

Entanglement beats diffraction limit

Physicists in Canada and Austria have succeeded in entangling more than two photons for the first time. Aephraim Steinberg and co-workers at the University of Toronto have entangled three photons, while Anton Zeilinger and colleagues at the University of Vienna have created a four-photon entangled state. The wavelengths of these entangled states are three and four times shorter than the original wavelengths of the photons, which means they could be used to overcome the so-called diffraction limit. Entangled photons could therefore improve the resolution of applications such as lithography and microscopy (*Nature* **429** 161 and 158).

Entanglement is a feature of quantum mechanics that allows particles to be correlated in ways that are not possible in classical physics. If two particles are entangled, then we can determine the properties of one by making a measurement on the other, no matter how far apart the particles are. For instance, photons can be entangled so that if one photon is vertically polarized, the other will always be horizontally polarized, and vice versa.

Physicists routinely entangle pairs of pho-

tons using a technique called parametric down-conversion. Here, one photon is “split” into two entangled photons by shining a laser on a crystal that has nonlinear optical properties. The Canadian and Austrian teams have now used this principle – but different experimental techniques – to create entangled states of three and four photons, respectively. These entangled states have wavelengths of λ/N , where λ is the wavelength of a single photon and N is the number of entangled photons. However, both teams say that, in principle, their schemes can be extended to higher values of N .

As well as demonstrating multi-particle entanglement, these results could lead to faster computer chips, for example. Transistors and other features in chips are typically etched from a photosensitive substrate on silicon using optical lithography. However, the minimum feature size possible with this technique is about the same as the wavelength of the light. By using entangled photons, it would be possible to beat this diffraction limit and significantly reduce the size of chip features.