Low-Mass Stars: Born to Make Planets?

Do most newborn stars have the potential to form planets? A new study suggests they do.

Peering deep into the celestial wombs that give birth to low-mass stars similar to the sun, astronomers have uncovered evidence that the vast majority of these infant stars possess disks of tiny dust grains. Such grains may eventually clump together to make planets.

The same research team also reports that most stars are born in small families rather than alone or in large clusters, as conventional wisdom has held.

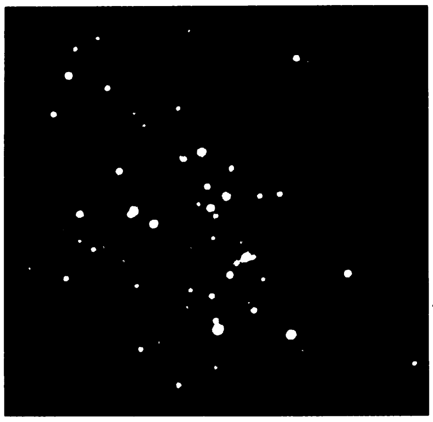
Karen M. Strom and Stephen E. Strom of the University of Massachusetts at Amherst and K. Michael Merrill of the Kitt Peak National Observatory in Tucson, Ariz., reported their findings last week at a meeting of the American Astronomical Society in Phoenix.

In their study, the researchers relied on a state-of-the-art infrared camera to observe a maternity ward for stars – a giant molecular cloud called Lynds 1641. Located 1,500 light-years from Earth in the constellation Orion, Lynds 1641 is the nearest such cloud and contains so much dust that its newborn stars remain hidden from view in visible light. But emissions from the stars and surrounding dust light up the cloud in the infrared.

To their surprise, the researchers found that the youngest stars in the cloud, which are only a few hundred thousand years old, belong to small families of 10 to 50 stars. Each family was born from the same stellar womb, measuring about a light-year across. Astronomers had previously believed that most stars flame to life in isolation or in rich clusters containing hundreds to thousands of siblings.

Measuring the velocity of gas surrounding older stars that appear to have been born in the same small groupings suggests that the families are short-lived. After the astronomically brief time of a million years, says Karen Strom, members separate from their core family. Perhaps carried by the turbulent motion of gas in the molecular cloud, the stars move an estimated 3 light-years apart in about 1 million years.

Using an infrared array attached to the 1.3-meter telescope on Kitt Peak, the team gathered tantalizing evidence that many of the young stars have the raw material to form planets – and that some of the older stars might already have done so. The researchers recorded much more infrared radiation than expected from the vast majority of the young stars, which range from about one-tenth the mass of the sun to a few times the sun's mass. The infrared excess, however, matches the pattern of emission from a disk of heated dust particles orbiting each of the stars.



National Optical Astronomy Observatories

False-color infrared image of families of newborn stars in the Orion cloud Lynds 1641. Blue denotes the shortest infrared wavelength (1.25 micrometers), green an intermediate wavelength (1.65 micrometers), and red the longest (2.2 micrometers).

In contrast, older stars in the cloud have much weaker infrared emissions, similar to the radiation recorded from the sun and other middle-aged stars of like mass. The difference in emission patterns between young and older stars, says Stephen Strom, fits a popular scenario for planet formation. In this model, young stars have circumstellar disks composed of swarms of dust particles; over a few million years, the particles may come together to form orbiting, asteroid-size bodies – the building blocks of planets – which emit much less infrared light.

Dust rings recently imaged around young stars in the Orion Nebula, as well as a remnant disk encircling an older, nearby star called Beta Pictoris, support this picture (SN: 12/19&26/92, p.421). And given the findings in the new study, says Stephen Strom, "I believe that all [low-mass] stars are born with a disk." Over time, he notes, not only may dust grains gather into "planetesimals," but the entire star may wander from its original family, maturing on its own as a possible solar system in the making.

