Catacaustics

Art Installation Proposal for
The Kavli Institute for Theoretical Physics

Catacaustics is a reactive art installation designed for the open-air meeting space within the Kavli Institute for Theoretical Physics in Santa Barbara, California. The primary structure consists of two concentric rings suspended from the ceiling with a support beam suspended in the center. Numerous individually controlled stepper motors are fixed to the rings, each with a plastic mirror disc attached to a motor, enabling the discs to rotate at precise angles. The center column supports a ring of bright LED's angled toward the discs. This configuration results in patterns of overlapping reflections on the ceiling. Inspired by hydrogen electron orbital cross sections (fig. 9) and other properties of quantum mechanics, the orientation of the reflective elements and consequently the reflected pattern on the ceiling, will change according to approximately how many people occupy the space as viewed by a thermal camera. *Catacaustics* refers to the mathematical term of the same name: the envelope of rays emitted from a source and reflected off a curve.[1]

The Kavli Institute for Theoretical Physics is one of the most important institutions in the world for theoretical physics. The National Academy of Science recognized it as having the highest degree of impact for a non biomedical research organization in the United States [2] and continues to host a plethora of luminaries and Nobel laureates.

KITP sits on the east end of the University of Santa Barbara's campus along a windswept stretch of ocean cliffs. Its open-air courtyard is tucked in the center of the complex and measures 18 x 18 meters with a 10 meter ceiling. A tapered, semi translucent roof is bisected by a large steel crossbeam. It is from this crossbeam where *Catacaustics* will be suspended. Tables and chairs as well as entry points on opposite ends of the courtyard make it a frequently used space.

Kavli Chair and Nobel Laureate Dr. David Gross expressed interest in an art installation in the vein of a Calder Mobile. From the 1930s to the 1960s, artist and engineer Alexander Calder built large scale mobiles that were highly asymmetrical yet carefully balanced, not unlike energy systems in quantum mechanics. As a media art installation, *Catacaustics* responds to Dr. Gross' suggestion by actively responding to scientists and visitors while depicting the beautiful symmetries found in wave functions. The pattern transformation is analogous to atomic energy states as they are governed by specific thresholds. An electron can only reach a higher orbital when it receives a specific amount of energy.[3] In *Catacaustics*, as more people enter the domain of the installation, variety and complexity of light patterns increases. The visitor's presence becomes a metaphor for the potential to discover: as more minds interact in the space below, the scope of creative thought expands, increasing the chances for novel ideas.

Quantum physics experiments were also taken into consideration when designing the piece. Their precision lies at the extremes of engineering and fabrication. The resulting aesthetic is often coldly complex and delicate. Form and space take on markedly different principles from what is normally encountered. The presence of this art piece was intended to evoke such principles to share with the public and offer a vaguely familiar assemblage to the scientists who might have worked with such machines.

Figure 1
Simulation of caustic reflections using light caching in Vray for Maya.

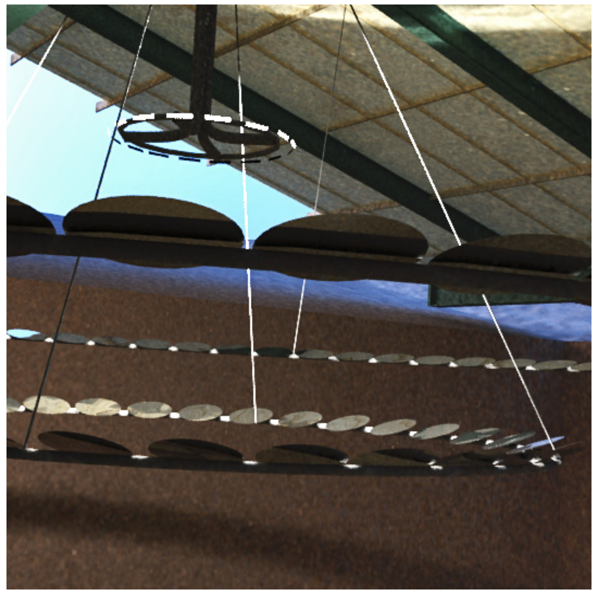

Figure 2
Close up of outer ring with opposing side and inner ring visible.

Figure 3
Result of outer control curve assuming p1,q4 torus knot and inner control curve assuming p1,q2 torus knot.

