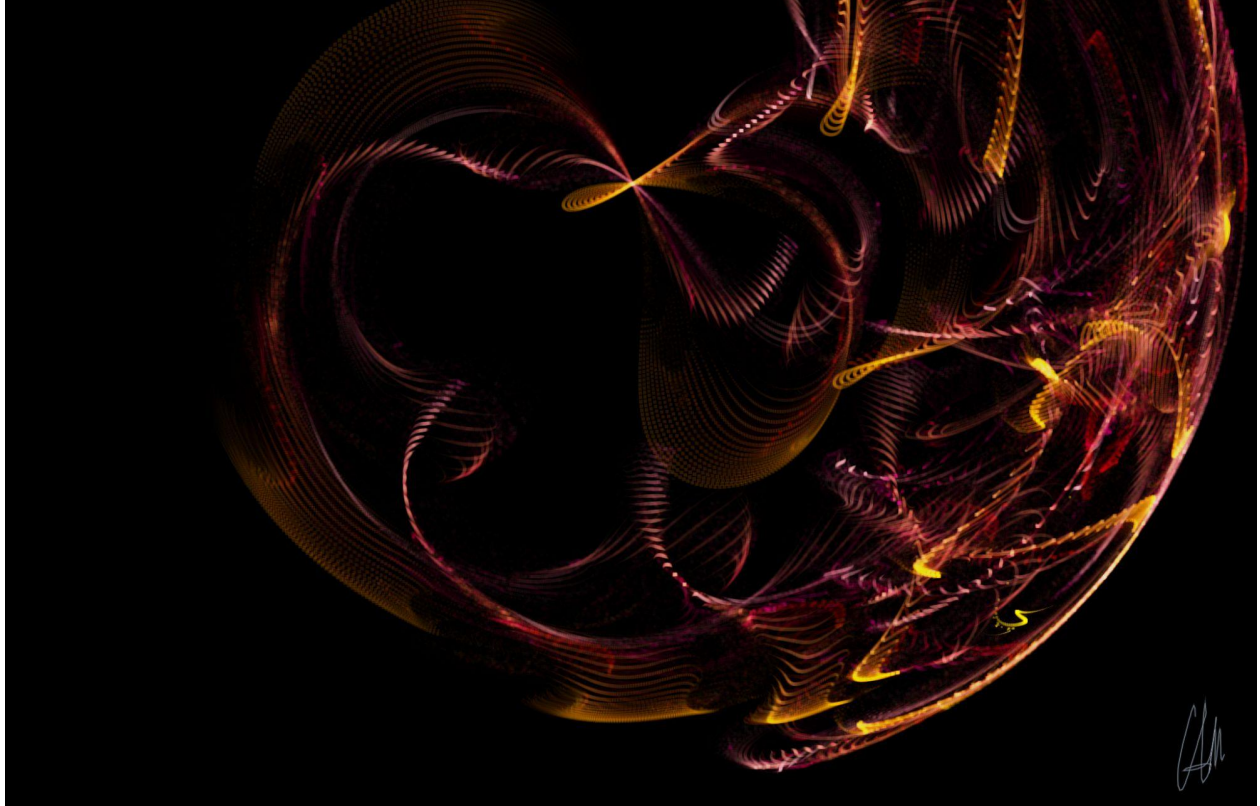


# Engineering Chaos

*Breakdown of the '**Eternal Chaos**' project, collection and journey*



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09.02.2022

(updated 10.05.2022)

In loving memory of my Dad, Alan Machin

## ETERNAL CHAOS

This project is my genesis project as a generative artist and my first fully on-chain art project on Cardano. I wanted something exciting that I could build in my spare time alongside my primary work which is programming and architecture for VR medical training simulations.

Why did I choose chaos? because it's been a fascination of mine. Chaos and the patterns that it forms are an emergent phenomenon of a special kind of mathematics.

