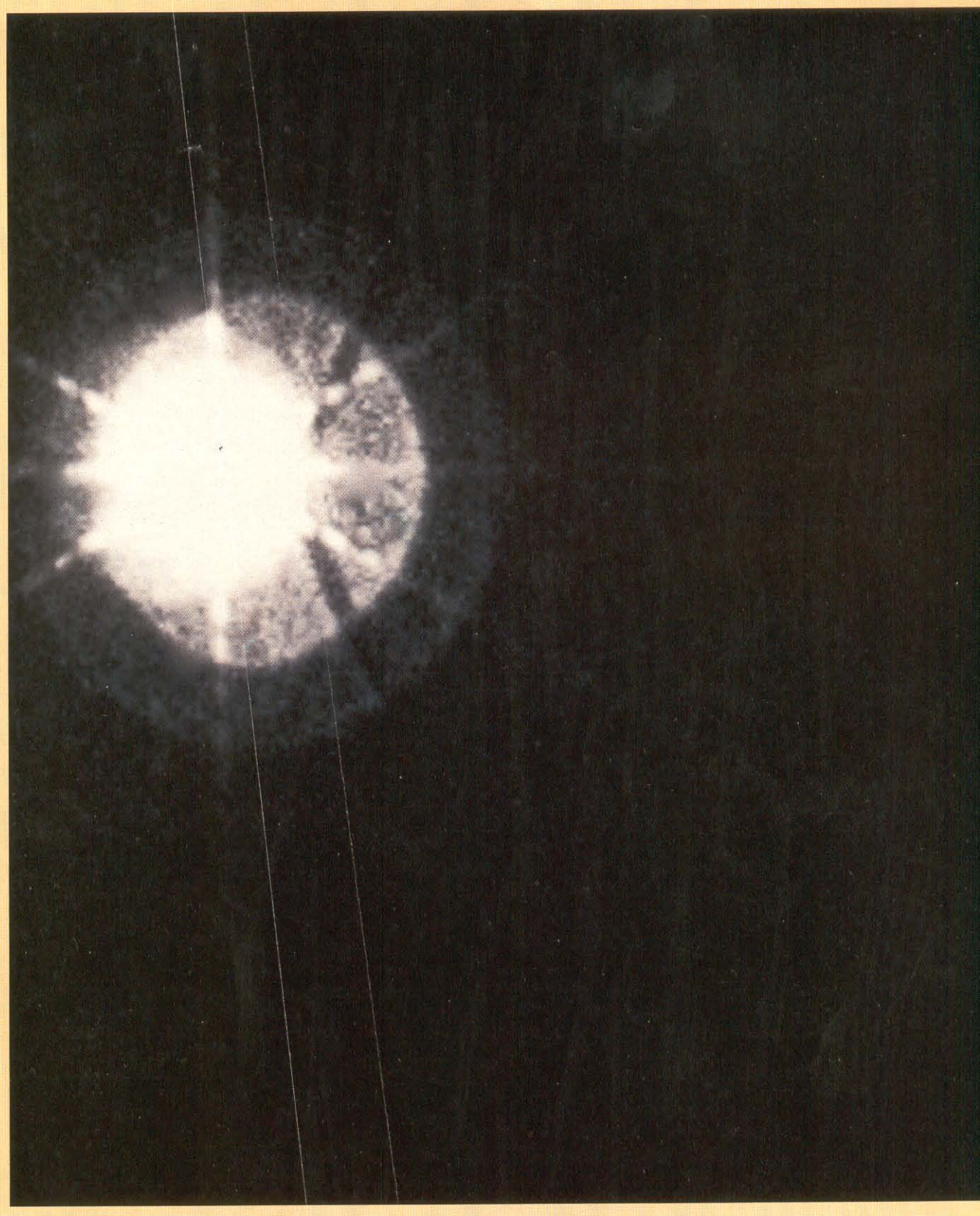
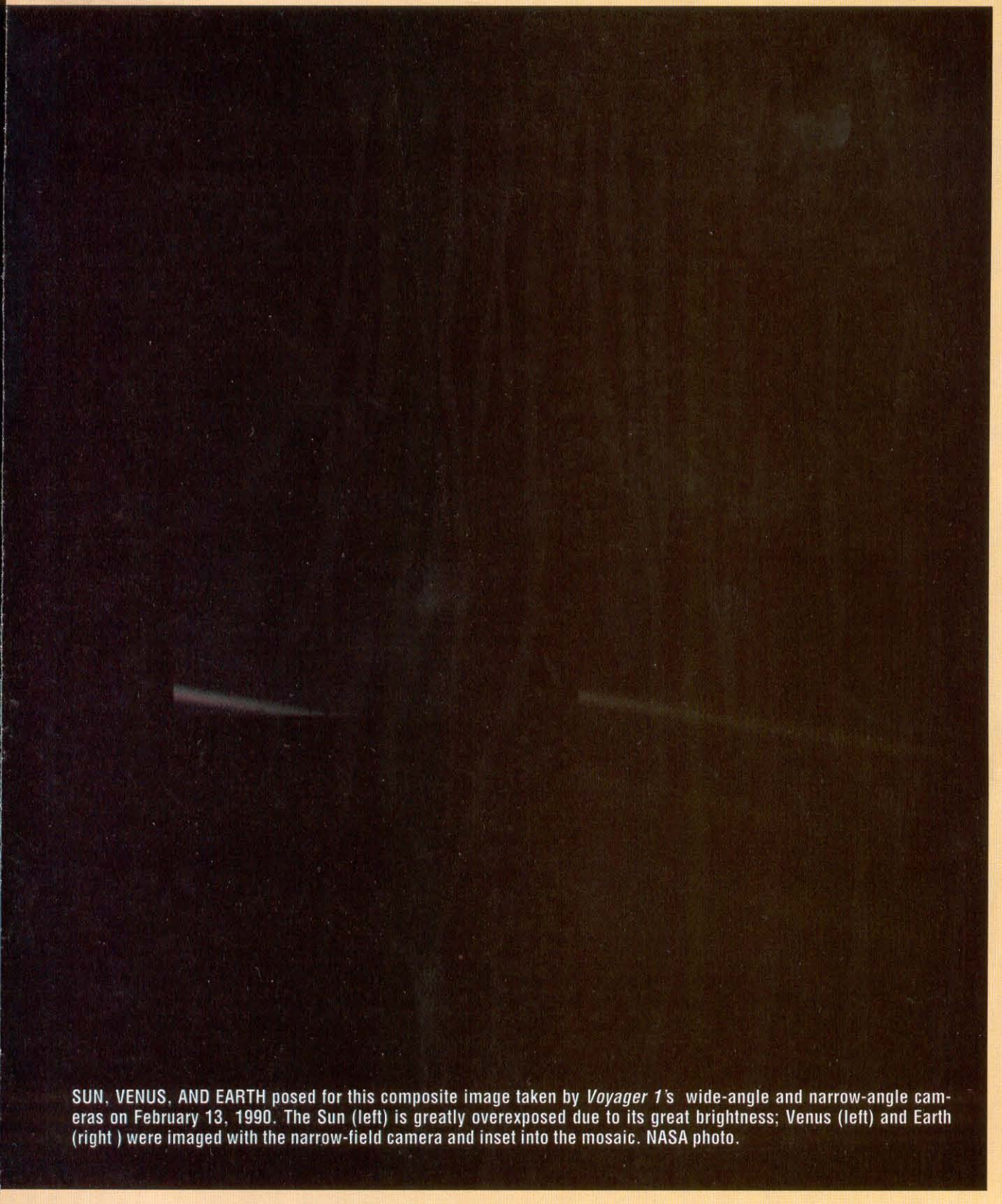


