VISUAL IMAGES
FROM THE STUDY OF PHYSICS

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The disciplines of fine arts and science may seem worlds apart. Perhaps artists seem emotional, romantic or subjective to the scientist; artists often feel that scientists are too cold, rational, and focused on data. Physics, in particular, may seem like a scientific discipline totally contained by obtuse, abstract mathematical equations about things that nobody can see or even apprehend! Actually, scholars and historians are able to identify many similarities between the pursuit of visual arts and the study of physics. An examination of the symbols and illustrations used in physics research and theory yields a variety of visual material that is not only enlightening as a tool for understanding aspects of the universe but also aesthetically rich in its own right.

Physics is the branch of science that examines matter, energy, and the structure of atoms. There is a strong emphasis in physics on abstract, mathematical thought that can be very intimidating to those unfamiliar with higher mathematics. In recent years, however, a number of scholars with an interest in both art and science have examined what artists and physicists have in common.

Several scholars assert that artists and physicists are trying to do the same thing: explain what is unseen in the universe. Physics may be about abstract concepts, but artists deal in abstractions, too. Modern artists may take common artistic practices such as portraying perspective, depicting light and shadow, and color theory for granted, but all of these were discoveries made by artists over centuries, after much research, trial and error.[1] Leonard Shlain's book *Art and Physics, Parallel Visions in Space, Time and Light* describes many such similarities and parallel histories between art and science. One of the topics he discusses is how Renaissance artists mastered the abstract thought necessary to use perspective theories in artwork (using conic sections to describe three-dimensional

[1] Shlain, 55.

objects on a two-dimensional plane) long before scientists like Johannes Kepler used the concept of conic sections to map the elliptical orbits of the planets.[2]

How does one explain what one is unable to actually see? Physicists may be trying to explain the vastness of the cosmos, the smallest pieces of matter, transfers of energy, the movement of light, a means to create a sense of order out of the chaos of experience. Artists may be trying to communicate human emotion, the justice or injustice of human transactions, the fragility of memories, or, just like a physicist, a means to create a sense of order out of the chaos of experience. A physicist may use a mathematical formula, an artist a painting, sculpture, or performance, but they are both trying to answer the same human questions of finding meaning in the universe. In his book *The Visionary Eye*, Jacob Bronowski writes: "Science uses images, and experiments with imaginary situations, exactly as art does."[3]

Physicists and artists share another attribute—the application of intuition to inquiry. In his book *Einstein, Picasso,* Arthur I. Miller explains the work methodologies of both men at the beginning of the twentieth century, as one formulated the theory of relativity and the other developed the artistic concept of Cubism that ushered in the abstract art of the twentieth century. Miller describes how both men were able to harness the new philosophical concepts and *zeitgeist* of the early twentieth century and combine them with the creativity of their own minds to create breakthroughs in the fields of science and art. He writes "[Einstein and Picasso] were working on the same problem: How to represent space and time at just the moment in history when it became apparent that these entities are

2 Shlain, 67.
3 Bronowski, 20.

not what we intuitively perceive them to be...both men sought representations of nature that transcend those of entrenched classical thought and reach beyond appearances."[4]

The field of physics uses many visual images to explain concepts; some are graphic and some imaginary. An examination of just a few examples can help illustrate the cross-cultivation that can exist between the worlds of art and physics. Laura Mattson, a recent physics graduate and scientist with the McLaughlin Research Corporation in Newport, Rhode Island, identifies two examples that she finds especially intriguing: Feynman diagrams and particle collision diagrams.[5] Examples of each are in figure 1.

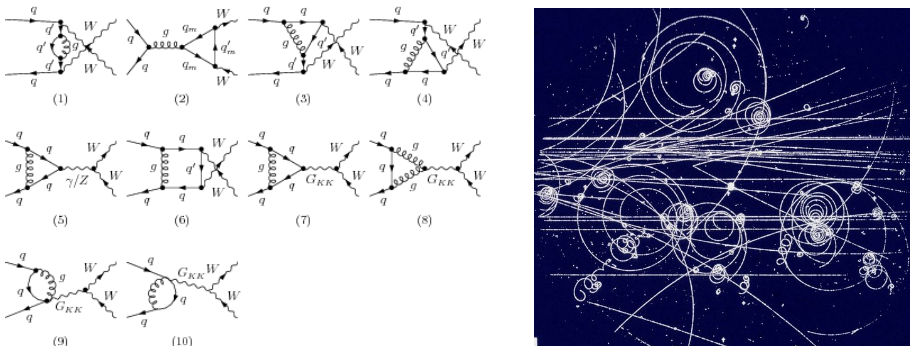

Figure 1. Feynman Diagrams and Particle Collision Diagram
Source: http://inspirehep.net/record/1082448/plots
Source: http://prancer.physics.louisville.edu/astrowiki/index.php/Subatomic_Particles

Feynman diagrams were developed in the late 1940's by physicist Richard Feynman as a way to explain quantum mechanics and the electromagnetic properties of elementary particles.[6] When Feynman first presented his graphic method of explaining quantum mechanics problems at a conference in 1948, many colleagues were unimpressed, preferring instead the complex mathematical equations of physicists Julian Schwinger and Sin-Itiro Tomonaga. It soon became apparent, however, that Feynman's diagrammatic

[4] Miller, 175.
[5] Mattson, interview.
[6] Lindley.

method was just as accurate as the mathematical formulas but quicker to use, especially as calculations became more and more complex.[7]

Today Feynman diagrams are a standard part of quantum mechanics practice. In their simplest form, they consist of straight lines with arrows (particles) connected to wavy lines (interactions). As particle behavior becomes more varied and complex, the diagrams do as well, but even so they have a graphic simplicity that makes complex theories understandable. Physicist Flip Tanedo states: “The simplicity of these diagrams has a certain aesthetic appeal, though as one might imagine there are many layers of meaning behind them.”[8] Mattson says, “I do not find them particularly beautiful but they are interesting. Using arrows to explain particle decay adds a simplicity to an otherwise complicated process.”[9]

Of particular interest is the Feynman Penguin, seen in figure 2. The actual scientific event being illustrated is a quark changing type. The story behind the penguin diagram, according to Mattson, is this:

> Two physicists were having fun together (aka drinking) and one bet the other he couldn't publish a paper with the word “penguin” in it. He took the challenge and manipulated his research's Feynman diagram to have a penguin shape. And that's how they're known now![10]

[7] Ibid.
[8] Tanedo.
[9] Mattson, interview.
[10] Ibid.

