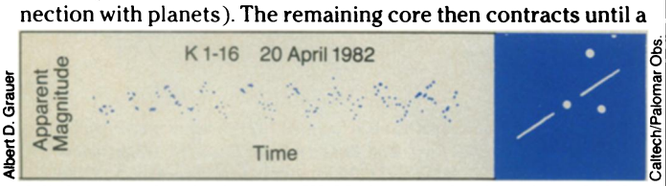
SCIENCE NEWS of the week

Tracking Down Hot Stars and a Cold Sea

Astronomy has four hot, newly discovered stars that may represent a missing step in the stellar evolutionary path traveled by stars like our own sun. Surface temperatures estimated to be in excess of 100,000K (perhaps 20 times hotter than the sun), gravities about 10,000 times earth's, similar light spectra and pulsations in brightness characterize this new breed. It is hoped that this new class of stars will give astronomers the unique opportunity to actually witness, over a period of just a few years, changes in individual stars linked to a million-year stellar evolutionary phase.

Since high temperatures cause stars to emit more blue and violet light than red, it is not surprising, in retrospect, that the first of these stars to be discovered, PG1159-035 (the numbers denote the galactic longitude and latitude of the star), turned up in Richard F. Green's ultraviolet-excess sky search at Palomar Observatory in 1974. But it was in 1979—after PG1159 was subjected to spectral analysis to measure the intensity of light emitted at individual wavelengths, and photometric studies to look for variations in its light output over time—that the star's peculiar nature became apparent. This prompted searches for similar stars, and researchers told SCIENCE NEWS this week that observations of three other hot stars have defined a new class, believed to be in a transitory, unstable stage of stellar evolution.

Stars with masses similar to that of the sun spend most of their lives burning hydrogen fuel, hanging in a balance between an outward thermal pressure created by internal nuclear reactions and an inward gravitational pressure. When the fuel is nearly exhausted, the aging stars are believed to eject some of their matter by gently blowing a stellar smoke ring called a planetary nebula (a historical misnomer—the halo of matter has no connection with planets). The remaining core then contracts until a



Albert D. Grauer

Caltech/Palomar Obs.

A light curve for the hot star K1-16 shows pulsations in its brightness(l); photograph of K1-16, shown bracketed by dashes (r).

new outward pressure, generated by the quantum-mechanical dislike of electrons for close-packing, balances the gravitational pressure. The resulting white dwarf then leaks energy into space and dies a slow, cold death.

The hot, blue PG1159-like stars represent the poorly understood contracting step in the late evolution of middleweight stars. According to Albert D. Grauer, astronomer at the University of Arkansas at Little Rock and presently at Louisiana State University (LSU) at Baton Rouge, "We are seeing the stars after they have...given off planetary nebulae. They are contracting on down to become white dwarfs at this point."

The instability of this relatively short-lived (a few million years) stage is exhibited in pulsations in the light output of PG1159 and its relatives. The stars are "ringing" in non-radial gravity modes (SN: 6/18/83, p. 392) that set up oscillations in the stellar material. Green, of Kitt Peak National Observatory in Arizona, explains, "When you hit a piece of metal it rings with a fundamental period. Because the pulsation periods in these stars are so long, relative to the fundamental, we know they have to be different modes of oscillation."

The long periods—a period is the time for a complete cycle—of these pulsators are believed to shorten as the stars contract and approach their white dwarf destinies. PG1159, originally discovered by Green and analyzed by John McGraw of Steward Observatory in Arizona and collaborators, shows two distinct

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In any list of the solar system's wonders, besides the vast volcanoes of Io, the rings of Saturn and Jupiter's stormy Great Red Spot, any reasonable being would surely include the oceans of earth. All that liquid water, with all its far-reaching implications, concentrated on the surface of a single world in a planetary family whose other members all seem variously too hot, too cold, too low in gravity or too short on atmosphere. Surface oceans of liquid *anything,* in fact, have yet to be confirmed, with long-ago-disgarded ideas about Mars and Venus leaving even speculation about oceans largely confined to still-evolving hypotheses about Saturn's huge moon, Titan.

Now another possibility has been raised. And it is based not merely on hypothesis, but on what one of the suggestion's three authors calls "the first direct evidence for an ocean on an extraterrestrial body." Located in the far reaches of the solar system, the proposed location is the surface of Neptune's satellite Triton, which may be the site of a near-global ocean, not of water, but of liquid nitrogen.