SOLAR SYSTEM EXPLORATION

Voyager's Last Light

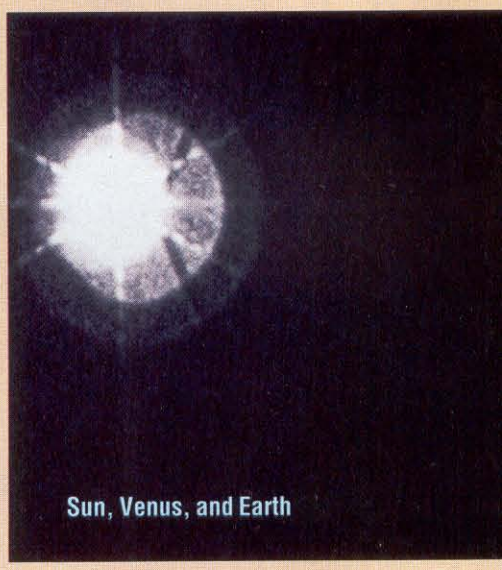


SUN, VENUS, AND EARTH posed for this composite image taken by *Voyager 1*'s wide-angle and narrow-angle cameras on February 13, 1990. The Sun (left) is greatly overexposed due to its great brightness; Venus (left) and Earth (right) were imaged with the narrow-field camera and inset into the mosaic. NASA photo.