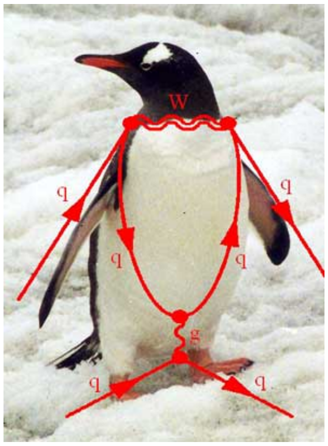

Figure 2. Feynman Penguin
Source: http://physicscentral.com/explore/action/feynman.cfm

In addition to their flexible illustrative qualities, the simple lines and shapes of Feynman diagrams have an aesthetic of their own. Clustered together on a page, they have a typographic quality, and indeed, they are a pictorial written language of science. They share a hieroglyphic quality with the pictograms of numerous ancient cultures, and have been used as a decorative motif on wallpaper and automobiles.

Particle collision diagrams are another visual device from the study of physics that are admired for their aesthetic beauty. These diagrams are computer generated simulations based on data from particle accelerators, such as the Large Hadron Collider at CERN near Geneva, Switzerland. These diagrams use lines to represent the movement of the particles, and colors to represent their intensity (i.e., how many particles are following that particular track).[11] The symmetrical image in figure 3 is of the proton collision that produced the Higgs boson particle at the CERN laboratory in Switzerland. Figure 4 shows a kaon proton collision.

[11] Ibid.

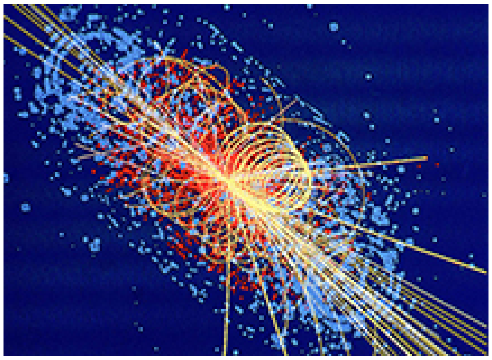

Figure 3. Higgs Boson Collision
Source: http://home.web.cern.ch/topics/higgs-boson

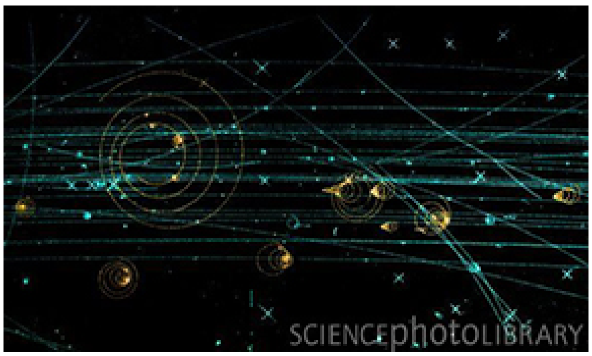

Figure 4. Kaon Proton Collision
Source: http://scienceblogs.com/startswithabang/2011/07/06/is-this-where-the-matter-in-th/

Collision diagrams share a number of elements: delicate spirals, the subtle curves that reach out from the spirals, and smaller marks that resemble tiny bursts, or sparks, that seem more randomly placed, and yet balance each other in their placement. The diagrams have a line quality that resembles careful, delicate drawings or etchings. Several twentieth century artists come to mind when considering the collision diagrams. Some of Paul Klee's drawings and etchings have similar shapes and line quality. *Twittering Machine* and *Destruction and Hope* are two examples shown in figure 5. The spirals, curves and arcs of the collisions also bring to mind the abstract paintings of Joan Miro, such as *Singing Fish* and *Wedding*, in figure 6. Sonia Delaunay's *Electric Prism* paintings (Figure 7) consist of blocks of color, not line work, but the concentric circular shapes and curves emanating from them also share visual qualities with the collision diagrams. Even the titles of

Delauney's paintings, *Electric Prisms*, suggest a piece of equipment that might be found in a physics laboratory. All of these twentieth century artists lived and worked decades before the computer simulated graphics of particle collisions were created, but elements of their work seem to express a prescient knowledge of some of the elemental forces of the universe that were discovered after their time. Leonard Shlain believes that artists have an ability to function as prophets in society: "...blindsight is the ability to see that which is physically impossible to see...Artists are nonverbal prophets who translate their visions into symbols before they are words: Artistic precognition is civilization's blindsight."[12]

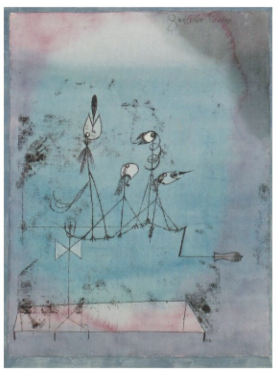


Figure 5. Paul Klee, *Twittering Machine* and *Destruction and Hope*
Source: http://www.moma.org/collection/object.php?object_id=37347
Source: http://www.moma.org/collection/object.php?object_id=59763


Figure 6. Joan Miro, *Singing Fish* and *Wedding*
Source: http://joanmiro.co.uk/

[12] Shlain, 428.

Figure 7. Sonya Delaunay, *Electric Prism*
Source: http://www.artexpertswebsite.com/pages/artists/delaunays.php

Contemporary artists are also inspired by the beauty of particle collision diagrams. Antonie Los is a Dutch painter for whom the particle collision is a recurring theme. Los is also interested in Eastern philosophies and Jungian psychology, and the metaphysical aspects of particle physics is a way for him to combine aspects of the material and spiritual worlds.[13] Some of Los' paintings are colorful, simplified enlargements of the computer simulations. Other paintings simplify the shapes still further, but add whimsical, wallpaper-like background patterns, as if to domesticate the abstruse scientific concept. Two are shown in figure 8.

