The Night Skies of Venus: Another Kind of Aurora?

Venus wasn't thought to have what it takes to possess an aurora — and the fact that there may be one anyway poses a midnight mystery

By JONATHAN EBERHART

The spectacular auroras of earth, such as the aurora borealis or "northern lights," have counterparts in similar phenomena at Jupiter, Saturn and Uranus. All are worlds with substantial atmospheres, as well as magnetic fields that guide in energetic particles from outside those atmospheres to help produce the characteristic, glowing emissions. An aurora is a complex effect, but it has been generally assumed that the key properties necessary for auroras to appear are an adequate atmosphere and a proper magnetic field.

Venus, for example, has plenty of atmosphere — its pressure at the planet's surface is about 90 times earth's. However, it has little or no "intrinsic" magnetic field that is born of dynamo-like internal processes as opposed to the type that is merely induced around it by the passage of the solar wind. Many scientists have thus felt that auroras would be one phenomenon missing from the otherwise exotic world.

Yet a Venus aurora seems to exist.

It has even been seen, and often, in "images" produced from ultraviolet emissions recorded by a spectrometer (UVS) aboard the U.S. Pioneer Venus Orbiter spacecraft (PVO). The signs were first noticed in 1982 by Larry Paxton, now a scientist with the Naval Research Laboratory in Washington but who was then a graduate student working for UVS principal investigator Ian Stewart at the University of Colorado in Boulder.

What he saw was "a few puzzling patches of brightness" on a UVS image of the night side of Venus, made at a 1,304-angstrom wavelength whose emissions are attributed to a particular energy transition (the ^3P-^3S permitted resonance triplet) of atomic oxygen. Bright and widespread on the planet's day side, such emissions were expected to be so rare on the night side that Paxton initially wondered if there might be something wrong with the image. A glance showed similar features on other images, so he next looked to see if there was perhaps a mistake in the "mapping algorithm" that had been used to make "pictures" out of the spacecraft's data. There was such an error, it turned out, but correcting it just made the patches brighter.

Other evidence, such as the ratio of the 1,304-angstrom brightness to that of another oxygen emission at 1,356 angstroms, indicated not only that the patches were real, but that they seemed to represent signs of an aurora. This presumably meant that they were associated with particles arriving from outside the atmosphere and then transported down into it, yet the lack of an intrinsic magnetic field to send them there made the idea of a Venus aurora a loaded one. Still, confronted with the evidence, says Paxton, "we made a conscious decision to use the word [aurora]."

That was more than four years ago, but only recently was a description of the observations published in a scientific journal (the October GEOPHYSICAL RESEARCH LETTERS), together with some of the images. The black-and-white images in the journal (as well as the false-color ones in this article and on our cover) were produced by John L. Phillips of UCLA, who prepared the paper together with Stewart and UCLA colleague Janet G. Luhmann.

The press of other business contributed in part to the delay, acknowledges Phillips, but the key mystery remains: How does this improbably bright "aurora" (if it indeed is) exist at all, sometimes covering almost the whole of the planet's night hemisphere? On earth, auroras occur in a pole-circling belt or arc, formed where magnetic field lines carry energetic particles down far enough to enter the atmosphere and visible in images from earth-orbiting satellites (SN:1/2/82, p.6).

On Venus, there is no such ordered pattern. The bright crescent in each image is part of the sunlit hemisphere, where the 1,304-angstrom brightness is produced by "resonant scattering" — the absorption and re-emission of sunlight by atomic oxygen. But, says Phillips, "the nature of this scattering is such that it declines in importance very rapidly once you look nightward of the terminator plane," or day-night boundary. The brightness should decline regularly from dawn and dusk in toward midnight, yet "this is not the case. It is quite common to see bright patches near midnight, surrounded by darker regions." In short, according to Phillips, "it is really impossible for significant emissions of this type to occur near local midnight."

