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Electromagnetic induced transparency and slow light in strongly correlated atomic gases HSIANG-HUA JEN, BO XIONG, ITE A. YU, DAW-WEI WANG, National Tsing Hua University, PHYSICS DEPARTMENT, NATIONAL TSING HUA UNIVERSITY TEAM, FRONTIER RESEARCH CENTER ON FUNDAMENTAL AND APPLIED SCIENCES OF MATTER,NATIONAL TSING HUA UNIVERSITY TEAM, PHYSICS DIVISION, NATIONAL CENTER FOR THEORETICAL SCIENCES TEAM — We develop the quantum theory for the electromagnetic induced transparency (EIT) and slow light property in ultracold Bose and Fermi gases. It shows a very different property from the classical theory which assumes frozen atomic motion. For example, the speed of light inside the atomic gases can be changed dramatically near the Bose-Einstein condensation temperature, while the presence of the Fermi sea can destroy the EIT effect even at zero temperature. This quantum EIT property is mostly manifested in the counter-propagating excitation schemes in either the low-lying Rydberg transition or in D2 transition with a very weak coupling field.
Using linear response theory, we further derive an exact and universal form for the EIT spectrum, which applies even in strongly correlated systems of ultracold atoms. We find that the spectrum is closely related to the single particle Green's function, which is not easily observable in most experimental technique. As an example, we show results of 1D Luttinger liquid, Mott-insulator state, and BCS pairing phase, and compare to the results of standard classical theory. Our theory therefore paves the way to measure strongly correlated physics of ultracold atoms via the state-of-art manipulation of light propagation inside the quantum gases.

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