# Astronomy

*Ivars Peterson reports from Kansas City, Mo., at an American Astronomical Society meeting*

## Probing a lithium vanishing act

One of the few ways to probe beneath a star's surface is to look for traces of the element lithium in the spectrum of visible light emitted by the star. By working out the amount of lithium present at a star's surface, researchers indirectly obtain information about circulation patterns within the star itself. Recent measurements by astronomer Ann M. Boesgaard, a visiting professor at the California Institute of Technology in Pasadena, show dramatic variations in lithium content that appear to depend on a star's mass and age.

Using sophisticated detectors, Boesgaard and her students determined the lithium content of stars in several clusters, including the Hyades and the Pleiades, both found in the constellation Taurus. Stars in young clusters such as the Pleiades (70 million years old) generally show a normal lithium level – about 1 lithium atom for every billion hydrogen atoms. In contrast, certain stars in older clusters such as the Hyades (800 million years old) show lithium amounts as low as 1 percent of the normal value. Such deficiencies tend to occur in stars 10 to 40 percent more massive than the sun and whose surface temperatures range between 6,800 and 7,100°C.

"This was a totally unexpected finding," says Boesgaard. The sharp drop in lithium levels may be caused by flows that carry lithium atoms from the surface deep into the star. When the lithium reaches depths at which the temperature is near 2.5 million°C, thermonuclear reactions destroy the element.

What drives such deep flows isn't clear yet, says Boesgaard. Researchers have proposed three possible mechanisms. Lithium atoms, pulled by gravity, may slowly sink into the star's interior until they are consumed. Alternatively, the star may have a turbulent layer just below its convection zone to produce the necessary mixing. The phenomenon may also be connected with the rate at which the star rotates. Recent observations indicate that higher rotation rates seem to correlate with lower lithium levels. Whatever the cause, the observation that lithium deficits are not seen in young stars implies that the circulation process is slow and the effects don't show up for at least 100 million years.

Boesgaard has also looked at the levels of the element beryllium in various types of stars. In this case, even stars in the Hyades show no beryllium depletion. Because beryllium is destroyed in thermonuclear reactions occurring at 3.5 million°C, the results mean that circulation patterns within a star don't go deep enough to burn up beryllium.

The abundance of lithium and beryllium at star surfaces serves as a probe of the internal structure of stars, says Boesgaard. These observations are one of the few direct checks on theoretical models of the way stars work. In addition, they provide clues about what may be happening inside the sun, which, like stars in the Hyades, has normal beryllium levels and a lithium deficiency.

## The mystery of the missing gas

The shapes of galaxies vary widely – from compact balls of stars known as elliptical galaxies to spirals with sweeping arms extending from a central bulge, and irregulars, which have no bulge. Spiral galaxies, like our own, contain large amounts of interstellar gas – mainly hydrogen and helium – from which new stars form. Until recently, elliptical galaxies appeared to contain no detectable gas. That difference seemed consistent with the supposition that elliptical galaxies contain only old stars while spiral galaxies contain stars of all ages.

But the picture wasn't complete. What happens to the gas shed by dying stars in elliptical galaxies? What fuels the enormous amount of radio-wave activity observed coming from the centers of such galaxies? These questions made it worthwhile for researchers, using improved instruments, to continue their search for traces of interstellar gas, and they started finding it in isolated cases. Now, Gillian R. Knapp of Princeton (N.J.) University and her colleagues have discovered that almost all elliptical galaxies contain interstellar gas.

Knapp and her colleagues came to their conclusion after carefully analyzing data collected in 1983 by the Infrared Astronomy Satellite (IRAS). They put together thousands of individual observations covering several hundred galaxies, averaging the data to increase sensitivity and thereby detect fainter sources of infrared radiation, which would signal the presence of interstellar gas.

"The results amazed me," Knapp says. "These findings are in disagreement with the conventional wisdom that ellipticals contain no gas. It gives us a whole new way of looking at the evolution of elliptical galaxies." For example, it's likely that, like spirals, elliptical galaxies contain stars of all ages, though probably with a different mix. This calls into question the assumption that elliptical galaxies look much the same now as they did billions of years ago. It means that astronomers can no longer safely use the brightness of elliptical galaxies as a way of mapping the expansion of the universe.

In addition, the results indicate that enough gas is present to power the radio-wave sources found at the centers of elliptical galaxies. One possibility is that the emissions occur as gas atoms are pulled into black holes sitting at the galactic centers.

"There remain many areas to investigate," says Knapp. For example, how do the stars and gas in elliptical galaxies evolve, and what did ellipticals look like in the past? "We hope to tackle these and other questions in the coming few years."

## The gloomy fate of interstellar dust

Although interstellar dust makes up only 0.5 percent by mass of all interstellar material, these tiny, solid particles are amazingly opaque, says John S. Mathis of the University of Wisconsin at Madison. An observer staring into a volume of this dilute material compressed to the density of air would penetrate the gloom by scarcely a millimeter. To account for the efficiency with which interstellar dust absorbs starlight, Mathis proposes that each grain consists of tiny silicate and carbon particles stuck together to form a loose, fluffy aggregate. Each grain, structured somewhat like a sponge, traps a substantial amount of vacuum in the spaces between the particles.

Mathis also finds that the carbon particles necessary for his theory must come in two forms: one consisting of carbon atoms in a rather disorganized array and another in which the carbon atoms are arranged at least partially in a graphite-like structure. The presence of a small proportion of free graphite accounts for a strong spectral feature characteristic of graphite observed in the interstellar medium.

Theoretical calculations show that over a wide range of wavelengths, the postulated composite grains have optical properties closely matching those observed in interstellar space. Further evidence for the theory comes in the form of interplanetary, or cometary, grains captured high above the earth, which sometimes have a similar fluffy structure.

The new theory provides an alternative to earlier theories suggesting that interstellar dust consists entirely of separate silicate and carbon particles or largely of carbon-coated silicate particles. Mathis says his theory takes into account the way interstellar grains evolve. Exploding stars generate either silicates or carbon. Occasional collisions between these particles shatter the original stellar solids, and the small fragments collect into composite grains. In dense clouds, particles are more likely to clump together and the resulting grains tend to be larger than those found outside of clouds.