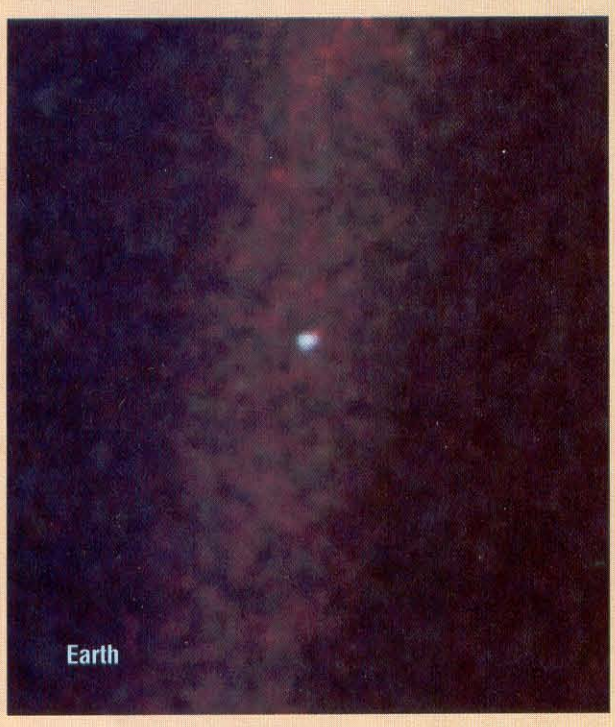
From a distance of 3.7 billion miles, Voyager 1 snaps an historic family portrait of the Sun and planets.

