1D Chain of Coupled Pendulum in a Turbulent Flow

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Ned Kahn is an American artist who has implemented numerous exhibits inspired by the ephemeral nature. Among his works is the kinetic facade, which is composed of a matrix of small aluminium plates that cover facades of buildings. As the wind blows over the wall, the plates oscillate freely creating some wave-like large scale patterns (Fig.1a), that could be either wind generated waves [1], or the signature of turbulent pressure fluctuations [2,3].

To unravel the physical origin of these deformations, we designed in a wind tunnel a one-dimensional chain of coupled pendulum in a reduced version (Fig.1b), composed of rectangular 3d printed thin plates. Inspired by the works of Brouzet *et al.* [4], we use nylon fishing wires to achieve a precise coupling with an elastic coupling constant controlled by the wire diameter. In the absence of external wind, the dispersion relation of the chain oscillatory motions follows the theoretical prediction (discrete sine-Gordon equation):

$$\omega_r^2 = \omega_p^2 + 4\omega_w^2 \sin^2\left(\frac{kW}{2}\right), \tag{1}$$

Where ω_p denotes the angular frequency of a single pendulum under gravity, ω_w the elastic coupling frequency and W the distance between two plates. For a wind velocity ranging from 0 to 8 m.s^{-1}, we observe long trains of linear waves and local gusts propagating downstream. We equally report on a wind-induced modification of the dispersion relation, as a result of an interaction between turbulence, pendulum and the pendulum coupling, and we discuss the physical mechanism of these wave generations.

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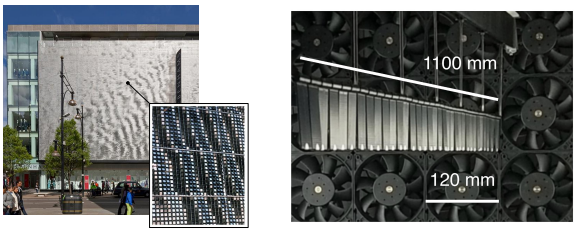

Figure 1: (a) One of Ned Kahn's kinetic facade exhibits, wave like patterns can be seen. (b) Photography of our 1-dimensional chain of coupled pendulum located at the center of the wind tunnel's test section, each plate is 3 cm wide and 5 cm high.

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