Figure 8. Antonie Los, particle collision paintings
Source: http://masqua.ca/2013/07/25/particle-collision-2/
Source: http://masqua.ca/paintings/

[13] Los.

Carter Hodgkin also uses the particle collision concept to create paintings, as in figure 9. He plots the shapes and lines with computer software first, and then bases his paintings on the outcomes: “ I play with color, transparencies and line widths until what was a random event emerges as an iconic form...Through the infinitesimal realm of physics, I explore a relationship between algorithmic data and the pictorial. What emerges are paintings which reflect a tension between technology and handcraft; the rigor of a scientific process and the emotional possibilities of abstraction.”[14]

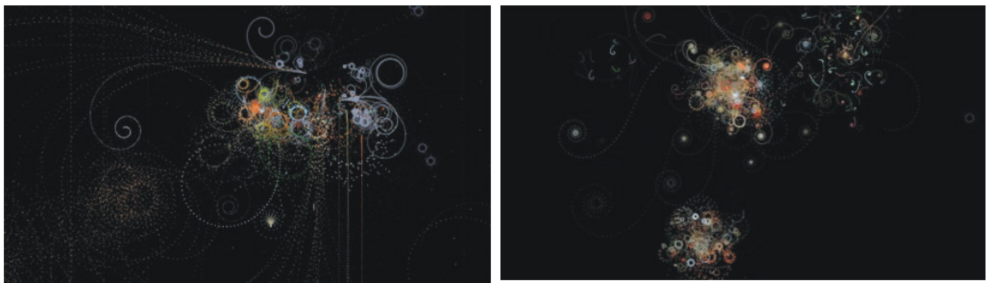

Figure 9. Carter Hodgkin, Particle collision paintings
Source: https://carterhodgkin.see.me/atts2012

Mike Field's bronze sculptures are also inspired by the Higgs boson collision (Figure 10). Not only does he recreate the forms of the collision, but he finishes the sculptures with an anodized-looking “Steel Chameleon” paint that is reminiscent of the colors of the original computer simulations.[15]

[14] Hodgkin.
[15] Fields.

Figure 10. Mike Field, *Supersymmetry*
http://chesterfieldsbronzes.com / supersymmetry-contemporary-sculpture-particle-collision/

Sometimes the visual images created by physics inquiries are not specific graphic material, but images of the imagination which allow individuals to create their own mental pictures, which can become very engaging or amusing. One of the best examples of this is Schrodinger's cat.

Schrodinger was an Austrian physicist of the early twentieth century, one of the major contributors to the theory of quantum metaphysics. One of the problems of this field is determining the location of a particle *before* its location is determined by a precise measurement. This location is called a "superposition." Schrodinger formulated an equation to describe the probabilities of particles in space, and to illustrate his reasoning he devised a thought experiment, the now famous "Schrodinger's cat paradox."

> Suppose we have a radioactive atom with a half-life of one hour. In other words, it is 50 percent likely to decay during that period. A cat inside a cage is hooked up to a device that will expose it to lethal gas when and only when the atom decays. If the atom, device, and cat are left unobserved, then after one hour, the entire apparatus is in a superposition: were we to examine the apparatus, there is a 50 percent chance that the measurement outcome will be that the atom has decayed and the cat has been killed, and a 50 percent chance that the outcome will be that the atom has not decayed and the cat

> has not been killed. But what in the world can it mean for a cat to be in a superposition of being alive and being dead?[16]

> The formula for Schrodinger's cat paradox is this:

$$H(t)|\psi(t)\rangle = i\hbar\frac{\partial}{\partial t}|\psi(t)\rangle$$ [17]

Such a mathematical equation is not accessible to most of the human population. Creating a mental image of a cat inside a box is easy, though; a search on the internet for “Schrodinger's cat images” demonstrates just how easy it is. Is the cat dead or alive? The question adds a new level of interest—it seems most people have an opinion of cats, and are willing to vote on which is most desirable! What if we say the cat is both dead and alive at the same time, because we have no sure way of knowing which statement is totally true? Now everyone is happy. Also, the human mind seems to be intrigued by this example of ambiguity, probably because in our daily lives ambiguity is something we face constantly. We go through our lives always having a vague idea of what *might* happen, of what we *want* to happen, and then we have to deal with what actually *does* happen. The pathetic cat in a box is a being we can all relate to. Confronting the fact that we all live in a universe of shifting, unknowable information that can determine our very life or death is unnerving, and making jokes about an unfortunate cat is a way to deflect our discomfort.

An internet search for images of Schrodinger's cat reveals thousands of interpretations; clearly this visual picture has captured the public's imagination. There are, of course, the schematic line drawings of the cat experiment used to illustrate scientific

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[16] Lange, 259.
[17] Zyga.

texts. There are cartoons, amateurish sketches, Japanese manga-style illustrations, and digitally altered photos. Many internet-meme type graphics show various photos of cats such as an angry cat tearing its way out of box or a cat dressed up in a lab coat; the photos are accompanied by slogans such as “Schrodinger's Cat: Wanted Dead and Alive” and “Schrodinger's cat walks into a bar, and doesn't.” A more sophisticated graphic is a silhouette of a cat's body filled in with a repetitive pattern of Schrodinger's equation.

Schrodinger's cat images are emblazoned on T-shirts and hoodies, tattooed on people's bodies, and provide inspiration for craft projects. People have made Schrodinger's cat stuffed toys and even a gingerbread box and cats. It is also inspiration for many creative Halloween and party costumes, some more provocative than others. Mattson says this about Schrodinger's cat:

> Schrodinger's cat is a physics reference that has kind of morphed into a pop-culture reference as well. A lot of physics material that is projected out more to the general public carries this motif because I think they are hoping the cat is something the public can relate to and will generate more interest in the field of physics. I think it's nice that there is this more commonly understood concept that the public knows about but at the same time it represents a slick oversimplification of one of physics' most complicated concepts.[18]

In addition to identifying with the ambiguity of Schrodinger's cat and appreciating the subtle, somewhat cynical humor of its condition, the general public enjoys having a sense of ownership in what is a very complex scientific idea. Employing images of Schrodinger's cat allows one to be an “insider” of a scientific clique which understands (or at least attempts to understand) quantum theory, a position of considerable intellectual prestige.

