

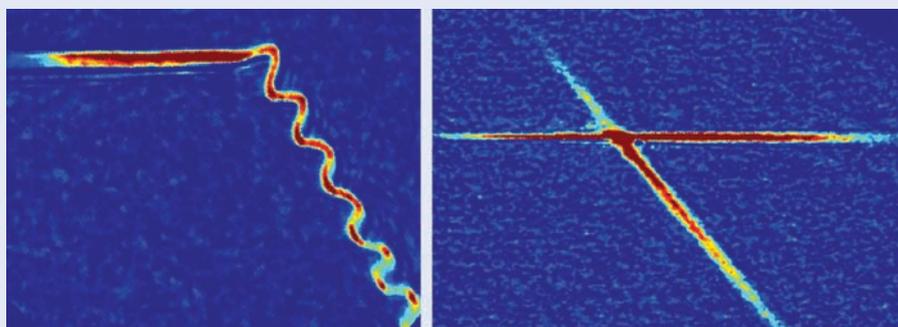
ATOM OPTICS

Switch or split

The beam splitter is a fundamental and much used device in optics, and its counterpart for matter waves is highly sought after to facilitate experiments in atom interferometry. Giovanni Luca Gattobigio and co-workers from France and the United States have now demonstrated a photonics-assisted design that uses light to guide propagating matter waves into several different beam paths (*Phys. Rev. Lett.* **109**, 030403; 2012). The device can be configured to operate as either a beam splitter or a beam switch.

Two laser beams are crossed with a 45° angle between them in an X configuration, creating four possible paths from the point of intersection. One of the laser beams is used as a guide for rubidium-87 atoms that have been out-coupled from a Bose-Einstein condensate. The atoms have a mean velocity of $13 \pm 2 \text{ mm s}^{-1}$, and the crossing takes place $700 \mu\text{m}$ downstream from the condensate trap.

Whether the system functions as a beam splitter or as a switch depends on the relative powers of the two crossed beams. When the crossing beam is much weaker than the laser beam guiding the atoms, no splitting occurs and the path of



the atoms remains unchanged due to only weak coupling between the different modes in the crossing region. When the powers are roughly equal, the system enters the switching regime and the path of the atoms is completely switched to be guided by the crossing beam. Between these two regions exists the splitting regime, where all four beam paths become populated.

To better understand the splitting regime, the researchers performed both quantum and classical numerical simulations. The split-step Fourier algorithm was used to compute the dynamics of the quantum wave packets, and a direct simulation Monte Carlo method allowed the atoms to be treated classically. Both quantum and classical simulations

produced very similar results and the authors report that the splitting regime results from chaotic scattering dynamics. Within this chaotic region, a slight variation of the initial conditions changes the output path such that on average the guided atoms populate all possible paths.

The researchers say that many applications in guided atom optics, such as sensing and interferometry, could benefit from their device. For example, the smaller effective wavelength of matter waves could potentially provide interferometry that is several orders of magnitude more sensitive than optical interferometry.

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BIOPHOTONICS

The slow fade of cell fluorescence

The short flash of a femtosecond laser induces a complex physiological response in mammalian cells that manifests as a slow bleaching of fluorescence from green fluorescent protein.

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The understanding of various dynamic processes in living systems — from simple bacterial or eukaryotic cells to complex multicellular organisms such as mice — was revolutionized by the introduction of green fluorescent protein¹ (GFP) as a fluorescent label for cells. Indeed, its importance was publically recognized in 2008 with the Nobel Prize in Chemistry being awarded for its discovery and development. GFP is a protein from the jellyfish *Aequorea victoria* that becomes

fluorescent without help from other proteins or cofactors except molecular oxygen, which is normally present in the aerobic organisms. This is in contrast to other natural pigments, in which light-absorbing molecules are formed by multistep pathways that are catalysed by several enzymes.

A single GFP gene can be introduced into model cells or organisms by standard methods, and expression of this gene results in specific fluorescence labelling of live cells

without the need for exogenous chemicals. Being a protein, GFP can be fused to any cellular protein of interest to visualize its localization and dynamics in a live cell. Also, GFP can be easily targeted to various cell compartments and subcompartments using protein localization signals. A number of fluorescent sensors for various ions and small molecules, enzymatic activities, signalling cascades and other important cellular events have all been constructed by fusing GFP with sensitive protein domains.