carbon fragments irreversibly as methane, thereby driving the C–C cleavage reaction to completion. The organometallic product also forms a strong metal–phenyl bond, which undoubtedly contributes to making the C–C cleavage reaction more favourable.

One reason for the difficulty of inserting into the C–C bonds in saturated hydrocarbons is that the two carbon atoms contain 'directed' sp^3 hybridized orbitals that lie directly along the bond axis. The inaccessibility of these orbitals makes the bond less reactive. Milstein's system cleaves the bond between sp^2 and sp^3 hybridized carbons, which are abundant in petroleum resources. The sp^3 hybridized carbon contains additional orbitals with which the metal may interact, allowing it to get close to the C–C bond before the actual cleavage.

That C–H bond activation occurs reversibly, but that C–C activation once it takes place is made irreversible by hydrogenation implies that the anchoring of the aromatic group to the metal centre may not be a requirement for C–C cleavage to occur. If so, then free alkylated aromatic hydrocarbons might also be subject to attack. Many metal systems are known to reversibly activate aliphatic hydrocarbons, so it may ultimately become possible to cleave these sp^3–sp^3 C–C bonds. In this sense, the new work opens the door to further studies that may change the way petroleum is processed. □

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ASTRONOMY

Being around at the death

Harm Habing and Paul Murdin

As its hydrogen fuel runs out, in five billion years, the Sun will become a red giant — a star so large (30 per cent of the size of Jupiter's orbit) that the Earth will be swallowed and evaporated. At its centre it will have a small, very hot and dense core, made of oxygen and carbon; the core will be surrounded by an envelope of helium and hydrogen at very low density. This envelope will be gradually ejected into space. Jupiter will raise large tides on the solar surface, and make the Sun spin faster, causing the solar wind to blow into an elliptical shell. Finally, when the solar core is bare, the Sun will become a white dwarf — a tiny, hot star that slowly fades and cools. The white dwarf will ionize the solar wind, and other civilizations in the Galaxy will observe a fine non-circular planetary nebula where the Sun once was. Such is our future, as foretold by N. Soker (Oranim, Israel) at a meeting* last month.

The matter that surrounds many dying stars was the theme for the conference. It was the first time that astronomers interested in modest stars, such as our Sun, met colleagues with an interest in more massive stars, which, in contrast to our Sun, die as supernovae. In both cases, circumstellar material alters the appearance and the evolution of the object.

The detailed study of this material has become possible in recent times thanks to technical progress and luck. Luck is represented by two nearby supernovae — SN1987A in the Large Magellanic Cloud, and another this year (SN1993J) in the nearby spiral galaxy, M81 — both of which revealed circumstellar material generated earlier by the exploding stars. Technical progress has come in the form of the sensational maps taken with the new French–German millimetre-wave array of interferometers (see figure on next page). M. Guelin (IRAM, Grenoble) showed these maps of circumstellar nebulae with an angular resolution of about 100 stellar radii, maps that allow the measurements of temperatures, densities and outflow velocities.

What controls the outflow from red giant stars? Outflowing matter cools rapidly and a fraction of the gas condenses into small solid particles. The solid particles are accelerated outwards by radiation pressure from the star, and they carry the gas along by friction. The warm particles are detected by their infrared emission. They exist, but why? Normal condensation processes in operation on Earth do not work so far out of thermodynamic equilibrium.

For one of the two main species — carbon-containing particles — the chemistry, if not the physics, is available from the 'Detroit connection': the study of the formation of soot in the exhaust of cars (A. Tielens, NASA/Ames). Acetylene (C_2H_2) combines to form benzene rings, which agglomerate into planes of polyaromatic hydrocarbons. These stack into

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**Circumstellar Media in the Late Stages of Stellar Evolution*, 34th Herstmonceux Conference, Royal Greenwich Observatory and the Institute of Astronomy, Cambridge, UK. 12–17 July 1993.

RÉSUMÉ

Heart of coke?

WHAT is at the centre of the Earth? Going by the cosmic abundances of the elements, the core is chiefly iron with about 8% nickel, but a lighter element must also be present to account for its density. Sulphur is the popular candidate; carbon has been reckoned too volatile to be present in substantial concentrations. But Bernard Wood believes that something has been overlooked: the volatility strongly depends on pressure (*Earth planet. Sci. Lett.* **117**, 593–607; 1993). From calculated phase diagrams and experiments, he shows that at 0.01–5 GPa, pressures applicable during the Earth's accretion, 2–4 wt% carbon could have been stable in the iron-rich melt. Even if the core started out overall with a mere 0.5 – 0.6 wt% carbon, the phase that first precipitated out, and hence forms the solid inner core, could well be iron carbide (Fe_3C), rather than an iron–nickel solid solution.

End game

THE *Listeria* bacillus, once infamously said to nestle in every Camembert, drives itself by throwing out an ever-growing bundle of actin filaments from one end. Its passage through the host cell cytoplasm is marked by an exhaust of actin. Last year C. Kocks *et al.* reported that the formation of the actin tail fibre was inseparable from the expression of a gene, coding for a protein which they called ActA. They have now shown by immunofluorescence (*J. Cell Sci.* **105**, 699–710; 1993) that the protein is indeed absent from one end of the bacterial surface and abundant at the other. It is laid down asymmetrically at cell division, and evidently seeds actin polymerization. Another protein, not yet identified, must cross-link the F-actin filaments into a tail. Kocks *et al.* offer the conjecture that actin nucleation is regulated by the local ATP/ADP balance and note that in the related pathogen, *Shigella*, a protein which may do the same office as ActA possesses ATPase activity.

Soldering on

LEAD-free solders are highly desirable, given the toxicity of lead. Alloys of silver and tin offer high resistance to fatigue — welcome news to those who torture their circuits by repeated bending or thermal cycling — but frequently suffer from non-uniformity and surface roughness. By adding just a smattering of zinc to an alloy of Sn–3.5 wt% Ag, M. McCormack and colleagues have now developed a solder in which the microstructure is much more uniform. Gone are the pervading dendrites of nearly pure, soft tin found in the binary alloy; instead, an alloy with 1 wt% added zinc shows a fine dispersion of Ag_3Sn precipitates, giving it a peak strength 48% higher than the zinc-free equivalent, and an order of magnitude better high-temperature creep resistance.