Probing the variety among the giant planets

The four largest planets in our solar system share a common feature: a core of rock and ice some 15 to 20 times as massive as Earth. Yet these giants divide into two distinct subtypes – gas-rich Jupiter and Saturn, cloaked in envelopes of hydrogen and helium that far outweigh their solid cores, and gas-poor Uranus and Neptune, whose envelopes account for less than 15 percent of their total mass. The exact cause of this marked difference has remained a mystery.

Three astronomers now propose that the youthful sun's output of extreme ultraviolet (UV) radiation may explain the disparity. They suggest that for an extended period the primitive sun emitted extreme UV at an intensity as high as that observed today in newborn stars of similar mass. In this scenario, the abundance of extreme UV photons would disperse gas from the solar system's outer reaches before Uranus and Neptune could gravitationally capture most of it.

Doug Johnstone and Frank H. Shu of the University of California, Berkeley, and David Hollenbach of NASA's Ames Research Center in Mountain View, Calif., describe their theory in the November Icarus.

Their model relies on the assumption, generally accepted by astronomers, that all of the planets arose from a disk of dust and gas that encircled the young sun. In this scenario, the terrestrial planets – the rocky bodies of Mercury, Venus, Earth, and Mars – coalesced from dust in the inner part of the disk. The four giant planets arose from an agglomeration of gas, ice, and rocky particles in the colder, outer parts of the disk.

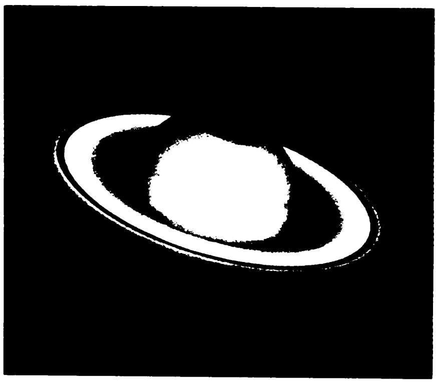
Johnstone and his colleagues calculate that if the early sun emitted a high intensity of extreme UV radiation for some 10 million years, the energetic photons would have ionized and heated some of the hydrogen and helium in the inner disk. This gas would have enough energy to rise just above the disk, but the sun's gravity would still hold the gas in place.

Farther from the sun, just inside the orbit of Saturn, the picture changes, the team reports. Here, the sun's weaker gravitational force can't compete with the outward flow of gas heated by two sources: some of the original extreme UV photons emitted by the sun and the ultraviolet radiation produced when ionized gas in the inner disk recombines with electrons to form atoms. According to the researchers, most of the gas in the outer reaches of the fledgling solar system would escape before Uranus and Neptune assembled cores massive enough to trap it.

The team argues that its model easily accounts for an intriguing difference between Jupiter and Saturn. Although both planets have much more gas than solid material, Saturn has only about one-fourth the mass of hydrogen and helium gas that Jupiter possesses. In the model, Saturn's orbit constitutes the transition radius between gas that remains trapped and gas that can escape. Since Jupiter lies well within that radius, it can more easily acquire gas. (The terrestrial planets lie even closer to the sun but lack sufficient mass to trap most of the available gas.)

Johnstone notes that magnetic and gravitational interactions between the inner disk and the young sun could produce the enhanced radiation his team's model requires. Other astronomers have observed enhanced UV emissions from T Tauri stars – youthful, low-mass stars thought to resemble the infant sun.

Jack J. Lissauer of the State University of New York at Stony Brook says the study provides a "reasonable mechanism" to explain the compositional differences among the giant planets. But he adds that it may not represent the dominant mechanism, or even be necessary to account for the variety.


NASA

A new theory may explain why Jupiter and Saturn (above) have much more gas than the other two giant planets, Neptune and Uranus.

According to calculations by Lissauer, James B. Pollack of NASA's Ames Research Center, and their colleagues, Neptune and Uranus may take two to 10 times longer to accumulate gas than Jupiter and Saturn. During that extra time, the sun's disk may have all but completed its breakup, thus accounting for the lower gas content of these two planets, Lissauer says. *– R. Cowen*

Long-lived worm hints at genetics of aging

Who hasn't dreamed of extending his or her life span?

A lowly worm can do just that. The tiny nematode *Caenorhabditis elegans* more than doubles its normal life expectancy when carrying a mutation in a gene called daf-2, announce researchers at the University of California, San Francisco.

Equivalent in age to a 150-year-old person, the daf-2 mutants appear healthy until a few days before their demise, says developmental biologist Cynthia Kenyon. Adult, fertile daf-2 mutants feed and move normally for about 60 days, while wild-type, or normal, worms die at about 25 days, Kenyon and her co-workers report in the Dec. 2 Nature.

"This study is the first clear demonstration that aging in this worm is not a random degeneration event but is regulated by identifiable genes," comments geneticist James H. Thomas of the University of Washington in Seattle.

"It was striking to see how much faster the wild-type worms [aged]," Kenyon says. "When the wild type aged, they lost their muscle tonus, looked flaccid and decrepit. At that time, the mutants still looked young and zipped around."

In normal nematodes, Kenyon says, the daf-2 gene acts as a brake on a second gene, daf-16, located further downstream in the DNA. In worms lacking daf-16, the daf-2 mutation does not prolong life, suggesting that both genes are involved in regulating the rate of aging.

That finding may give researchers a handle on unlocking the genetics of aging in mammals, Kenyon adds. "We'd like to find the counterparts [of daf-2 and daf-16] in mammals. Often, genes having important functions in the nematode turn out to be homologous to genes that do similar things in mammals," she explains.

Both of these genes were already known, but scientists had never tested whether they influence the life span of adult worms. The genes control when the immature worm enters a peculiar stage, the "dauer" larva. This long-lived larva can simply stop developing – sitting out hard times when food is scarce.

Scientists had believed that the dauer owes its longevity to its immature, infertile state. Since the larva did not mature, it also did not age, scientists reasoned. Kenyon's team shows, however, that the daf-2 gene can control nematode life span independent of the dauer stage. Daf-2 probably affects many genes that determine the worm's longevity, says Kenyon.

Though previous studies have found a host of changes in aging cells – such as the accumulation of free radicals or the breakdown of DNA – these could be either causes or consequences of aging, Kenyon holds. "Nobody knows what sets the rate of aging; it could be a genetic program."

The nature and function of the proteins encoded by daf-2 and daf-16 are still unknown. Since both genes are involved in the worm's response to harsh environmental conditions, Kenyon says her group's findings remind her of studies showing that underfed mice and rats outlive their well-nourished peers. "These two processes might be related," she speculates. *– G. Strobel*