by John Williams

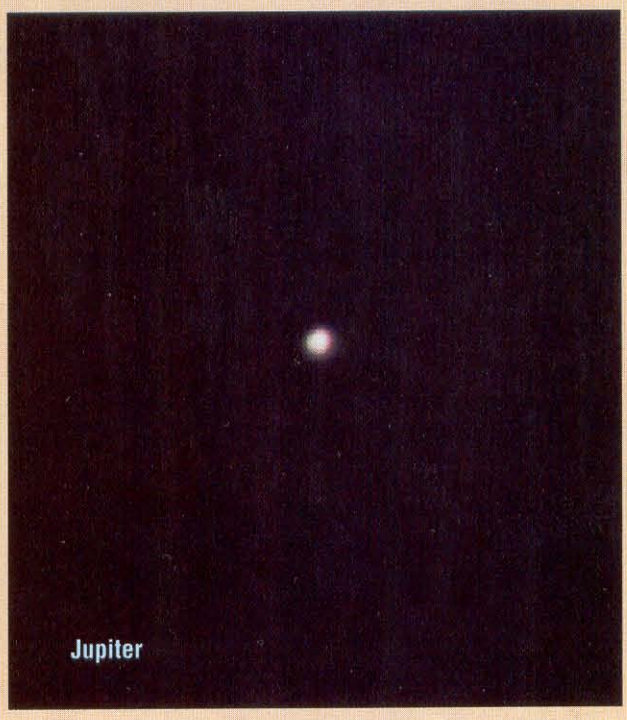
Venus



Sun, Venus, and Earth



Earth



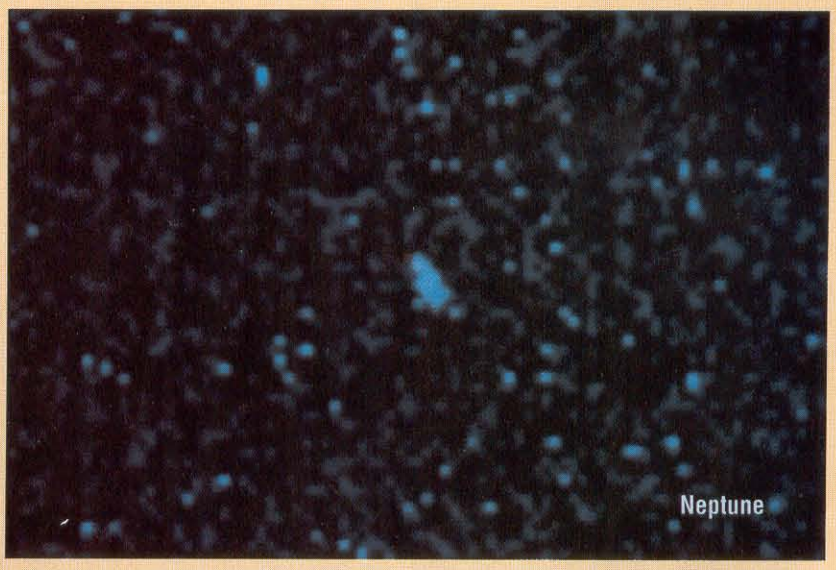
Jupiter

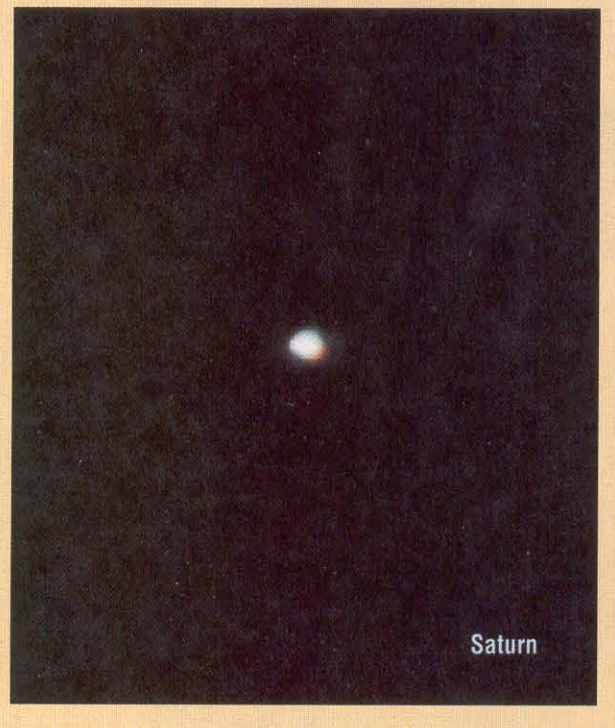
Alone some 3.7 billion miles from Earth, *Voyager 1*'s slewing motors came to life again in February after an almost 10-year hiatus. The mission this time was very different from the spacecraft's successful string of planetary flybys, however. This time *Voyager 1* turned its cameras back toward the Sun and planets and, for the first time in history, took a series of images showing the solar system from the outside — a family portrait of our planetary system.

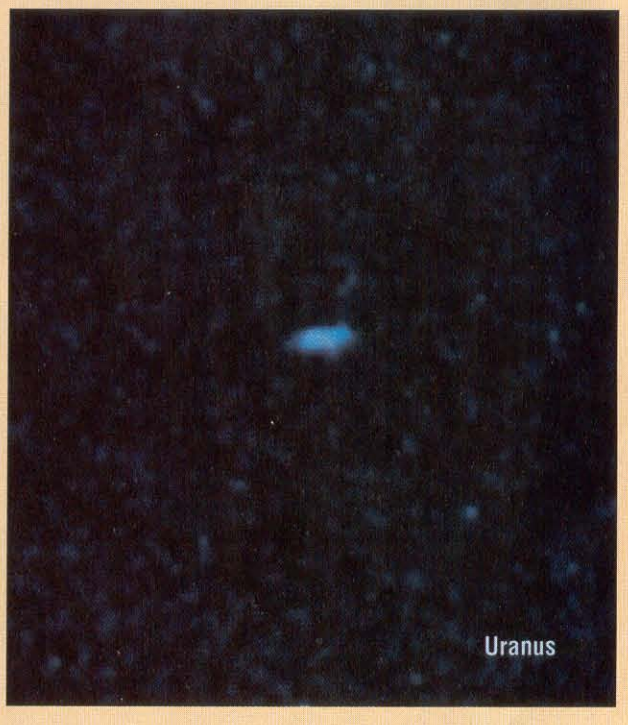
"This is not just the first time, but perhaps the only time for decades, that we will be able to take a picture of the planets from outside the solar system," says *Voyager* project scientist Edward C. Stone of the California Institute of Technology.

