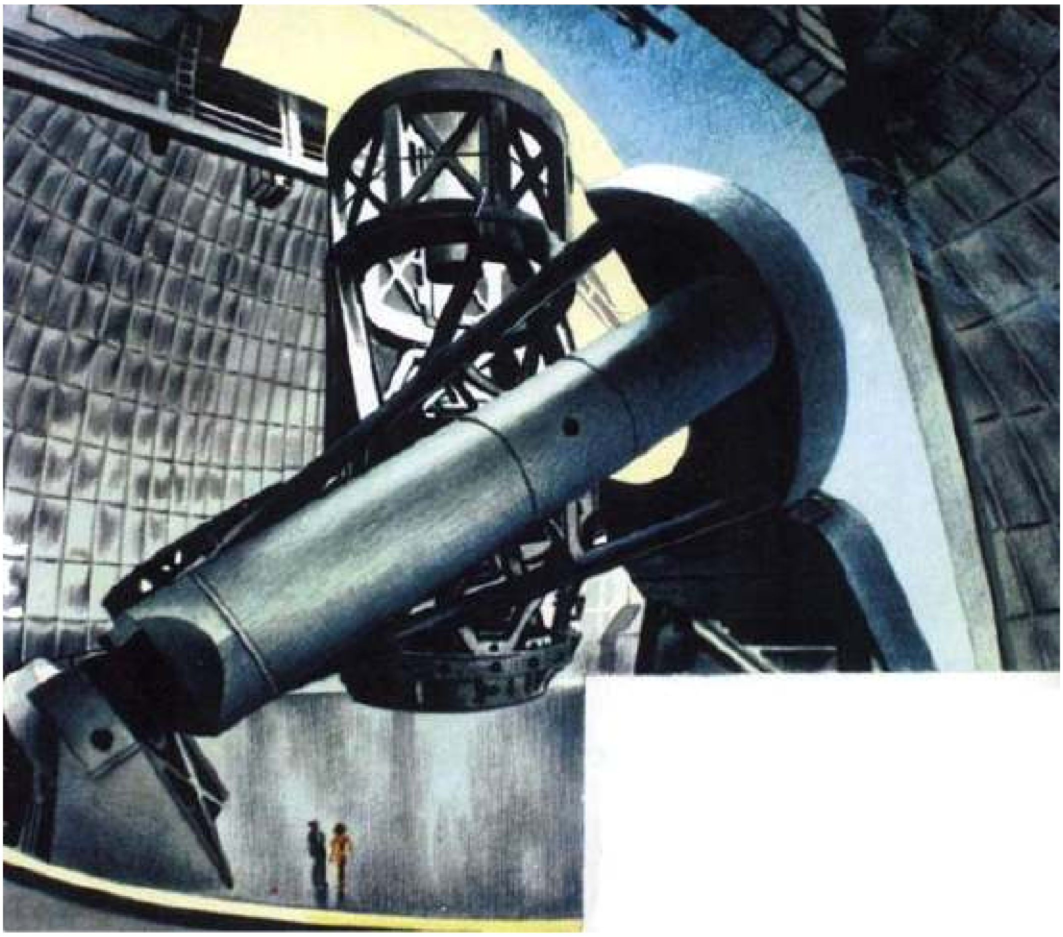
40-Inch Refractor, Yerkes Observatory

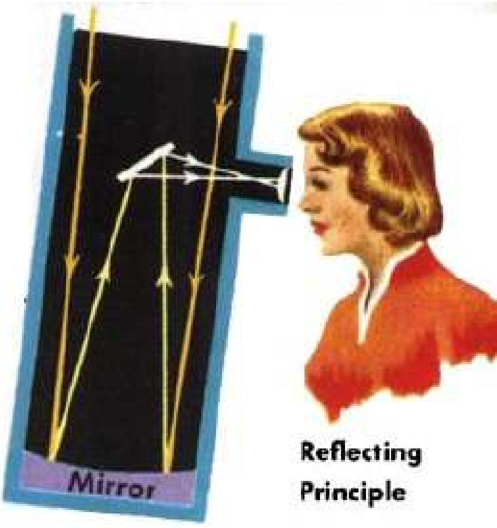
The simple reflecting telescope has a curved mirror at the bottom of the tube. This reflec

the light in converging rays to a prism or diagonally placed mirror, which sends the light t
the eyepiece or to a camera mounted at the side of the tube. Since mirrors can be made larg
than lenses, the largest astronomical telescopes are reflectors. Reflectors with mirrors up to
inches in diameter are made by amateurs as the best simple, low-cost telescope. Mar
astronomical bodies emit invisible radio, infrared, ultraviolet, X-ray, and gamma radiation, a
well as visible light; each kind of radiation gives important information to astronomers abo
the physical state of the source. New types of telescopes, some of them in orbit around th
earth, are used to observe these parts of the spectrum.



200-Inch Reflector, Palomar Mountain, Calif.





THE LARGEST TELESCOPE of the reflector type in the United States is on Paloma Mountain, near San Diego, Calif. Its 200-inch (16.6-foot) mirror is a marvel of scientific ar engineering skill. The great disc of pyrex glass was cast with supporting ribs to bear i weight. It is 27 inches thick and weighs 14½ tons. Yet because of its design, every part within two inches of the air — permitting the mirror to expand and contract uniformly wi changes in temperature. The great piece of glass has been polished to within a few millionth of an inch of its calculated curve. Despite its great weight it can be tilted and turned precise without sagging as much as the thickness of a hair. The mirror gathers about 640,000 times a much light as the human eye. With it, astronomers photograph stars six million times fainte than the faintest stars you can see, and galaxies over two billion light-years away.

STARS

Stars are suns: heavenly bodies shining by their own light and generally so far away from u that, though moving rapidly, they seem fixed in their positions. All are composed of at lea 99 percent hydrogen and helium.

NUMBERS OF STARS On the clearest night you are not likely to see more than 2,000 star With changing seasons, new stars appear, bringing the total visible during the year to abo 6,000. A telescope reveals multitudes more. The total in our galaxy runs into billions, b even so, space is almost empty. Were the sun the size of the dot over an "i," the nearest st would be a dot 10 miles away, and other stars would be microscopic to dime-size do hundreds and thousands of miles distant.

DISTANCES OF STARS The nearest star, our sun, is a mere 93 million miles away. The ne nearest star is 26 million million miles — nearly 300,000 times farther than the sun. F these great distances, miles are not a good measure. Instead, the light-year is often used. Th is the distance that light travels in one year, moving at 186,000 miles per second: nearly million million miles. On this scale the nearest star (excluding the sun) is 4.3 light-yea away. Sirius, the brightest star, is 8.8 light-years off. Other stars are hundreds, thousands, ar even millions of light-years away.

STARLIGHT All stars shine by their own light. This light is produced by nuclear reaction similar to those of the hydrogen bomb occurring at the centers of stars. When the eleme hydrogen is transformed into helium, which happens in most stars, about 1 percent of i mass (weight) is changed into energy. This energy keeps the temperature in the star's interi at millions of degrees. At the surface the temperature varies from about 5,500 degrees F. t over 55,000 degrees, depending on the kind of star. One pound of hydrogen changing t helium liberates energy equal to about 10,000 tons of coal. In a single star the energ released in this way requires the transformation of millions of tons of matter per second.