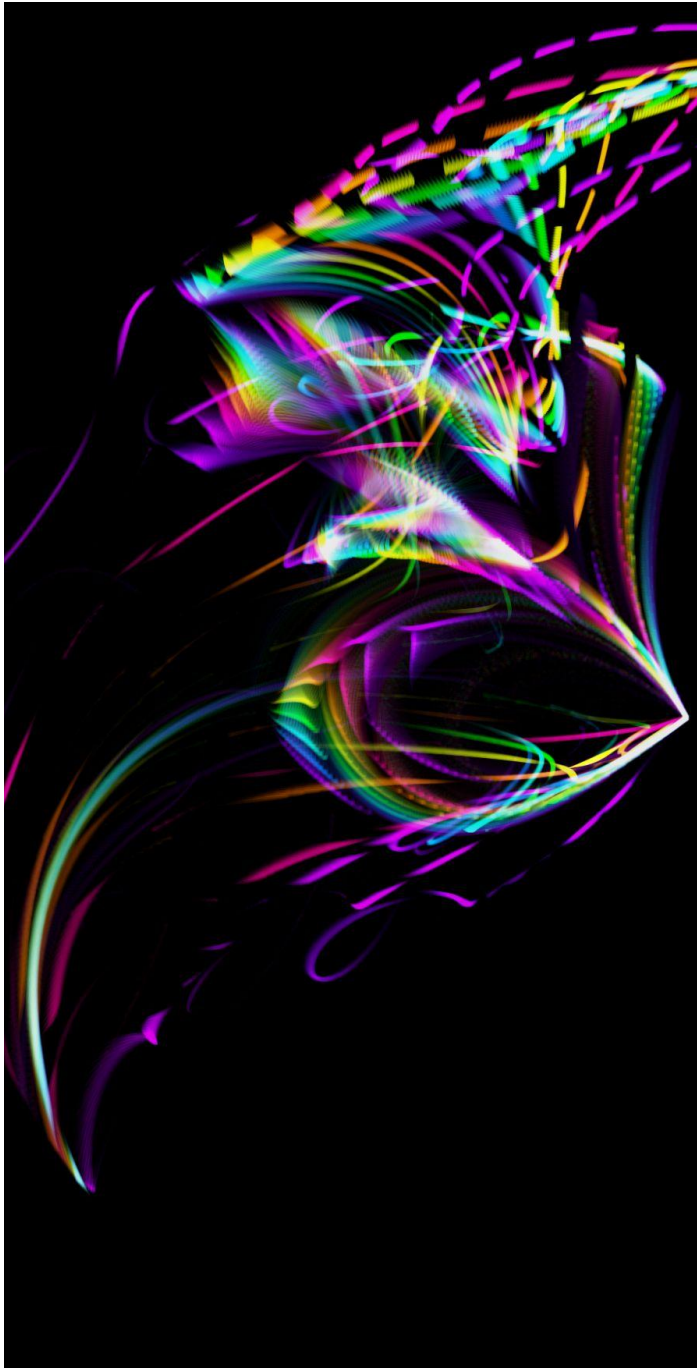


## SO... WHAT EXACTLY IS CHAOS?

Threads, vortices, galaxy formations, spinning particles in pairs or triplets. All these things can emerge from chaos.. Fascinating universes of form and pattern hidden within number systems.

If I was going to try to reduce the way it works to a single sentence, I could say... It's a looped mathematical process that feeds back into itself in a way where small changes in one early calculation can ripple across the later ones creating wild, fascinating and sometimes unpredictable patterns! Simple right!.. Well actually it is quite simple. Like many emergent and generative processes it is, at its core, actually quite simple, and a raw chaos function can be described in about 7-8 lines of code. Or even smaller.

An interesting property of the chaos used in these pieces is that every calculated point is related to the next. Intrinsically linked in a chain of ripple effects. Not just all the points you see on a single frame but also along the time direction.



last calculation result of the previous frame.

Another way of putting this is that once the chaos starts, the values from the calculations of the first frame (and all others after) have an influence on all the frames generated past that point. One precise continuous flow that always happens the same way due to the magic of deterministic computation.

Formations can often be seen building up until a tipping point where a larger shift occurs and explosions of new forms come into existence.

