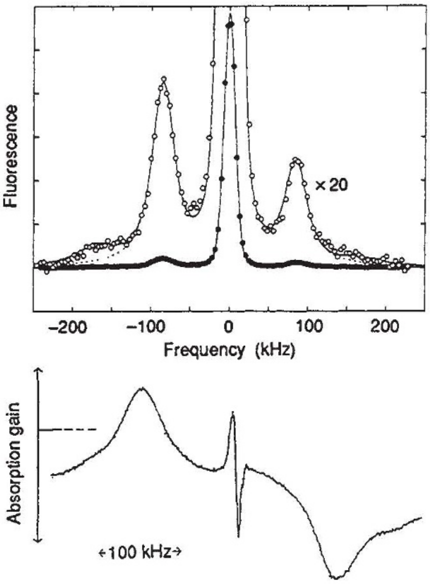

Crystal clear: two spectra reveal quantized motion of atoms trapped in an array of light-force-induced potential wells in a standing wave of laser light. Top, Jessen *et al.* recorded the spectrum of the trapping light scattered by the trapped atoms. Below, Verkerk *et al.* used a second laser beam to probe the atoms and found absorption at higher energies and stimulated emission at lower energies (broad dip and peak). In addition they observed a very narrow central feature which indicates long-range order over many wavelengths.

the light–atom interaction would raise the average energy above the well depth in a few microseconds.) This is also done with light, using laser cooling in which many photons scatter off a moving atom, slowing it down. This method reduces the temperature for the atomic motion to just a few microkelvin, low enough for most of the atoms to be in the lowest level of the well.

In each of the new experiments, a one-dimensional laser standing wave was used for simplicity. A cloud a few millimetres across, with 10^8 atoms cooled to a temperature of a few microkelvin, was placed in the standing wave. Jessen *et al.* probed the atoms by recording the spectrum of the scattered light (top figure). High resolution was obtained by mixing the atomic fluorescence with light at the same frequency as the incident laser beams. This optical heterodyne technique enables the small difference introduced in the scattering process to be seen directly on a Fourier transform spectrum analyser.

The central peak in the spectrum is light scattered at the laser frequency. Its width is less than the natural atomic linewidth; this alone implies that the atomic motion is localized to less than an optical wavelength (which causes narrowing of the spectrum by the Lamb–Dicke effect). The two sidebands are shifted by a frequency equal to the level separation in the optical potential wells, and will be recognized by spectroscopists as Raman transitions which transfer the atom from one level to another in the well. A classical oscillator would also have sidebands, but the quantum nature of the motion here is shown by the asymmetry between the red and blue sidebands; the difference in strength is due to the population difference between adjacent levels. At the lowest temperatures achieved, the results imply that 60 per cent of the atomic population is in the lowest level of the well.

Verkerk *et al.* recorded the absorption spectrum of a second, weak beam directed almost parallel to one of the two travelling waves of the radiation field to identify their 'crystal' (lower figure). The frequency of the probe is scanned a few hundred kilohertz above and below the frequency of the standing wave (pump frequency). Once again there are two features in the spectrum which correspond to Raman transitions transferring an atom between levels in the quantum well. And they also indicate the presence of a significant difference in population between levels. When the probe frequency is 100 kHz above that of the pump, there is absorption of the probe through Raman transitions which transfer atoms from the lowest to the next higher levels in the wells. 100 kHz below the pump frequency, the probe is not absorbed but instead is amplified: it stimulates atoms excited to a higher level (by the standing-wave radiation) to radiate their energy and drop down again. Indeed, laser action (light amplification by stimulated emission) has been obtained off a similar transition using cold atoms in a magneto-optical trap by another group in Paris.

Between the two Raman features, there is an extremely narrow central structure. The explanation of this is more involved, but a crucial feature is that many wells of the periodic potential are involved, each having an atomic population. The pump beams are scattered through Bragg diffraction off the whole atomic distribution, producing a wave which interferes with the probe beam by two-wave mixing — the authors were observing the special quantum-optical properties of the collection of atoms, an atomic sample which is in a state intermediate between vaporous (or fluid) and crystalline. The magnetic properties of the sample are involved. For example, one can deduce that atoms in alternate quantum wells have their angular momentum aligned in alternate directions — the light-trapped lattice has an antiferromagnetic structure. □

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DAEDALUS

The wages of sin

THE mass media are widely feared. They can force publicity, unwelcome and even disastrous, on any individual, whose only defence is an expensive and uncertain libel action. More effective privacy laws seem impossible to formulate. Last week Daedalus proposed a computerized market in personal data, forcing bureaucrats to pay for their intrusive demands. He now plans to extend it to the media.

The principle is very simple. Advertisers already pay the media a free-market price to publicize their claims. Conversely, people who are unwillingly publicized by the media should be legally entitled to a free-market payment.

Take, for example, that enduring favourite of the British tabloid press, the hapless vicar or religious dignitary caught in some sexual misdemeanour. Give the victim a legal right to bargain for recompense, and his claim is at once subject to market forces. Suppose the price is set too high. Vicars all over the country will leap into bed with their parishioners to claim the wages of sin. The market will be saturated, and the price will plummet. A going rate will soon emerge, at which the supply of naughty vicars exactly equals the demand. Thereafter, any vicar exposed by the press could automatically demand the going-rate payment. Rarely traded stocks, like those of amorous cabinet ministers, would of course be more volatile: even so, payment would be spread far more fairly than by the current system, in which a mass of disregarded victims is balanced by the occasional libel millionaire.

Privacy will thus acquire a fair market price. The media will remain uncensored, but will pay for what they now steal. Furthermore, payments will go to the victims, not the unsavoury crew of snoopers, informers and photographers who now shop them to the media for money. A criminal who shops his own accomplice, however, or a mistress who informs on her own lover, could be sued by the other party for a defined share of the takings.

A distributed computer-net, like those of the financial world, could easily convert thousands of such daily bargains into a set of going rates for the various categories of news. They will be most revealing. A simple photograph or interview, for example, might almost be free: people will be torn between embarrassment and pride. Exhibitionists may even pay to confess a night of shame, or boast of a crime. Daedalus will be interested to discover, for example, whether in strict cash terms a TV crew is more anxious to film a mob of rioters than the rioters themselves are to get on TV. David Jones