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NON-QUANTIZED MAGNETIC BUNDLES INSIDE SUPERCONDUCTORS. What happens when a superconductor is placed in a magnetic field? Currents will be induced inside the sample which generate a magnetic field of their own, neutralizing the external field. This exclusion of the external field is called the Meissner effect. If the field is strong enough, however, some of the external field lines will be able to penetrate the superconductor, although only by organizing themselves into flux bundles (also called vortices) of discrete sizes. That is, the bundles are commonly thought to possess a flux in multiples of a basic unit equal to Planck's constant divided by 2 times the charge of the electron. Decades ago theorists pointed out that this is indeed the case for flux bundles deep inside superconductors but not for bundles near the boundary of the sample. Now researchers at the University of Nijmegen in Holland (Andre Geim, geim@sci.kun.nl) and the University of Antwerp in Belgium have demonstrated this experimentally, verifying that some flux vortices do not encompass quantum values of the basic unit of magnetism; indeed some vortices have but a tiny fraction (as small as 1%) of the unit value. (Geim et al., Nature, 7 September 2000; for experimental background, also see Geim et al., Physical Review Letters, 14 August 2000.)

SINGLE-MOLECULE STM CHEMISTRY. The versatility and exactitude of the scanning tunneling microscope (STM) is demonstrated in a new experiment at the Free University of Berlin, where scientists have for the first time manipulated single molecules to perform a complete chemical reaction. Saw-Wai Hla (011-49-30-838-52-813) and his colleagues start with several iodobenzene (C6H5I) molecules resting on a terraced copper substrate. Then they dissociate some of the molecules into iodine and phenyl (C6H5) by injecting electrons from the STM tip. Next the iodine atoms are herded up and moved away with the STM tip. Now the tip pulls one phenyl close to another; they are not yet chemically bonded, though: pulling on one phenyl does not bring the other one along. Finally, another splash of electrons from the tip effectively welds the two phenyls together; proof that binding occurs is that when one phenyl is pulled with the tip, the other comes along for the ride (see a drawing of this sequence at www.aip.org/physnews/graphics). In summary, the making of C12H10 molecules from C6H5I molecules, normally carried out on a copper catalyst and using thermal activation (a process chemists call the Ullmann reaction), has here been forced to proceed by employing one molecule at a time at a cryogenic temperature of 20 K. The researchers believe that new manmade molecules, never before seen in nature, can be engineered in this way, including the selective detachment or replacement of parts of larger molecules for individual assembling of molecular based nano-devices. (Hla et al., Physical Review Letters, 25 Sept; Select Articles.)

ENTANGLED PHOTONS CAN DEFEAT THE DIFFRACTION LIMIT, a new paper suggests. This might lead to a much sharper form of microchip lithography than is possible with "classical" photons. The factor that ordinarily determines how small a standard lithography technique can write features on a chip is known as the diffraction limit, or Rayleigh criterion, which says that you can't inscribe a feature, or see a detail, smaller than half the wavelength of the light or other radiation used to perform the task. But new research (Jonathan Dowling, JPL/Caltech, 818-393-5343, Jonathan.P.Dowling@jpl.nasa.gov) shows that the Rayleigh criterion applies to classical physics but not quantum physics. In their proposal for "quantum interferometric lithography," two entangled photons enter a setup containing mirrors and beamsplitters. The two photons--acting as a single unit--constitute a light wave which is split up and then recombined on a surface, creating patterns on the surface equivalent to those that would be made by a single photon with half the wavelength. On a 2-D surface, this would allow researchers to write features four times smaller than prescribed by the Rayleigh limit. Preparing three entangled photons (still more difficult) and sending them through the device would create even better results: effectively a single photon with a third of the wavelength, enabling nine-fold smaller features on a 2-D surface. Although more work is needed to realize this proposal, the technique potentially allows the creation of features smaller than 25 nm, the size limit below which classical computer designs would begin to fail because of phenomena such as electron tunneling. (Boto et al., Physical Review Letters, 25 Sept 2000; Select Articles.)