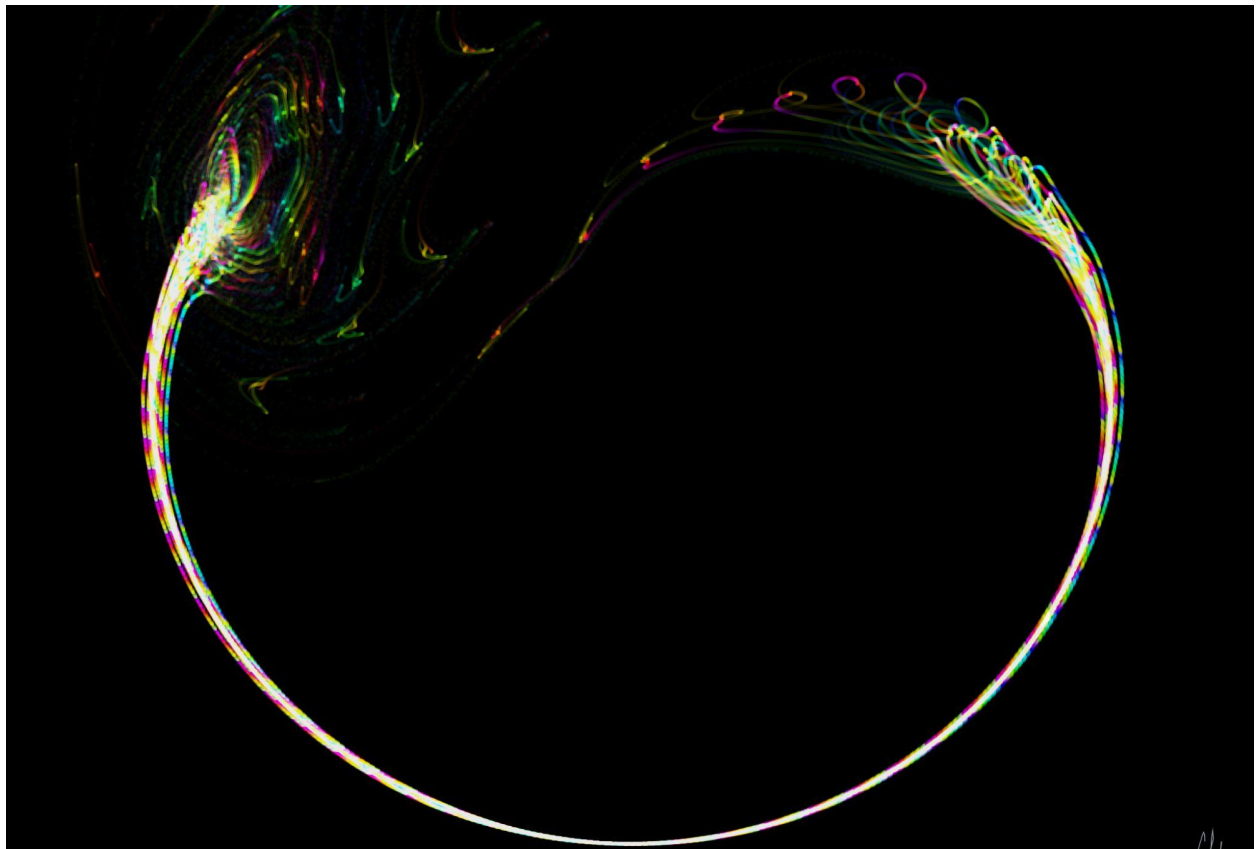
I see the interconnection between the calculations as similar to how the universe is connected and how all particles have common ancestry in the big bang and are forever related. There is something cosmic about how chaos behaves.

Another interesting property of chaos is that it is 'stateless'. The opposite to this would be a particle system that remembers position and velocity on every particle from frame to frame. But for chaos no data is stored on where the points are. The only stored carry over value is the

## THE GREAT FRAMEBUFFER

This was an idea that me and one of the smartest people I know, who goes by the name of Daniel, came up with many years ago.

Some theories and measurements of reality indicate that it's almost like the entirety of space and matter are popping in and out of existence at a hyper fast rate while giving the illusion of permanence. Relating this effect to rendering we called it the “pass of the great framebuffer!” Throughout the entirety of space and existence... It was a crazy ‘what if’ moment and the idea stuck with me.



So a frame buffer... (to non-geeks) is where a renderer draws to. It's a block of memory that represents the screen that you see.

For each frame, the chaos formation is remade from the single carry over value along with a  $t$  value for time. Each Eternal Chaos piece draws 8000 chaos points approximately 60 times per second when running live.



## CURATION OF CHAOS

A big part of the creation process for this collection was the refinement and curation of the mathematical formulas used to run the chaos, and the number groups that define variation. Curating the collection was a slow explorative process lasting a few months. Each day gaining more insight into the subtleties of chaos engineering.