On February 13, nearly four billion miles out, all was relatively quiet as the spacecraft prepared for a four-hour photo shoot. *Voyager 1* turned its cameras toward the intensely bright point-like Sun (measuring a mere 40 arcseconds across) and then toward the specks of faint planets floating against the starry background of the constellation Eridanus the River. *Voyager* was 32° above the ecliptic plane and was nearly 1.5 times more distant than Pluto. Slowly and methodically, the spacecraft's wide-angle and narrow-angle cameras snapped sixty-four images, beginning with the dimmest of the targets, Neptune, and working Sunward. Although Mars, Mercury, and Pluto lay in the field of the composite photo, these planets remained elusive. Mars was made invisible by sunlight scattered in the camera's optics. Mercury was too close to the Sun to be seen. And Pluto was simply too distant and dim to be recorded.

Because NASA's Deep Space Network was scheduled to track several other spacecraft, the *Voyager* data were simply recorded on tape aboard the spacecraft and transmitted to Earth in late March. On June 6





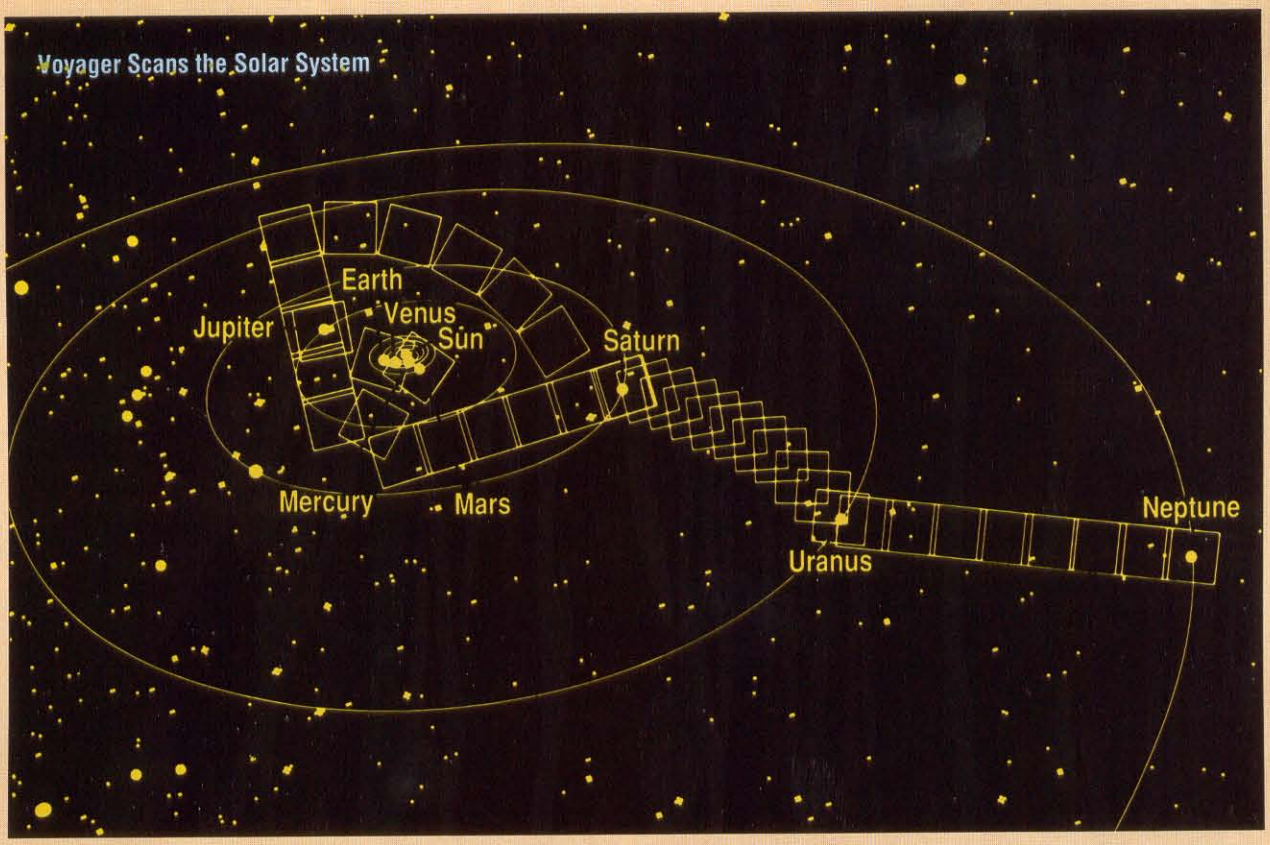


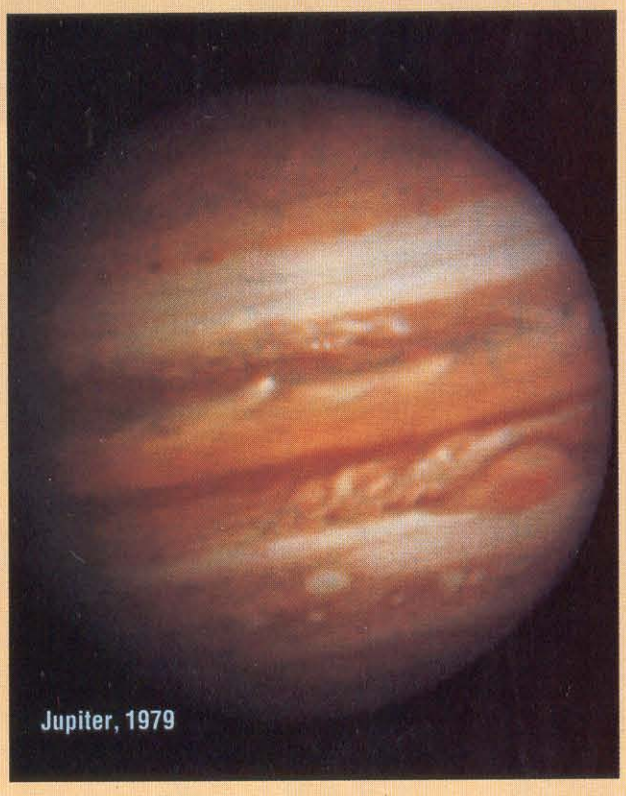
PERSONALIZED PORTRAITS of the home star system were taken from outside the solar system for the first time by *Voyager 1*. The spacecraft's narrow-field camera recorded the images over a four-hour period on February 13. Venus is a tiny bluish blob only 1.3 pixels across, and the crescent Earth spans only 1.4 pixels. Jupiter and Saturn are clean disks, and Saturn's rings are visible as a five-pixel extension on one side of the planet. Because Uranus and Neptune required long exposure times to record, their bluish light appears smeared into linear blobs. NASA photos.

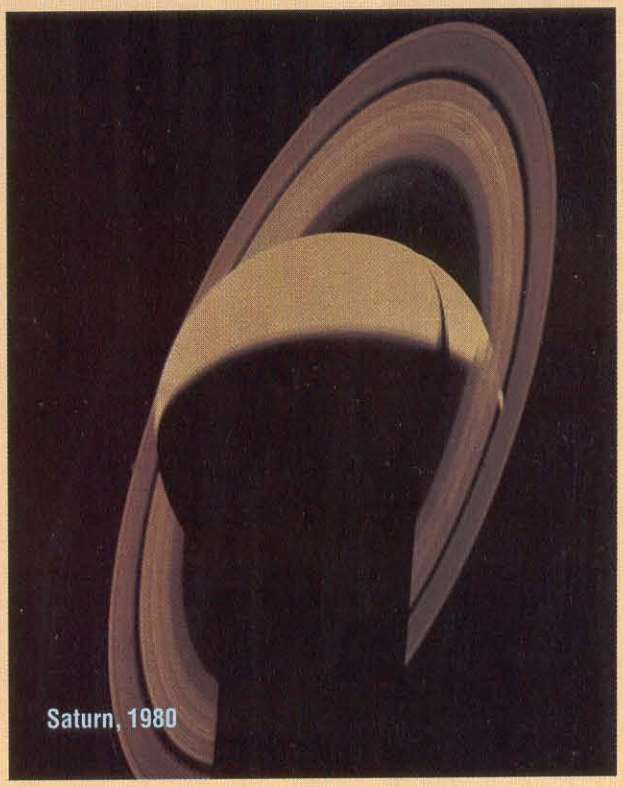
NASA released a collection of photos that included a composite image showing the Sun, Earth, and Venus, as well as individual pictures of Earth, Venus, Jupiter, Saturn, Uranus, and Neptune. Further mosaic images yet to be released may show more of the solar system in a single composite image.