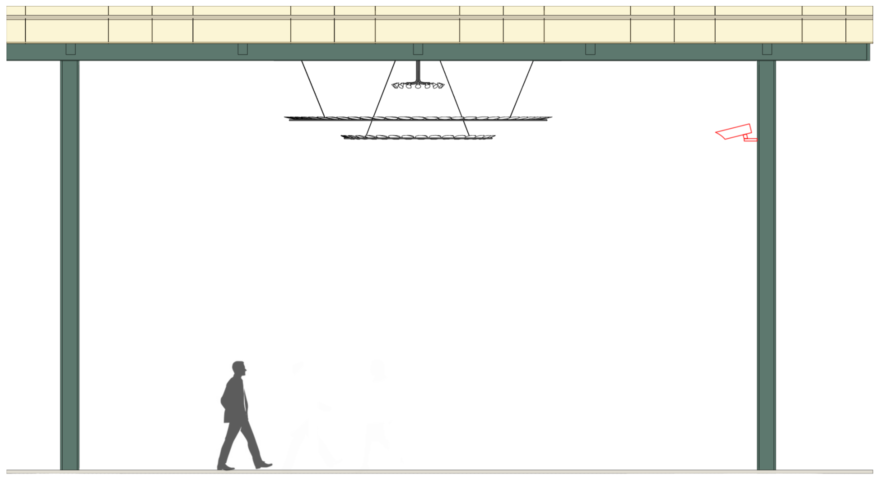

Figure 4
Depicting scale relative to a 180cm person. Thermal camera is shown in red.

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Each stepper motor will be individually controlled by an Arduino with preprogrammed target orientations. It will interpolate between new patterns when predefined thresholds of heat are registered by the thermal camera. Orientations are created by an algorithm built in the animation software Houdini. The algorithm takes a control curve which has an equal number of points as reflective elements in a ring, rotating each element to face its corresponding point on the control curve (fig 5). The control curve assumes different shapes which are themselves parameterized mathematical knots of the (p,q)-torus, but only in two dimensions. The control curve can then be scaled and positioned for optimal clarity. The resulting rotation values will be saved as instructions for the Arduino.

Light simulation was done using Vray for Maya as well as Mantra in Houdini to test various configurations (fig. 1-3, fig. 8).

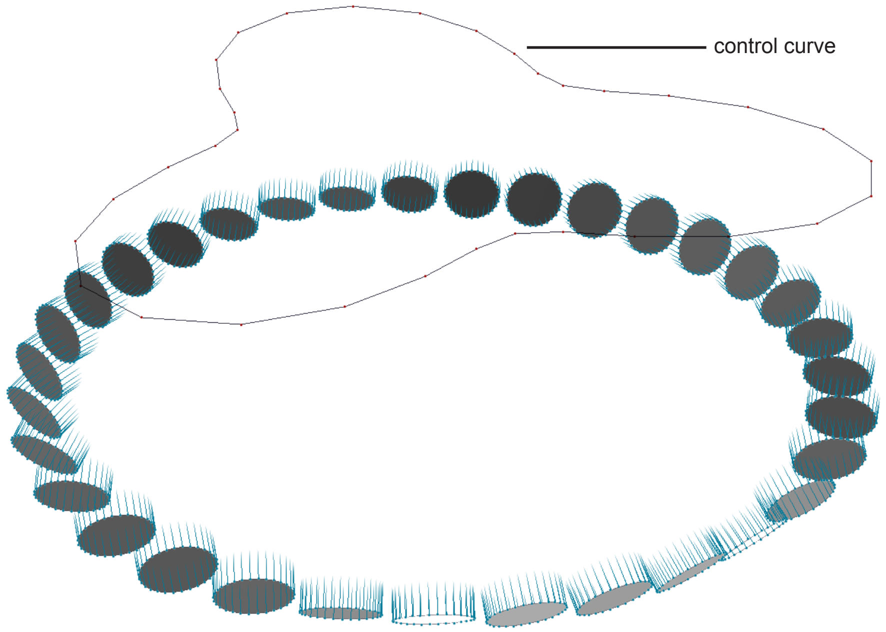

Figure 5
Example of control curve and reflective element relationship. Control curve is exhibiting a p1,q3 torus knot. Reflective elements' point normals shown in blue to emphasize orientation.