### Exploration phase 1 - chaos god formula creation

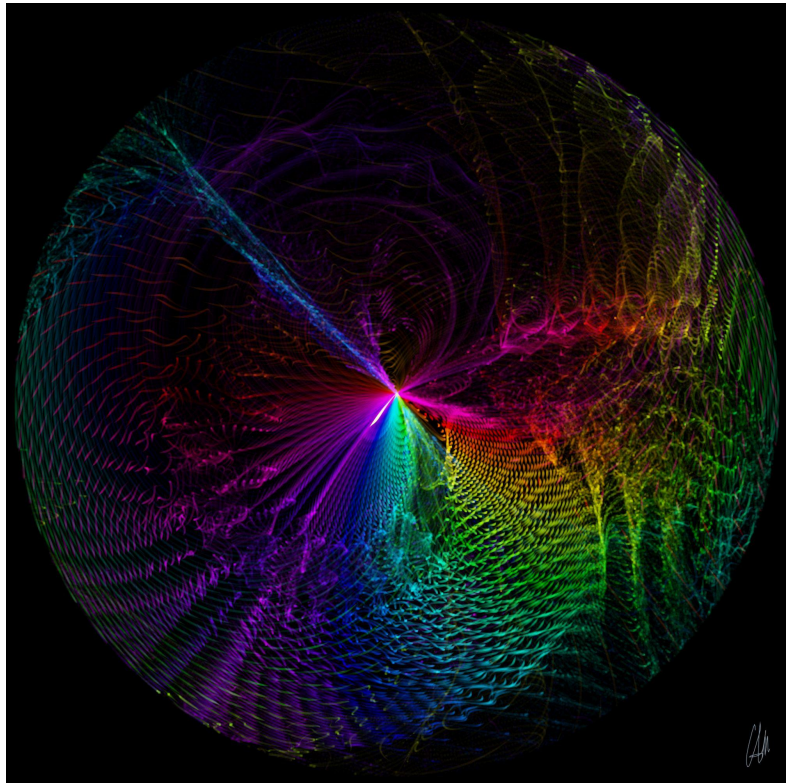
So exploration began! Starting with simple forms and evolving them into greater complexity. Occasionally stumbling upon a cosmic stash of chaos. Hidden in a formation and only visible within certain ranges. These were exciting times and it was like exploring for secret treasure... then boom! troves of new forms and a potential god candidate!... We'll add you to the "potential gods" pile!

Next was to add extra parameters to enable variety while maintaining the integrity of the original chaos formation.

### Exploration phase 2 - finding style

Each god formula could now produce a variety of interesting forms. So the next phase was to find and pin down the main different varieties that exist within each formula, these we call '**styles**'. By the end of this process there were about 6-10 styles for each god formula that showed something distinct. A custom editor was created to facilitate incremental exploration of each parameter and colour group.

The seed value within the certificate determines the randomness and exact values within the style used in a live piece.



## Fully on-chain art

If you don't already know, this means that each art piece works "as is" with only the data contained within the CNFT metadata with no external dependencies. The only exception to this is the browser thumbnail that gets stored on IPFS.

Having the entire piece on-chain places some severe restrictions on the code. Very heavy restrictions! This means the code has to be less than 16kb of text.

A typical generative art piece would use libraries of varying kinds and have many structures, functions and generative agents. Maybe even be built on an engine like processing or the p5js library. The Eternal Chaos pieces have to work without any of those super handy functions. To get the art piece to this size all functionality had to be tiny and reduced to the absolute bare essentials.



Above is the actual code for "Eternal Chaos 001" in its entirety. This is a postage stamp of approximately 14kb minified javascript code. A version of this is inside of every Eternal Chaos CNFT metadata.

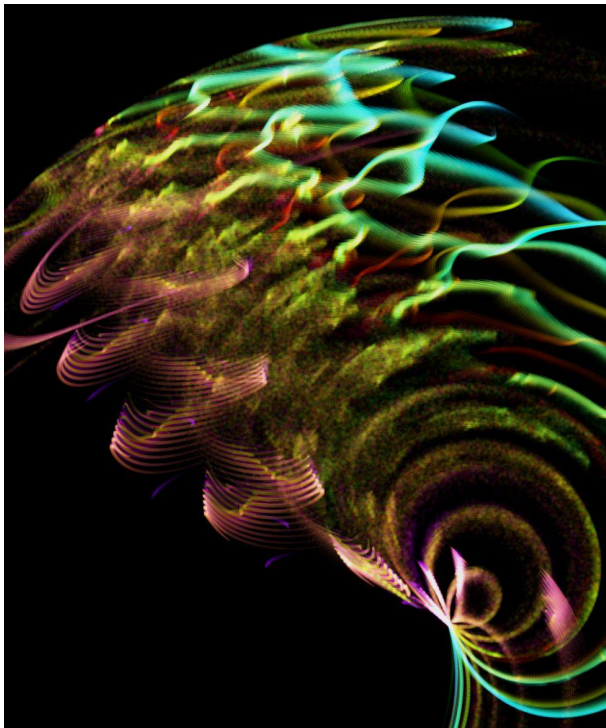
## The demo scene

Interactive on-chain generative pieces like this are a renaissance of the demo scene. I have huge respect for demo scene coders and artists and how they've pushed graphics rendering to beyond the limits of normal use. For those who've not heard of the demo scene here's what it is in a nutshell.

