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Bifurcation and Nonlinear Behaviour Analysis of Dual-directional Coupled Aerodynamic Bearing Systems

Cheng-Chi Wang[1,a] and Chih-Jer Lin[2,b]

[1]National Pingtung University

[2] National Taipei University of Technology

[a]wccpipn@gmail.com, [b]cjlin@ntut.edu.tw

Abstract

Dual-directional coupled aerodynamic bearing (DCAB) systems have received much attention over the past few years. They are used primarily to solve air lubrication problems in precision instruments and mechanisms that run at high rotational speed and require exceptional rigidity and precision. Coupled aerodynamic bearing have the advantage of both axial and radial thrust and provide high rigidity, dual-directional support and load carrying capacity. They also exhibit better stability than other air bearing systems. In the bearing system under study here, non-linearity of the air film pressure and actual dynamic problems, including critical speed, unbalanced air supply or poor design, are all possible causes of rotor bearing system instability and such phenomena as non-periodic or chaotic motion under certain parameters or conditions. Irregular motion can lead to severe damage or even the destruction of mechanical parts. Therefore, to investigate what conditions will lead to non-periodic phenomena and avoid irregular vibration, detailed explorations of the properties of the bearing system were carried out using three different numerical methods, including one that combines finite difference and differential transformation. Non-linear rotor behavior was also studied using bifurcation diagrams(Figure 1 and 2)and Lyapunov exponents(Figure 3).

Results

To determine if the bearing system behavior under various parameters was stable or not, different rotor masses and bearing numbers were used as parameters in the analysis. In addition, Lyapunov exponents were used to establish the stable and unstable regions of the bearing system. As shown in Figure 1, the red and pink areas are unstable regions while blue and purple areas are stable. Therefore, it can be seen that the non-stable regions are concentrated in the areas where rotor masses were the greatest. However, the system exhibited non-periodic motion at lower rotor mass with low bearing numbers. These results can be effectively used to determine the stable and unstable regions for a working dual-directional supported and coupled air bearing system. They also provide important guidance for the design of bearing systems.

