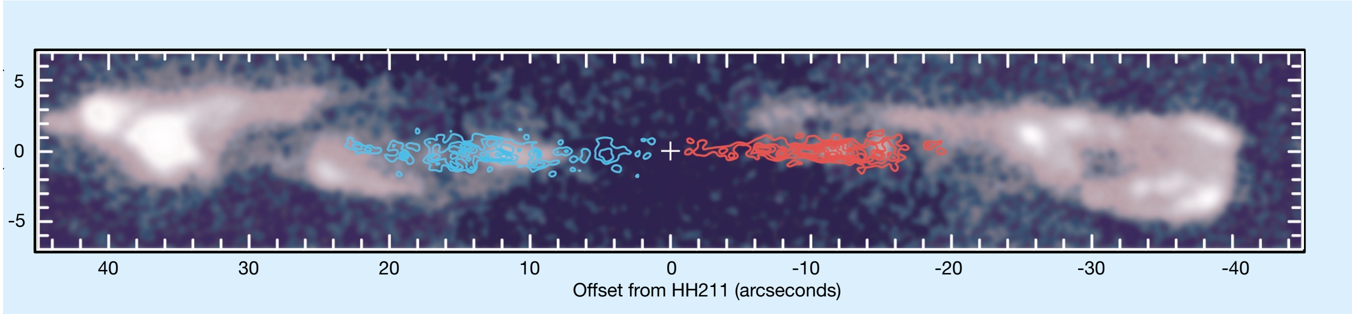

Figure 1 **Models of stellar formation indicate that jets of material form near the poles of young stars and move outwards, forming bipolar outflows, which carry away excess angular momentum. Observations of the young stellar object HH211 reveal two jets in the 2.2-μm molecular transition of molecular hydrogen (grey scale)[11]. High-resolution observations of SiO, which can trace the boundary layers of the material, also show two jets moving in opposite directions (red contours indicate redshifted emission and blue contours blueshifted emission)[12]. The small cross marks the likely location of the protostellar source (HH211) responsible for the formation of the jet. New interferometric observations[1] of a different source in the Cepheus A star-forming region suggest that this particular star is ejecting material in a spherical shell, rather than bipolar jets. If this source turns out to be a young star, this finding would bring current models of star formation into question. (Image courtesy of Claire Chandler.)**

Astrophysics

A stellar performance

Kevin B. Marvel

Using a network of telescopes spread across the United States, astronomers have made a movie of an expanding shell of gas that sheds light on the intricate processes of how a star is born.

Our galaxy is a big place. Even the most fundamental objects in galaxies, the stars themselves, are of huge dimensions compared to human scales and are separated by even greater distances — the Sun has a diameter of 1.4 million km and its nearest neighbour, Alpha Centauri, is 41 trillion km away). Yet despite these vast distances, things change and move about on human timescales. As we orbit about the Sun, we move at an average speed of about 30 km s^{-1}, causing a slow but steady change in the positions of the stars we see each night.

On page 277 of this issue, an international team led by J. M. Torrelles[1] reports some striking observations of a shell of material expanding away from a young star in the Cepheus A star-forming region. The observations indicate that this material was ejected from the young star 33 years ago and is moving into the surrounding medium at the moderate speed of 9 km s^{-1}. The authors also observe that the material forms a spherical shell, contrary to models and observations of similar young stars, in which the ejected material forms two jets that flow in opposite directions.

A star is formed when a large, slowly rotating cloud of dust and gas collapses under the effects of gravity. Models of star formation predict that the jets of material formed near the poles of young stars carry away excess angular momentum (Fig. 1, above). The colour coding in Fig. 1 indicates the Doppler shift of the gas, with blue contours indicating motion towards the Earth, and red contours indicating motion away from the Earth.

