# Non-linear couplings in atomic magnetometer

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We explore the ways in which the different components of the magnetometer configuration (i.e. atomic sample, pump and probe beams) can introduce non-linear couplings into the atomic system. In particular, we are going to discuss how linear and nonlinear spin-exchange coupling, acting in an analogous way to a wave-mixing mechanism, can lead to the generation of atomic coherence in a Bell-Bloom magnetometer, Fig.1, [1].

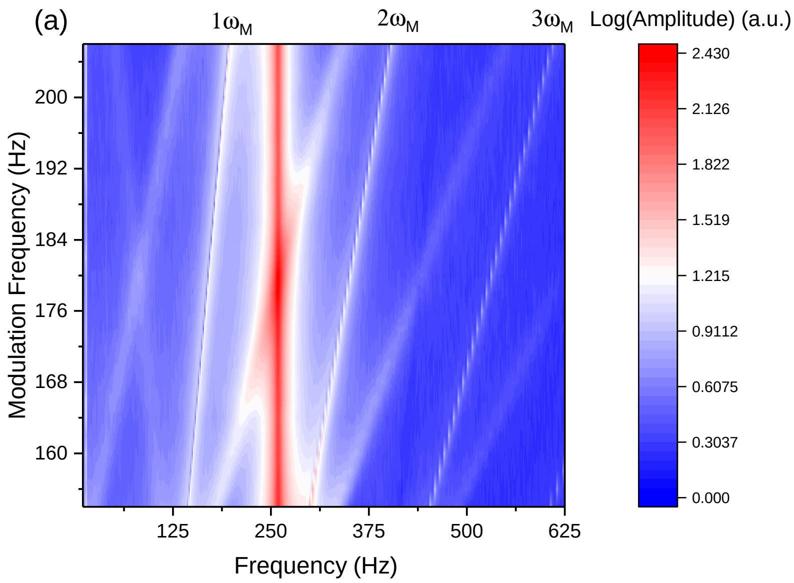


**Figure 1.** FFT spectrum of the magneto-optical rotation signal detected for atoms in F = 4 for different modulation frequencies of the pump beam power, $\omega_M$. This portion of the spectrum shows the evolution around the Larmor frequency $\omega_L/2\pi \sim 270$ Hz. Together with the peak at $\omega_L$ and the first three harmonics of $\omega_M$, additional peaks (and dips) depending on $\omega_M$ are visible around integer multiples of $\omega_M/2$ (highlighted by black arrows in the figure). The pump and probe beam powers have been set to 80 $\mu$W and 600 $\mu$W and for each modulation frequency the spectrum is the result of over 100 different acquisitions.

Periodic modulation of the pumping beam in a Bell-Bloom magnetometer introduces modulation of the damping rate, i.e. a parametric perturbation of the system dynamics. The effect is equivalent to that observed in mechanical oscillators [2]. Due to the phase sensitive gain of the parametric process, the amplitude of the signal component in-phase with the parametric modulation is amplified, while the out-of-phase quadrature experiences attenuation. The