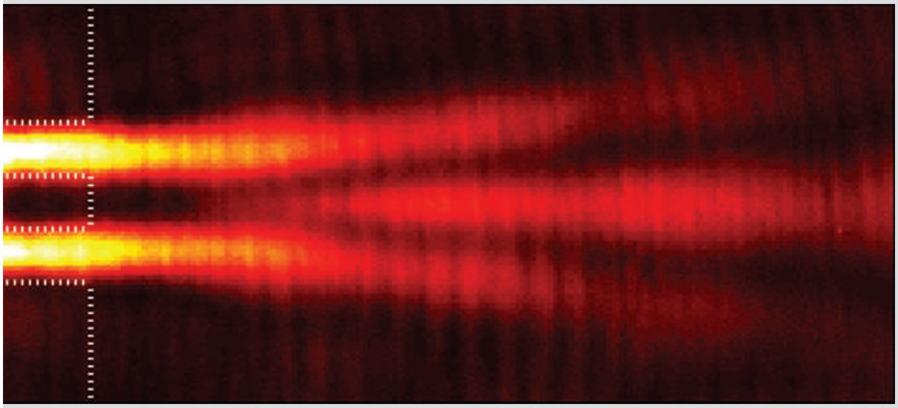
PLASMONICS

# New first for double slits



The double-slit experiment has a long and distinguished history in physics and optics that can be traced back to the work of Thomas Young in 1805. This venerable experiment has now been performed with objects that are part-light, part-electron. On page 426 of this issue Rashid Zia and Mark Brongersma of Stanford University report that they have observed the diffraction and interference of surface plasmon polaritons (SPPs) — electromagnetic waves that are coupled to the free electrons in a metal — for the first time (*Nature Nanotech.* **2,** 426–429; 2007).

In its simplest form the double-slit experiment involves sending waves through two slits in a screen and observing the interference pattern they create on another screen. This pattern is not a simple shadow of the two slits but a series of bright and dark fringes: if the waves from the two slits are in phase when they arrive at the second screen, constructive interference produces a bright fringe; however, if they are out of phase, they cancel each other out, resulting in a dark fringe.

Interference patterns can also be observed when particles are used instead of waves, thus demonstrating the well-known wave-particle duality of quantum mechanics. Over the years these demonstrations have been performed with larger and larger particles, including atoms and molecules. Moreover, interference patterns have been observed when there was just one photon or particle in the apparatus at a given time, confirming that it is the two possible paths — rather than the photons or particles themselves — that actually interfere, as predicted by quantum theory.

Zia and Brongersma used electron-beam lithography to pattern a 48-nm-thick gold film on a glass surface so that it contained two 2-μm-wide slits that were 2 μm apart. The SPPs were excited on one side of the slits with a laser, and a photon scanning tunnelling microscope probed their intensity on the other side (see Fig. 1a on page 427). The image above shows the near-field intensity measured by the microscope as the SPPs travel from left to right through the slits and then diffract and interfere to form a three-peaked distribution (yellow corresponds to the highest intensities). The results agree with theory if it is assumed that SPPs are only supported by metal stripes with widths above a certain minimum value. The existence or otherwise of such a diffraction limit for SPPs has been the subject of controversy for a number of years.

**Peter Rodgers**

THERMODYNAMICS

# Highs and lows in the density of water

Water contracts when it is cooled but, unlike other liquids, it then starts to expand at temperatures a few degrees above the melting point of ice. However, a new experimental study suggests that normal behaviour returns if the water is supercooled to low enough temperatures.

Austen Angell
**is in the Department of Chemistry and Biochemistry, Arizona State University, Tempe, Arizona 85287 and the School of Chemistry, University of Sydney, New South Wales 2006, Australia.**
**e-mail: caa@asu.edu**

Among the many unusual properties of water, the most famous is probably the fact that its density reaches a maximum a few degrees above the melting point of ice. On cooling to 4 °C, water stops contracting and starts to expand, whereas most liquids contract continuously when they are cooled. This anomalous behaviour persists even when water is supercooled — that is, cooled below the temperature at which, under equilibrium conditions, it would form ice.

Ice crystals typically nucleate near defects, such as cracks or dust particles, but bulk samples of extremely clean water can be supercooled to just below −31 °C at 1 atm (smaller, 2 μm droplets can be cooled to just below −40 °C). Below this temperature, known as the homogeneous nucleation temperature of water, $T_h$, it becomes nearly impossible to avoid crystallization and freezing occurs spectacularly fast, with ice needles shooting through the liquid faster than the eye can follow. Indeed, only high pressures or huge quenching rates (>$10^5$ degrees per