A full understanding of the kinematics of an object requires not only observations of Doppler motion, but also measurements of proper motion — the motion of an object in the plane of the sky. Proper motions are exceedingly small because of the vast distances to celestial objects (the distance to Cepheus A is about 30.9 trillion km, for example). Astronomers divide up the sky into angular degrees, such that 90° is the distance from the horizon to a point directly overhead. Barnard's star has the largest measured proper motion, 10.3 seconds of arc per year (1 arcsecond is 1/3,600 of a degree), whereas most stars move only a small fraction of an arcsecond during a year.

At the distance of Cepheus A, a velocity of 10 km s^{-1} completely in the plane of the sky leads to a proper motion of only 3 milliarcseconds per year. Measuring such a small change of position requires extremely high resolution. The resolving power of telescopes increases directly as their diameter increases. But the size of telescopes is limited by cost and material strength, which can be overcome only by combining light from two or more widely separated telescopes — this is the basis of interferometry. One example of this design is the Very Long Baseline Array, a set of ten radio telescopes spread across the United States. It can produce images with resolutions as fine as 100 microarcseconds and can measure relative changes in position as small as 20 microarcseconds, or better, depending on observing frequency and source strength.

Not all objects can be observed using this technique, however. Only very compact, bright objects — or material seen against a bright background — are good targets for very-long-baseline interferometry (VLBI). Torrelles *et al.*[1] picked one of the best targets for their VLBI observations: astrophysical masers. Masers are volumes of molecular gas that can amplify radio waves because there are more molecules in an excited vibrational, rotational or vibrational–rotational state than in the ground state (this is known as population inversion). Water, methanol, SiO and OH can all produce bright and compact maser emission in astrophysical environments.

Astrophysical masers most commonly occur near both old and young stars. Observations similar to those of Torrelles *et al.* have shown that, in many young stars, water masers form and move in association with bipolar jets[2–6]. The proper motions of masers are measured by making several observations of the same source over a period of time, which can be sequenced to form a movie. A sample movie showing the changing distribution of the SiO masers around a mature star has been produced[7]. Proper motions of masers around young stars, combined with their line-of-sight motions determined by Doppler shift, show that the masing material moves at speeds as high as 75–80 km s^{-1} and often traces out shocked regions where the jet collides with the surrounding medium. In contrast, masers near old stars move more slowly (10–30 km s^{-1}) and form spherical shells, although they rarely exhibit perfect symmetry[8–10].

The water masers observed by Torrelles *et al.*[1] seem to be associated with a circular distribution rather than a bipolar outflow, indicating that they are part of an expanding spherical shell. Spread along arcs 0.4–70 AU in size (where 1 AU is the Sun–Earth distance), the masers are expanding at about 9 km s^{-1} and lie on a circle with a radius of about 60 AU. The deviation from a perfect circular fit is less than 0.1%. Because few masers lie away from the circular distribution, it is likely that the shell is quite thin. After determining the position of the centre of the circle, the authors consulted archival radio data and detected a very faint source, probably the young star powering the expanding shell. But the maser circle is not complete, perhaps indicating that other portions of the shell are disrupted by interactions with the surrounding medium or other nearby stars undergoing formation.

The uniform shape and the thinness of the maser arc in Cepheus A strongly suggest that the material originated in a single, short-lived ejection event. If the object associated with this maser distribution is a young star, as Torrelles *et al.* argue, this means that, at the very earliest stages of stellar formation, mass can be ejected in episodic, spherically symmetric and brief events. Further observations, looking for molecules associated with stellar jets such as molecular hydrogen or SiO, would help to prove that the source is young, but the necessary resolution is not yet available. The planned Atacama Large Millimeter Array, a large interferometer to be built through international collaboration in Chile, could help shed light on the exact nature of the source when it is completed.