[18] Mattson, interview.

Feynman diagrams, particle collision diagrams, and Schrodinger's cat images are only a few examples of the use of visual images in the world of physics. As scholars like Shlain and Bronowski have pointed out, both artists and physicists attempt to portray unseen aspects of the universe, and both have intuitive and imaginative talents that allow them to see beyond the immediate, material world. Mattson says this about the relationship between physics and the arts: “I love that these two worlds can be combined. The people involved in these areas of interest are often completely opposite (left-brained vs. right-brained) and the fact that they can be ‘smashed’ together...reiterates the circularity of the universe and how everything is connected to everything else.”[19]

When artists and scientists make an effort to understand each other's ideas and accomplishments, not only are they enriched by understanding new aspects of the world, but they are given new intellectual tools to apply to their own fields of practice.

[19] Mattson, interview.

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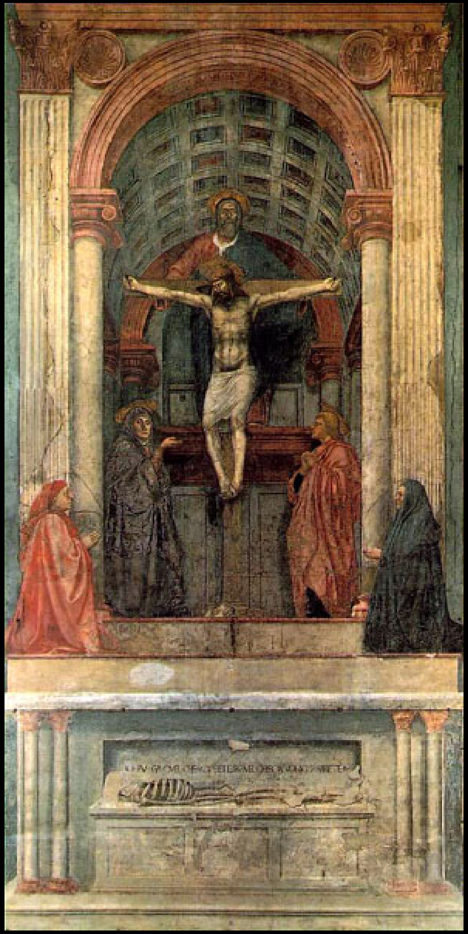


Massaccio's *Holy Trinity* –

Early 1400's

http://www-history.mcs.st-and.ac.uk/HistTopics/Art.html

Johannes Kepler- 1620

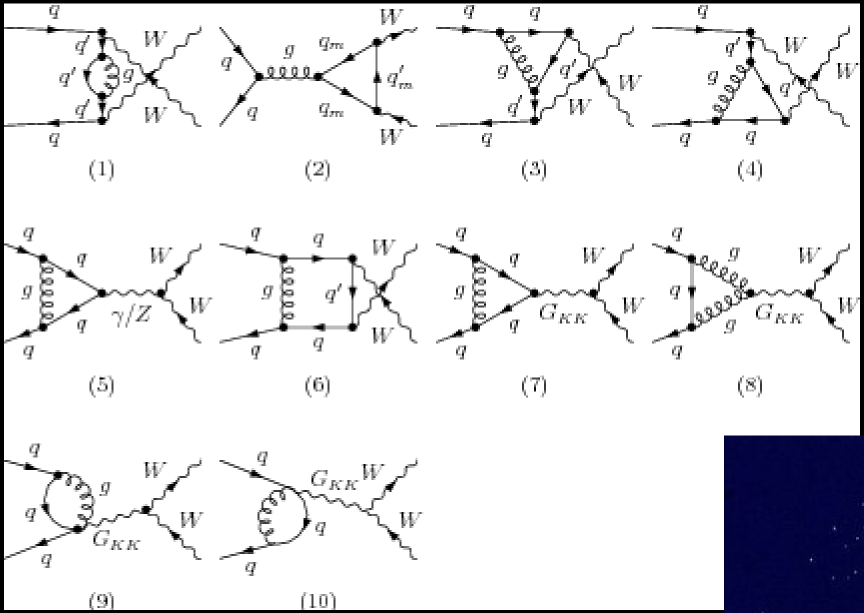
http://kepler.nasa.gov/Mission/JohannesKepler/

Einstein

http://www.wired.com/2012/10/12-decades-of-geek-part-1/

Picasso

http://en.wikipedia.org/wiki/Pablo_Picasso



Feynman diagrams

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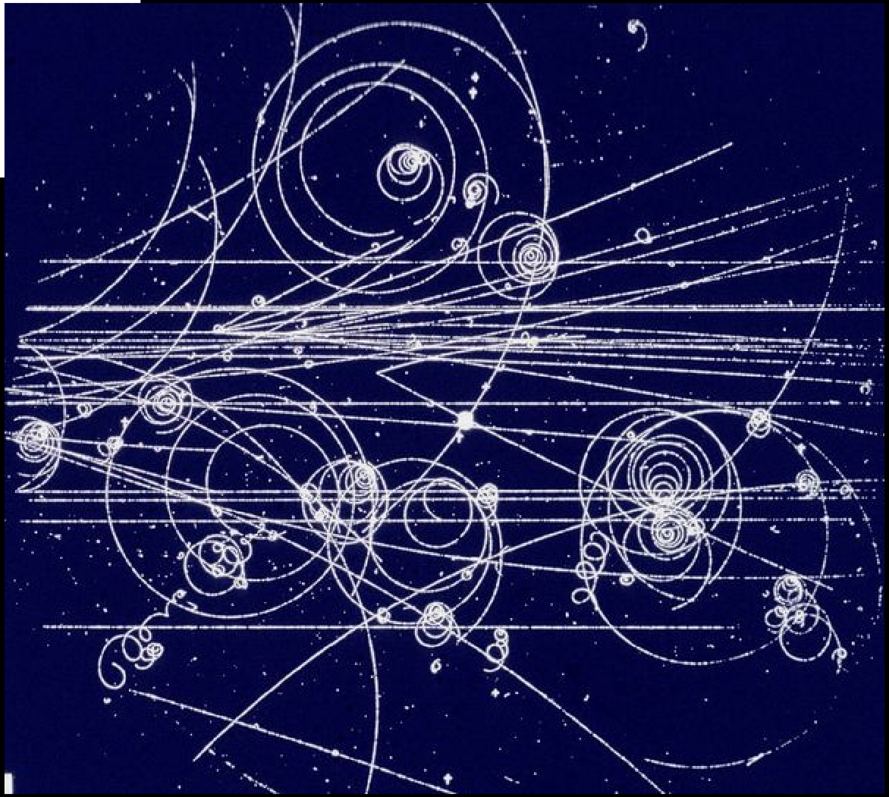
Particle collision diagram



