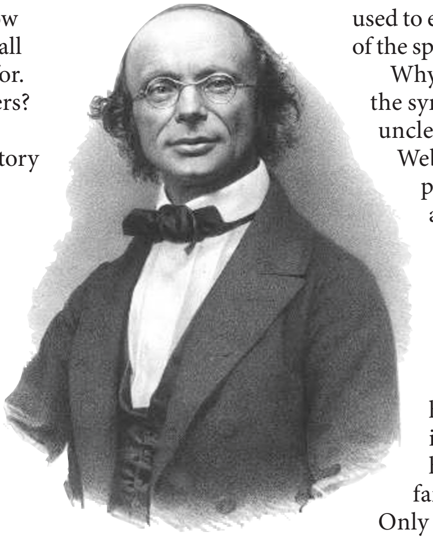
c the light



Of course, we all know that $E = mc^2$, and we all know what *c* stands for. But why 'c', of all letters? Kenneth Mendelson brings the symbol's story to light (*Am. J. Phys.* **74,** 995–997; 2006).

The use of the character c in this context can be traced back to Wilhelm Weber (pictured), who, in 1852, used it to denote the ratio of electrical charge units; charge units can be defined either via the force between two static charges or via the attraction between two current elements. One approach involves the permittivity, the other the permeability of the vacuum — ε_0 and μ_0, respectively — and it was soon realized that these two entities could be used to express the value of the speed of light.

Why Weber chose the symbol c remains unclear, but it is Weber's c that prevailed over alternative notations — most notably the 'V' that Maxwell came up with and Einstein used in his 1905 paper introducing his most famous formula. Only in 1907 did Einstein change his habit and start using c instead of V, but soon enough to ensure that c, not V, entered the popular culture.

CHAINED TOGETHER

The notion of a 'thin' wire can be pushed to the extreme. By mechanically stretching the contact between two metal electrodes until it is reduced to a short chain of only a handful of atoms, it's possible to create wires that are only one atom thick.

Such atomic chains have been studied in pure systems of one metal — but can different atomic species be strung together? Jefferson Bettini and colleagues show that alloying can indeed persist down to the atomic scale (*Nature Nanotech.* doi:10.1038/nnano.2006.132; 2006).

Bettini *et al.* produced atomic wires from gold–silver alloys, making chains of typically three atoms hanging between the metal electrodes. Transmission-electron micrographs and simulations suggest that two of the atoms in the chain are silver and one gold — a surprising result, as many materials are known to expel impurities at the nanoscale.

The convergence of the twain

Helium-3 is rare, and expensive (as anyone who has accidentally vented a closed-cycle ^{3}He cryostat knows). Its relative abundance in the Universe is about 0.001 percent — unchanged since a few minutes after the Big Bang.

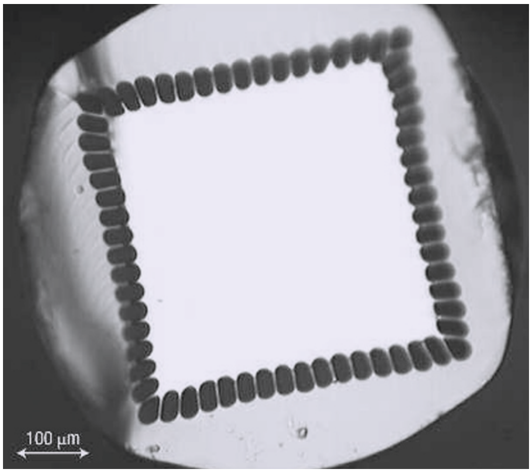
But according to models of star evolution, low-mass stars (up to two solar masses) produce helium (both ^{3}He and ^{4}He) by fusing hydrogen. As the heavier He gravitates to the core and heats up, an outer shell of H forms and continues producing He. When the core gets hot enough, He undergoes fusion into carbon, which leads to a new C core and another shell layer. Larger stars can continue this process, with carbon fusing into neon, neon into oxygen, oxygen into silicon and silicon into iron (heavier elements require a supernova furnace). All the while, the outermost shell produces ^{3}He. And yet the abundance is measurably stable.

Peter Eggleton and collaborators think they know why (*Science* doi:10.1126/science.1133065; 2006). They use a three-dimensional hydrodynamic simulation of a low-mass star to reconcile stellar and Big Bang nucleosynthesis. They find that just outside the He core, an unexpected mixing mechanism churns up bubbles, slightly depleted in ^{3}He, to the surface. Fresh ^{3}He then enters the turbulent mixing region to be burned away.

Horizontal lasing matters

Atom lasers, which produce coherent and concentrated beams of matter waves, need two components: an atomic trap in which a Bose–Einstein condensate (BEC) is formed, and some means to allow a fraction of the atoms held within the trap to leak out controllably. The latter is commonly achieved by perturbing the BEC with a radiofrequency field, which causes some of its atoms to break free of the trap and fall vertically under gravity. Unfortunately, the acceleration of the free-falling matter waves causes their wavelengths to continuously shorten, limiting their use in atom interferometry and related applications. To enable better control of the motion, and therefore the wavelength, of the matter beams extracted from a BEC, William Guerin and colleagues have developed an atom laser that emits its beam horizontally by coupling it into an atom waveguide — directly analogous to the coupling of light from a conventional laser with an optical fibre (*Phys. Rev. Lett.* **97,** 200402; 2006).

Hip to be square



© JOHN HAYES

There are many advantages in using optical fibres rather than conventional focusing optics to guide the light generated by high-power industrial processing lasers — the most obvious being that it reduces the potential exposure of workers to injury. For many industrial applications, the ideal intensity profile of the laser spot at its final destination is that of a 'top-hat' — in which the intensity at the edge of the spot rises sharply from zero to a constant value — and the ideal shape of the spot is a square. To this end, John Hayes and colleagues have constructed an optical fibre that consists of a square silica core surrounded by air holes and tethered to a protective silica jacket (*Opt. Express* **14,** 10345–10350; 2006). Despite its simplicity, this structure (pictured) performs remarkably well, which the authors demonstrate by cutting flat, square holes in a transparent conducting film, without the need for complex beam shaping optics at the exit of the fibre.