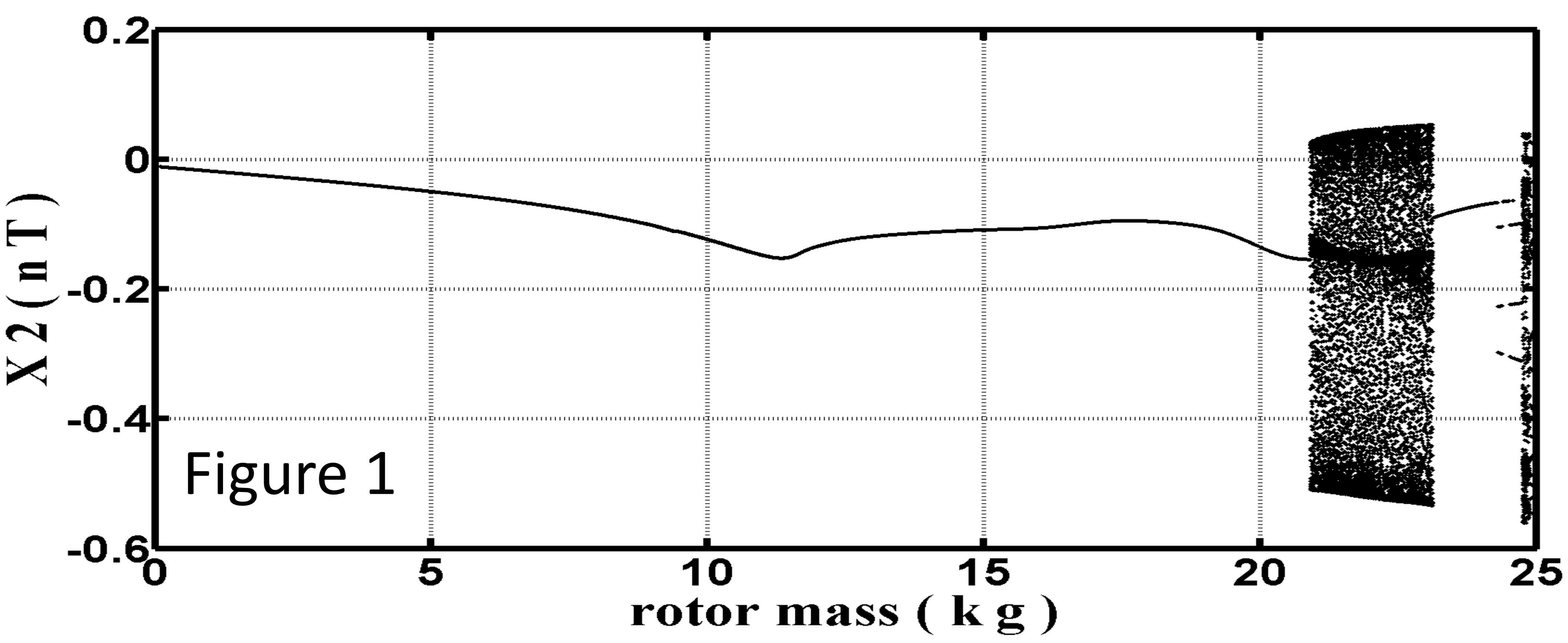

Figure 1

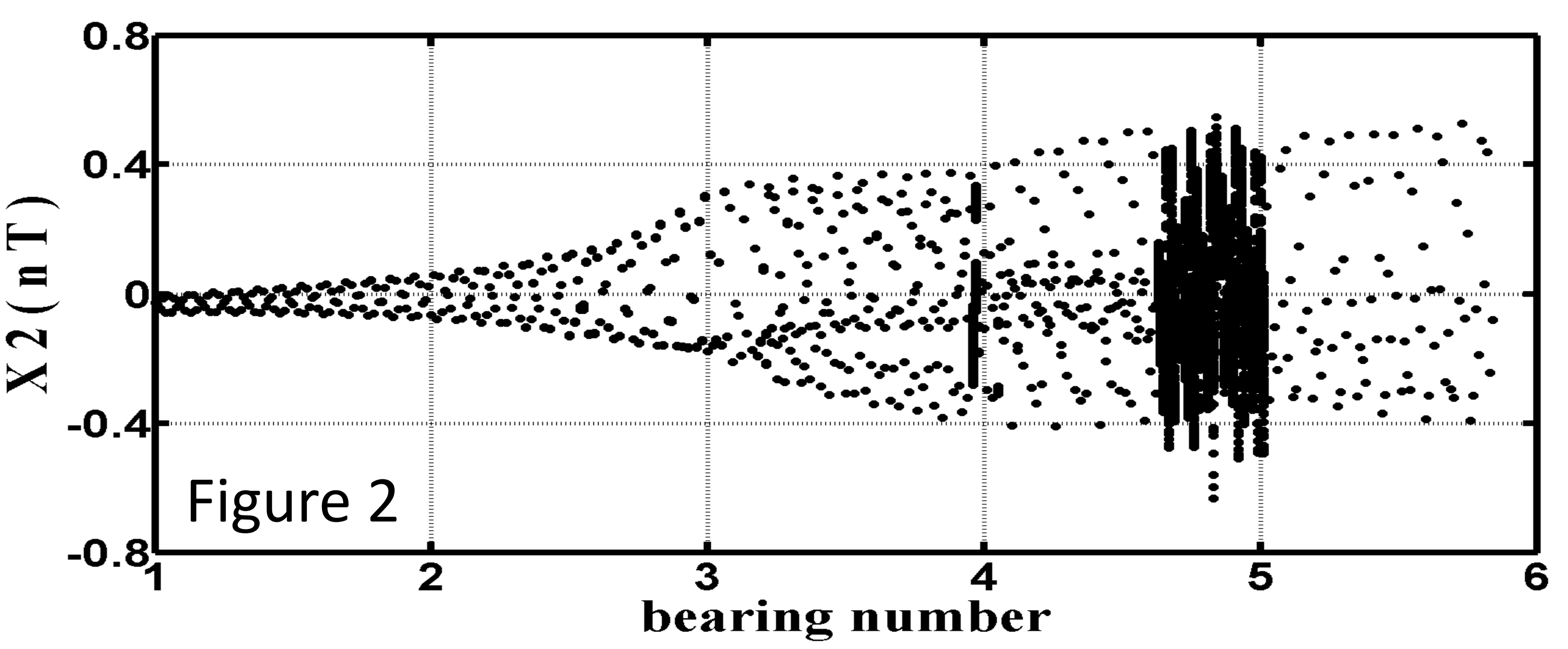

