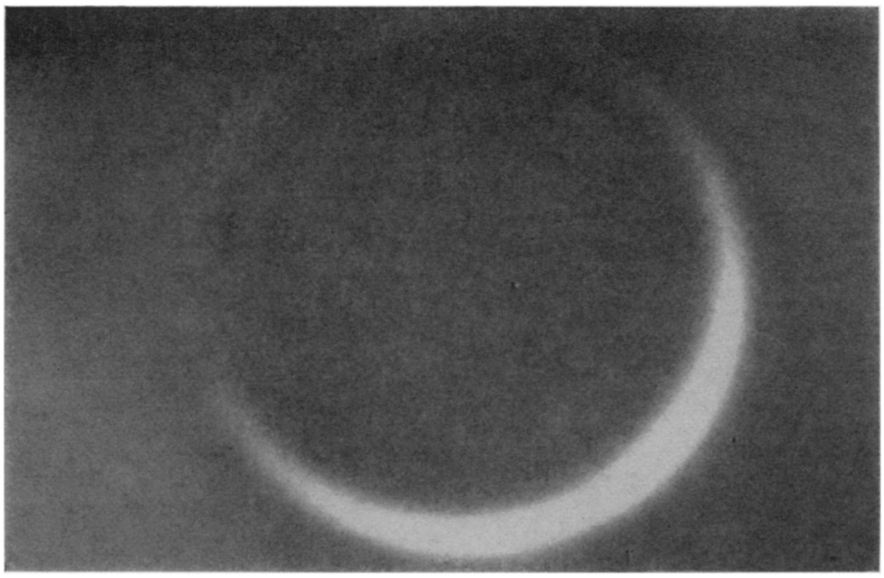

Lowell Observatory

Ring of light photographed around Venus in 1938—is it dust or water or—?

PLANETARY ASTRONOMY

Earth's Secretive Sister

Scientists ought to know more about Venus than any other planet—instead, it's a bright mystery.

by Jonathan Eberhart

The Russians and the Americans are shooting at a common target, yet neither can see it and at least one shooter hopes to miss it completely.

The Soviet projectile is Venus 4, a space probe that beat the U.S. Mariner 5 into space by two days in the middle of last month. Both spacecraft are bound for earth's mysterious sister planet Venus, both should arrive some time in October, and both represent attempts to settle one of the biggest planetary controversies ever waged.

The Russian probe is so much larger than Mariner—it weighs more than 2,400 pounds compared to Mariner's 540—that it may even be two spacecraft in one, with a secondary capsule to land on the planet's surface while the parent vehicle flies by. Mariner 5 carries instruments to measure Venus' magnetic field, to pierce its atmosphere with radio waves, to hunt for hydrogen and oxygen in its upper atmosphere and to examine the space around it for radiation, charged particles and the solar wind. Yet all this information will be but a drop in the virtually empty bucket of information on earth's nearest neighbor outside the moon.

Cloaked in a seemingly impenetrable blanket of clouds—and recently doubt has been cast even on that—Venus has intrigued and defied astronomers for centuries. The first photographs of the planet that showed even any shading were taken in 1911, and Venus has yet to be revealed as anything more distinct than a smudge.

The noted British astronomer Patrick Moore spent 30 years studying vague visible shadings on Venus, looking for a clue to the hidden planet's period of rotation, but in vain. Fairly accurate estimates, however, have been made by other methods.

Until 1964, the best guess at the rotation period was about 266 earth days, but that estimate, made by scientists at California's Jet Propulsion Laboratory, was accurate only to within four weeks either way. Then the huge radio telescope at Arecibo, Puerto Rico, was used to bounce radio waves off the planet's surface; Cornell researchers measured the Doppler shift of the returning waves to pin down the period at 253 days, plus or minus five days. The direction of the shift also confirmed the suspicion that Venus rotates in the opposite direction from the earth and all the other planets in the solar system except Uranus. A year later, radar measurements refined the number to 247 days, give or take five.

In 1966 it was suggested that earth itself played a hand in Venus' rotation. Drs. Peter Goldreich and Stanton J. Peale of the University of California said that earth's gravity was enough to cause the same side of Venus to be facing the earth every time the two planets were lined up with the sun. If that were true, the rotation period of the planet would be 243.16 days. Only two months later, measurements at JPL confirmed the time, trimming off a half-day to compensate for an electronic error in the equipment, leaving a final estimate of 242 days 14 hours and 24 minutes.

Few if any other Venusian details have been settled upon with such accuracy, however. One summary of Venus research, prepared for the National Aeronautics and Space Administration, observes with considerable understatement that there is "uncertainty" about the abundance of carbon dioxide in the planet's atmosphere: recent estimates range from four to 90 percent. The atmosphere of the planet, in fact, is its most discussed feature, since it has much to do with most of Venus' other characteristics—temperatures, winds, surface features, even the possiblility of life.

Venus is indeed a near twin to earth, and the similarities of the planets themselves are largely responsible for the similarities, however disputed, of their atmospheres: Venus' density is about .934 times that of earth, its diameter .956 times that of earth, and the speed required to escape from its gravity .913 times that of earth. As a result, Venus is much more able than, say, Mars, which is smaller and has about a third of earth's gravity, to retain an atmosphere with gases as light as those on earth.

