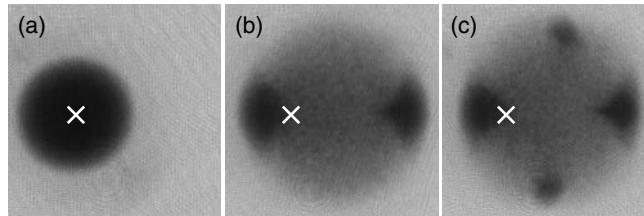


## Generation of macroscopic pair-correlated atomic beams by four-wave mixing in Bose-Einstein condensates

By colliding two Bose-Einstein condensates we have observed strong bosonic stimulation of the elastic scattering process. When a weak input beam (third wave) was applied as a seed, it was amplified by a factor of 20, and an initially unpopulated conjugate wave was created [1]. This large gain atomic four-wave mixing resulted in the generation of two macroscopically occupied pair-correlated atomic beams. Since each collision process adds one atom each to the seed and conjugate waves, fluctuations in the relative atom number are suppressed (squeezed). For the observed gain of twenty, the number fluctuations should be below the shot noise by a factor of  $40^{1/2}$ . We have also identified some limitations for using collisions to create twin beams, including loss by subsequent collisions, and competition between other modes with similar gain.



High-gain four wave mixing of matter waves. The wavepackets separated during 43 ms of ballistic expansion. (a) Only a 1% seed was present (barely visible), (b) only two source waves were created and no seed, (c) two source waves and the seed underwent the four-wave mixing process where the seed wave and the fourth wave grew to a size comparable to the source waves. The crosses mark the center position of the unperturbed condensate. The field of view is 1.8 mm wide.

1. J.M. Vogels, K. Xu, and W. Ketterle, *Generation of macroscopic pair-correlated atomic beams by four-wave mixing in Bose-Einstein condensates*, Phys. Rev. Lett. **89**, 020401 (2002).