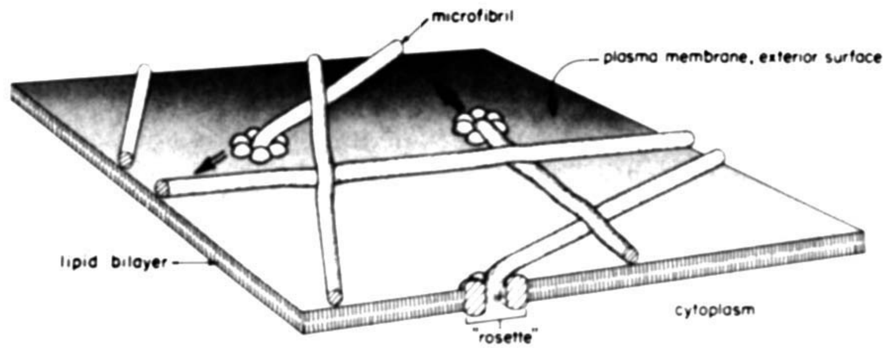

Fig 2 Model of microfibril deposition during primary wall formation in *Micrasterias*. Above: side view. Below: surface view. Single rosettes apparently give rise to randomly oriented microfibrils. (from Giddings *et al. op. cit.*)

turgor for visualizing the terminal complexes. A brief (1 min) exposure to glycerol before freezing causes the cells to lose turgor whereupon microfibril impressions are no longer observed. An accompanying paper by Giddings, Brower and Staehelin (*J. Cell Biol.* **84**, 327; 1980) proposes a similar view of cellulose biosynthesis drawn from work on the green alga *Micrasterias denticulata*. Here, the hexagonal rosette, together with the central microfibril-terminating subunit, are pictured as a transmembrane complex responsible for the elaboration of the basic single 5 nm cellulose microfibril (Fig. 2). Rows of such complexes are believed to form sets of microfibrils which aggregate laterally to form the larger fibrils composing the secondary wall. This view of wall formation in *Micrasterias* supports that of Kiermayer and Dobberstein (Protoplasma, **77**, 437; 1979) who also indicated that these specialized areas of membrane are derived by the insertion of Golgi-derived 'flat vesicles' into the plasma membrane.

These investigators are properly cautious in designating these particle complexes as the cellulose synthesizing machinery. However, if correct, the next major question for plant morphogenesis is what determines the orientation of cellulose deposition and hence plant cell shape. Perhaps the linearity of crystalline cellulose fibrils is sufficient to steer through the membrane the ordered groups of particle complexes which extrude them. On the other hand, there are grounds to believe (in higher plants) that cytoplasmic microtubules, which may be bridged to the plasma membrane, influence the orientation of cellulose deposition — but that is another story. □

Interstellar violence observed

from Robert Kirshner

SUPERSONIC shocks created by stellar winds or supernova explosions are capable of heating large volumes of the interstellar gas in our Galaxy to temperatures approaching those of the solar corona. Thermal emission from this torrid interstellar medium emerges as soft X rays in the vicinity of 1 kV. The A-2 experiment on the HEAO-1 satellite spent the time from its launch in August 1977 until its demise in January 1979 in a patient effort to construct an all-sky map in soft X rays. The virtue of this approach is that it can reveal new sources in unexpected places and that it can detect very large and nearby objects that are too diffuse for imaging detectors. This scheme has paid off handsomely in the discovery of a very large (13° diameter) soft X-ray source in the constellation Cygnus which may be the fossil remains of a series of violent explosions in the interstellar gas.

As reported at a recent American Astronomical Society Meeting (San Francisco, 16 January, 1980) Webster Cash of the University of Colorado and his collaborators from Berkeley, Caltech and the Jet Propulsion Laboratory have examined a portion of the soft X-ray survey. From their map of the Cygnus region, they find several known supernova remnants together with an immense horseshoe of emission they term an X-ray superbubble. Their data show that the emission comes from gas near 2 million K, and that there is substantial cold gas between us and the emission source which absorbs many of the X rays. From the absorption data, Cash *et al.* estimate that the distance to the giant loop of X-ray emission is about 2 kiloparsecs. Although the distance is uncertain, it implies that the diameter of the X-ray source is an astonishing 450 parsecs, 10 times larger than an ordinary supernova remnant. From the distance and the observed X-ray flux, they use the estimated temperature to derive an electron density of about 0.02 cm^{-3}, and a total thermal energy content of about 6×10^{51} erg. This is about an order of magnitude larger than the total energy output of an ordinary supernova.

