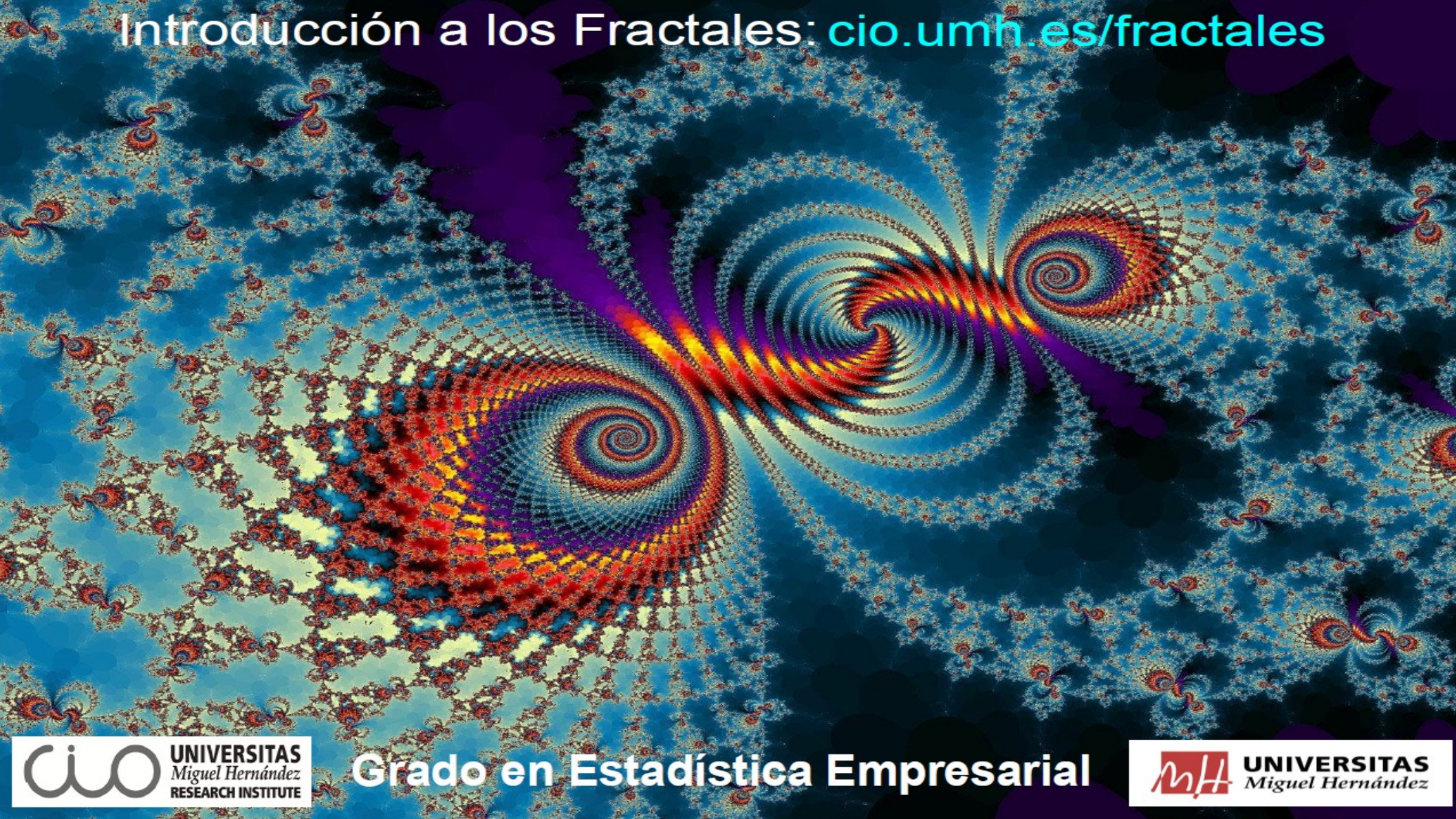


Introducción a los Fractales: cio.umh.es/fractales



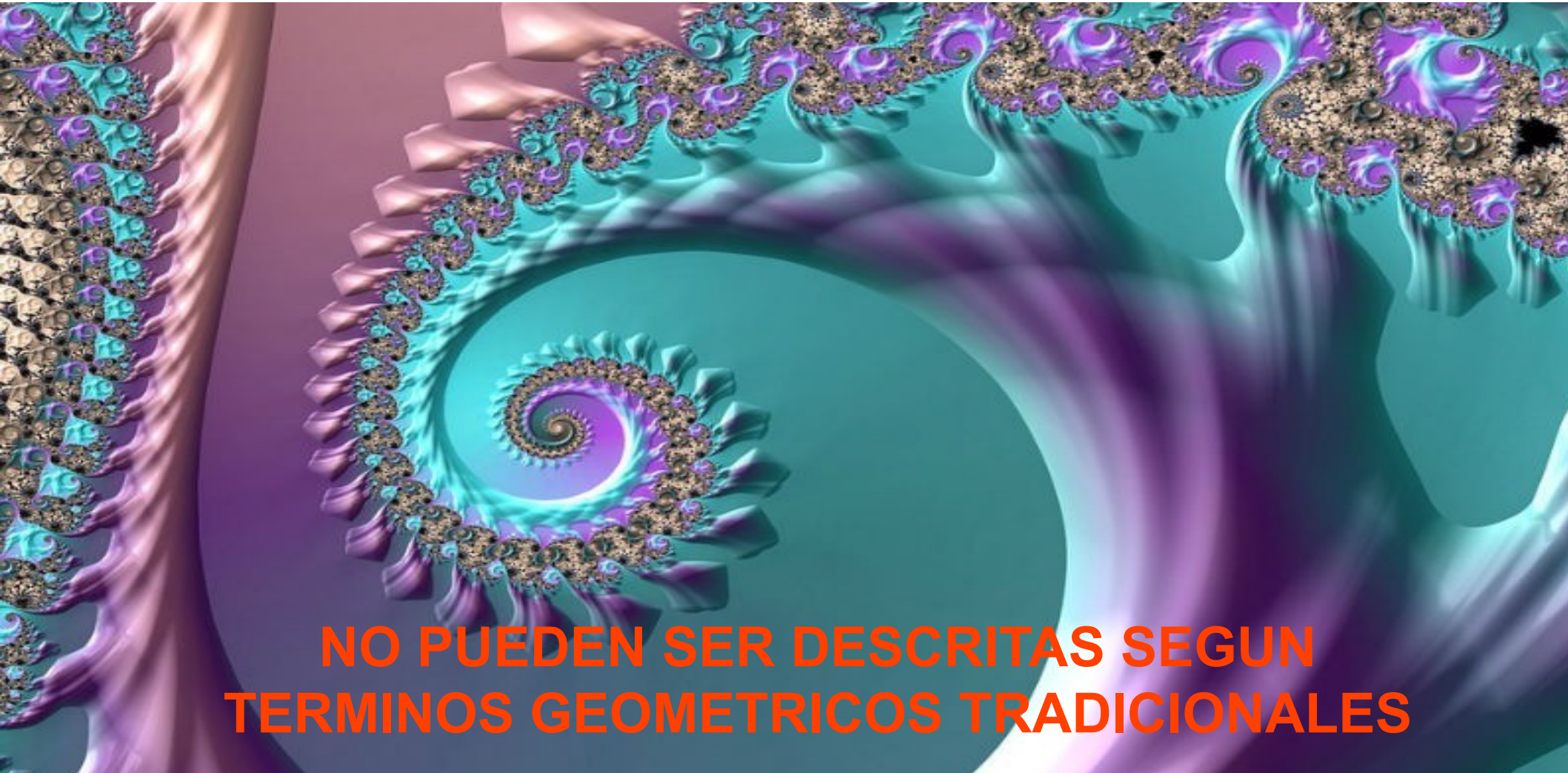


José Luis Sainz-Pardo Auñón

Prof. Dep. Estadística, Matemática e Informática UMH
Investigador Centro Investigación Operativa

