Observation of Optically Induced Transparency

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Electromagnetically induced transparency (EIT) allows for rendering optical opaque transmission windows to a transparent one under illumination of a strong light beam. The representative example of EIT has its unique ability of optically controlling transparency windows with relative low light in atomic systems [1], though its practical applications are limited due to rigid experimental requirements. Recently, a set of elegant experiments have cloned the idea of EIT in an opto-mechanical micro-cavity with the aid of mechanical oscillations within [2,3], where the mechanical oscillation can be excited by an intensive beam through Brillouin scattering (BS) nonlinearity. Such strong confined mechanical oscillations can provide enough phonons to tunnel some hybrid optical-mechanical modes similar to their counterparts: photons in the EIT. However, most of them still require cooling and vacuum systems to preserve high-quality mechanical modes. Meanwhile, EIT-like transmission spectra can be also obtained by coupling two adjacent optical resonances of two spatially spectated micro-cavities [4]. But unlike EIT, these approaches lack an active control to switch on/off the transparency windows.

Here, we demonstrate a new form of optically induced transparency (OIT) in a micro-cavity by introducing four-wave mixing (FWM) gain in order to couple nonlinearly two separated resonances of the micro-cavity in ambient environment, which directly results from the interference between two resonances coupled nonlinearly through FWM process. Active-controlling of the OIT can be achieved by varying a strong pump beam, while a signature Fano-like resonance is also observed owing to the nonlinear interference of two coupled resonances with a small frequency-detuning of the pump. Moreover, we show that the unidirectional gain of four-wave mixing can lead to non-reciprocal transmission at the transparency windows, since FWM has to satisfy the conservation law of momentum, giving a unidirectional gain along the forward direction of the pump. Optically induced transparency may offer a unique platform for a compact, integrated solution to optical isolator, all-optical processing, and quantum information, etc.

References