To understand this object, Cash *et al.* have considered its possible relation to other interesting objects in the same region of the galactic plane. A ring of optical filaments emitting Hα coincides with the boundary of the X-ray ring. The HEAO-1 observers suggest that the same interstellar shock which has heated the interstellar gas to produce the X-rays may be responsible for exciting these optical filaments. A large expanding loop of neutral hydrogen, one of several reported by Carl Heiles on the basis of 21 cm observations (*Astrophys. J.* **229**, 533; 1979), lies in the same direction. The most important object in the region is the group of young stars known as the Cygnus OB2 association, which lies within the boundaries of the X-ray source.

This assembly of hot and luminous stars might provide the energy for the X-ray superbubble, either through a slow sustained energy input due to violent stellar winds or by impulsive energy input from supernova explosions of the most massive stars in the association. Cash *et al.* show that a single supernova explosion would require 10^{54} erg to create the X-ray source, an energy 10^3 times larger than any observed supernova. The energy demands need not be so severe if the supernovae are frequent enough. In that case, each succesive event will take place in the low density cavity blown in the interstellar gas by its predecessor. In this way, a bubble of the immense size observed with HEAO-1 could be created by several successive supernova explosions in the OB association.

The Cygnus superbubble is not the only large region of the interstellar gas which has been observed to be filled with a hot low-density medium. Reynolds and Ogden (*Astrophys. J.* **229**, 942; 1979) have examined the energetics and kinematics of a 280 parsec diameter region which is connected to the I Orion OB association that excites the Orion Nebula. Just as in the Cygnus case, faint Hα filaments and 21 cm features outline a large soft X-ray source. Because the Orion bubble is only 460 parsec away, this object covers a full 40° on the sky. The measurements of Reynolds and Ogden show that the optical filaments are expanding at about 20 km s^{-1}. The picture in Orion, as in Cygnus, seems to be that several stars from the OB association have already lived out their lives and detonated as supernovae, carving out a large, hot bubble in the interstellar gas from their overlapping shock waves.

The idea that a substantial fraction of the interstellar medium might be maintained at a temperature of 10^6 K and a density near 10^{-2} cm^{-3} by means of overlapping supernova remnants is not new. In 1974, Cox and Smith (*Astrophys. J. Lett.* **189**, 105; 1974) pointed out that supernova explosions are frequent enough that their remnants might often connect, and more recently McKee and Ostriker (*Astrophys. J.* **218**, 148; 1977) have developed a comprehensive model for the interstellar

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medium which predicts that coronal gas, in rough pressure equilibrium with cooler phases of interstellar gas, may fill a substantial fraction of the galactic disk. The HEAO-1 survey, and particularly the new Cygnus superbubble, provide direct evidence that the mechanisms envisioned by these theorists actually do take place. Both the Cygnus object and the Orion bubble emphasize that OB associations, where large collections of massive stars can be found, may play a prominent part in creating the overlapping supernova remnants that can fill large portions of the galaxy with coronal gas. □

Topical fusion

from M. Keith Matzen

EDWARD Teller (Lawrence Livermore Laboratory) opened a recent meeting on inertial confinement fusion (ICF)* by stressing the importance of research over premature emphasis on development. We were reminded that an ICF reactor is technologically more complex than a fission reactor, that it took 20 years to develop an economically feasible fission power plant after the demonstration of the first fission reactor, and that the first demonstration of an ICF reactor is many years away. Teller believes that there is a "small chance" that a magnetic fusion reactor could be built in this century, but that the chances of an ICF reactor in the same time are "extremely remote". On the other hand he believes that a magnetic fusion-fission hybrid could be built in about 10 years and should be pursued as an energy-producing alternative.

According to Lawrence Killion (Department of Energy, Office of Inertial Fusion) the emphasis in the ICF programme during the next decade will be to define an appropriate driver. He stated that lasers are no longer considered necessarily to be the dominant long-term driver because of their high cost and the uncertainties in the laser–target coupling. The goals for the programme in the 1980s must include the demonstration of a high-gain driver–target system, the determination of the size of a reactor driver, the understanding of driver–target coupling, the achievement of breakthroughs in driver technology, and the achievement of breakthroughs in target fabrication technology.

John Nuckolls (LLL) provided further requirements and perspectives for future ICF research. The basic requirement of an ICF reactor system is an energy gain of greater than 100 with a driver energy of less than 10 MJ (10^7 Joules). Computer calculations now predict that an energy gain of 100 can be obtained with driver energies of 2 MJ (± a factor of 3). He stated this energy requirement had not changed in several years, in contrast to the inflation of the driver energy required for breakeven (gain 1) targets. The increase in the break-even driver energy from 1 kJ (see *Nature* **239**, 139; 1972) to the present estimate of 300 kJ (± a factor of 3) is due to the inability to approach the theoretical limits of the early calculations, both in laser technology and in laser–target coupling physics.