**Wiki:** The demoscene is an international computer art subculture focused on producing demos: self-contained, sometimes extremely small, computer programs that produce audiovisual presentations. The purpose of a demo is to show off programming, visual art, and musical skills

## 4k image renderer

There is so much more detail in the chaos formations than what a real time simulator can display so I decided to squeeze a micro renderer into the code. This enables each piece to bake out a 4k image locally on the viewing device.



When it's activated it creates a virtual 4k canvas within the live piece. This canvas is invisible and only exists in memory. The code then targets the small 'god' function at that new canvas and sends 420 frames of chaos with tiny time step increments... all softly accumulating, like a long exposure creating a beautiful deeper view into the finer qualities of the piece.

It then signs the canvas, stamps it with the piece number and lets the user download it as a PNG image format.

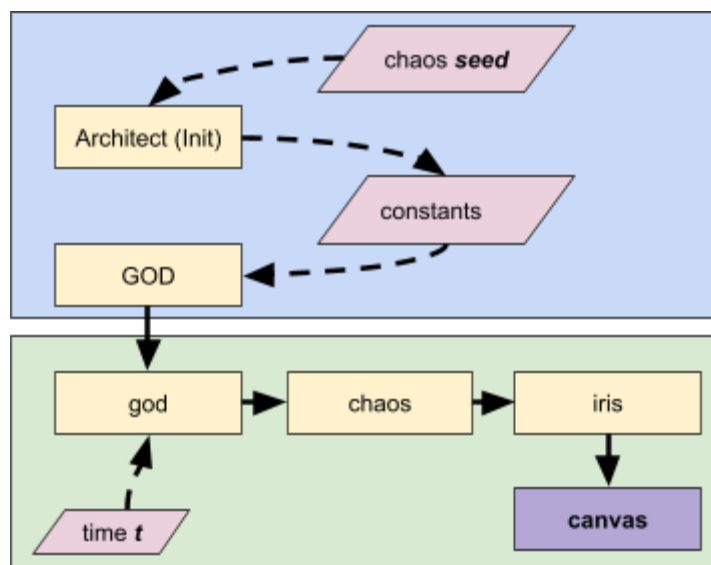
All of the chaos images displayed in this breakdown are rendered in the way described here. This feature is within every piece and can be accessed on the back

where the certificate is.



## Internal components

I like to have fun with the components and give them names to add a bit of character. And sometimes the naming takes on a life of its own.



The architect gets given the **seed** stored in the certificate and produces a set of **constants**.

Those constants go into a big '**GOD**' function which produces a small '**god**' object in return.

That small '**god**' object takes in **time** and produces **chaos**.

That **chaos** goes through the **iris** function receiving colour and is drawn to the **canvas**.

The blue area is the setup phase and is only done once. The green area is the drawing loop and happens 60 times a second.

## Artist signature

A drawing routine called 'SIGN' within the pieces contains a sequence of relative line segments that get drawn every frame. If these segments are accumulated in order relative to the previous the correct shape appears. These segments form my art signature and were traced from a written signature using a separate editor tool created for the job. The signature is also visible on the certificate and on the 4k outputs.



## Secrets

In all of my pieces there are secrets. Some of those close to me know what they are and friends within the community have noticed and pointed some out. I'll not be describing them here. These are for the inquisitive.