"The biggest problem was identifying which blip was which planet," says Candy Hansen of the *Voyager* imaging team. "Jupiter and Saturn were easy, but the others were hard to find. Unfortunately, Mars couldn't be identified with any degree of confidence. The image of Earth is the most significant because it's the only place in the solar system that can support life. That's a mind-blowing concept when you see it photographed from outside."

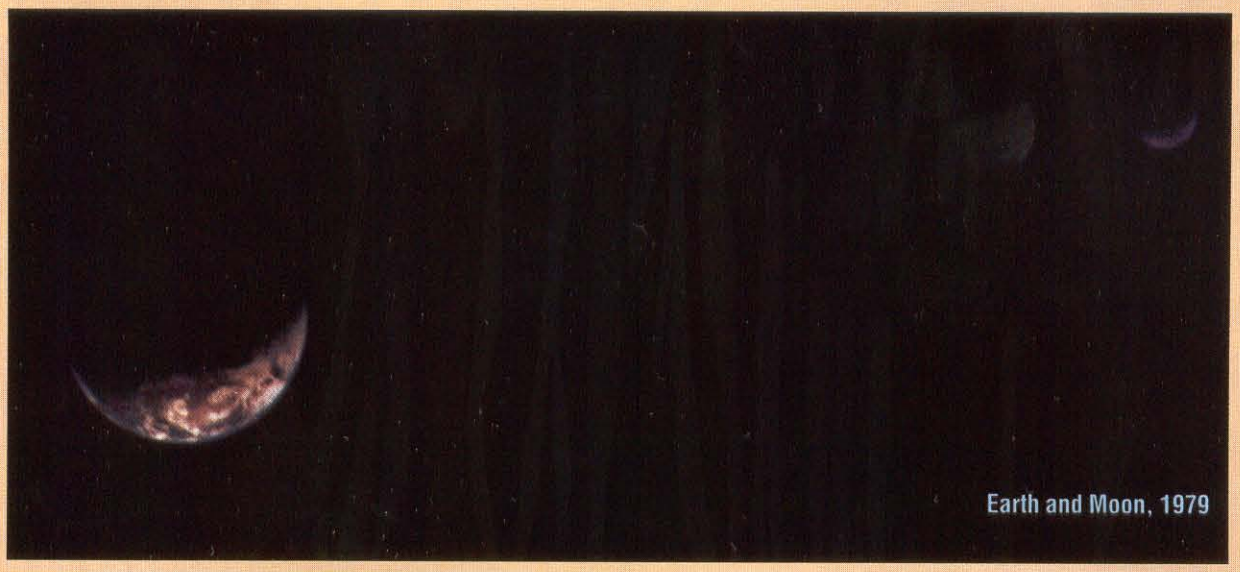
The color image showing the Sun, Earth, and Venus is a portion of a wide-angle image showing the Sun with narrow-angle images of Earth and Venus dropped into the correct spots. Because the Sun's great brightness might harm the cameras, scientists employed a dark methane-band absorption filter and a 1/200-second exposure, the shortest possible. The photo shows a greatly overexposed image of the Sun, tiny at the spacecraft's distance, but still over eight