Dale P. Cruikshank and colleagues at the University of Hawaii in Honolulu have been studying Triton for several years, and in 1979 Cruikshank published its first infrared (IR) spectrum, indicating the presence of methane in either gaseous or solid form. Subsequent studies confirmed that finding, time and again yielding five clear IR spectral absorption bands characteristic of methane. More recent spectra, however, have revealed another feature, an absorption band located at a wavelength of 2.15 microns. It was Tobias Owen of the State University of New York at Stony Brook, says Cruikshank, who suggested that the additional band might represent nitrogen. Nitrogen as a gas has just such an absorption feature, note Cruikshank and colleagues R. Hamilton Brown and Roger N. Clark, but so does the liquid, and at Triton's low surface temperature of −360°F (55K), they maintain, the gas would have condensed into a liquid. "At the moment," says Brown, "we can find no other way to explain our data than to have on the surface of Triton a layer of liquid nitrogen at least a few inches deep."

It could, in fact, be appreciably deeper, Cruikshank points out, if, for instance, the nitrogen is diluted with something else so that a greater depth of nitrogen produces the same amount of light-absorption in the spectrum.

"We can't be sure how much of the surface of the satellite is covered by the liquid," adds Clark, "but we think it is large enough to call it an ocean. It seems to be distributed irregularly around the globe, and we are using our new observations made this year at [the NASA Infrared Telescope Facility of] Mauna Kea Observatory in Hawaii to map out the oceans and continents of Triton." As Triton rotates, Cruikshank notes, the face of Triton as seen from earth changes, and the nitrogen absorption band depth changes with it, suggesting that the ocean's coverage, if such it is, is not uniform. As for the "continents," they may well be where the methane resides, either as permanent "land" masses or as great icebergs floating in the nitrogen sea. "We're confident," Cruikshank says, "that both these phases exist."

In addition, he reported last week at Cornell University in Ithaca, N.Y., at a conference about "natural satellites"—moons—"the atmosphere of Triton is probably dominated by nitrogen with a surface pressure regulated by the vapor pressure of the gas over the liquid at Triton's temperature." The result, he calculates, would be a nitrogen atmosphere with a surface pressure of 100 millibars—a tenth of the total surface atmospheric pressure of earth, and an eighth of the partial pressure of earth's nitrogen.

As Cruikshank prepared to present the group's report at the Cornell meeting, he said he was looking forward to finding out whether any of the other scientists in the audience would offer an alternative to the dramatic conclusion, but none was im-

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modes of oscillation at present, with periods of 460 and 540 seconds. Two other hot stars discovered by Green, Grauer, Howard E. Bond of LSU and James W. Liebert at Steward also show more than one mode of pulsation, with similar periods.

These stars are probably further along in their development than the unusual fourth member of this class, K1-16, recently analyzed by Bond and Grauer. The relative youth of K1-16 is revealed by the thin, but still visible, planetary nebula that envelops the central star and by its longer primary pulsation period of 28.3 minutes.

Hugh M. Van Horn of the University of Rochester in New York and his co-workers report in the June 30 NATURE that theoretical simulations of the thermal and physical structure of these stars indicate that changes in their periods as they age may be observable in as short a time span as 1 to 3 years. The exact mechanism driving the oscillations is not understood, but may be linked to ionized layers of material beneath the stellar surface. In a kind of feedback process, observations of period changes will serve to update and improve current stellar models. Since the rate of change of the period is also a measure of the hot stars' cooling by neutrino emission, it is possible, says Van Horn, that future astronomical observations may even provide a test for theories that govern the interactions of elementary particles.

—P.D. Sackett

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mediately forthcoming. "I think," he said as he left the speaker's platform, "we have an interesting new world to play with in the next few years."

Ironically, even as Cruikshank spoke, some other researchers at the same meeting were worrying about the state of future opportunities to study Triton. In 1989, the Voyager 2 spacecraft is scheduled to fly by Neptune and its newly fascinating moon (depending upon the trajectory selected for the probe's 1986 flight past Uranus), but there has been some recent concern about whether NASA's tight funding will permit the full range of scientific observations to be conducted. The issue is under study.