Existing theories of stellar formation cannot explain this unique source, so there is a chance it could actually be a mature star. The current observations only reveal details about the masers themselves, not their stellar host, and so we cannot be entirely certain of the host star's age. Only time will tell if the source that has formed this symmetric shell of water masers will eject more material, perhaps allowing a sequel to the stunning set of images presented by Torrelles and colleagues. ■

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Neurobiology

Snails, synapses and smokers

Dennis A. Dougherty and Henry A. Lester

The discovery of a protein that controls the transmission of nerve impulses in snails is significant in its own right. It also advances our understanding of the vertebrate neurotransmitter receptor that responds to nicotine.

On pages 261 and 269 of this issue[1,2], Sixma and colleagues describe how they identified a protein, found in snails, that controls communication between nerve cells; how they characterized that protein's properties; and how they analysed its structure on the atomic scale. This comprehensive set of studies is impressive in itself. Even more important, the structure reveals the essential features of a key region of the nicotinic acetylcholine receptor — the prototypical member of a group of proteins with diverse roles in vertebrate and invertebrate nervous systems. How can we be so sure that a small soluble protein from a snail is relevant to a receptor in the vertebrate central nervous system? First, the amino-acid sequences of the snail protein and of the relevant portion of the vertebrate receptor are similar. And second, the new structure rationalizes almost every result from over 40 years of biochemical and electrophysiological studies of the vertebrate receptor.

Communication between neurons occurs at junctions known as synapses. When stimulated, the presynaptic neuron releases a neurotransmitter, such as acetylcholine at 'cholinergic' synapses. The neurotransmitter diffuses away, and some binds to receptors, which are large proteins in the membrane of the postsynaptic neuron. The nicotinic acetylcholine receptor not only has a binding site for the neurotransmitter, but also has a channel portion (Fig. 1a); when the receptor binds acetylcholine or other 'agonists' (including nicotine), the channel opens to allow ions to flow.

Sixma and colleagues[1] started by studying a cholinergic synapse in cultured snail neurons. They detected the new protein —

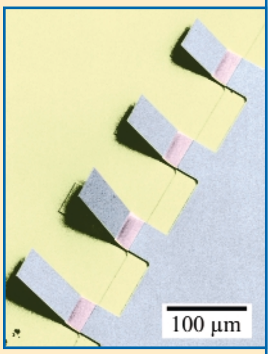
Micromachines

Strain against the machine

The world of microelectromechanical systems (MEMS) is a tiny one, in which fully functional devices, ranging from electronic circuits to biosensors, operate on micrometre scales. Unfortunately, this world is still mostly a dream, because important elements such as hinges are not only difficult to make but also break easily. P. O. Vaccaro *et al.* address this issue by using elastic strain to make a hinge that moves itself into position (*Applied Physics Letters* **78,** 2852–2854; 2001).

The first generation of MEMS devices was limited to only two dimensions as they were formed by etching techniques. Making devices in three dimensions provides much more flexibility and functionality. This can be done by using hinges that rise above the base layer, known as the substrate. But previous attempts at making hinges involved many steps that required manual or electrostatic intervention. Furthermore, these conventional hinges are prone to defects, tend to stick, and may wear out quickly as sliding parts rub against each other.

Vaccaro *et al.* have taken a simpler approach by bonding two different semiconductors (indium–gallium–arsenide and gallium–arsenide) together to form part of their MEMS device. These materials have different-sized unit cells in their crystal lattices, and the mismatch causes strain. When the semiconductor layers are released from the substrate by etching, they stand up by themselves (see picture). This effect is similar to the way the bimetallic strip works in thermostats — it flexes according to changes in temperature because of the strain between the two metals. The authors also deposited a reflective layer on top of the strain layer to make the hinges into tiny mirrors.



These hinges appear to be fairly robust — they bend with ease and move back to their original position after bending. By creating hinges of different lengths, the authors can change the angle of the mirrors relative to the substrate. More generally, by varying the amount of indium, or by using different materials altogether, the authors can design mirrors with specified angles. And because there aren't any other moving parts, wear and tear shouldn't be a problem. **Josette Chen**