jose.sainz-pardo@umh.es

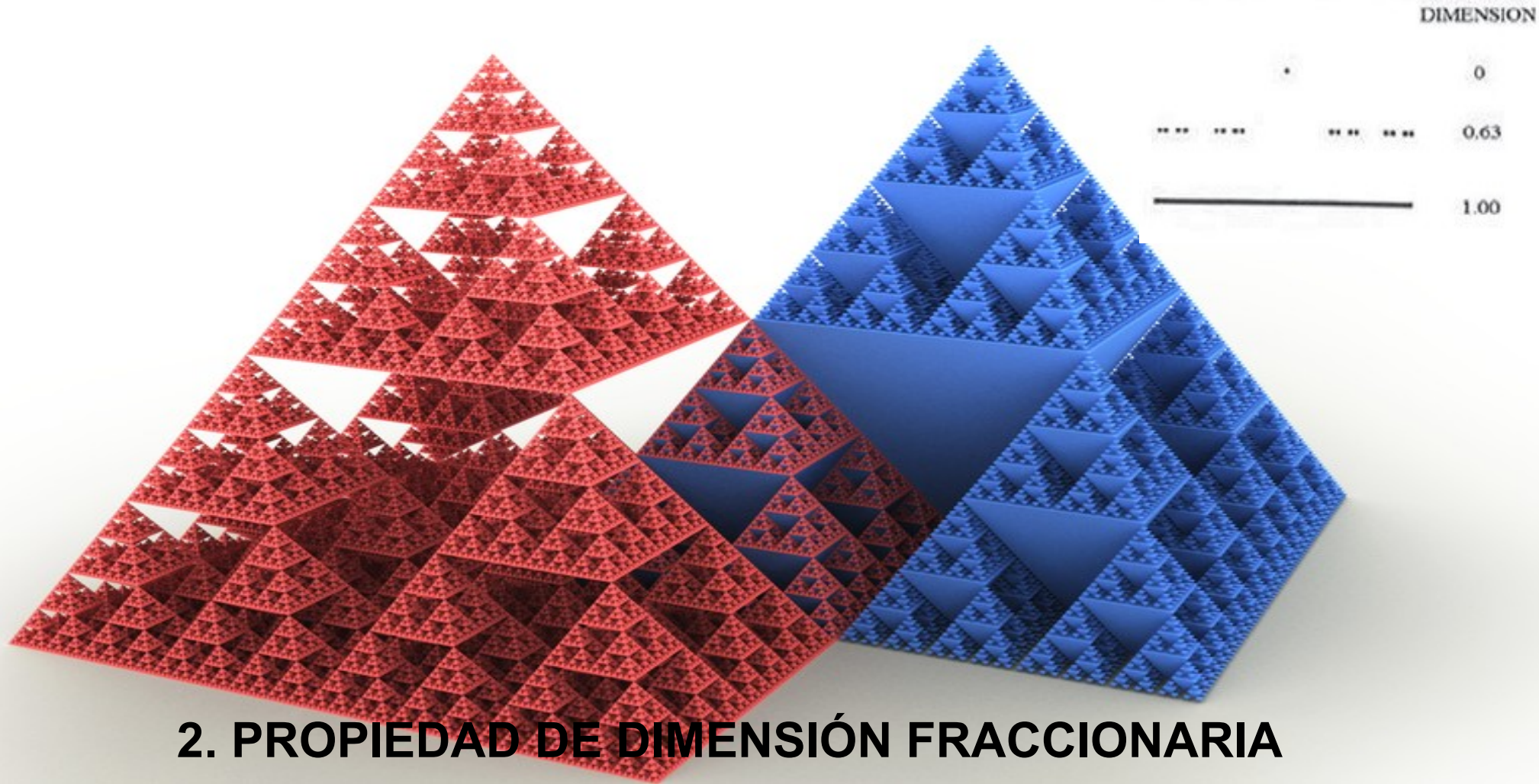

@sainzpardo



**NO PUEDEN SER DESCRITAS SEGUN
TERMINOS GEOMETRICOS TRADICIONALES**



1. PROPIEDAD DE AUTOSEMEJANZA: CUALQUIER PARTE ES SEMAJANTE AL TODO



2. PROPIEDAD DE DIMENSIÓN FRACCIONARIA



3. PROPIEDAD DE RECURSIVIDAD: EXTENSIÓN INFINITA

ANTECEDENTES

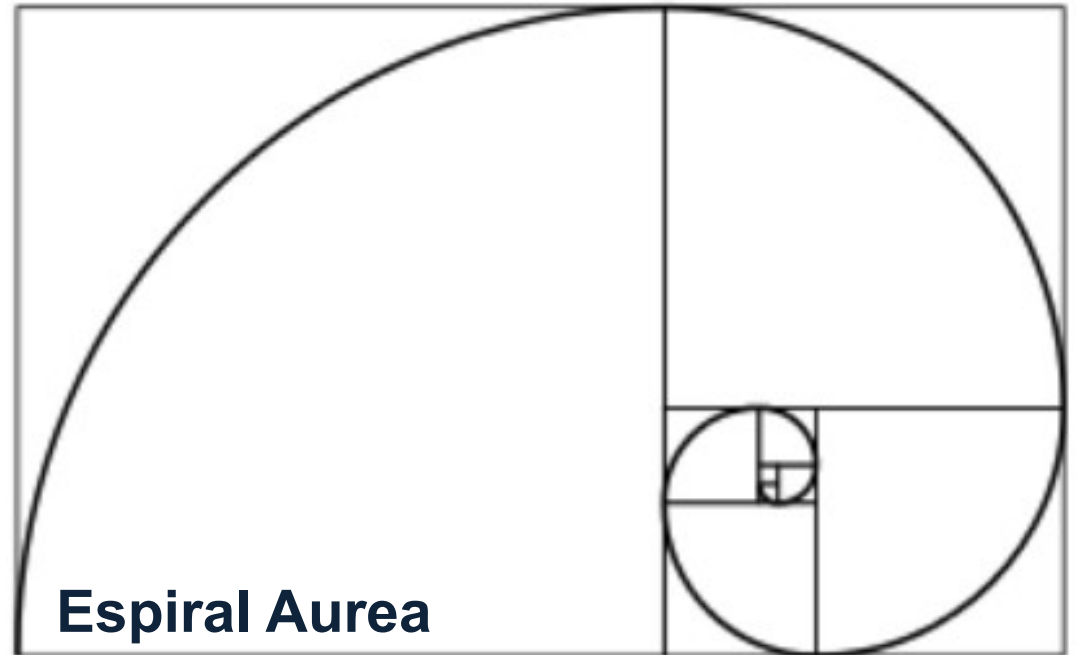
SUCESIÓN: función sobre el conjunto de los números naturales

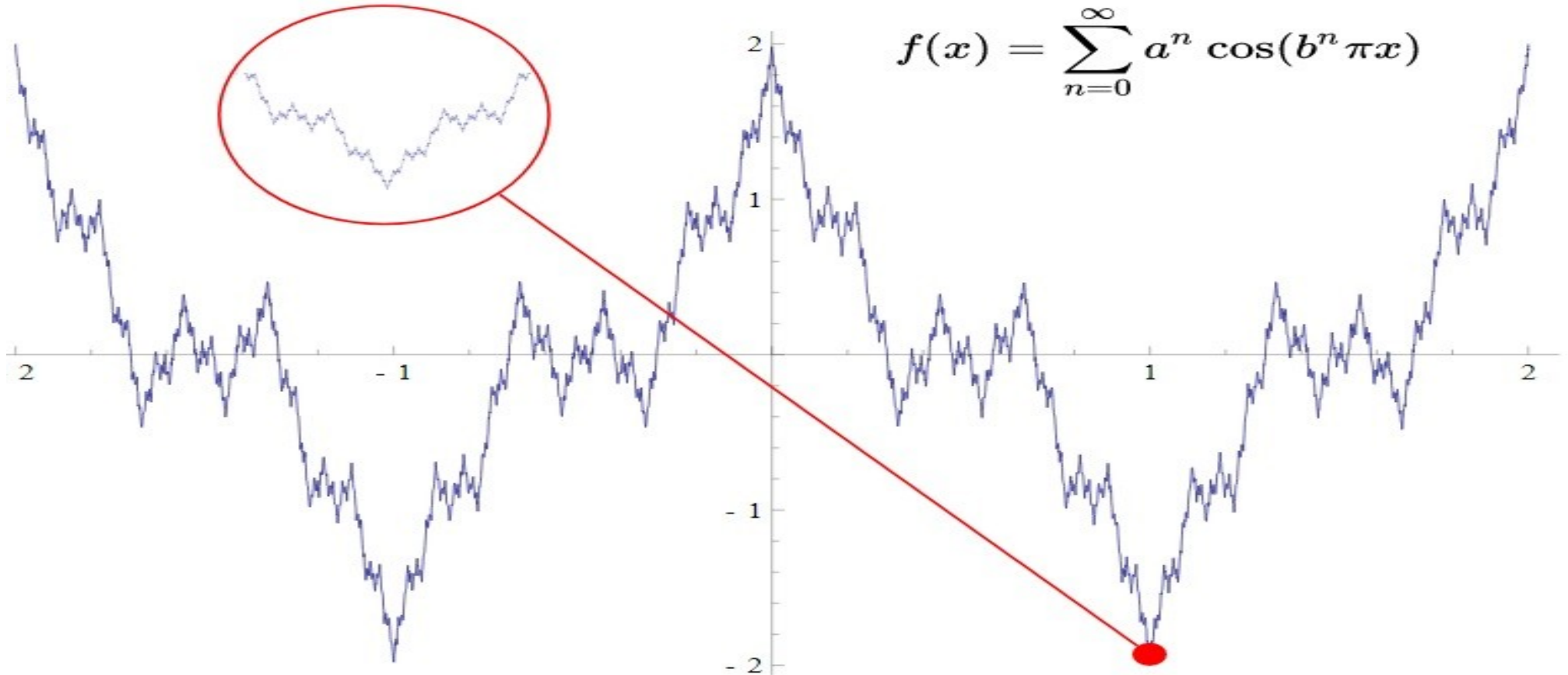
SUCESIÓN DE FIBONACCI: 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233 ...

