The Art of the Celt

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Abstract

“Celt” is a term that archaeologists use for various kinds of stone objects found in excavations of Celtic and other early civilization sites. Their original purpose is unknown. Some of them have the novel feature that when spun on a smooth flat surface they have a preferred spin direction. Beginning at the end of the 19^{th} century, physicists, artists, artisans and others have designed many variations on this dynamical object. Here we present a short overview of some of these, including a new one designed by the author during the past year. It is called the “DeltaCELT” (or “δCELT”) and its design incorporates the Feigenbaum dynamical constant $\delta \sim 4.6692\ldots$

Celts, Rattlebacks and Wobblestones

Throughout this paper I will refer to the objects under discussion as celts (originally, the Latin word for “chisel”, one suggested use for celts). There are many other names for them: in English it is wobblestone or rattleback (so named in 1979); in French it is anagyre; in German, Keltisher Wackelstein (for stone versions) and Keltiches Wackelholz (for wooden versions). Commercial versions have been called by names like “space pet” and “Astro-Spinner”. One is named “The Ark” because it is based on the supposed shape of Noah’s Ark! The most amusing name: “Tate’s Compass” as in “He who has a Tate’s is lost”!

Figure 1: *(left) Neolithic stone celt; (right) modern stone celt (from the German company Experimentis).*

Figure 2: *Various types and sizes of celts from my personal collection are shown here. Three of them can be seen sitting on plastic, marble and agate spinning plates (from top to bottom).*

What distinguishes the objects discussed here from the broader range of objects called "celts" is their dynamical property: when spun on a smooth flat surface, they have a preferred spin direction. They spin in either a clockwise or counter clockwise direction when viewed from above, then rattle or wobble, stop and then spin in the opposite direction. When tapped on one end, even without being spun, they will start to spin. Though the preferred spin direction (i.e., handedness or chirality) of natural and worked stones may have been noticed by early man, it is only during the past century that people (mostly physicists, but also artists and craftsmen) have consciously fashioned such objects with many designs, made from almost every imaginable material: wood, metal, glass, plastic or even dental plaster, in addition to stone.

There are seemingly an infinite number of objects, from bent spoons, to cell phones inside belt holders, to natural stones that can exhibit this wonderful spin property. Modern celts can be considered a type of kinetic art that combines art and artisanship with both mathematics and physics. Celts can be adjustable (Figure 3) to demonstrate the effect of a change in their mass distribution on their dynamics.

Figure 3: *Adjustable celts: (left) celt with orientable turtles (designed by Russian V. Krasnoukhov); (center and right) celts with orientable bars.*

The Physics of Celts

The underlying physics and mathematics of celt dynamics is quite complicated. It involves mechanics, gravity and the properties of surface friction, both rolling and sliding. The first paper analyzing their dynamical property was published in 1896 [9]. The next major paper on the underlying physics waited nearly a century [2] to appear. No complete analytical treatment of their dynamics has been achieved to date, but some good but complex analytical and numerical treatments appear in [6] and [7]. Though celts may appear to violate the law of conservation of angular momentum, they do not!

Crafting Celts

There is no obvious approach to designing the "optimal" dynamic celt, whatever that might be. Many of those made to date have an overall elongated bar shape as seen in Figure 2 with a ratio of length to width anywhere between 3 and 10 to 1. In designing these objects, there are two basic schemes: either design the objects with a rounded bottom which contains an asymmetric swirl or S shaped spline (Figure 4, top); or make the bottom symmetric as in the shape of the bottom of a boat, and make the body out of different density materials or use different mass density distributions throughout the object (Figure 4, bottom). Walker [10], Pippard [8] and Boardman [1] discuss various ways to design them.

Figure 4: *Artistic Wooden Celts: Jack Mankiewicz design (upper); Emmanuel Peluchon design (lower).*

