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Simultaneous excitation of Fano-like resonance at multiple frequencies in RF domain using Brillouin pathways

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Abstract

We report the simultaneous excitation of Fano-like resonance in the RF domain using coherent interaction of optical pathways using backward Stimulated Brillouin scattering in single mode fiber.

Introduction

The importance of exciting Fano resonances is emphasized in areas that require fast switching, sensing, and lasing. Fano resonances have been demonstrated in a large cluster of systems such as nanostructures and metamaterials [1, 2]. The challenge in many of these cases lies in the tunability of the attained Fano resonance. It is constrained by the device geometry and requires tweaking them. Recently, we demonstrated the excitation and control of Fano-like resonance in the RF domain [3] using backward stimulated Brillouin scattering.The technique which relied on coherent interactions offered a straightforward tunability over a range from 100 MHz to 43 GHz.

In fields that require simultaneous presence of switching or sensing at multiple wavelengths, controllable Fano-like profiles spread over a range can be helpful. Nanostructures and metal-insulator-metal waveguides [4, 5] have been used to demonstrate excitation of Fano-resonances at multiple wavelengths.

Here, using an intensity modulated Brillouin pump, we demonstrate the simultaneous excitation of Fano-like resonances at three frequencies centred at the Brillouin shift and separated by the pump modulation frequency.

Method

Figure 1 is the experimental setup used to demonstrate the simultaneous excitation of Fano-like resonance. A distributed feedback laser is intensity modulated with a radio frequency generator at 200 MHz to create 3 lines that are 200 MHz apart. We then split it into the pump and the probe arms. The pump arm passes through an erbium doped fiber amplifier. The probe is further intensity modulated at 10.808 GHz, the Brillouin frequency corresponding to the laser's wavelength. The pump and probe beams are then let to counterpropagate in a 500 m standard single mode fiber using circulators. Polarisation controllers are used along the pump and probe arms to maximise the Brillouin gain and loss interactions. Optical and RF detection are then carried out on the Brillouin gain and loss witnessed signals.

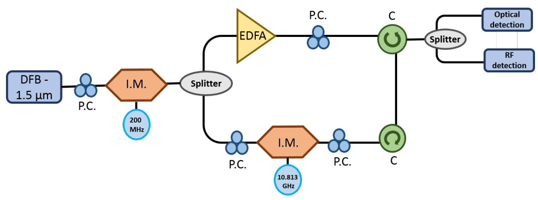

Figure 1. Experimental setup for the demonstraion of simultaneous excitation of Fano-like resonance in the RF domain: DFB - Distributed feedback laser; IM - Intensity modulator; PC - Polarisation controller; C - Circulator; EDFA - Erbium doped fiber amplifier

Discussion

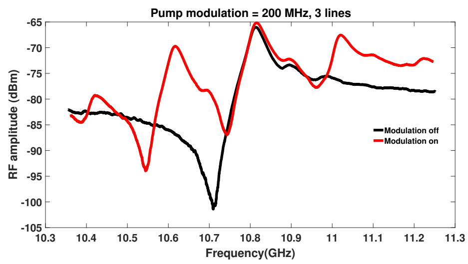

Figure 2. Simultaneous excitation of Fano-like resonance at multiple frequencies using coherent interaction of Brillouin pathways.

When just the Stokes probe is counter propagated with the Brillouin pump, the RF response is a Lorentzian with its linewidth determined by the lifetime of phonons in the material. In our recent Brillouin interaction based demonstration of wide-band Fano-like resonance [3], we showed that when both Stokes and anti-Stokes are simultaneously counter-propagated with the Brillouin pump, the RF response shows an asymmetric behaviour. This is due to the coherent interaction between the Brillouin gain and loss pathways.

With just a single wavelength pump, the asymmetric response is as seen in Figure. 2 (black line). Such an asymmetric response can be used in applications such as microwave switching [6]. Now, on modulating the pump at 200 MHz, we can see that, in addition to the Fano-like profile at Brillouin shift, there are additional Fano-like resonances separated from the central resonance by 200 MHz. This can be seen in Figure. 2 (red line).

We thus show a straightforward way of simultaneously exciting Fano-like resonance at multiple frequencies which is of importance in microwave photonic applications. Owing to the similarity in the way of excitation, electromagnetically induced transparency (EIT)-like features can also be obtained at multiple frequencies. Further, the technique has the advantage of being incorporated on chip for device fabrication.

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