Chaotic synchronization between Malkus' waterwheel and the Lorenz system

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In 1972, W.V.R. Malkus invented and constructed the waterwheel that bears his name, along with a publication on toroidal convection that presents the same dynamics. The waterwheel was intended as a lab device capable of resembling the behaviour of the equations published a decade before by E. Lorenz.

Though simple in its conception, Malkus' waterwheel is not completely intuitive in its performance. Since it was first proposed, many experimental and real-world applications for the waterwheel where also presented. A series of lab and natural phenomena share the dynamics of Malkus' Waterwheel: Electro-rotation (see Lemaire, 2002), Haline Oceanic Flow (see Huang, 1996), Rayleigh-Benard Convection (see Fontenele, 1999).

In this poster, the general equations of the discrete (bucket-based) waterwheel are obtained via analytical mechanics. The result is an (N+2) dimensions system that can be derived into a 3 dimensional system of differential equations. These equations in turn are simply a rescaled form of the Lorenz system, and present the same dynamics. We show to what extent the Lorenz-like equations can be synchronized with the original discrete waterwheel system, and the requirements needed for this synchronization to take place robustly under minimal driving sync forces.