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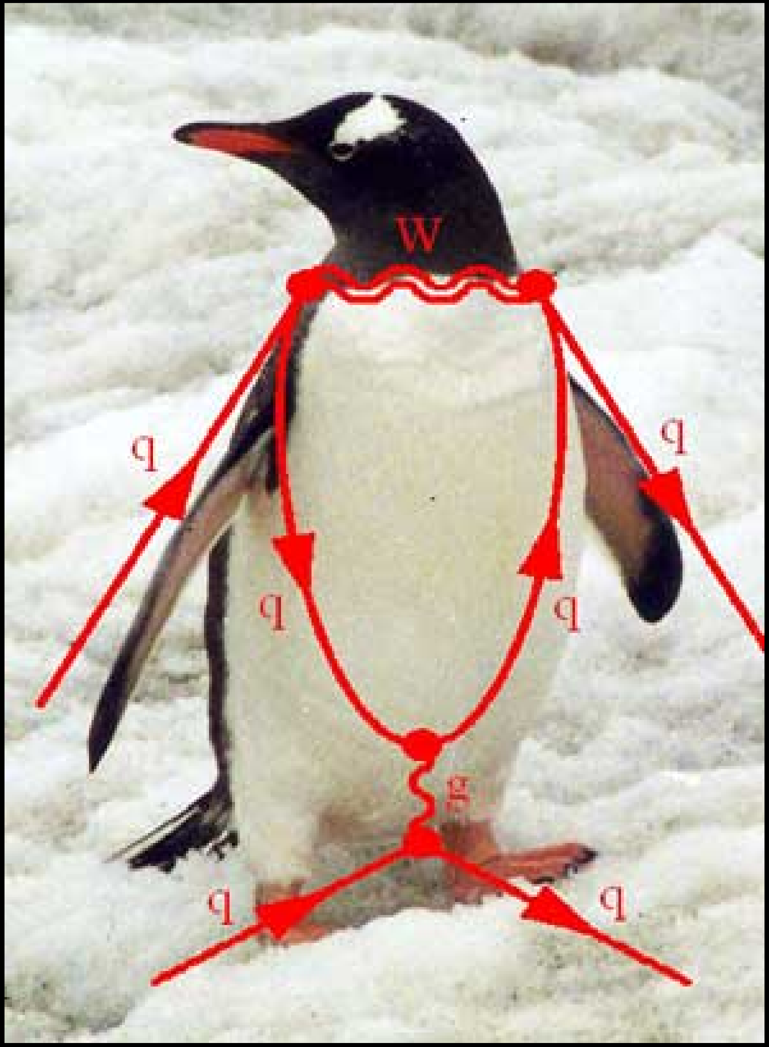

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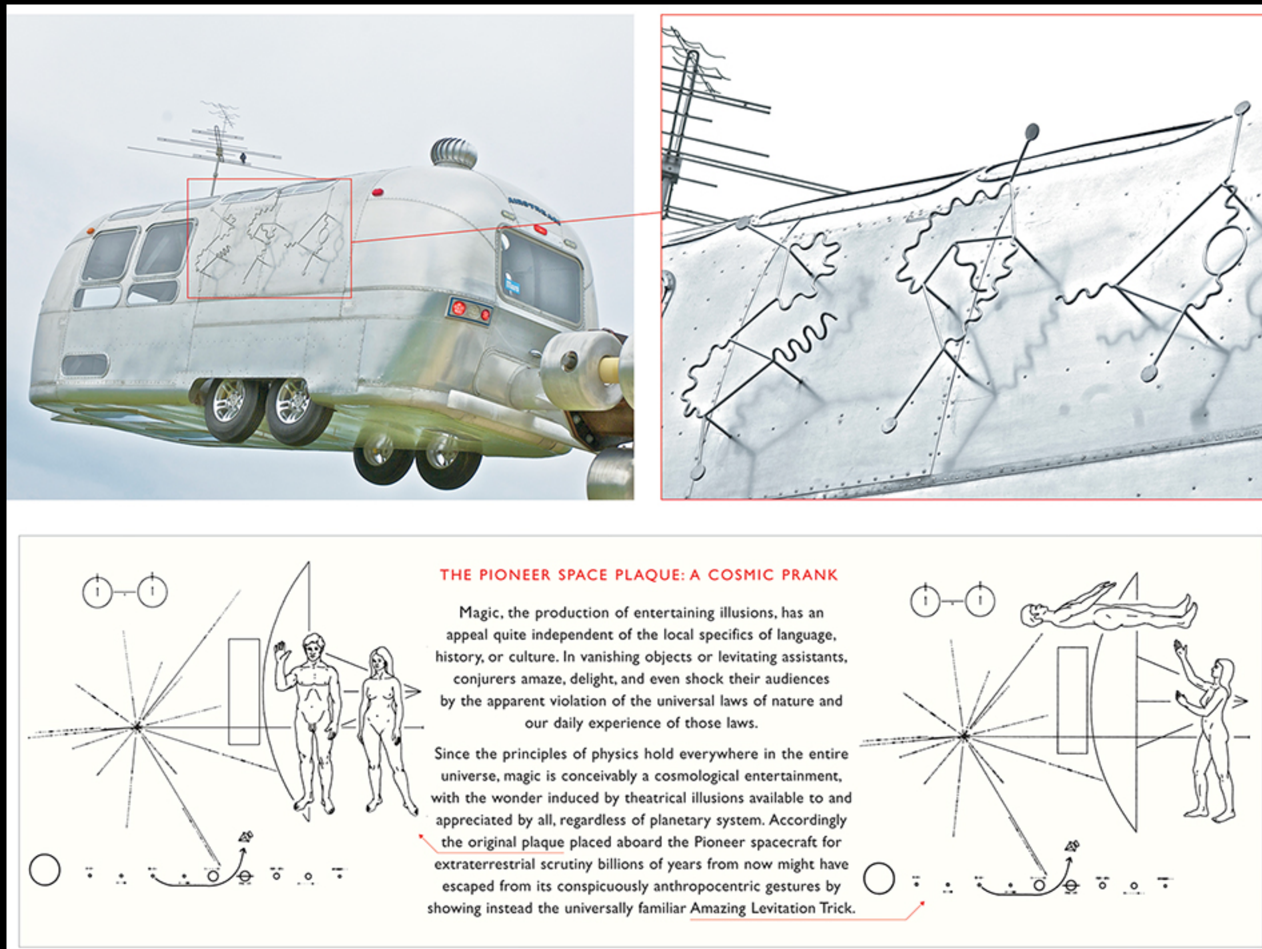
Feynman penguin



