

Preface

Parametric Resonance in Dynamical Systems contains a collection of contributions presented at an invited workshop with the same name held from June 22–26, 2011 in Longyearbyen, Svalbard, Norway.

The subject of the book is parametric resonance in marine and mechanical systems with focus on detection, mathematical modeling, and control. The book contains new results on modeling, detection, and control of parametric resonance and it is a supplement to engineers who are familiar with nonlinear systems.

What is Parametric Resonance?

Parametric resonance is a phenomenon not caused by external excitation, but by time-varying changes in the parameters. The archetypical example is the *Mathieu–Hill equation*:

$$\ddot{y} + a(t)y = 0$$

where $a(t + T) = a(t)$. If the period T or $2T$ is an integer multiple of the natural period N , a resonance occurs causing the origin to become unstable.

Not only mechanical systems, vehicles, motorcycles, aircraft, and marine craft but also micro–electro–mechanical systems are prone to parametric resonance. Sparse offshore platforms and ships also exhibit parametric resonance. For ships, parametric resonance is known to occur in roll in certain conditions. The resulting heavy roll motion, which can reach 30–40 degrees of roll angle, may bring the vessel into conditions dangerous for the ship, the cargo, and the crew. Container ships, fishing vessels, and cruise ships are also known to be prone to parametric roll and several incidents have been reported with significant damage to cargo as well as structural damages for millions of dollars. The origin of this unstable motion is the time-varying geometry of the submerged hull—more specific, time-varying changes in water area produce periodic variations of the transverse stability properties of the ship. This is seen as periodic oscillations of the ship’s meta-centric height and consequently the spring stiffness. Other examples feature similar effects as described in the aforementioned ship example.

Can Parametric Resonance be Controlled?

There are a few potential methods for controlling the parametric resonance phenomenon. Detuning the resonance condition by (semi-)active control is possible if the control objective can be properly defined. Alternatively, feedback can be used to provide additional damping. In order to understand the effect of detuning and active control, it is necessary to study the *Poincare maps* and *Ince–Strutt* diagrams for bounded and unbounded solutions of the *Mathieu–Hill equation*. This gives insight in how nonlinear observers and controllers can be designed for systems exhibiting parametric oscillations. However, the subject of parametric resonance and passive and/or active control of it, is still far from being fully understood, and it forms the theme of this book. Our particular aim is to bring together contributions and insights from the different disciplines where parametric resonance occurs. It is our belief that this will be of great importance for researchers in these disciplines.

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