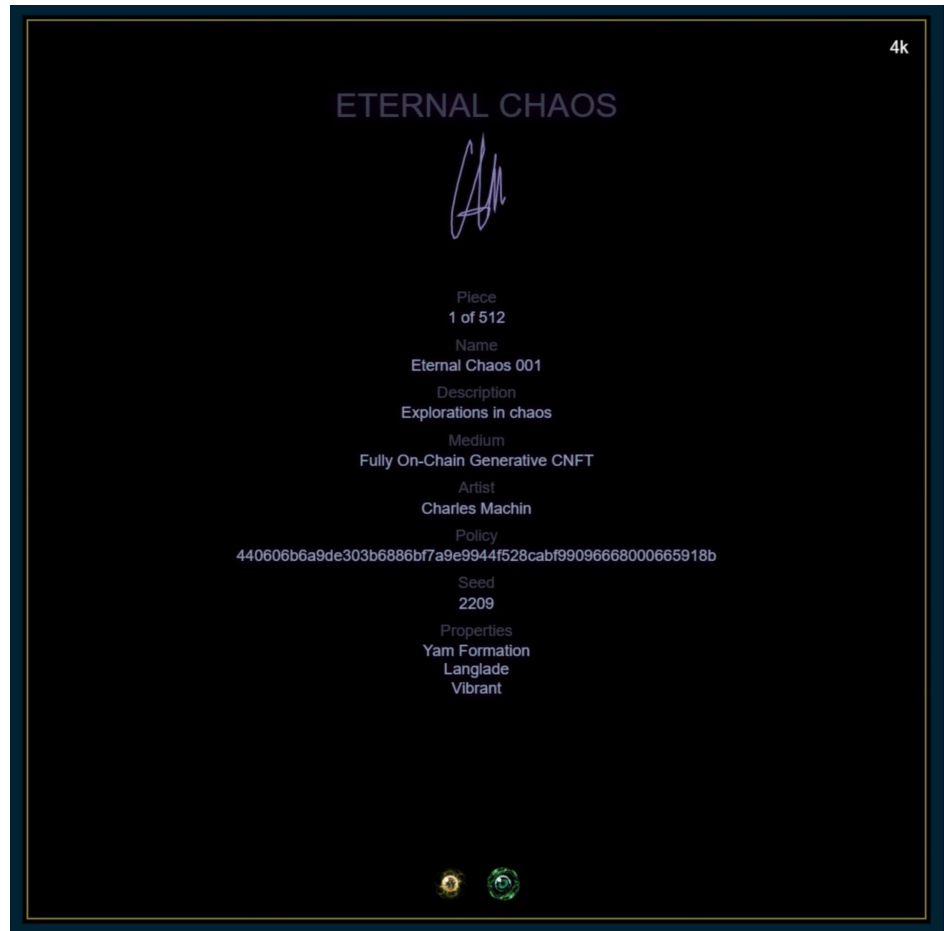


## Certificate

Every Eternal Chaos piece has a certificate. See this by clicking on the art and revealing the back of the piece.

Here you can see details about the art, seed, properties and a short description. You can also see additional information within the metadata.

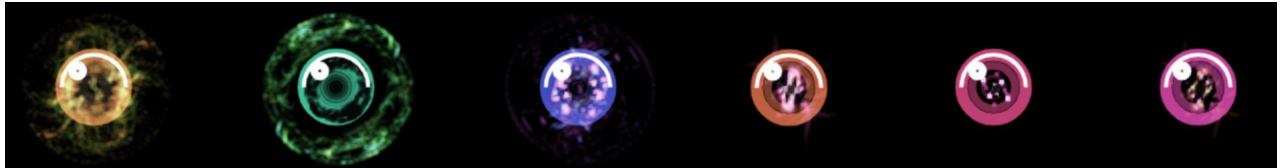
On the back you'll also find the 4k image render button (top right). When clicked it starts a high quality single frame capture and makes it available for download.



Artefacts can be seen towards the bottom of the certificate. These are extra special and will be connected to a future experimental project called "FORGE". So if you're lucky enough to own one of these, keep it safe!

## Artefacts

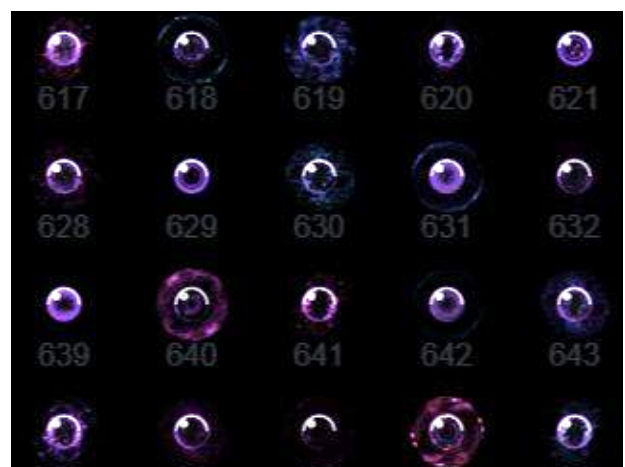
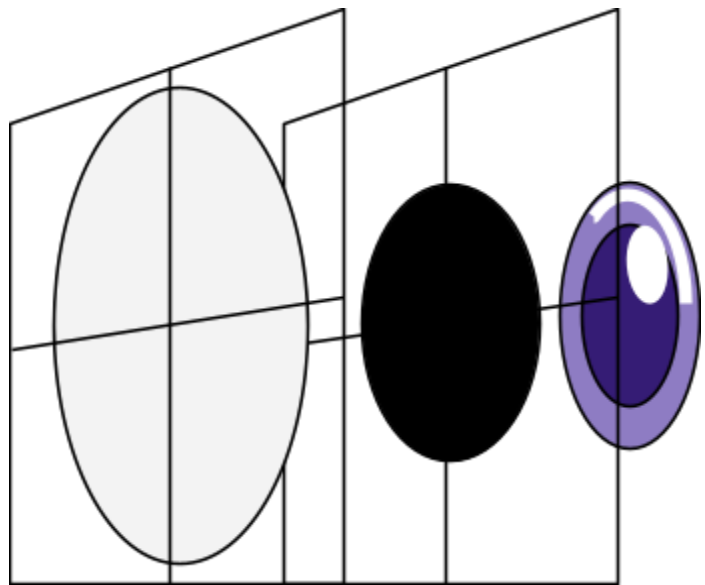
Within the collection are chaos artefacts. Each artefact is a generative impression that represents special numbers within the collection.