The other leading candidate for an ocean, meanwhile, continues to be Titan. Liquid methane has been proposed for Titan by several research groups, but two recently published analyses have concluded that global methane oceans on the gigantic satellite are unlikely, possibly permitting only small patches on the surface if anything (SN: 7/9/83, p. 28). At the Cornell meeting, however, Jonathan I. Lunine and colleagues from California Institute of Technology in Pasadena proposed that Titan may have a global ocean consisting largely of ethane, with only about 25 percent methane and 5 percent nitrogen. A question is whether photolysis of methane (a source of ethane) would instead be tied up in producing the brown, organic "goo" that some other researchers believe lies thick on the surface. *—J. Eberhart*

VDTs: User stress and eyestrain largely due to job design

The government estimates that more than 7 million U.S. workers spend a sizable fraction of their business day at video-display terminals (VDTs) — those television-like screens for displaying computer-processed data. Recently, VDT-induced visual fatigue, especially among clerical workers, has reached dramatic proportions: Surveys show that between 40 and 80 percent of all occupational VDT users complain of eyestrain and other symptoms of stress.

The National Academy of Sciences (NAS), asked to ferret out why, has just completed a two-year study. Summarizing its findings this week, study chairman Edward Rinalducci said, "We suspect that many of the complaints about VDTs are from workers in ... poorly designed jobs. Let me stress here that we feel the problem is with job design, not the VDT."

According to the NAS study panel, "Most features of VDT work tasks that may contribute to discomfort or visual difficulty are also found in various jobs not involving VDTs; however, poorly designed VDTs, workstations, and work tasks often produce a particularly problematic concatenation of adverse features."

The conclusions were based partly on an NAS symposium in August 1981 (SN: 8/29/81, p. 137), where labor leaders described the type of working conditions associated with the highest frequency of complaints involving vision and stress. Here VDT operators, usually female clerical workers, were required to quickly perform highly repetitive tasks, with no opportunity to vary either their work's structure or its pace. In the worst cases, supervisors monitored the daily productivity of respective workers by comparing the number of keystrokes tapped out on each worker's keyboard as that worker manipulated displayed information.

That is a very stress-provoking environment, observed panel member Robert Guion. "I don't think there's anything that the person who has that job can do to make it one I would consider bearable," the industrial psychologist from Bowling Green University in Ohio added.

In most cases, it should be possible to design VDT-related jobs so that the work experience is both satisfying and productive. However, the NAS panel found, few jobs are, in fact, really "planned." Moreover, it said, whatever planning does occur is usually more involved with accommodating VDT equipment than its operators. And that, the NAS panel points out, is probably the mistake underlying much, if not most, of the symptoms plaguing VDT users today.

The NAS report does acknowledge that for some smaller proportion of workers, ill-chosen VDT equipment can itself be a serious problem. "What we have had," said panel member Harry Snyder at a press conference in Washington, D.C. last week, "is the misapplication of commercial television-receiver technology to the VDT environment." The industrial engineer, from Virginia Polytechnic Institute and State University in Blacksburg, pointed out that though cathode-ray tubes (CRTs) used in television receivers offer an inexpensive, off-the-shelf display technology for VDTs, they were never designed for close visual inspection. In fact, he noted, CRTs "were designed specifically to be viewed at a minimum distance equal to four times the height of the picture. For a 10-inch high CRT screen, that would be a distance of 40 inches. Yet most VDT systems using CRT technology have been designed so that users sit a mere 15 to 18 inches from the screen, he says.

Frequently aggravating the visual environment, he adds, has been the past use of screens that were both prone to flicker and insufficiently shielded from the glare of office lighting or incoming sunlight. Many screens compounded the eye's already difficult workload by offering poor image contrast and difficult character resolution.

Particularly because the incidence of low-grade visual discomfort has been so high among VDT users, there has been growing concern about whether permanent eye damage might develop. But, the NAS study reports, "We find no scientifically valid evidence that use of VDTs per se causes harm ... to the visual system." In fact, it notes, levels of radiation required to induce cataract formation "are thousands to millions of times higher than the levels emitted by VDTs."

Because it was limited to reviewing VDT risks to vision, the study makes only passing reference to the anecdotal reports which have surfaced in the past few years linking high rates of abortion and miscarriage with VDT use.

But this report is by no means the last wordson that or any other aspect of VDT risks. The National Institute for Occupational Safety and Health, for instance, has just entered into an epidemiological study involving more than 5,000 women. It will examine, among other things, whether and how VDT use affects pregnancy. Meanwhile, researchers at the University of Texas in Austin have just begun a $382,000 study, funded by IBM Corp. It will be looking for physiological changes in VDT operators that might serve as an objective measure of visual fatigue. *—J. Raloff*