The Pioneer Space Plaque: A Cosmic Prank 2010 digital print, animation electronics 6.9 x 2.2 x .5 feet or 2.1 x .7 x .2 meters

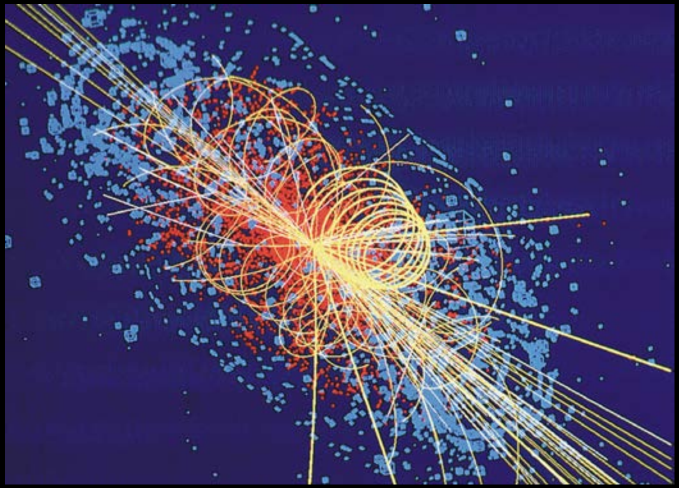
http://www.edwardtufte.com/bboard/q-and-a-fetch-msg?msg_id=0003uU

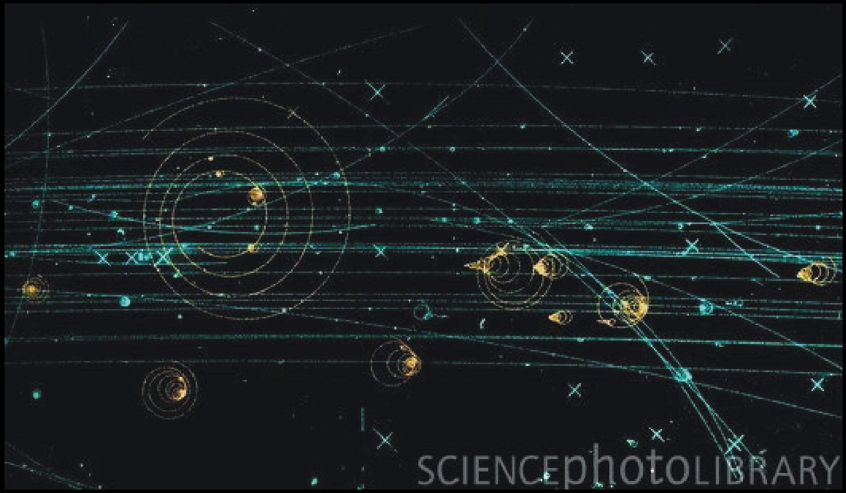
Sculpture by Edward Tuft, *Rocket Science 3*

http://www.fotuva.org/online/frameload.htm?/online/van.htm

https://plus.google.com/+AndreaKuszewski/posts/PRosUboeKYu

Feynman’s personal van; walls at CalTech





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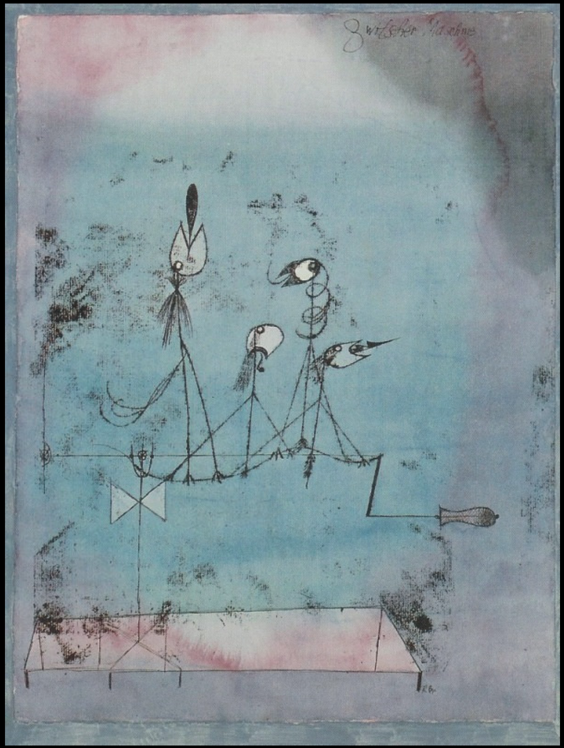
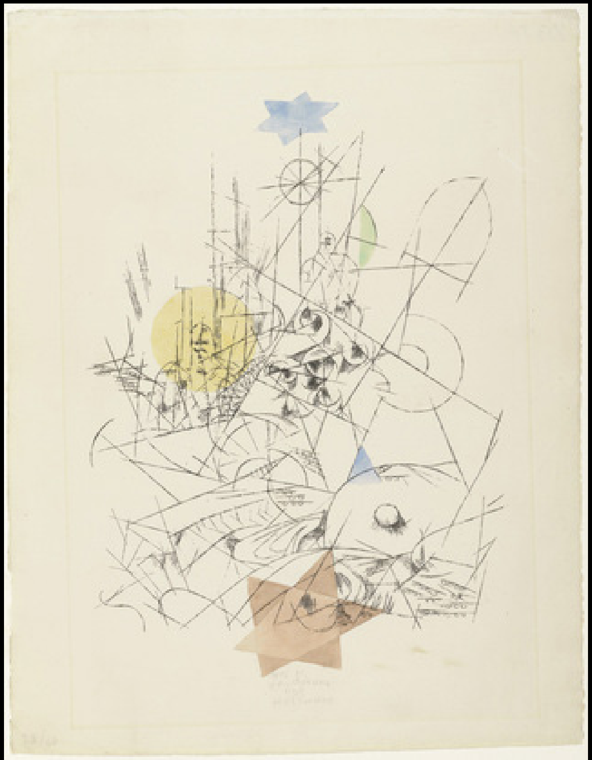
Higgs boson collision and kaon proton collision