The importance of understanding the laser–target coupling physics can be illustrated by a number of key theoretical issues: fast electron transport, competition between Brillouin scattering and inverse bremsstrahlung absorption, production of fast electrons, and beam filamentation. He suggested that future experimental work should emphasize studies with longer pulse lengths and shorter wavelengths, measurements of the underdense plasma, studies of the fast electron production and transport, and studies of bandwidth effects. Although ions (both heavy and light) must solve problems of achieving sufficient power density on target, their target-coupling problems seem minimal. There is a rigorous upper limit for the ion range in a target and there are apparently no problems with fuel preheat from the electron and nuclear reactions. The problem of transporting ion beams to the target is difficult but seems to be soluble. In summary, Nuckolls gave the following estimates for the parameters of a driver for an ICF reactor: 3 MJ energy, 150 TW power, 5-10% efficient, beam focusable to less than 5 mm, 5 Hz repetition rate, cost less than 10^9 dollars, and operate for 10^{10} shots. The candidate reactor drivers are short wavelength lasers (KrF for example), heavy ion beams (HIB), and light ion beams (LIB). The drivers that may show target ignition (DT gain ~ 5, target gain ~ 0.1) in the mid 1980s are Nova (at Lawrence Livermore Labs) and PBFA (at Sandia National Labs).

The recent emphasis in experimental programmes has been in the areas of intermediate density targets (10 times liquid DT density), techniques for measuring these compressed densities, X-ray backlighting techniques, ablative acceleration of thin foils, characterizing the back-reflected laser light, characterizing the thermal conductivity and fast-electron production by using multiple-layer targets, measuring the driver–target coupling efficiency, and experiments to examine the stability of implosion systems. With the trend towards shorter wavelength laser-drivers, several laboratories have begun experiments with doubled, tripled, and quadrupled glass laser light (wavelengths of 0.53, 0.35, and 0.26 μm, respectively). Although most experiments are still in their initial stages, the early results generally show better coupling to the target, decreased fast electron production, and better thermal conduction as the laser wavelength decreases. However, Fred Mayer (KMS Fusion) presented measurements in which the same absorption was observed for 0.53 μm and 1.06 μm irradiation of spherical targets with 60 to 100 ps pulses. These results are in contrast to the strong wavelength dependence observed in 0.26 μm, 0.53 μm, and 1.06 μm irradiation of planar targets (Fabre *et al.*, Ecole Polytechnique Palaiseau, France). The near future will see a great deal of effort devoted to short-wavelength ($\leqslant 0.53$ μm) irradiation experiments.

ICF reactor designs are still in the conceptual stages. Protection of the reactor walls from the radiation environment is a major consideration. Several reactor designs have been considered, although flowing-liquid-metal-walled reactors have received most attention and represent the only design in which protection is provided against all the fusion reaction products. Jerry Kulcinski (University of Wisconsin) reported that work is needed in the areas of fusion reactor economics, safety and environmental impact, as well as in recovery of pellet debris, protection of final focusing elements, small LIB reactors, minimum sized HIB reactors, and pulsed neutron damage. Both Kulcinski and Noel Amherd (EPRI) stated that LIB technology appears to offer the only approach to small ICF reactors at this time. John Caird (Bechtel National, Inc.) has projected the capital cost of a HIB power plant to be from 4.2 to 6.6 billion dollars for plants in the range from 1.125 to 2.25×10^9 Watts-electrical.

With the trend towards larger, more complicated high-gain targets, the technology of target fabrication continues to be challenged. High-gain targets, in general, consist of multiple shells and larger aspect ratios (ratio of spherical shell radius to shell thickness). Thus the questions of target-shell finish and stability of implosion become more important. The technology for building these multishell targets is not yet available. At this meeting, the emphasis was on target-shell and fuel-fill characterization techniques, pellet fabrication methods and mass production of pellets. Novel approaches to target fabrication include using a low-gravity environment to form large-diameter spherical bubbles, laser drilling of 2 to 4 μm holes in microballoons, followed by gas filling and hole plugging, and structural modification of polymers to reduce crystallinity and improve the surface finish. Nondestructive fuel fill characterizations is another area of active research.

Progress on the construction of new, larger drivers continues. Nova, the 100 kJ, 1-3 ns glass facility at Lawrence Livermore Laboratory should be available for target

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*The topical meeting on Inertial Confinement Fusion (ICF) was held in conjunction with the Conference on Laser and Electro-Optical Systems (CLEOS) in San Diego, California, February 26-28, 1980.

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