The instant the certificate is clicked the artefacts calculate themselves.

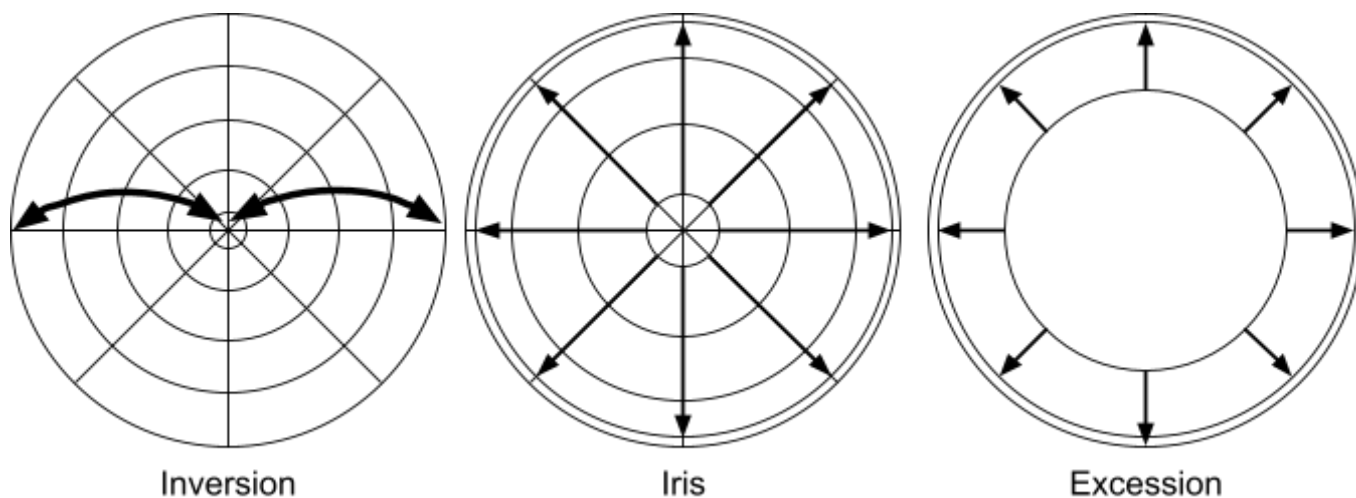
Each artefact is drawn using two opposing chaos simulations of 4500 points each. One for the inner darkness and another for the outer glow, plus circular bands to form the bead and highlights.

Inside the art code, artefacts are stored as a seed integer that can be used to generate a specific artefact impression. Out of hundreds, several were selected to represent the number groups such as prime, fibonacci sequence and perfect numbers along with a selection of other singular special numbers such as 42, 420 and others.



## Warps

These determine how the chaos is drawn to the screen. Inversion flips the centre point to the outside ring. In effect flipping it about its centre point. The iris adds a power curve that shifts the detail to the outer ring.



## The Excession

Then there's the **Excession**! An object from the culture sci-fi novel series by Iain M Banks.

The details of this piece were kept secret until it was randomly minted in the third drop by a collector. It contains a unique chaos warp pushing it to appear outside of a spherical void.

You may have considered the question:

If Excession is piece 000 and there are only 512 in the collection... and the last piece was numbered 512.

Doesn't that make 513 pieces?



**Wiki:** The Excession is a perfect black-body sphere that appears mysteriously on the edge of Culture space, appearing to be older than the Universe itself and that resists the attempts of the Culture and technologically equivalent societies (notably the Zetetic Elench) to probe it. The Interesting Times Gang (ITG), an informal group of Minds loosely connected with Special Circumstances, try to manage the Culture's response to the Excession. The Affront, a rapidly expanding race which practises systematic sadism towards subject species and its own females and junior males, also try to exploit the Excession by infiltrating a store of mothballed Culture warships and using them to claim control of the mysterious object.

The Sleeper Service, an Eccentric General Systems Vehicle (GSV) who had nominally left the Culture, is instructed to head to the location of the Excession by the ITG.

