Observation of spin-density wave propagation in a spinor Bose-Einstein condensate

JOON HYUN KIM, DEOKHWA HONG, YONG-IL SHIN,
Seoul National University — We report the observation of spin-density wave propagation in a spin-1 antiferromagnetic spinor Bose-Einstein condensate. We develop a spin-dependent optical obstacle which is attractive for $m = 1$ and repulsive for $m = -1$ with equal potential heights, by using a laser beam with its frequency tuned between the $D_1$ and $D_2$ transitions. By suddenly turning off the obstacle beam penetrating a condensate in an easy-plane polar phase, we observe that a magnetization pulse wave is generated. The pulse wave consists of a density dip of the $m = -1$ component and a density bump for $m = 1$, and it propagates non-dispersively with a constant speed $v_s$, which demonstrates the linear dispersion of magnon mode of the spinor superfluid system. For comparison, we generate a mass-density wave in the same system, by using an ordinary spin-independent obstacle beam, and measure its propagation speed $v_m$. In our experiment, the ratio of $v_s/v_m$ is measured to be 0.20, which asserts that $c_2$ is twice larger than the conventional value from [PRL 99, 070403 (2007)]. Finally, we investigate a situation where the condensate is perturbed with an imbalanced potential for the two spin components, and observe that both mass and spin excitations are generated simultaneously but propagate separately.