Mechanical Chaotic Oscillator

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EXECUTIVE SUMMARY

In this paper we explain the procedure for building a mechanical chaotic oscillator or MCO. The objective of this project was to create an apparatus for the Advanced Lab that enables students to observe nonlinear dynamics and chaos in an efficient and intuitive way .

The apparatus uses two Helmholtz coil pairs perpendicular to each other, one to provide a constant magnetic field within a given region of space and the other to give a perpendicular time varying field component in that same region. This region contains a magnetic dipole connected to a rotating shaft that supports an aluminum inertial disk. The inertial disc supplies some mass and also provides a means for magnetic damping. The MCO uses an optical encoder with a quadrature output signal to track the position of the magnetic dipole. A microcontroller collects and processes the position data while also generating a signal for the time varying field. The user has complete control over system parameters using a computer with a USB interface. System commands and inquiries can be made in real time. The MCO is a nonlinear damped oscillator capable of producing a chaotic trajectory given specific system parameter values.

The Advanced Lab is an excellent environment for undergraduate physics students to learn about nonlinear dynamics and chaos. Students can learn this concept more efficiently if they can control and track the systems behavior. While chaos can be observed in many experiments, few of them allow the control and precise measurement capabilities provided with the MCO. Because of these features, the MCO is a valuable tool for analyzing nonlinear dynamics in the Advanced Lab.