Len Lye: Stopped Short by Wonder
(Christchurch, 5 August – 26 November)

Some explanations by Dr S Gutschmidt (Mechanical Engineering, UC)

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Principles:

1) **Conservation of momentum**: "Conserve" is derived from the latin word "conservare" and means "to preserve" or "to keep". When relating this to objects in motion it means that these objects will continue in their current state of motion unless acted on by an external force.
2) **Resonance**: The noun "resonance" is related to the latin verb "resonare" meaning "resounding" or "echoing". Just like people "echoing" (reacting to) messages in different ways according to who they are, dynamical systems "resound" (respond to) different input signals according to their mechanical properties. Resonance occurs at certain frequencies (speed of the motion) and may result in high amplitude motion of the excited system.
3) **Vibration modes**: Theoretically, there exist an infinite number of possible vibration modes of a mechanical system. A vibrational mode is a specific type of motion that occurs at the system's resonance frequencies. The particular properties of the actuator(s) will determine how many of these vibrational modes can be excited. For large objects such as the Len Lye sculptures, no more than the first 2-3 vibration modes are observed.
4) **Nonlinear phenomena (jump).** The jump phenomena in nonlinear dynamics refers to an effect where at one instant in time the amplitudes are very large and at the very next instant, amplitudes are very small (or the other way around). This effect is based on multiple co-existing stable vibrational modes that can be switched back and forth (with a little help from the actuator).
5) **Nonlinear phenomena (internal resonances).** Internal resonances are particular ratios between natural frequencies. For example, if a torsional mode happens to be at a frequency twice that of a fundamental bending mode, this is referred to as a 2:1 internal resonance. When the actuator excites one of these modes (either bending or torsional mode) the other mode is automatically excited too. This results in the system vibrating in both modes simultaneously.

Fountains

- Based on Principle 1)
- Centre shafts are slowly rotating and suddenly either stopping or changing direction
- The initial motion of the rods continues while the shaft starts a new motion (or stops)
- This super-position of old and new motions causes the rods to also move vertically as the rotational speed of the shaft determines the maximum deflection of each beam (centrifugal force)

Fire Bush

- Based on principles 2) and 3)
- Each beam has slightly different mechanical properties and therefore different natural frequencies
- The actuator excites the system at different frequencies and if it hits a resonance frequency of a particular beam, that beam will oscillate with very large amplitudes and an associated vibration mode (standing wave)

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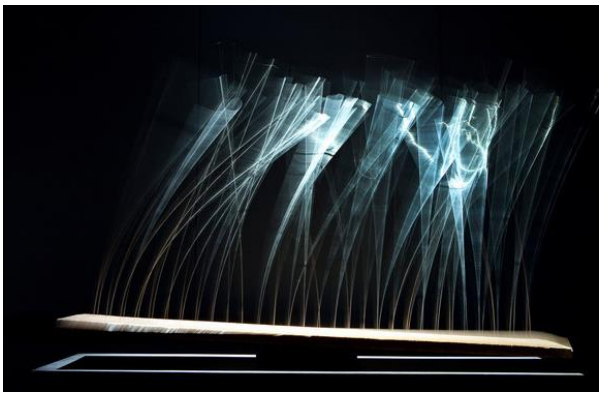
Grass

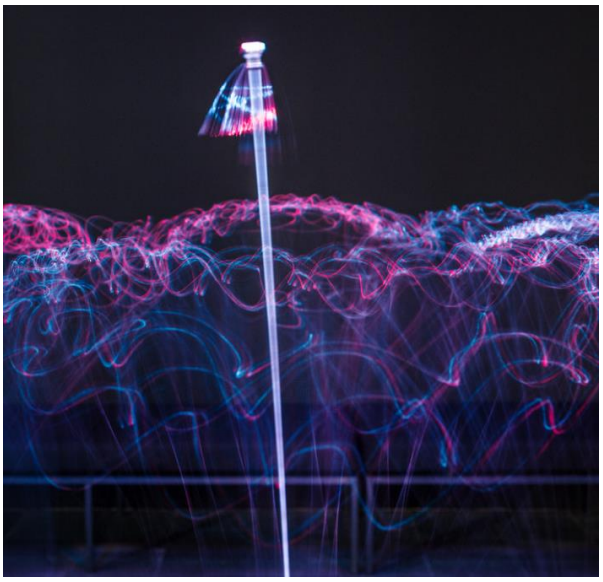


- Based on principle 1)
- The grass is actuated by the board and this induces a particular free motion
- When the board changes direction or stops, the grass wants to continue in its previous motion

Blade

- Based on principles 2) and 3)
- The picture clearly shows the second vibration mode (with one node towards the top and another one at the bottom), which is generated by the actuator when the operational frequency is equal to the Blade's second natural frequency
- The little hammer next to the blade has its own natural frequencies
- The two oscillators get excited in-phase and out-of-phase, which reveal different sound patterns
- The Blade performance also shows a nonlinear phenomenon (principle 4))

Witch Dance



- Based on principles 2) and 3), but also principles 4) and 5)
- This sculpture also illustrates several additional nonlinear phenomena such as synchronisation phenomena, period doubling and chaotic motion

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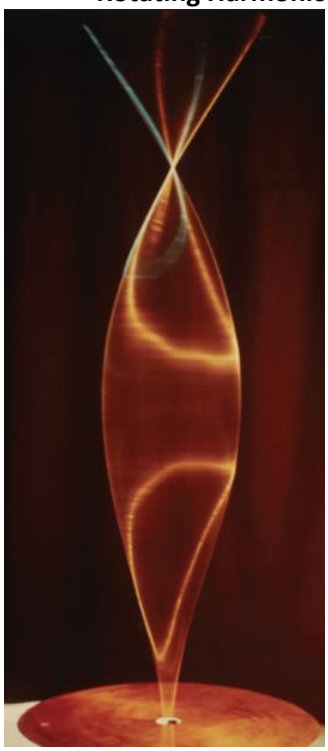
Rotating Harmonic



- Based on principles 2) and 3), but also principle 5).
- The actuator generates motion in only one direction, but when the system is excited at a particular internal resonance, the mode in the perpendicular direction is set in motion as well, thereby causing the whole system to swirl