$$f_0 = 0$$

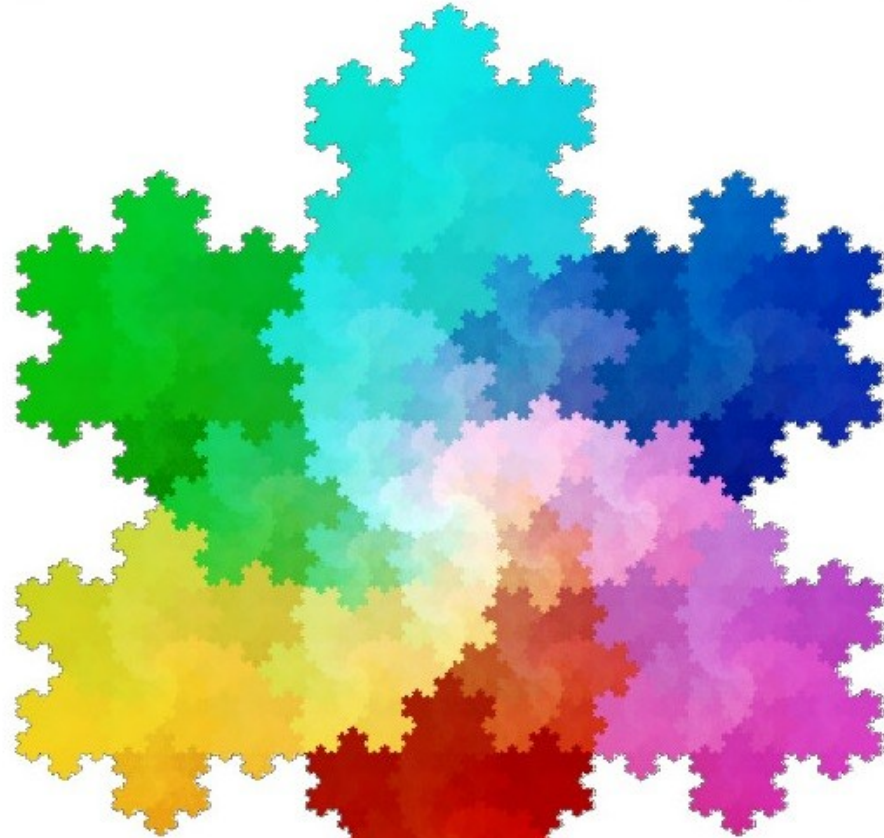
$$f_1 = 1$$

$$f_n = f_{n-1} + f_{n-2}$$

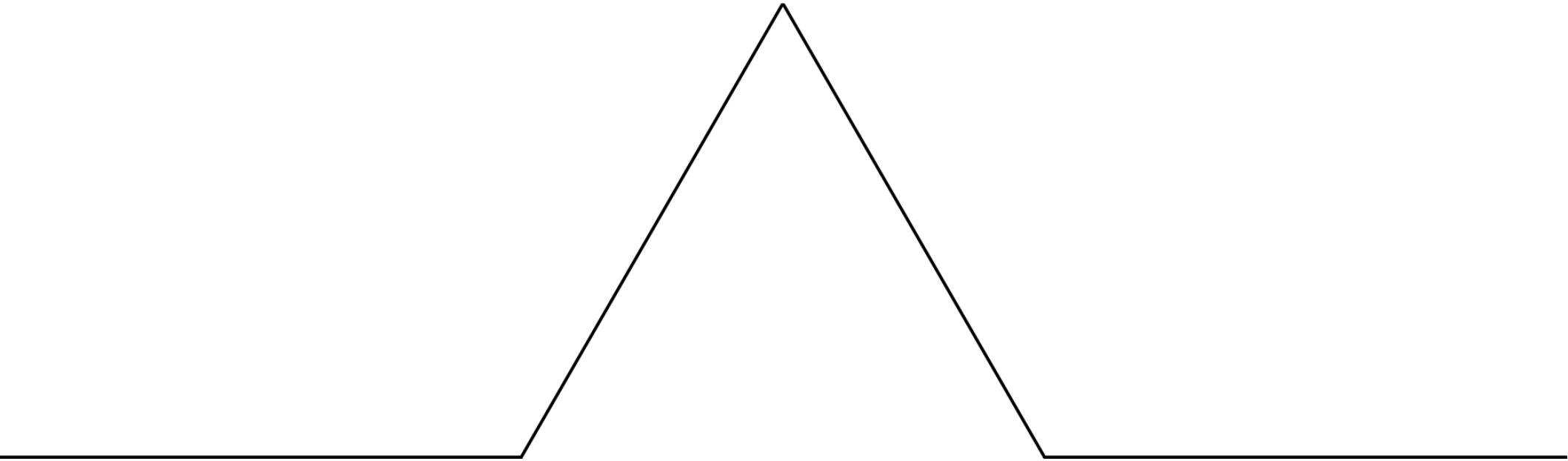


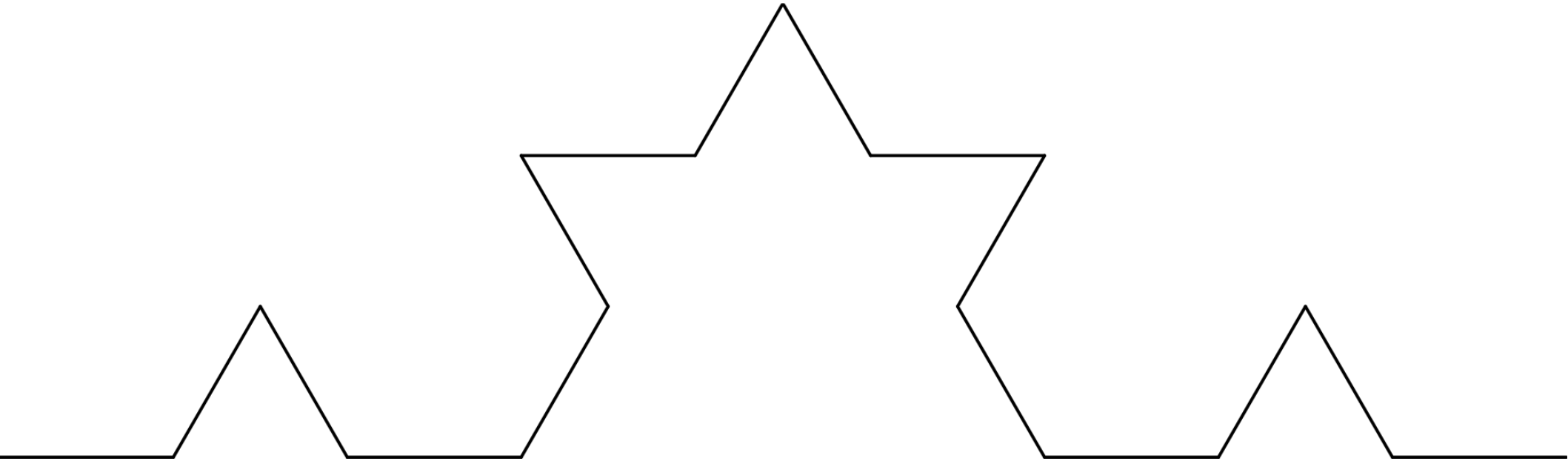


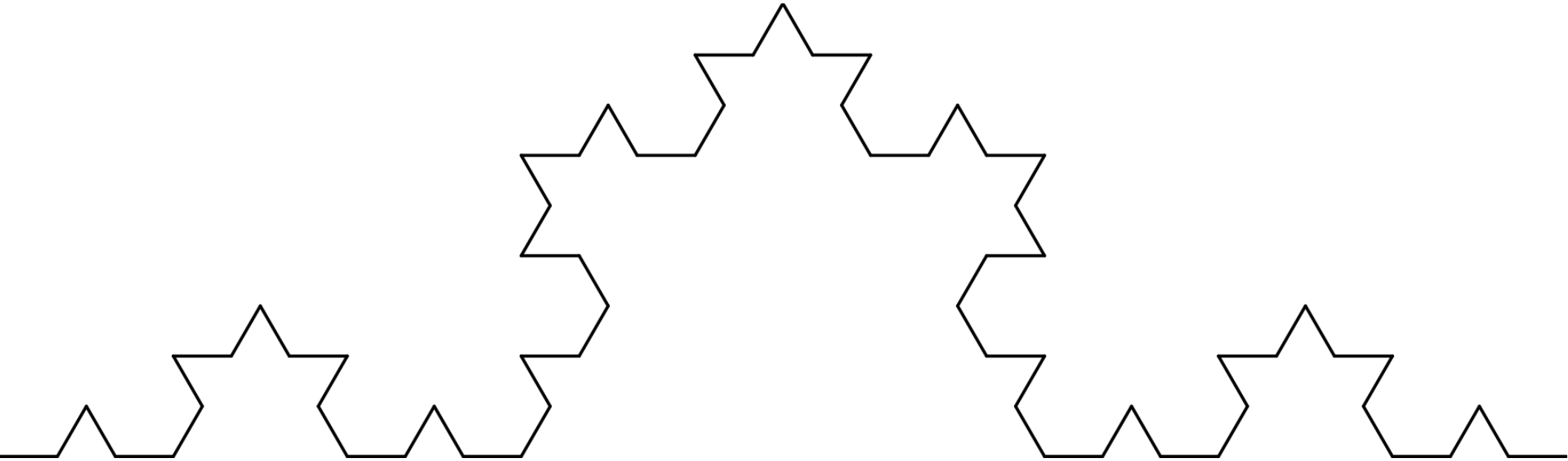
FUNCIÓN DE WEIERSTRASS: función continua no derivable en ningún punto
Cierta autosemejanza – Dimensión fractal: $1 < D < 2$