The DeltaCELT

Over the past five years I have designed a set of novel spinning tops based on each of the most important mathematical constants: ϕ, π, *e* and *i*. The PhiTOP was launched in 2015 [3]. The PiTOP was launched two years later, followed by the *e*TOP and the *i*TOP. In 1975 my good friend Mitchell J. Feigenbaum discovered the new mathematical constant δ (Delta) ~ 4.6692…. This number underlies what is called the period doubling route to chaos in dynamical systems [5]. Its universality was proven several years later. The constant δ is to dynamical systems what π is to geometry and what *e* is to calculus. In order to honor Mitchell, I decided to design a dynamical object that incorporates his constant δ. I chose to design a celt in the shape of a bisected prolate ellipsoid with the ratio of the length of the major axis to the minor axis equal to δ, with offset slots with the same shape inset into its top surface. Unlike in the cases of the PhiTOP and the PiTOP designs, where I did experiments to optimize their performances, no such experiments were done to optimize this celt's motion. I simply decided to incorporate δ into its design. A well-defined mathematical shape was chosen to make it easier to assess results of experiments with it and in order to gain some intuition about the cause of its counter-intuitive behavior. The USPTO has granted me patent No. D908,809 [4] for my "δCELT" design. Both right and left-handed versions can be made (Figure 5). Its dynamics can be adjusted by placing weights in the surface grooves (Figure 6). The version shown below is made from brass. Spinning it on a flat polished marble surfaces enhances its dynamics.

Figure 5: *Top view of right and left handed brass δCELTs and bottom view (15.2 cm x 3.2 cm x 1.6 cm).*

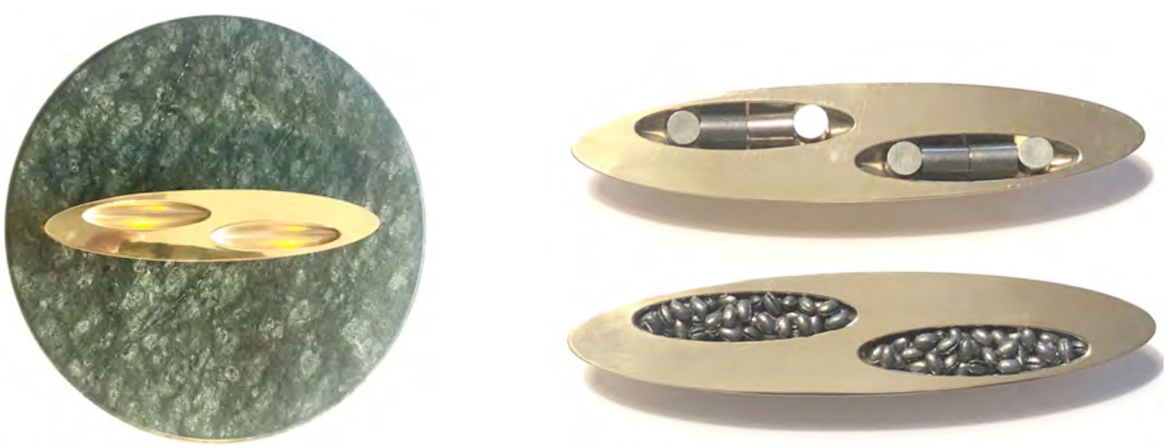

Figure 6: (Left image). *Brass δCELT placed on a polished flat green marble spin plate. (Right images). Brass δCELT with added tungsten weights (top) and lead weights (bottom).*

Summary and Conclusions

I have developed a new celt or rattleback called the DeltaCELT (or δCELT). It was designed as a bisected prolate ellipsoid with two offset indentations in its top surface to provide asymmetry around its spin axis. It incorporates the Feigenbaum constant δ into its design as the ratio of the length of the major axis to the width of the minor axis.

Modern dynamical celts are marvelous physical objects. They are as eye-catching and imaginative as many other works of kinetic art (such as Marcel Duchamp's "Bicycle Wheel" and his "Rotoreliefs", Alexander Calder's Mobiles and Gorge Rickey's kinetic sculptures). The counter-intuitive behavior of dynamical celts sparks interest in their underlying mathematics and physics. They offer a nice opportunity for people of any age to design and create their own new versions, using either 3D printers, or crafting them out of wood, plaster or other readily available substances. The material used for the celt and its overall shape, as well as the surface properties of the plate on which it spins, are all worthy topics for exploration.

Acknowledgments

I thank BU engineer David S. Campbell and BU undergraduate Bryan James for their help with making the SolidWorks printing files for the initial 3D printed plastic δCELT prototypes. My daughter Kaz Brecher has helped in many aspects of this project. I had fruitful discussions with Jack Mankiewicz about his celt designs that he calls "Chembongos". I had a useful correspondence with Emmanuel Peluchon about his celts. Most of all, I am grateful to Mitchell Feigenbaum for his more that 50 years of friendship.

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