Frequency detuning effects for a parametric amplifier

Frequency tuned parametric amplifiers may experience changes in both the two-to-one frequency ratio between the parametric and the direct excitation, and between the direct excitation frequency and the systems natural frequency. These effects are investigated theoretically using a Duffing-Mathieu equation as the model system, and investigated experimentally using a macro cantilever beam as the model object. The approximate analytical steady-state vibration amplitudes are derived using the method of varying amplitudes, and compared with results of direct numerical integration, showing good agreement. Theoretical predictions reveal that for detuned superthreshold parametric amplification some of the amplitude-frequency curves appear to collapse. Experiments show that a drop in the maximum steady-state vibration amplitude occurs for specific areas in the amplitude-excitation detuning domain, whereas for other areas frequency detuning may yield an increased maximum steady-state vibration amplitude. Thus frequency detuning is a feature which can purposefully be avoided or utilized, dependent on the usage e.g. for sensors or energy harvesters. We report experimentally obtained bistable amplified steady-state responses, which also support theoretical findings.