Space Telescope discovery raises question of star origins

by David Cherry

The occasional release of new images from the Hubble Space Telescope has appeased public curiosity, but the first big event for the scientific world is now approaching. At the end of January, *Astrophysical Journal* will publish a special issue of its *Letters* devoted to a score of papers based on Space Telescope results. "When they appear, they are going to make quite some scientific impact," said Lyman Spitzer, Jr., father of the Space Telescope, in a recent interview.

One of these papers reports the discovery of a massive jet—at least it is being called a jet—apparently emerging from a star in the Orion Nebula (see **Figure 1**). Jeff Hester at Cal Tech's Infrared Processing and Analysis Center and several colleagues discovered the jet when they trained the Space Telescope on a small square within the Orion Nebula no wider than one-fourteenth of its overall width and made ten-minute exposures at several different wavelengths with the aid of filters.

The jet is not the only discovery in these images. There are also wormlike structures in the gas of the nebula not comparable to objects previously seen (see **Figure 2**) and some dark rings that seem almost axially aligned. There is also a pattern of filamentary structure visible in one of the wavelengths that may indicate curtains of gas at photo-ionization fronts driven by starlight.

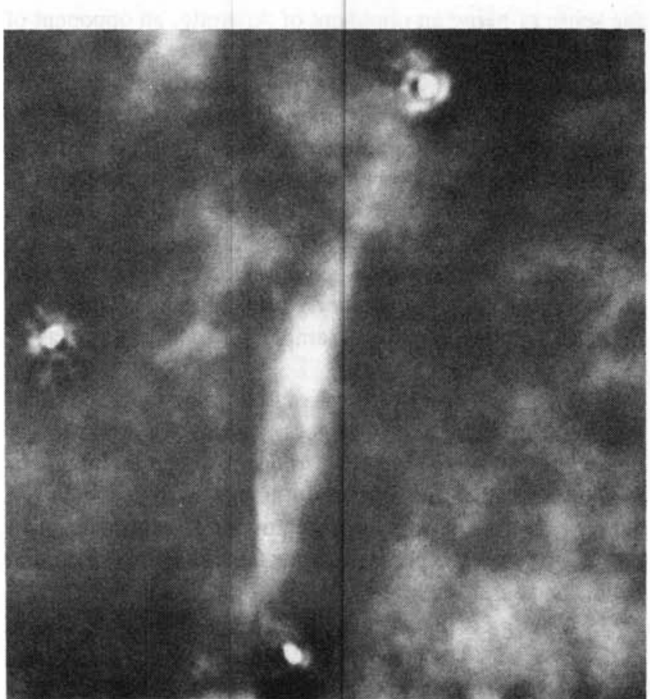
The Orion Nebula—a gigantic cloud of gas and dust illuminated by hot young stars within it—is well known to amateur skywatchers as a diffuse patch of light just visible to the naked eye at about the middle of Orion's sword. For astronomers, the Orion Nebula is important as the star hatchery nearest our Solar System. Stars are born in the arms of spiral galaxies. The Solar System and the Orion Nebula are a mere 1,500 light years apart in the same spiral arm of our galaxy.

The newly discovered jet is not at all on the order of a large solar flare: Its length is 228 times the mean distance from our Sun to Pluto, or one-seventh of a light-year. Layering in the jet (emission at different wavelengths) is interpreted as a difference between the gas on the inside, and the shock front where the gas on the jet's surface encounters the surrounding, relatively stationary gas. The star from which it appears to emerge, although catalogued, is unknown as to type, spectroscopy, possible variability, and so on. Ground-based telescopes, however, will soon fill in some of the blanks.

While this jet has not been seen before, it is not the first discovery of a jet or jets emerging from a star: The first case was seen in 1981, and now there are numerous instances. Such jets emerging from stars are not simply objects of curiosity. They seem to be associated with the very youngest stars, and hence are of interest in the attempt to understand the process by which stars come into existence.