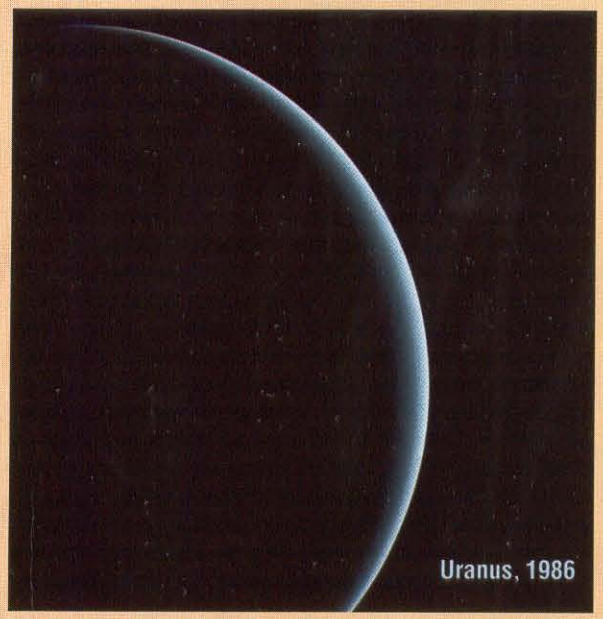




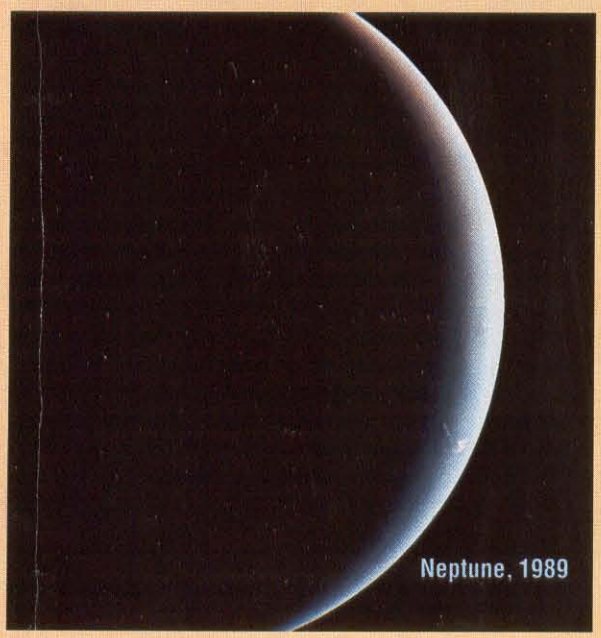
VOYAGER 1'S CAREER spanned thirteen years on a unique trek through the solar system. The final, historic operation occurred in February 1990 as the spacecraft panned its cameras from the dimmest target, Neptune, in toward the Sun, capturing Uranus, Saturn, Jupiter, Earth, and Venus along the way. Prior to the Sun's family portrait, *Voyager 1* carried out extensive reconnaissance of Jupiter and Saturn in 1979 and 1980 and photographed the Earth and Moon together shortly after its launch. *Voyager's* sister craft, *Voyager 2*, not only made scientific observations at Jupiter and Saturn but more recently encountered Uranus, in 1986, and last year flew past Neptune. NASA photos.



Earth and Moon, 1979



Uranus, 1986



Neptune, 1989

million times brighter than Sirius is in our night sky. (The Sun's magnitude from the spacecraft was –18.7, and this light all fell into 3.3 pixels in the wide-angle camera and 40 pixels in the narrow-angle camera.)

The "rays" around the Sun are a diffraction pattern caused by the calibration lamp mounted in front of the wide-angle camera. The insets were made with the narrow-angle camera and show Earth and Venus as dots surrounded by scattered rays of sunlight that streamed through the field. Image processing shows that *Voyager's* cameras faintly recorded the Moon as well as Earth, but it is invisible in these reproductions.

Individual color portraits made with the narrow-angle camera show the planets much better. The images were made using violet, blue, and green filters and were then combined into a single color photo. Jupiter and Saturn are resolved, but Uranus and Neptune are slightly smeared because of the spacecraft's motion during the15-second exposures required. Saturn's rings are visible as a five-pixel-long extension on one side of the planet. The crescent Earth appears to be centered in a band of light, actually a ray of sunlight scattered across the field by the camera's optics. Venus is centered and measures 1.3 pixels in diameter, slightly smaller than Earth's 1.4 pixels.

The family portrait is the last hurrah for *Voyager 1*. After its launch on September 5, 1977, the craft successfully completed flybys of Jupiter and Saturn in 1979 and 1980, respectively. *Voyager's* sister craft, *Voyager 2*, flew past Jupiter in 1979, Saturn in 1981, Uranus in 1986, and Neptune in 1989. Both are now racing toward the heliopause, the point where the solar wind slams into interstellar space. Scientists expect both craft will cross this boundary during the next ten to twenty years. As the *Voyager* craft head deeper into the darkness, scientists will also look for any variation in the spacecrafts' trajectories. Any deviance in these paths may reveal the presence of an unknown body in the solar system, the existence of which is suspected by some astronomers. That would be, in the words of one scientist, "one heck of a finale!" □

John Williams is a freelance science writer living in Jefferson City, Missouri.