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.

**EIR:** Why is Earth orbit best for large mirrors?
**Spitzer:** On the Earth, when you point a telescope in different directions, the mirror bends in different ways because of the Earth's gravitational field. The same would be true on the Moon. It wouldn't bend as much, because the surface gravity is less, but it would not be zero. In orbit, there is no gravity, and there is nothing to distort the mirror except for thermal problems, which can be controlled.

**EIR:** Have you ever, even in your dreams, thought about Mars orbit?
**Spitzer:** Yes, yes. I don't think it's such a great location for a telescope, that is, a telescope designed to look at stars, and systems outside of our own Solar System . . . but maybe there are some advantages I don't visualize.

I think Mars would be a great place to visit! But that's to find out what's there, not as a base for looking at other systems. If you had a lot of people living on Mars, why that's a different story. But that's so remote that it is hard to discuss.

**EIR:** Among the projects now accepted for the Space Telescope, are there any that you have had a hand in?
**Spitzer:** I have a project, proposed in collaboration with my friend Bob O'Dell at Rice University, that is concerned with matter between the stars. I have been interested in this for many years. We got some very interesting information with the Copernicus satellite that had a Princeton telescope-spectrometer, and we'd like to extend that with the Space Telescope. The observations which I have included in our joint program are designed to tell us the composition, density, temperature, and motions in the gas between the stars, and to clarify how this gas affects the evolution and future fate of our Galaxy.

**EIR:** May I ask what you are doing these days, now that you are in your 70s? You are retired from teaching?
**Spitzer:** Yes, that's right. But I am continuing my research. I take some time out to go rock climbing, but otherwise I continue my work, though on a more leisurely basis.

**EIR:** For a long time astronomers generally did not support the proposal for a space telescope first elaborated by you in 1946. You wrote that this observatory was not to extend the boundaries of existing knowledge, but rather to overturn the framework, to give us an entirely new view of the universe based upon much better information. Why were astronomers reluctant to see that?
**Spitzer:** Well, I don't think they necessarily disagreed with the possibility of doing that *if* one could send up and get the scientific results from rockets and satellites. But in the early days, even rather modest equipment often failed, and people thought it was impractical. I had a good friend who—when I told him I was getting involved in one of these projects—looked at me and said, "Well Lyman, you are young, you'll live to see it fail."


Courtesy of Lyman Spitzer, Jr.

*In his seventies, Lyman Spitzer is still scaling new heights. In this 1985 photo, taken when he was 71, Spitzer is climbing the Cima della Madonna in the Italian Dolomites.*

**EIR:** Amazing! I guess many more astronomers came to favor a large space telescope after the Moonwalk.
**Spitzer:** It was not so much the walk on the Moon as it was the success of smaller astronomical instruments. The early observations of stars by the Orbiting Astronomical Observatories were of great importance. These smaller instruments had their problems—two of the four were unsuccessful, but the other two were *highly* successful. Solar space telescopes obtained very significant data on the Sun, and the Stratoscope program also gave some fascinating results. Gradually people began to think, well, maybe there is some promise in this after all. And then when they looked at it, and when we talked to them as to what one could *do* with the Space Telescope, it became obvious to astronomers that it would be very powerful.

**EIR:** Professor Henry Norris Russell, your teacher, used to joke about where astronomers go after they died, and hoped they were allowed to take their instruments and set up on the Moon. Did Russell think seriously about putting a telescope in orbit or on the Moon?
**Spitzer:** I don't think very seriously. I don't remember. He was aware that the atmosphere is a terrible impediment to astronomical observations, which we discussed from time to time, but he never made up a systematic list of what one could do if one could only send a telescope up. This just didn't seem sufficiently imminent to make that calculation. If it hadn't been for the V-2 rockets and the RAND study of the possibility of satellites, I probably wouldn't have gotten involved either.