Another possibility might be the combining of electrons with positive oxygen ions from the ionosphere (in the outermost atmosphere) to produce neutral oxygen atoms plus photons of 1,304-angstrom emission. But the speeds of those reactions are known to be very slow, Phillips says, and combined with the low density of Venus's night-side ionosphere (measured by PVO) they appear capable of producing emissions less than 1 percent as bright (1 rayleigh) as those often observed.

A third candidate is "nightglow" — emissions due to the release of chemical energy stored up during the daytime. The problem here, says Phillips, is that "the feasible reactions at Venus all produce light at longer wavelengths (lower energies) than 1,304-angtroms." Adds Jane Fox of the State University of New York at Stonybrook, "all the known mechanisms" to explain the matter away this way are "far too weak." In other words, says Fox, who is working on the theoretical aspects of the problem, "No way."

Then there is the notion of accelerating oxygen and hydrogen from the outermost reaches of the atmosphere, or exosphere, downward into the nightside by means of magnetic and electric fields from the solar wind. "At one point, we considered this to be a likely candidate," Phillips notes. However, after analysis of the trajectories of such particles, the researchers concluded not only that it is difficult to get them to precipitate downward in the first place, but that "even under the most favorable circumstances, [they] could create only a few rayleighs of 1,304-angtrom emissions."

This leaves two possibilities, both of which, according to Phillips, are still under consideration as contenders for the source of the mysterious midnight emissions. One is the entry into the atmosphere of particles that have been accelerated by forces unrelated to Venus, such as shock waves in the solar wind. "The impetus for our consideration of this source," Phillips says, "came from our observation that the brightest emissions all occur during times of high solar activity — flares and shocks." Unfortunately, evaluating this mechanism *poses* a particularly difficult problem, since the various

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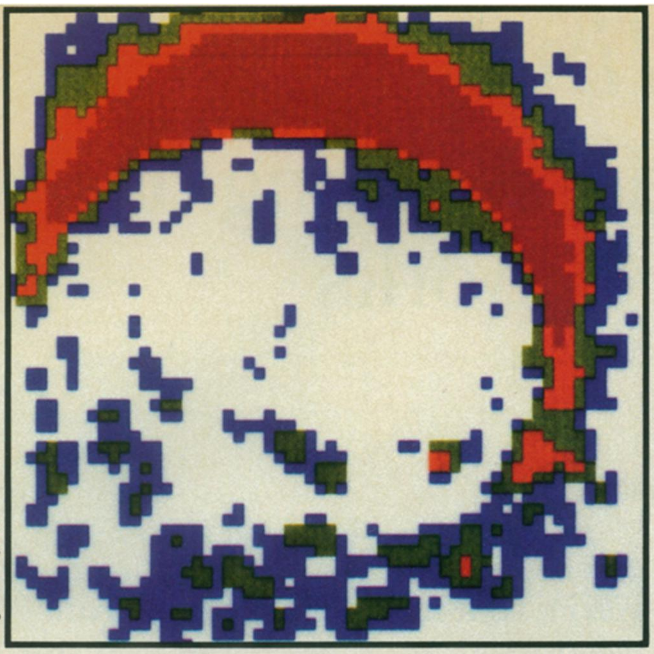
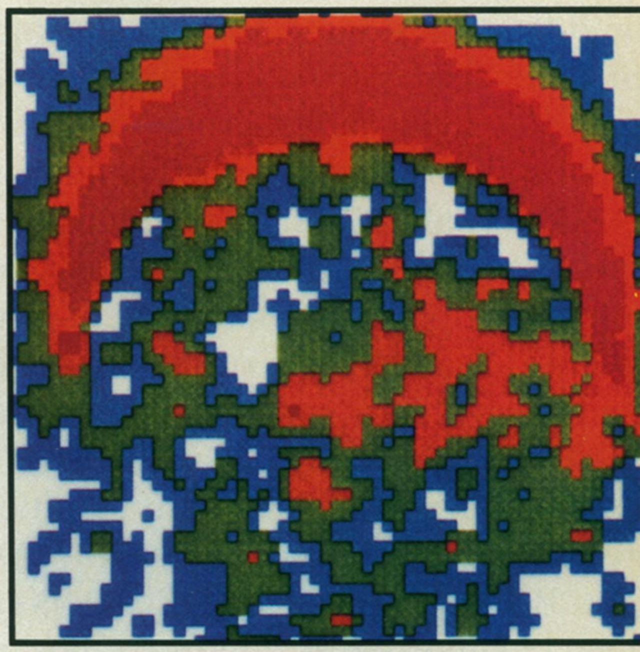
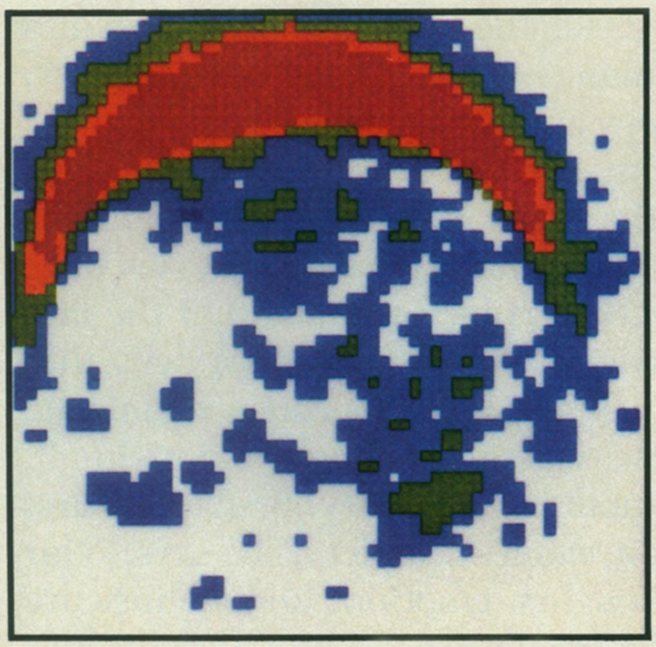
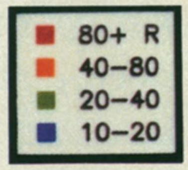