Lee W. Hartmann of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., says the work "emphasizes that stars don't form in isolation. One can't have a theory without considering that stars . . . form in groups."

Strom suggests that disks play a crucial role in star formation – without them, a condensing gas cloud might spin so rapidly that it would break apart and never form a star. His team, including University of Massachusetts graduate student Lynne A. Hillenbrand, is now investigating whether denser starbirth regions form more massive stars and whether their disks could form planets more rapidly. – *R. Cowen*

New chemistry boosts promise of natural gas

The world's reserves of natural gas could provide energy equivalent to 1,500 billion barrels of oil. But taking advantage of these reserves, which often exist in places far from big energy users, requires that scientists develop ways of transporting this fuel efficiently.

Toward that end, two research teams have developed new catalytic processes for converting methane, the major component of natural gas, into methanol, an easily transported liquid. They describe these advances in the Jan. 15 SCIENCE.

Typically, natural gas processors first convert methane to "syngas," a mixture of carbon monoxide and hydrogen; they then make methanol or gasoline from syngas.

Now chemists at Catalytica, Inc., have discovered that mercury can catalyze a more direct conversion of methane to methanol. Methane consists of single carbon atoms each tightly bonded to four hydrogen atoms. The Catalytica reaction works because a positive mercury ion can displace one hydrogen ion, report Roy A. Periana and his colleagues at the Mountain View, Calif.-based company. Then, in the presence of sulfuric acid, this displacement leads to the formation of a methyl sulfate compound that converts to methanol with the addition of water.

Schmidt/Univ. Minn.

Methane oxidation causes porous catalytic plug's golden glow.

Currently used reactions usually yield less than 5 percent methanol: In these, carbon dioxide and water tend to form because intermediate products outcompete methane in reacting with oxygen, explains Eric R. Evitt of Catalytica. But in the new process, methyl bisulfate resists further oxidation. So, much to the surprise of the Catalytica scientists, this mercury-catalyzed reaction yields 43 percent methanol. It also requires milder reaction conditions and a lower temperature than other approaches, Evitt says.

"It's very interesting – and good science," comments Richard H. Fish, an organometallic chemist at the Lawrence Berkeley (Calif.) Laboratory. "It's probably going to be a lot more energy-efficient [than other conversion strategies]."

"But a process that has mercury and sulfuric acid could be an environmental nightmare," he adds.

The Catalytica group stresses that more work is required to determine the commercial potential of this promising laboratory result. "We must learn more about the reaction and under what conditions it will work," says Evitt.

In a separate report, two chemical engineers have reconfigured conventional catalysts to streamline the production of syngas. Their reaction works so fast – on the order of milliseconds versus seconds – that it requires a much smaller reaction chamber than current syngas processes, says Lanny D. Schmidt at the University of Minnesota in Minneapolis. He and Daniel A. Hickman, now at Dow Chemical Co. in Midland, Mich., have also shown that the catalyst rhodium leads to very high yields of syngas – 10 molecules of hydrogen and carbon monoxide for each molecule of water and carbon dioxide.

Although methane usually catches fire when it comes into contact with oxygen, it will not burn when there is a large excess of oxygen present, Schmidt explains. He and Hickman force such an oxygen-rich methane mixture through a clear quartz tube with a diameter about the size of a quarter. Inside, a porous aluminum plug coated with rhodium or platinum causes the methane to ignite and convert to hydrogen and carbon monoxide.

To scale up for commercial application, "You just sort of build a bigger tube," Schmidt says. *– E. Pennisi*

Measuring superconductor magnetic noise

A superconductor carries electrical current without resistance. It also shields itself from the effects of magnetic fields in which it is placed by preventing such fields from penetrating into its interior. But if the electrical current is too high or if the applied magnetic field is sufficiently strong, a superconductor begins to resist the flow of current.

Now researchers have observed measurable, though minuscule, resistance in a thin, superconducting film of yttrium barium copper oxide fashioned into a tiny transformer – even when the applied magnetic field is extremely small.