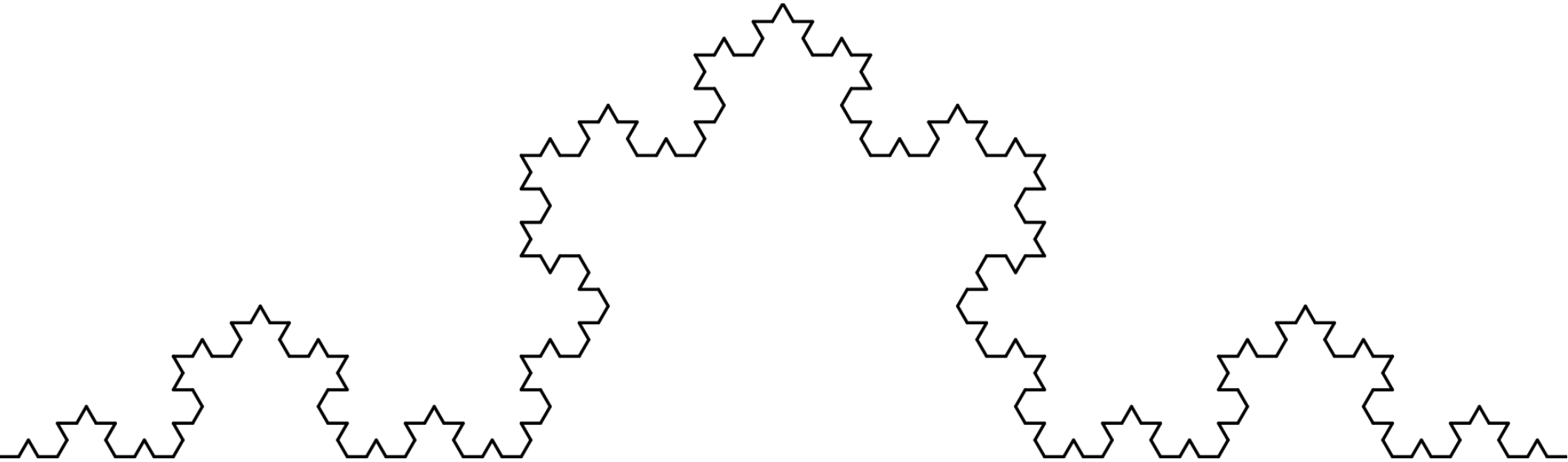


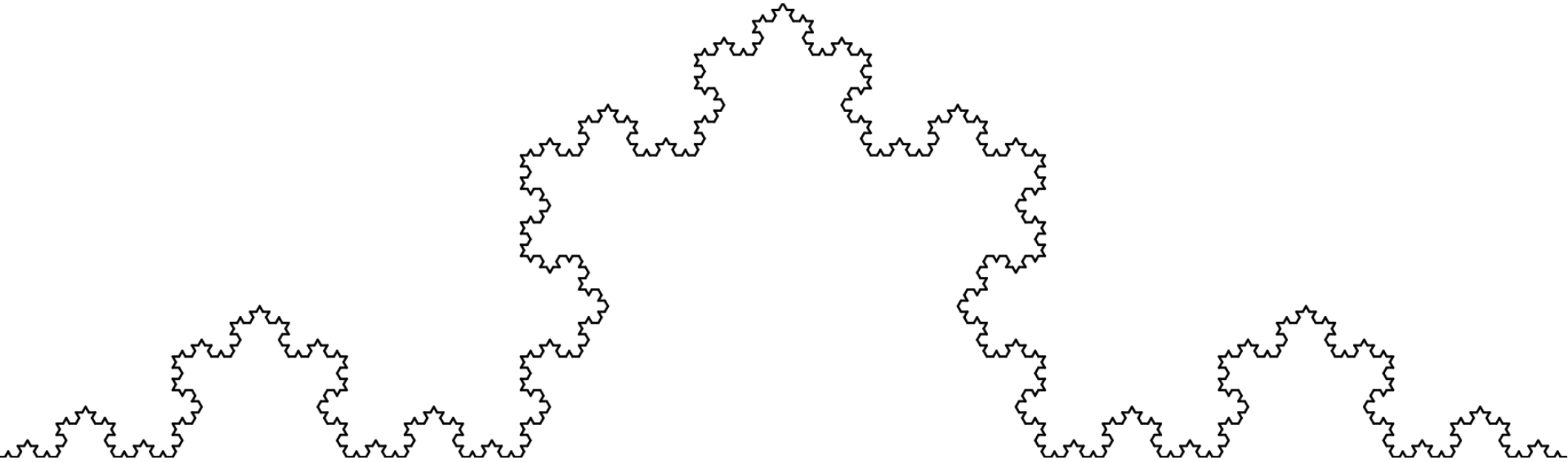
COPO DE NIEVE DE KOCH
curva cerrada continua no diferenciable en ningún punto

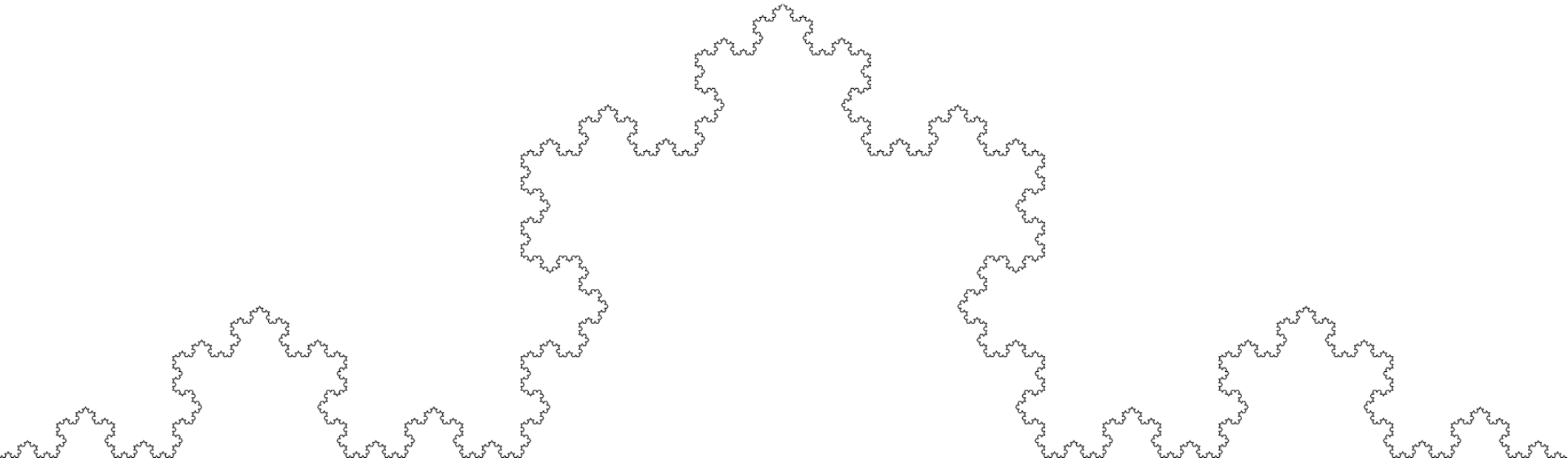


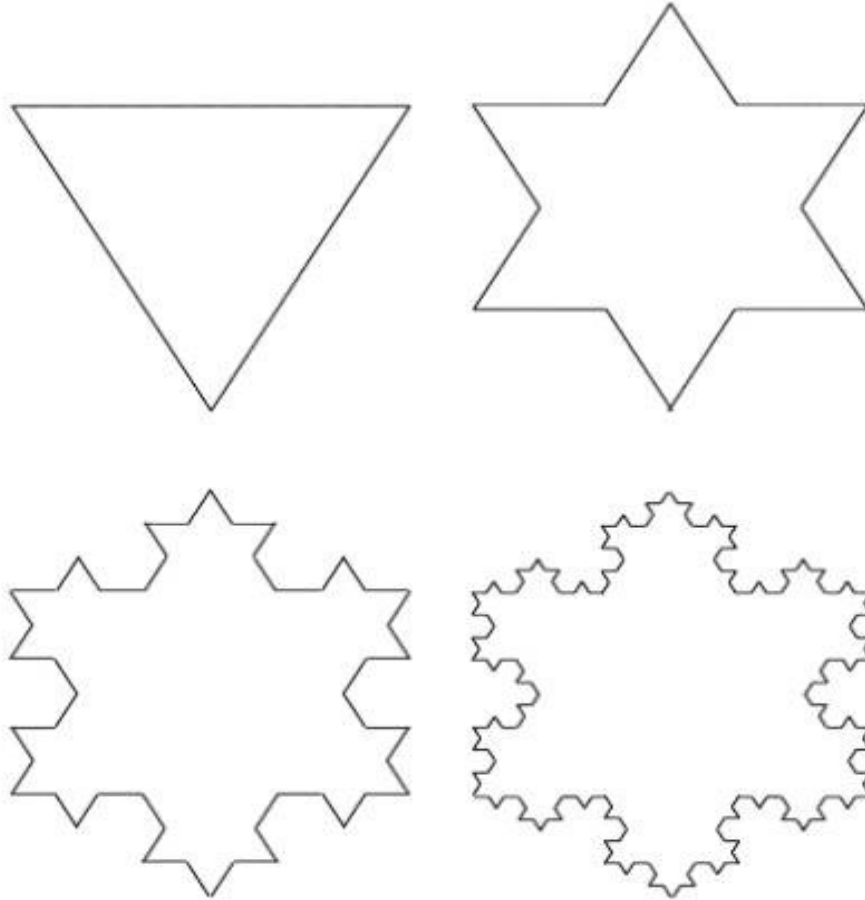




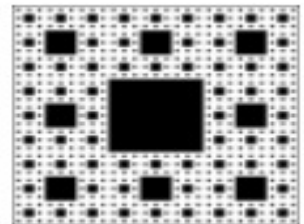
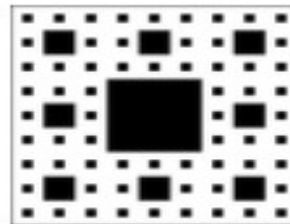
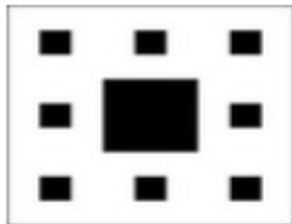
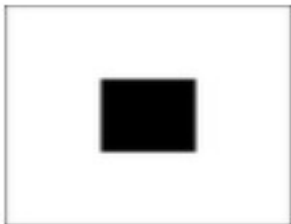




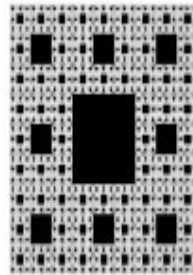




ALFOMBRA DE SIERPINSKI



¡ VAYA GALERÍA DE MONSTRUOS !



HENRI POINCARÉ (1854-1912)