This does not mean that our sister planet's atmosphere is the same as earth's, however. The air we breathe is about four-fifths nitrogen, with oxygen comprising almost all of the remainder; hydrogen, carbon dioxide and miscellaneous other gases make up the rest. An estimate of Venus' atmosphere is difficult with so many conflicting studies, but the NASA summary makes a reasonable attempt: the major constituent is again nitrogen, perhaps 63 percent; the next 31.5 percent is neon, based on the relative abundances of gases in the sun, minus the helium and hydrogen which would have escaped from the planet's weaker gravity; for carbon dioxide the report allows about 5 percent; with water, oxygen and all the other gases and vapors making up the remaining half percent.

Water is a sore point with Venus researchers. As a key factor in the life-or-not controversy, it has scientists lined up in opposing camps. Typical of one side is Dr. John Strong, director of Johns Hopkins University's Astrophysics and Physical Meteorology Laboratory in Baltimore, Md., who in 1964 sent a spectrometer up 17 miles in a balloon to study the light reflected from Venus' clouds. His finding,

which he declared accurate to within five percent because the balloon had been above "all but an insignificant amount" of the moisture in earth's atmosphere, was that there are "vast amounts" of water vapor in the Venusian sky. In fact, he said, "the clouds we see around Venus might very well be composed of water, not dust as many astronomers believe."

At the head of the opposition is Dr. Gerard P. Kuiper of the University of Arizona's Lunar and Planetary Laboratory. He says that the planet is "almost completely devoid of water," and furthermore that its clouds probably are dust. However, Dr. Kuiper's measurements, made recently from an aircraft flying over Canada, were taken from only about seven miles up, which one of Dr. Strong's colleagues believes is not high enough to eliminate the effects of earthly moisture. Dr. Kuiper stands behind his data. In order to prevent just such a problem, he took identical measurements of earth's waterless moon; when the lunar readings showed traces of vapor, presumably due to moisture in the fringes of earth's atmosphere that were still above the airplane, he subtracted the same earth-caused proportion from the Venusian measurements. Venus, he concluded, has less than four ten-millionths of the percentage of water in earth's atmosphere, and a correspondingly low possibility of life as we know it.

The other main index to the chances of life on Venus is the planet's temperature. Estimates had ranged down to minus 40 degrees F. until 1962, when the Mariner 2 spacecraft flew within 21,600 miles of the planet and indicated that the temperature was high enough to melt lead—800 degrees.

This great heat was considerably more than could have been predicted solely on the basis of the planet's closeness to the sun. Two other explanations have been suggested, either or both of which seem feasible. The most likely is the "greenhouse effect," in which the short wavelengths of the sun's ultraviolet radiation pass easily through the planet's dense clouds, but cannot get out again as long-wavelength heat waves radiating from the ground. The other possibility is that the high temperature is maintained from within the cloud blanket by heat from volcanic "vents" in the surface. "Apparently," says Dr. Kuiper, "the surface hot spots work like chimneys, drive the air upward and establish vertical circulation in the atmosphere."

One of the few things that the scientists seem to agree on is that the atmospheric pressure at the planet's surface is greater than it is on earth. But there the agreement ends. Dr. Kuiper thinks it is about three times as great. Last year two scientists from Columbia University Radiation Laboratory joined a NASA colleague in estimating that the pressure could be as much as 300 earth atmospheres. This is some 4,410 pounds per square inch, equivalent to the pressure almost two miles down in the ocean, well below the maximum depth reachable by all but the strongest research submarines.

The surface features of the planet are almost unknown, except from a few vague radar and polarization studies. Indications are that Venus is smoother than the moon, but rougher than Mars. Among the common materials are likely to be such things as fused quartz and a wide range of powdered oxides, carbonates and silicates. If the temperature is indeed as high as it is believed to be, there may even be lake-sized pools of molten tin, lead, aluminum, magnesium and other metals.

"It is indeed an understatement," says Dr. Donald Menzel, former director of Harvard College Observatory, speaking of the thorny state of Venus research, "to say that the disagreement among various workers is fundamental and widespread."

The Venus Log

U.S.S.R.		
Venus 1	2/12/61	passed within 60,000 miles with radios dead
unannounced	8/25/62	never got out of earth orbit, aloft 3 days
unannounced	9/1/62	earth orbit 5 days
unannounced	9/12/62	earth orbit 2 days
Zond 1	4/2/64	in heliocentric orbit, sent no planetary data
Venus 2	11/12/65	in heliocentric orbit, sent no planetary data
Venus 3	11/16/65	crashed on Venus 3/1/66, no data
Cosmos 96	11/23/65	earth orbit 16 days
Venus 4	6/12/67	should arrive in October
U.S.		
Mariner 1	7/22/62	destroyed by range safety officer at launch
Mariner 2	8/26/62	passed within 21,594 miles, returned data
Mariner 5	6/14/67	should arrive Oct. 19