Frederick C. Wellstood of the University of Maryland at College Park and his collaborators report their findings in the Jan. 4 PHYSICAL REVIEW LETTERS.

Normally, an external magnetic field begins to penetrate a superconductor when the field exceeds a certain critical value. The penetrating magnetic field exists within the superconductor in the form of separate vortices – whirlpools of electric current. The number of vortices present depends on the strength of the magnetic field.

But researchers have also detected vortices when the applied magnetic field is much less than the critical value. "Sometimes the magnetic flux will go in with even the slightest amount of field," says Roger H. Koch of the IBM Thomas J. Watson Research Center in Yorktown Heights, N.Y.

Wellstood and his co-workers apparently measured the electrical resistance caused by the motion of isolated vortices associated with defects in a superconducting thin film. "The picture we have is that there are two low-energy places where a vortex can be," Wellstood says. "It's the rattling back and forth from one to the other that produces the magnetic flux noise." This phenomenon, in turn, leads to resistance and a measurable voltage when an electrical current flows through the material.

"When we did the calculations, we realized that the voltages we were measuring were incredibly small – so small that we didn't know what units to use," Wellstood says.

The researchers came up with "milliattovolt" – one-thousandth of an attovolt, where the prefix "atto" represents 10^{-18}. They didn't realize that the international group charged with defining the modern metric system had anticipated such a possibility and adopted appropriate prefixes (see table).

Power of 10	Prefix	Symbol
24	yotta	Y
21	zetta	Z
-21	zepto	z
-24	yocto	y

Recent additions to metric prefixes list.

Wellstood and his colleagues have already used a special microscope for detecting magnetic fields to confirm that vortices are present in their samples. By increasing the resolution of their instrument, they hope eventually to locate vortices and see how much an individual vortex moves around. *– I. Peterson*

Depressing news for low-cholesterol men

Sometimes you can't win for losing. Case in point: New evidence indicates that elderly men boasting low cholesterol levels also suffer markedly more symptoms of depression than peers with moderate or high cholesterol levels.

If further research confirms this finding, medical attempts to lower concentrations of cholesterol in the blood should probably be restricted to people at high risk of heart disease, contend physician Elizabeth L. Barrett-Connor of the University of California, San Diego, and her colleagues. Additional studies may also find that the elderly have higher "ideal" cholesterol concentrations than younger people, Barrett-Connor's team suggests in the Jan. 9 LANCET.

From 1985 to 1987, the scientists measured the weight, cholesterol levels, and responses to a standard depression questionnaire of 1,020 white men age 50 to 89. Participants were part of a survey, begun in 1972, of risk factors for heart disease. They all worked or had worked in managerial or professional jobs.

Volunteers fell into one of four cholesterol categories: A concentration of less than 160 milligrams of cholesterol per deciliter of blood was considered low; between 160 and 199, normal; between 200 and 239, borderline; and 240 or greater, high.

Among men age 70 and older, nine of 75 in the low-cholesterol group – about 16 percent – reported symptoms of mild to severe depression. From 3 percent to 8 percent of their peers in higher cholesterol groups suffered mild forms of depression or worse. No link emerged between cholesterol and depression among younger men.

A person classed as depressed on the questionnaire does not necessarily meet psychiatric criteria for moderate or severe depression, the researchers note.

Reasons for the association between low cholesterol and more frequent and intense symptoms of depression, as well as the link's restriction to older men, remain unclear, they acknowledge. However, the investigators suspect that low cholesterol helps to produce depression.

Several cholesterol-reduction trials have found unexpected jumps in suicide and other violent deaths, they note. Low cholesterol may foster both aggressive behavior and depression by somehow reducing concentrations of the chemical messenger serotonin, possibly compounding natural serotonin loss in the elderly, the San Diego scientists assert.

Moreover, neither weight loss (which often lowers cholesterol) nor the presence of various medical problems accounted for the link between cholesterol and depression. *– B. Bower*