FRACTALES DE JULIA

$$z = z^2 + c$$

FRACTALES DE JULIA

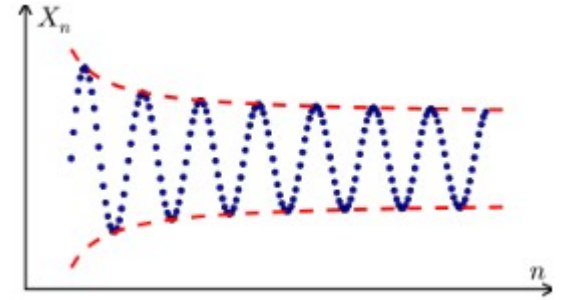
$$z_0 = z$$

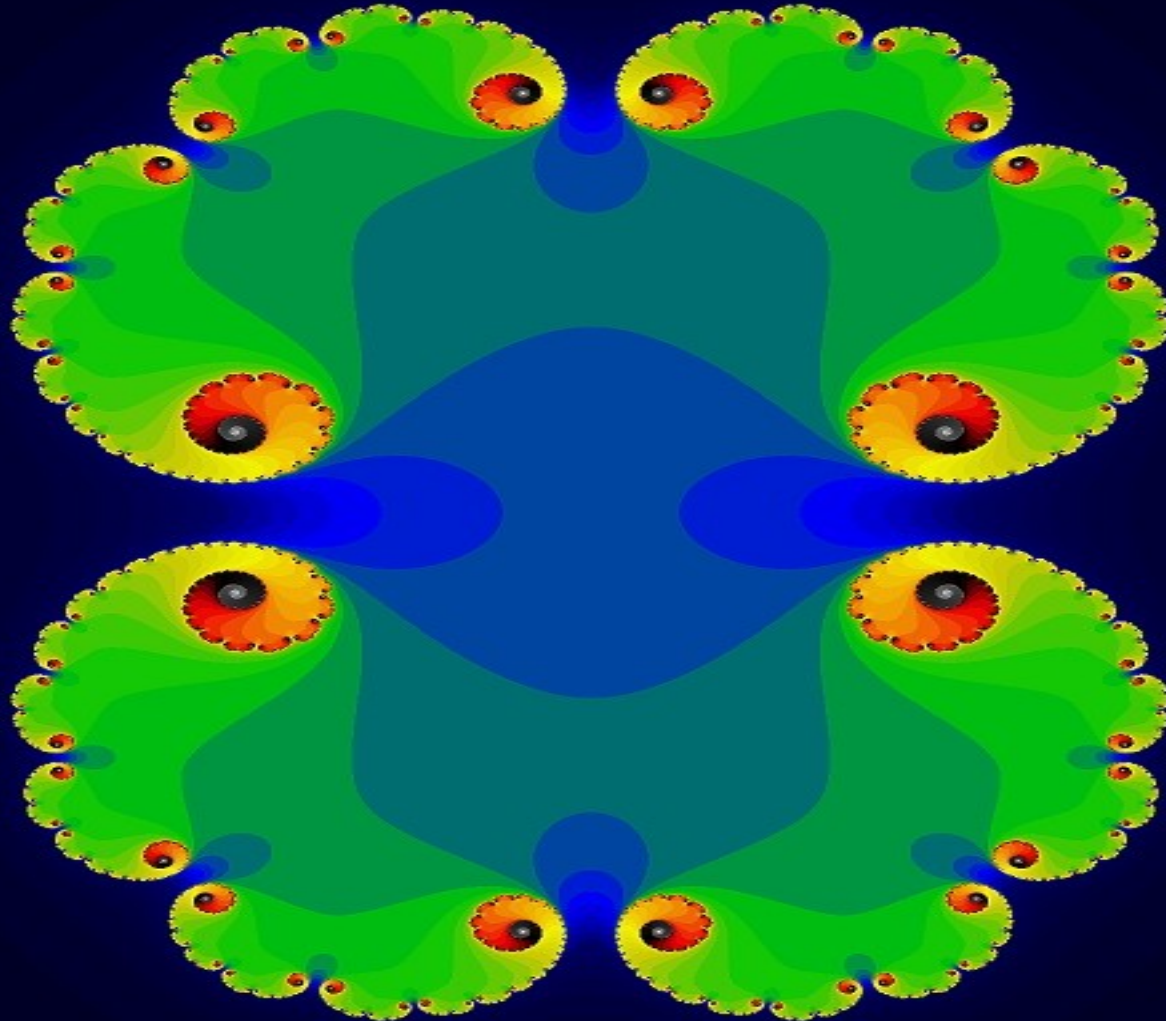
$$z_{n+1} = z_n^2 + c$$

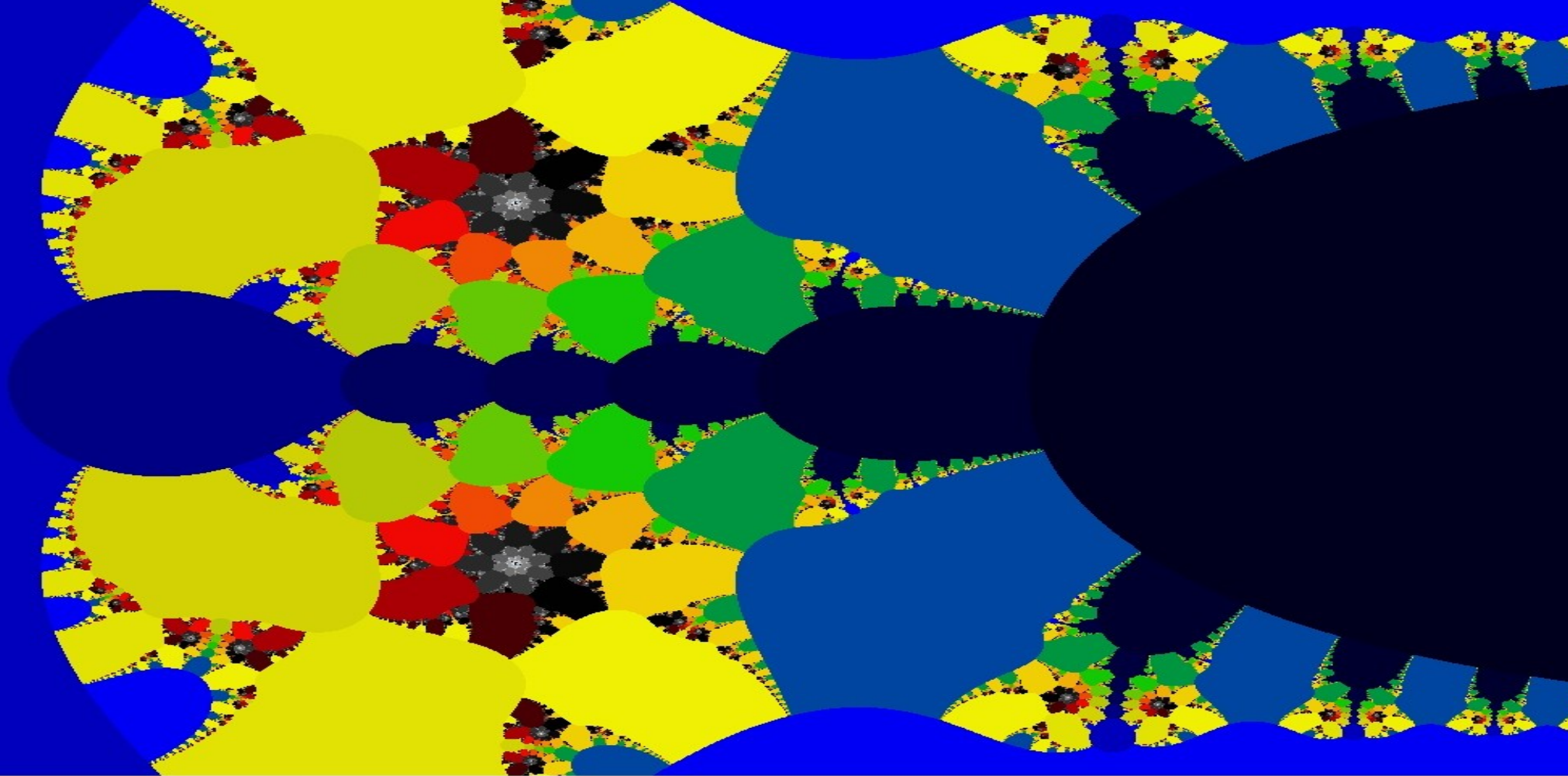
si $|z_n| > 2$ entonces la sucesión diverge

Cada pixel semilla $z_0 = x + yi$ se colorea:

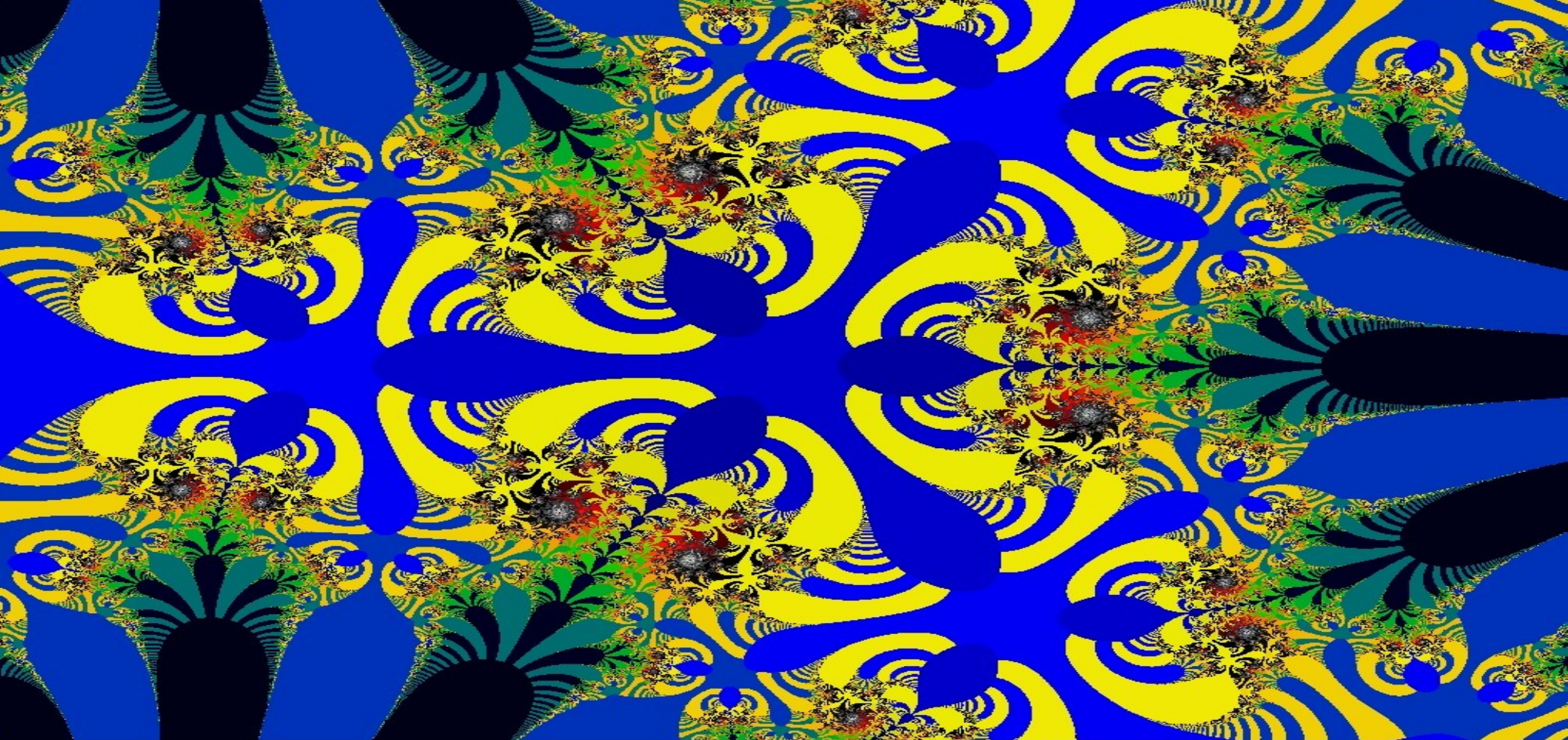
- * negro si converge (pertenece al conjunto de Julia)
- * distintos colores en función de las iteraciones necesarias para comprobar su divergencia