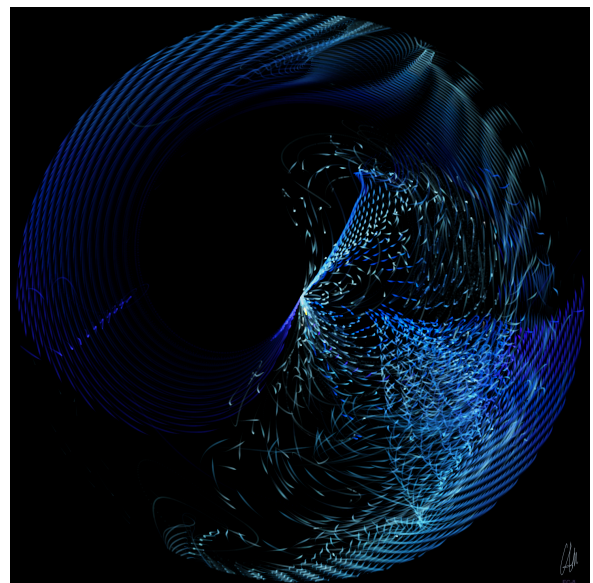


## Utility

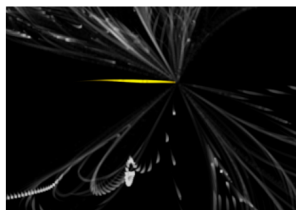
For more information about the utility and exciting role these pieces have in future collections see the [“Eternal Chaos Holders Club”](#) paper.

## Licence

Owners have the rights to use and remix their art within certain parameters. Details of the owners licence can be found [here](#)





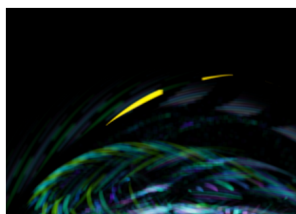
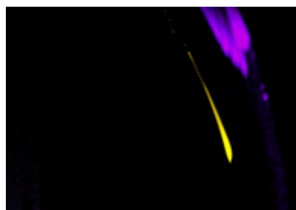


## The 'Dad' Particle

In every piece there is a wandering gold chaos point exploring the canvas. This is in memory of the loved ones who aren't with us anymore.

For me it's dedicated to my dad... An ingenious engineer, problem solver, loving father, husband and granddad... We miss him a lot.

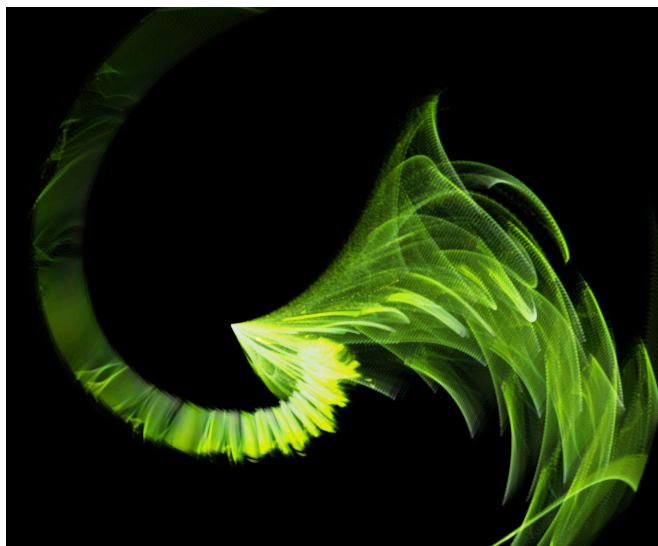
To the right you can see that he was the only sane one amongst us!



## The Stack

This is the set of automated processes that builds the collection. It features a large range of capabilities from distribution of the properties to meta assembly and minification of code, slaving chrome to take screenshots, metadata assembly, IPFS thumbnail upload, management of the seeds and the entire collections master seed along with many other things.

For those curious, the master seed of the entire collection is **9487**. This value primed the random number generator that created a set of unique seeds for all pieces. We called this the **seedbank**. Using this approach the entire collection could be regenerated perfectly as the code framework was still being finished. These seeds were then carefully reviewed, curated and advanced to the next seed in the bank where needed.



## Self validation

Eternal Chaos pieces have self validation. This involves a 2 way coupled token on a separate master policy. This token represents the collection and it's called the [Auth NFT](#). It exists on a personal artist 'master policy' for my work. This requires a paper in its own right but in short it creates an immutable link from the Eternal Chaos pieces to the master policy for validation and future collection features.

