

ULTRA-SLOW AND STOPPED LIGHT AND SUPERFLUID SHOCK WAVES AT THE 'LIGHT ROADBLOCK'

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We succeeded in slowing light pulses in a Bose-Einstein condensate to only 17 m/s, more than seven orders of magnitude lower than the light speed in vacuum. In our later experiments, we observed light pulse velocities as low as 50 cm/s. This method was brought to its logical extreme when we completely stopped and stored light pulses in an atomic medium for up to several milliseconds. Associated with the dramatic reduction factor for the light speed is a spatial compression of the pulses by the same large factor. A light pulse, which is 1-2 miles long in vacuum, is compressed to a size of $\sim 50 \mu\text{m}$, and at that point it is completely contained within the atom cloud. The extremely low light speeds, and stopped light, are obtained in a new optical medium created by illuminating ultra cold atoms with laser beams.

With the most recent extension of our method, the *light roadblock*, we have compressed light pulses from 2 miles to only $2 \mu\text{m}$. We have used this system to generate extremely localized defects and dramatic excitations in Bose-Einstein condensates and directly revealed the superfluid nature of the condensates. We have generated the superfluid analogue of shock waves: *Quantum Shock Waves*. These excitations result in the formation of solitons that in turn decay into quantized vortices. The vortices are created far out of equilibrium, in pairs of opposite circulation.

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