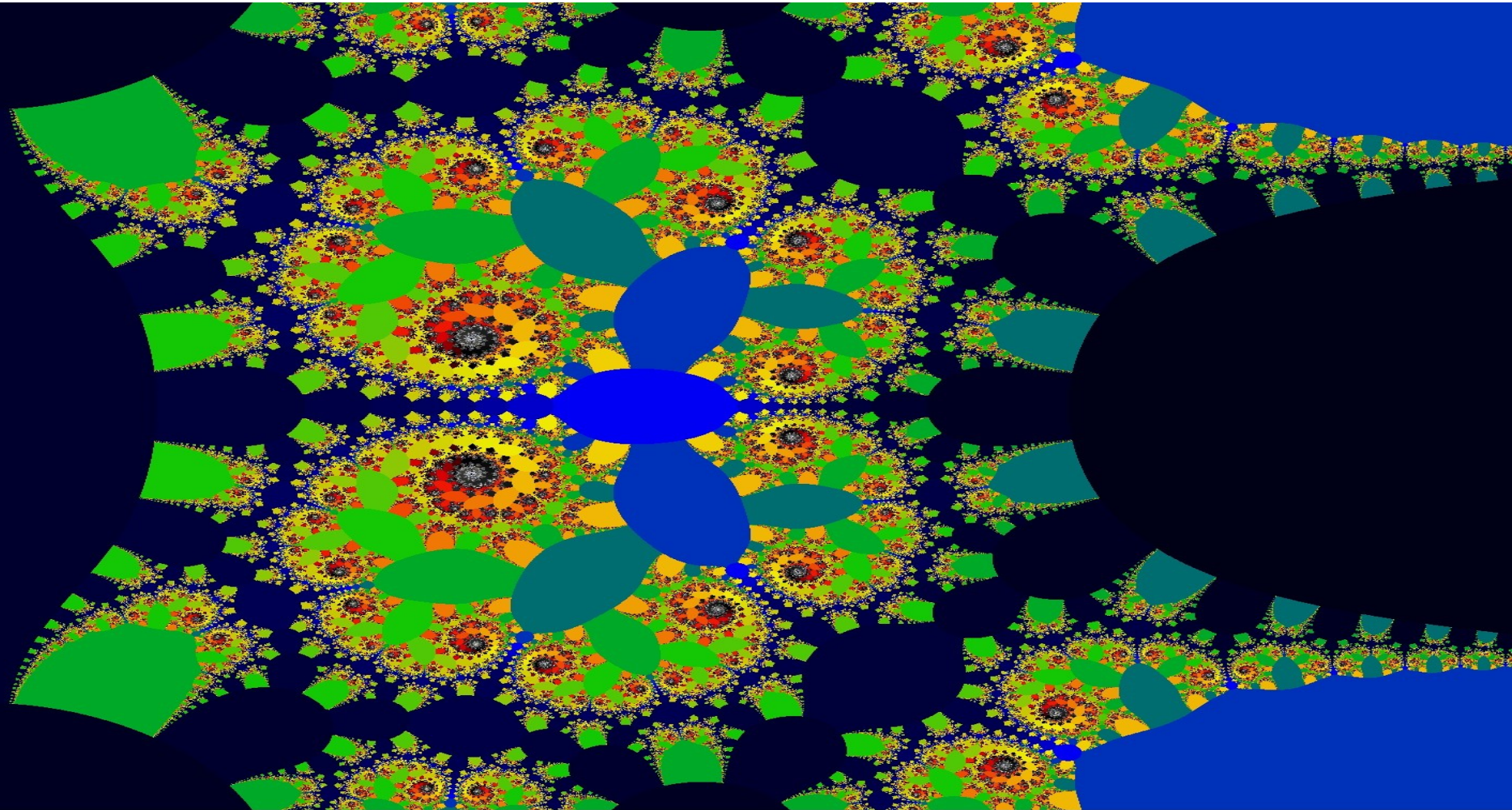




MÈTODE DE JULIA $Z = \text{EXP}(Z) + C$ $C_x = -0.65$ $C_y = 0.00$



MÈTODE DE JULIA $Z = \text{EXP}(Z^3) + C$ $C_x = -0.59$ $C_y = 0.00$



Mètode de Júlia. $Z_{n+1} = Z_n^2 * \text{Exp}(Z)$ $C_x = 0.21$ $C_y = 0.00$



FRACTALES DE MANDELBROT
 $z = z^m + c$

FRACTALES DE MANDELBROT

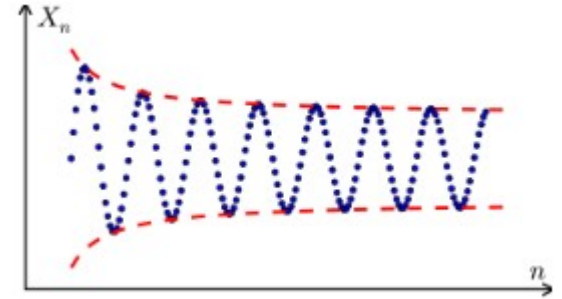
$$z_0 = z$$

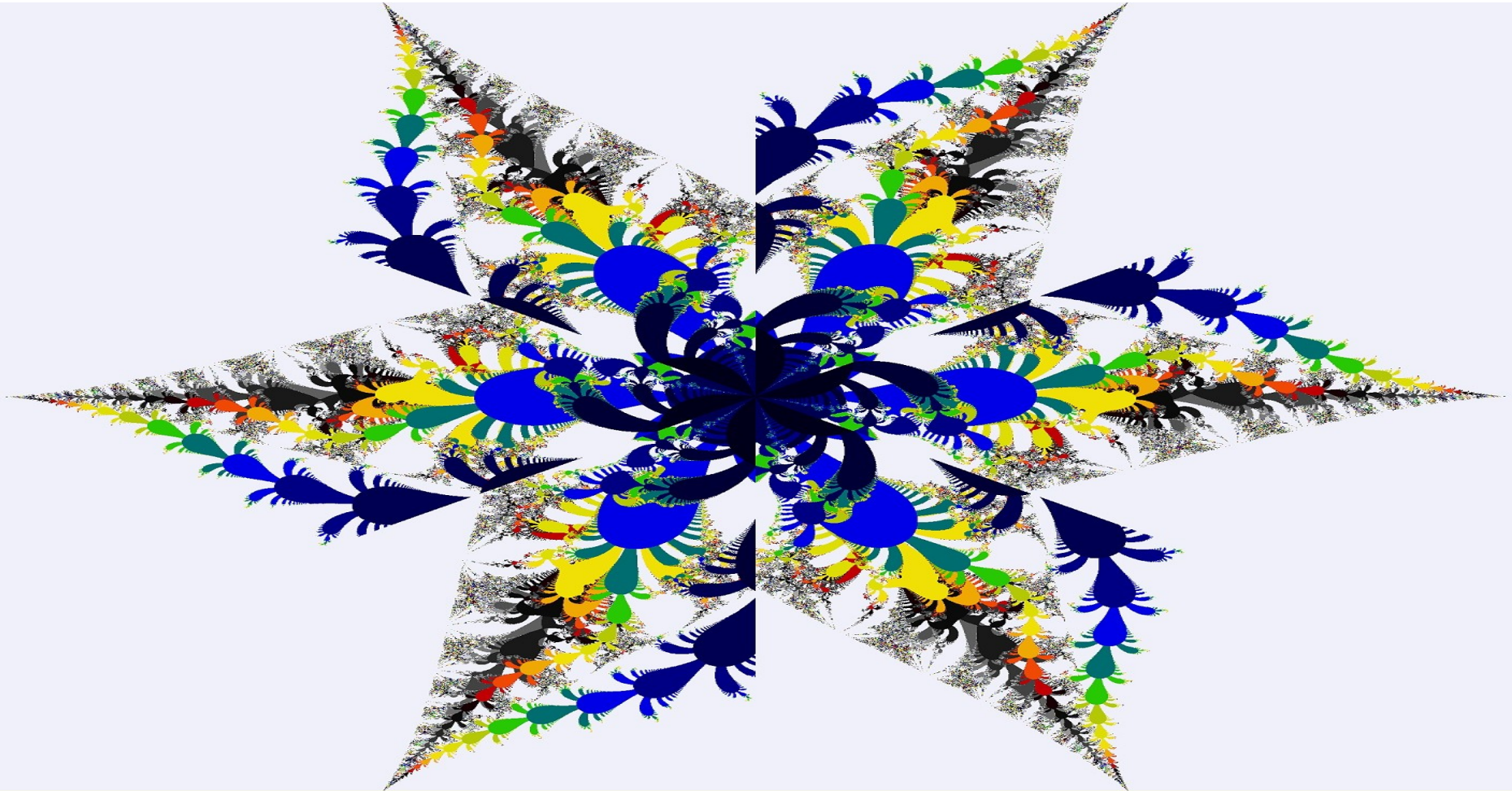