For the sake of scientific understanding, however, it is necessary to drop the term *jet,* which astronomers often adopt too readily (**Figure 3**). It presupposes one kind of mechanism and excludes others, when we are far from having direct

FIGURE 1
A huge finger of gas associated with a star



A gigantic jet or finger of gas appears to be associated with a star nestled in a cloud of gas and dust in the Orion Nebula. The star's characteristics are not yet known. The morphology of the structure may be consistent with more than one theory of how stars are born.

evidence of the mechanism involved in even a single case of fingerlike extensions of gas from a star. We *can* safely speak of "mass outflow" in some cases—certainly where red-shift measurements have shown that the finger of matter has a velocity away from the star.

How are stars formed?

The overwhelmingly dominant theory of star formation among astronomers is an elaboration of the simple Newtonian theory of gravity. A massive cloud of gas and dust collapses by self-gravitation to form a body so dense that thermonuclear fusion begins at its center, causing the body to emit heat and light. Even after the star turns on, matter typically continues to be drawn into it by gravitation. As this matter spirals toward the star, it forms an accretion disk around it. There is at least partial confirmation of the existence of circumstellar disks—accreting or otherwise—in actual observations. When astronomers see a finger of matter—or two oppositely directed fingers—projecting from a star, they conclude that the accretion disk is confining the outflow of matter to the disk's axial directions.

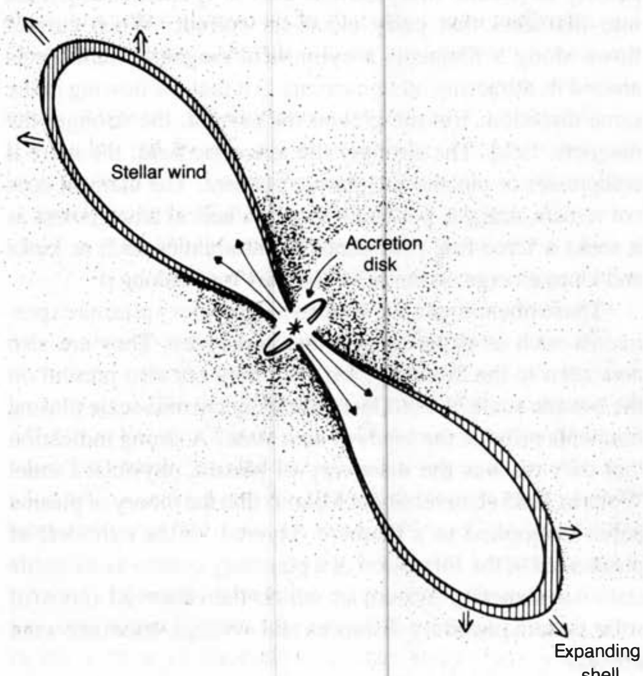
Such a theory is consistent with the prevailing stochastic or probabilistic view of cause and effect in the universe. But the mere existence of life and of human thought processes is not compatible with mere probabilism nor with the subsumed theory of stellar origins.

One courageous and prominent astronomer who sees the problem of stellar origins from this more rigorous standpoint is Victor Ambartsumian of Soviet Armenia. Ambartsumian studied the youngest low-mass stars, called T Tauri stars, for clues to the processes of star birth. T Tauri stars vary in brightness with time. Ambartsumian concluded that this variability is not a result of a thermal (randomized) energy source, but is "a result of the appearance in the outer layers of the star of an additional radiation source of a non-thermal nature . . . the release of additional energy in the outer layers of the star frequently occurs over a relatively brief period of time. All the data indicate that the radiation energy thus

FIGURE 2
A wormlike feature of unfamiliar structure

What is the wormlike feature to the right of the black dot? Has anything like it been seen before? Within its head are two well-defined dark points. In the original image, the structure does not, apparently, terminate at this head, but continues in very faint outline to the left and downward, ending like the large end of a crook-necked squash. To the lower left is the star and finger of gas shown in Figure 1.

FIGURE 3
Standard theory says gas fingers are jets



In the standard gravitational theory of star formation, fingers of gas extending from stars are seen as jets, whose direction of flow is controlled by the accretion disk rotating around the star. It is also assumed that such jets are bipolar—that they come in oppositely directed pairs. Sometimes this is in fact clearly seen. Sometimes an unseen second jet is assumed to be obscured by intervening gas and dust. Does the standard theory overlook the possible roles of electric and magnetic fields in star formation?

emitted is drawn not from those energy resources which are found in the outer layers, but comes from the inner layers" by means of a mechanism that is not understood.