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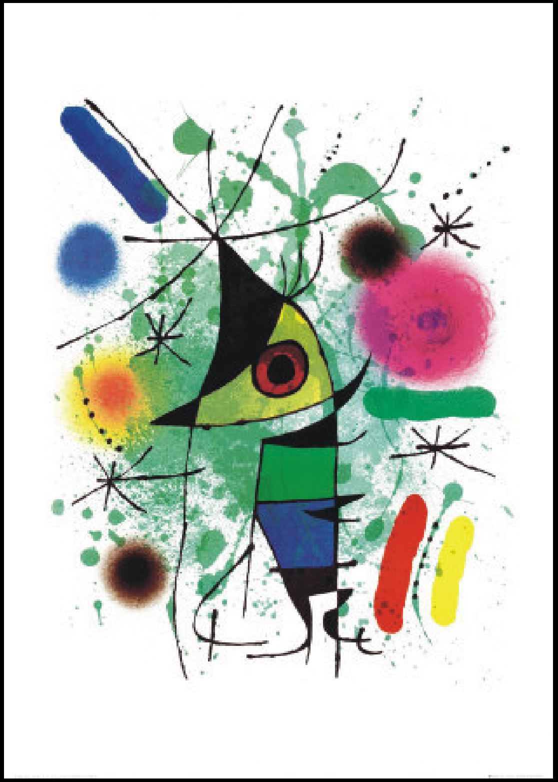
Paul Klee, *Twittering Machine* and *Destruction and Hope*



Source:http://joanmiro.co.uk/

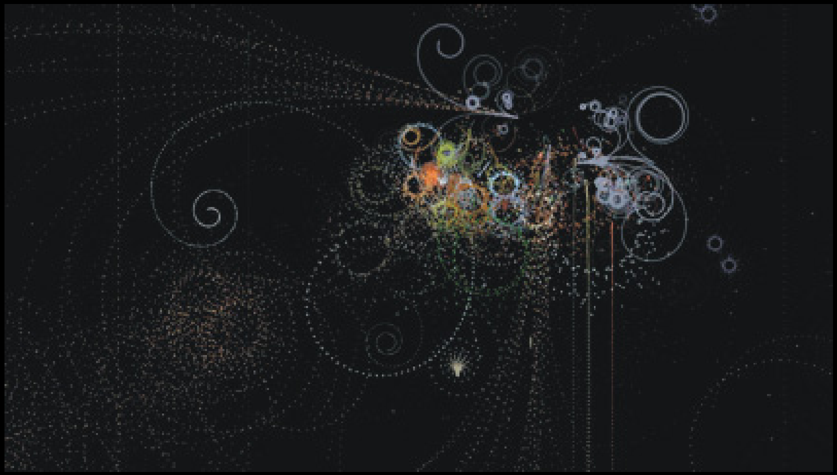
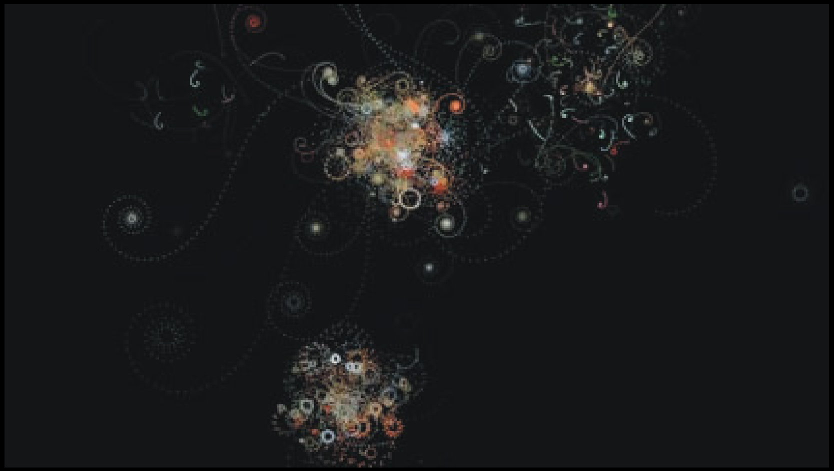
Joan Miro, *Singing Fish* and *Wedding*

Source:http://www.artexpertswebsite.com/pages/artists/delaunay_s.php

Sonya Delaunay, *Electric Prism*

Source:http://masqua.ca/2013/07/25/particle-collision-2/
Source:http://masqua.ca/paintings/