$$z_{n+1} = z_n^m + c$$

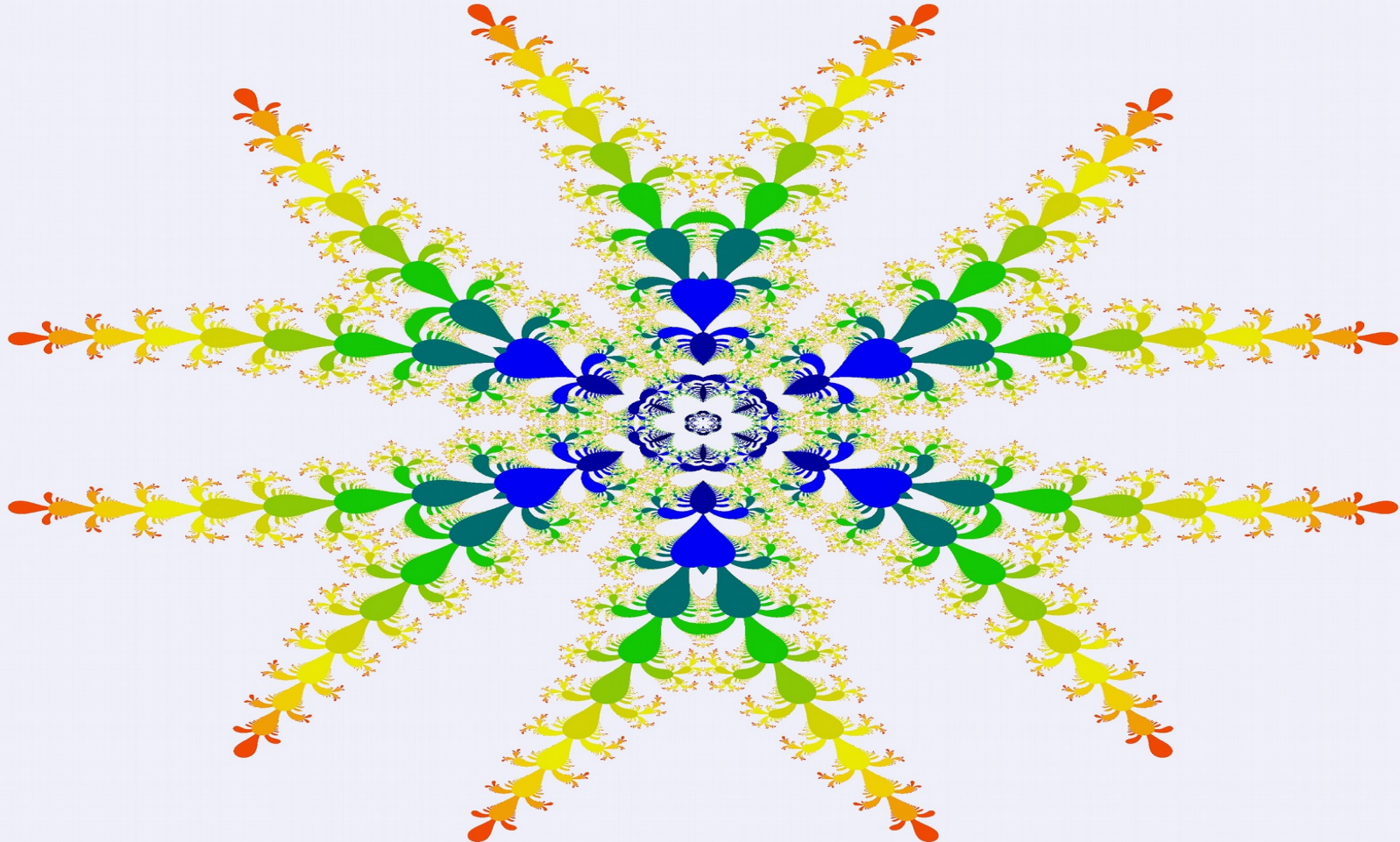
si $|z_n| > 2$ entonces la sucesión diverge

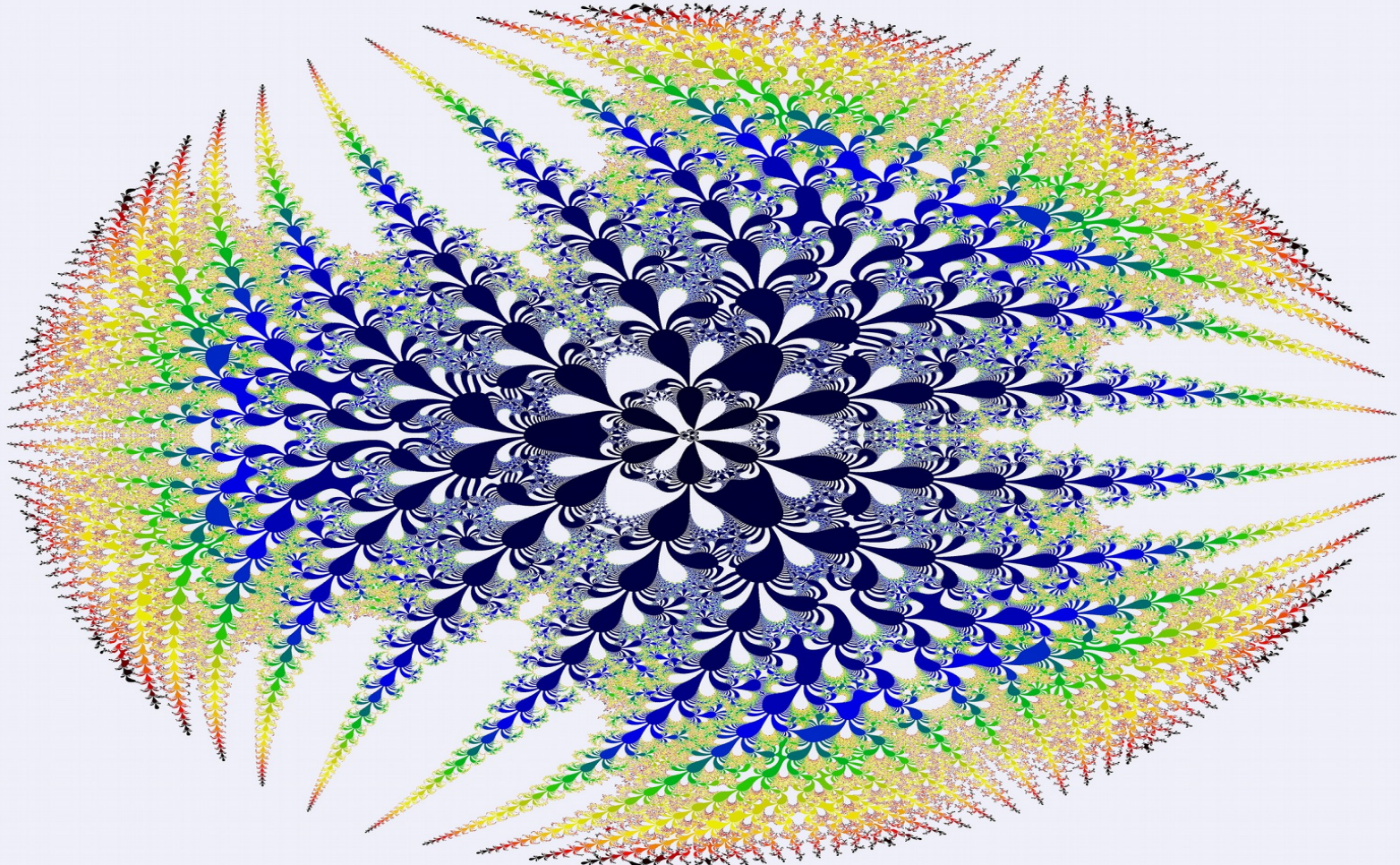
$z_0 = 0 + 0i$. Cada pixel $c = x + yi$ se colorea:

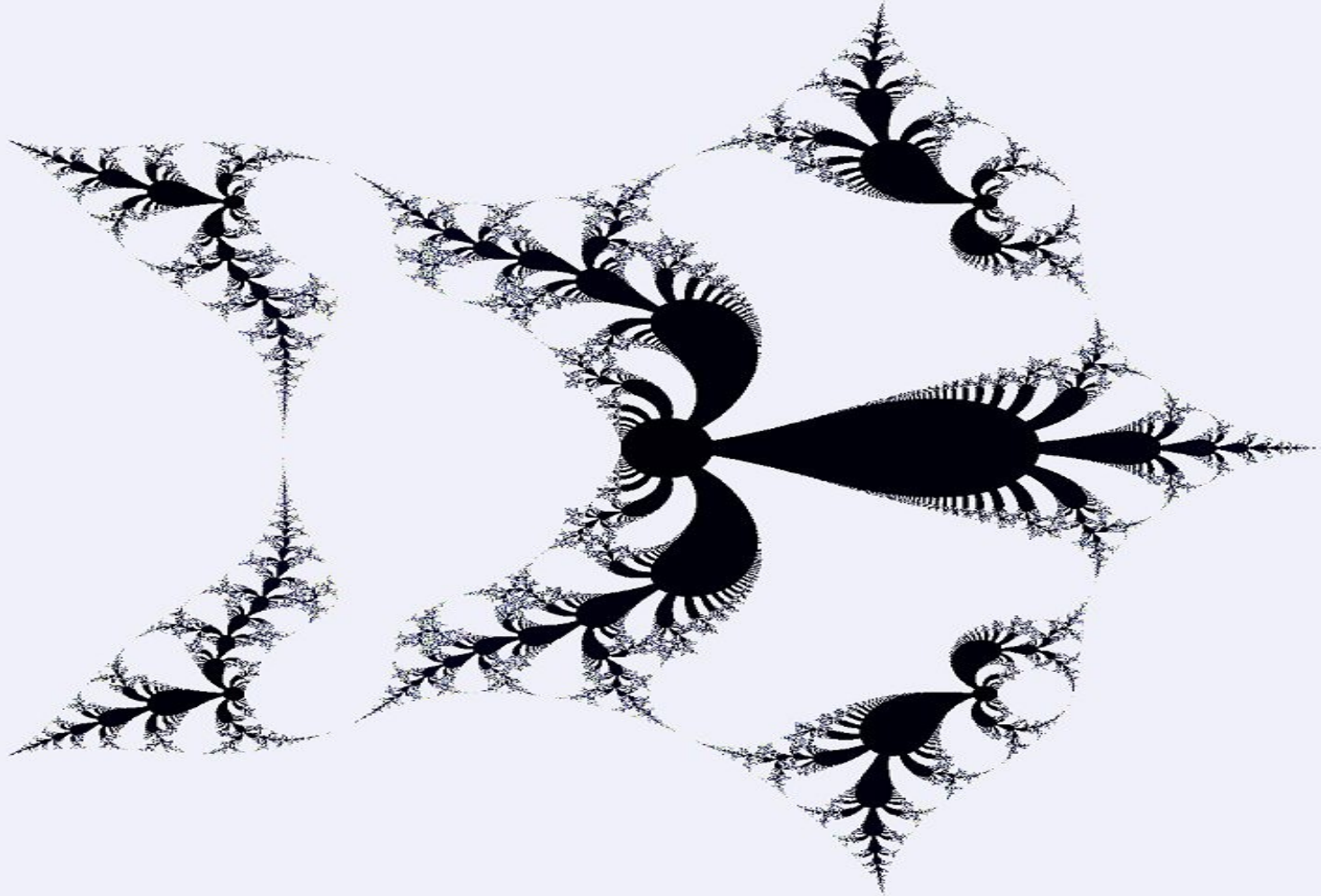
- * negro si converge (pertenece al conjunto de Mandelbrot)
- * distintos colores en función de las iteraciones necesarias para comprobar su divergencia