"Thus it becomes possible to observe directly the process which, in other stars, takes place only in their central regions." This liberation of energy is not thermonuclear, but ordered just as laser energy is ordered, and "is connected with the emergence of new atomic nuclei which are sometimes unstable and later decay." The question now is whether Ambartsumian's broad hints will be pursued by Space Telescope investigators.

Another important contribution—or group of contributions—to the problem of stellar origins is that of Hannes Alfvén and of physicists who have studied laboratory plasmas. On the basis of laboratory experiments, these scientists conclude that electrical and magnetic fields must play a large role on the astrophysical scale, a view that astronomers usually prefer to evade. Nevertheless, space probes sent into Earth's magnetosphere and into interplanetary plasmas have shown that electric and magnetic fields are responsible for highly elaborate structures there. At least solar system astronomers, therefore, have become much more attuned to the role of electric and magnetic fields.

Alfvén's theory of star formation is premised on the propensity of plasma (hot, ionized gas) to spontaneously form into filaments that carry electrical current. When current flows along a filament, a cylindrical magnetic field forms around it, attracting other currents to it that are flowing in the same direction. But the greater the current, the stronger the magnetic field. The stronger the magnetic field, the more it compresses or pinches the plasma filament. The filament does not remain straight, but tends toward a helical arrangement as it seeks a force-free configuration. Instabilities such as kinks and loops emerge on the helix and may travel along it.

These phenomena are all seen in laboratory plasma experiments such as experimental fusion devices. They are also now seen in the Solar System. Are they not also present on the cosmic scale? Could instabilities in cosmic-scale plasma filaments provide the seeds of new stars? A strong indication that they do was the discovery of plasma physicist Daniel Wells in 1985 (University of Miami) that the theory of plasma behavior applied to a filament (layered vortex cylinder) of plasma led to the formation of a planetary system as its stable state—a planetary system in which the observed ratios of solar system planetary distances and average velocities were obeyed.

These possibilities oblige astronomers to obtain information on magnetic fields wherever possible—through measuring polarization of the light—when studying the origins and earliest histories of stars. And when corrective optics are installed on the Space Telescope, a further improvement in resolving power may reveal crucial details of structure relevant to one of the most important questions we address to nature.

Interview: Lyman Spitzer, Jr.

'Mars would be a great place to visit'

Lyman Spitzer first proposed a large telescope in Earth orbit in a 1946 paper for Project RAND, and has been its leading advocate since then. He is now Professor Emeritus and Senior Research Associate at Princeton University. From 1947 to 1979, Spitzer was Director of the Princeton University Observatory.

While the following interview does not touch on star formation, Spitzer, more than most astronomers, approaches the problem from the standpoint of plasma behavior. He led the development of fusion research at Princeton, and was involved in its Plasma Physics Lab as late as 1966. While Spitzer has developed a version of Sir James Jeans' gravitational collapse theory of star formation, he believes our understanding "is rough, uncertain, and tentative." "[W]hat about the effects of magnetic fields produced by electric currents in the ionized interstellar gas?" he asks, at the conclusion of his 1982 book, Searching Between the Stars. *These magnetic effects "may be of predominant importance in certain aspects of star formation," he adds.*

Spitzer was interviewed by David Cherry on March 7, 1990, before the Space Telescope was launched.

EIR: Beyond the Hubble Space Telescope and the x-ray, infrared, and gamma-ray instruments in NASA's Great Observatory series, I understand there are plans for lunar-based observatories in various wavelengths.

Spitzer: There are studies—whether you'd call them plans or not I don't know. People have suggested all sorts of things, and one characteristic of NASA, quite properly, is that it makes detailed studies of all sorts of possibilities before it decides just what to recommend.

EIR: If you were to put a telescope on the Moon, you could have a very large collecting surface, couldn't you, because gravity would be less constraining?

Spitzer: There are advantages and disadvantages of being on the Moon. Quite apart from the large additional effort required, and the large cost of maintaining an observing station on the Moon, the gravitational flexure gets to be a technical problem. It can be solved with enough engineering and apparatus, but Earth orbit is really ideal for a very large diffraction-limited telescope.