Antonie Los, particle collision paintings

Source:https://carterhodgkin.see.me/atts2012

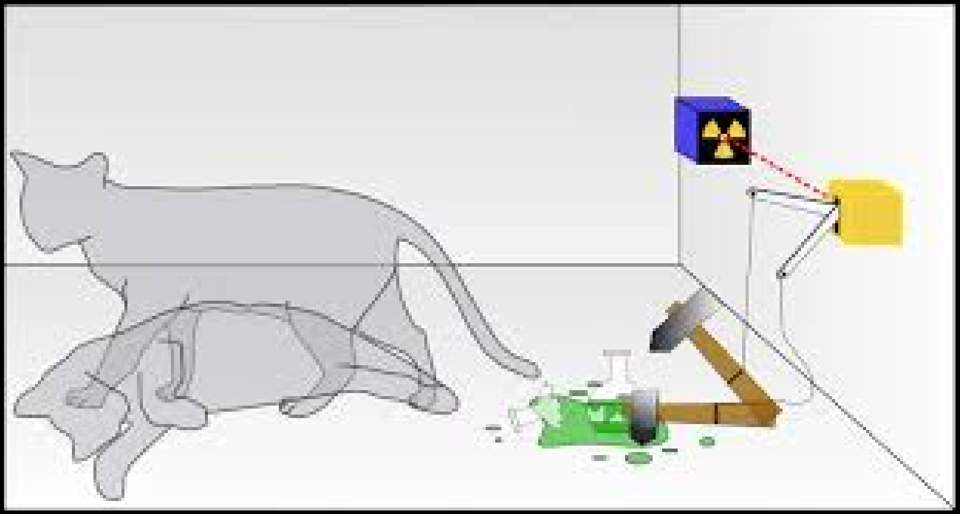
Carter Hodgkin, Particle collision paintings

Source: ChesterFieldsBronzes.com

Mark Field, *Supersymmetry*

Particle collision ring

$$H(t)|\psi(t)\rangle = i\hbar\frac{\partial}{\partial t}|\psi(t)\rangle$$



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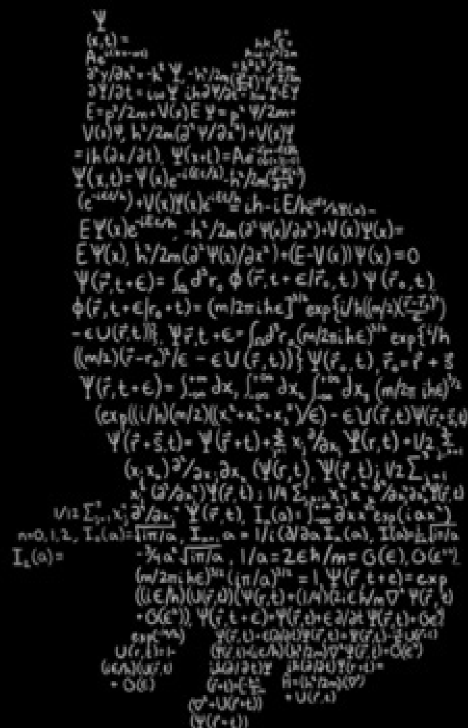
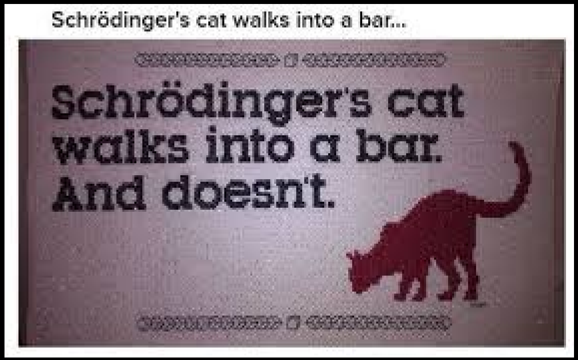
Schrodinger’s Cat



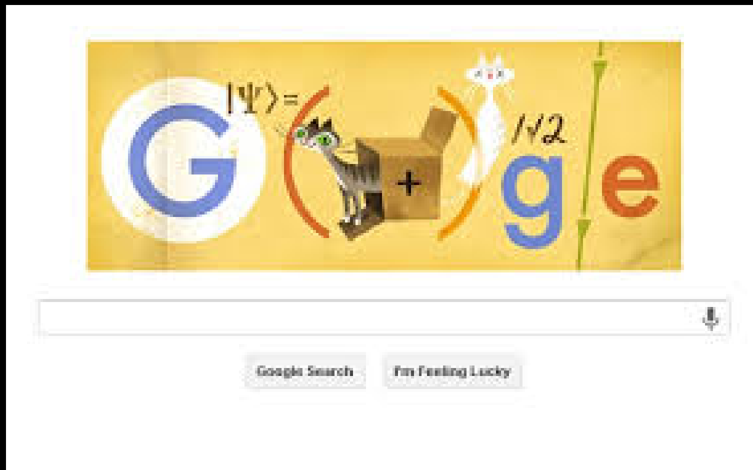
$$i\hbar(\partial/\partial t)\Psi=\hat{H}\Psi$$

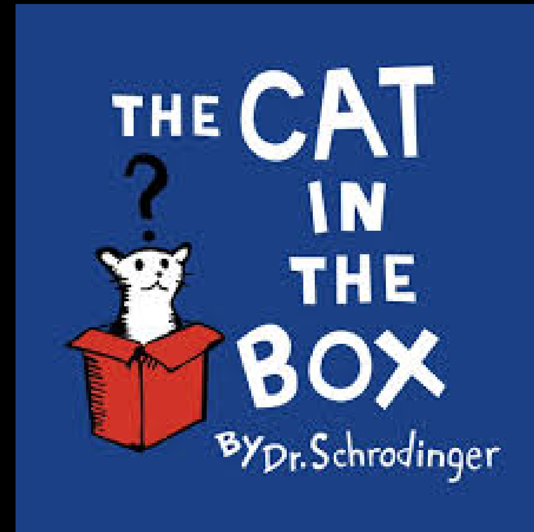

Schrödinger's cat walks into a bar...
Schrödinger's cat walks into a bar. And doesn't.


Schrödinger's cat is alive.
And very angry.


WANTED
DEAD&ALIVE
SCHRÖDINGER'S CAT


$E\Psi = \hat{H}\Psi$


Google Search
I'm Feeling Lucky


THE CAT IN THE BOX
By Dr. Schrodinger


SET
1
8/8

Schrodinger’s cat costumes