Images: Phillips et al.

The "aurora" of Venus is shown in these false-color images produced from brightness measurements recorded at a wavelength of 1,304 angstroms by the ultraviolet spectrometer of the Pioneer Venus Orbiter spacecraft. The bright crescent in each image is part of the day side, but scientists were surprised to discover that the night side is never completely dark either, its brightness varying in patches from the instrument's background level (about 4 rayleighs) to 100 rayleighs and sometimes more. The brightness asymmetry between each image's near-dawn and near-dusk edge suggests that particles triggering the aurora are associated with the sun, but the weakness (or absence) of Venus's intrinsic magnetic field has had the researchers struggling for four years to determine how the particles get low enough into the night-side atmosphere to generate the emissions. These images (and the one on the cover) are from measurements recorded in June of 1982.







"reaction cross-sections" are only poorly determined.

The other idea has to do with electrons, whose travels into the lower atmosphere have been detected both by PVO and by Soviet Venera spacecraft. This is a focus of Fox's theoretical study, involving comparison of emissions at several wavelengths. Phillips calls it "the most likely candidate so far," as does William Knudsen of Knudsen Geophysical Research in Monte Sereno, Calif., in charge of the PVO instrument that measures the electron fluxes. Or, there could be multiple factors, such as a combination of the electrons with the solar-wind shocks. More research remains, however, and a number of scientists such as Fox would love to have an updated spacecraft that would simply return to Venus for a better look. (PVO, though still at work, reached the planet in late 1978.)

A fascinating sidelight, for example, is whether the invisible ultraviolet emissions being studied by the PVO team are accompanied in the Venus "aurora" by anything that can actually be *seen.* Some earthbound astronomers have mentioned a pale "ashen light" on the planet's night side, for example, but any connection at this point, notes UCLA's Luhmann, is "anybody's guess." Would a human explorer standing on the surface of — or flying past — Venus be able to *see* anything of one of the solar system's most unusual light shows? Says Fox, "Good question."

But what she is really wondering is, would the answer be a clue to what makes the bizarre thing tick? □