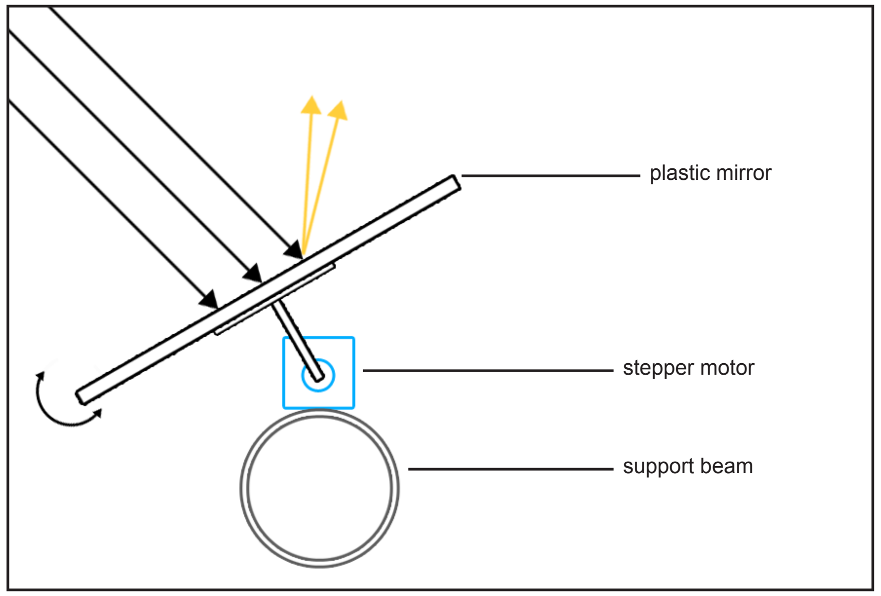

Figure 6
Illustration of reflective element with stepper motor. Reflection rays are slightly warped due to imperfections in plastic.

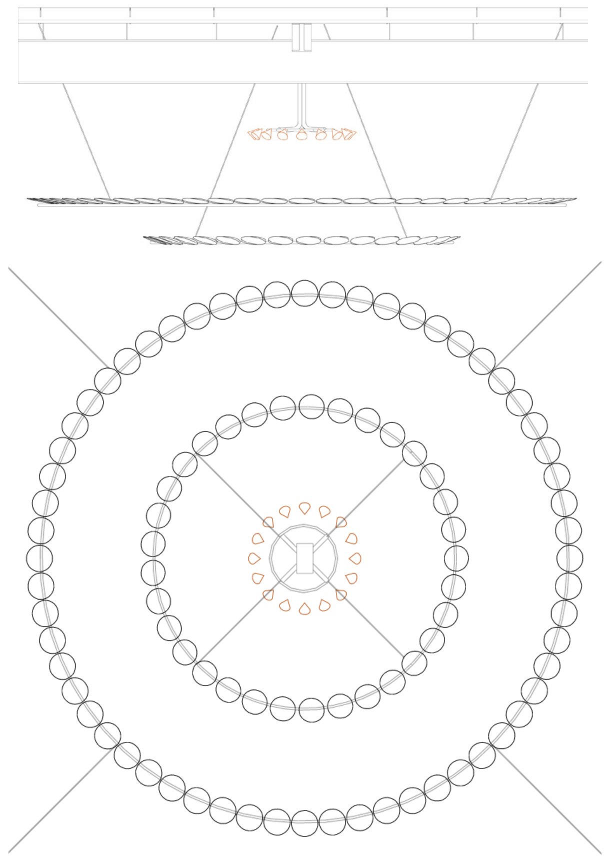

Figure 7
Orthographic side and top views. The outer ring has a diameter of 4.3 meters, the inner ring 2.5 meters. Light positions are colored orange.

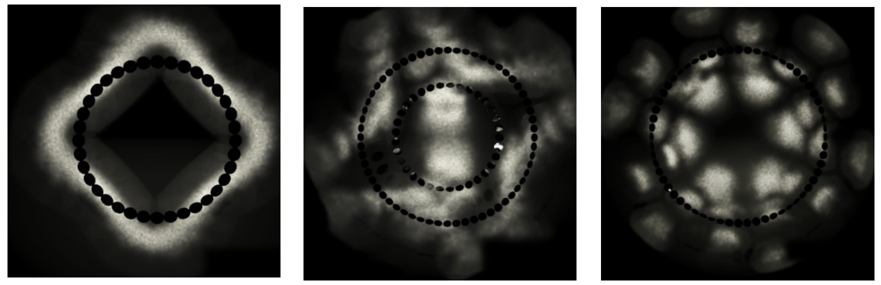

Figure 8
Examples of patterns generated with the torus knot control curve.

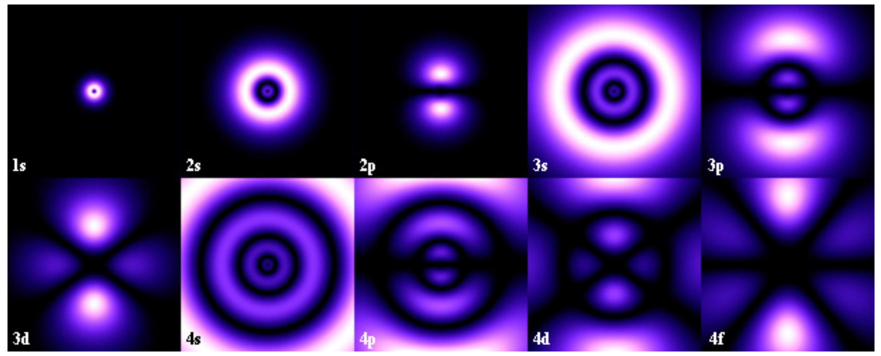

Figure 9
Table depicting electron orbital cross sections of a hydrogen atom in different energy states. Image by Paul Nylander. [5]

References

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