Figure 2

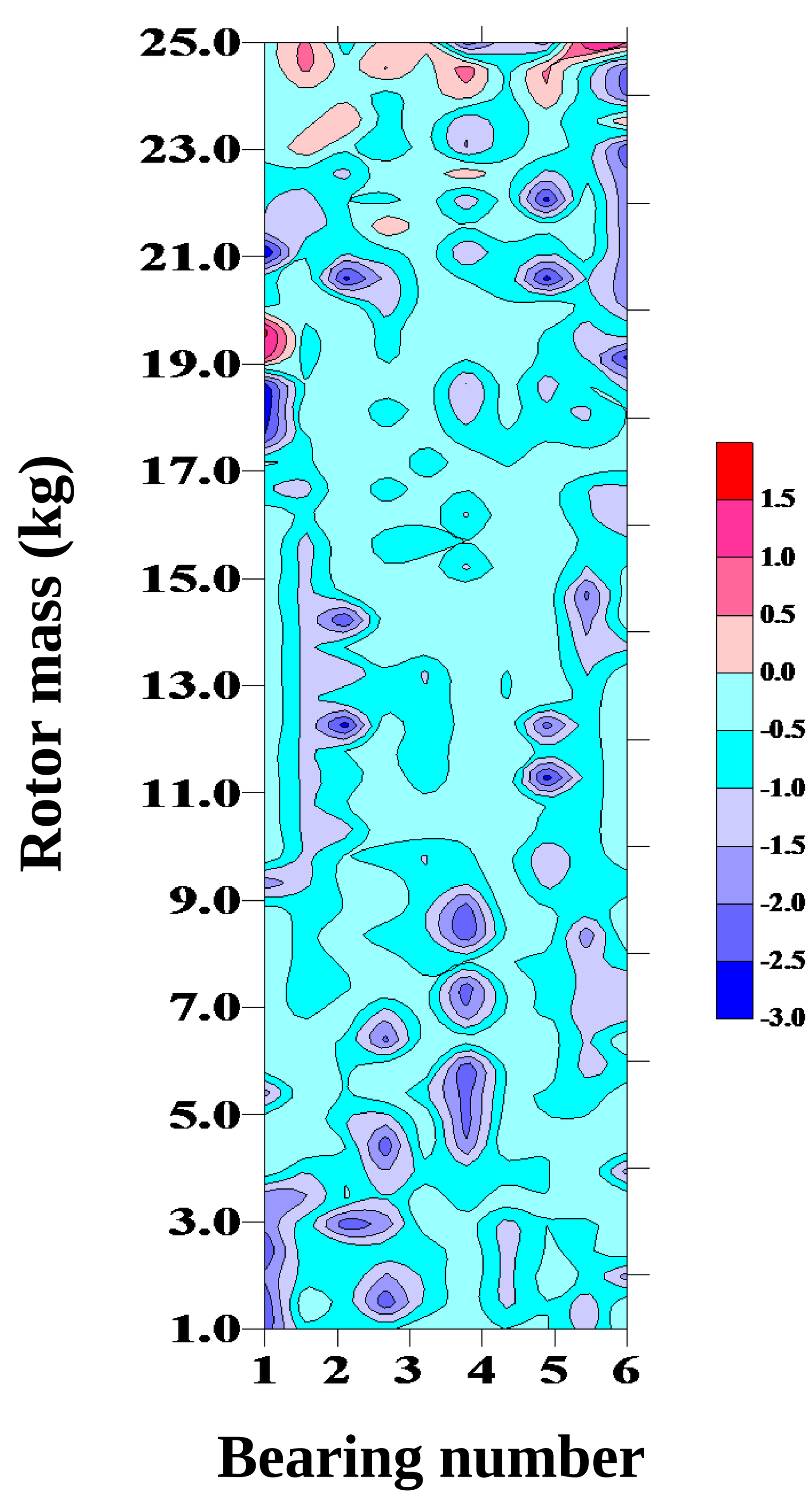

Figure 3