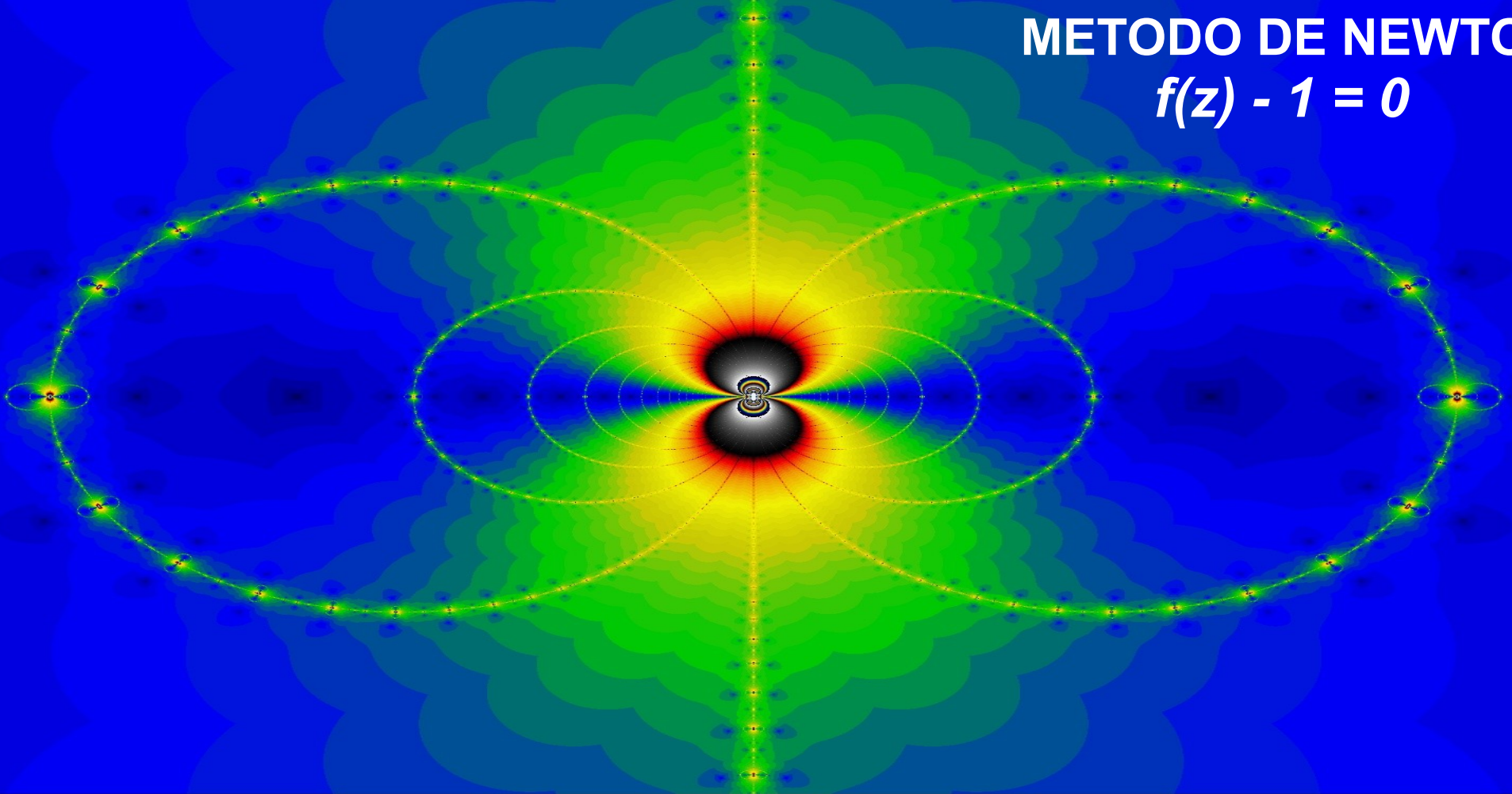






METODO DE NEWTON

$$f(z) - 1 = 0$$



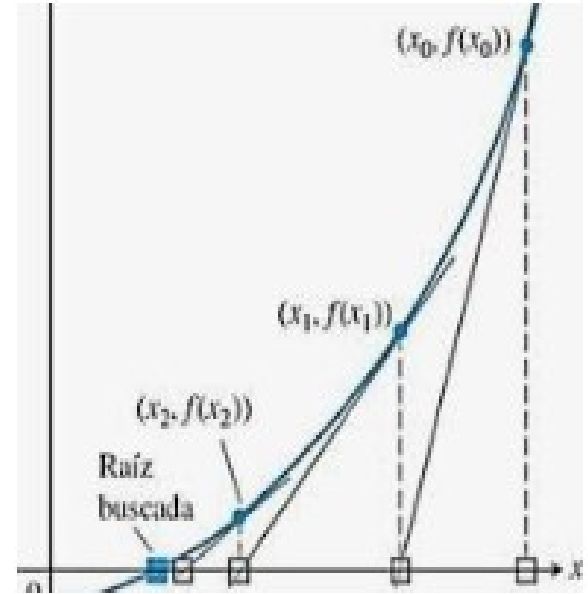
METODO DE NEWTON

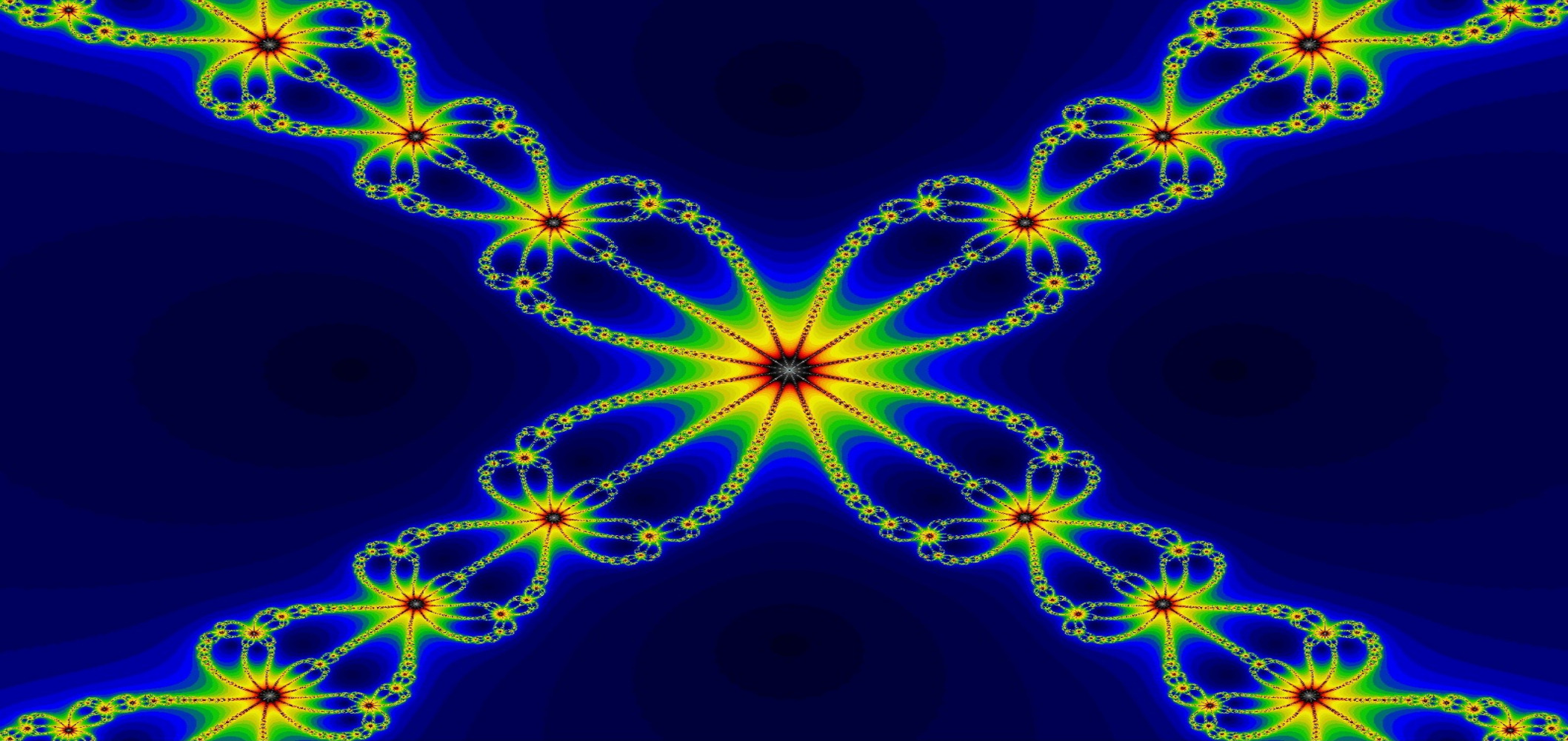
intenta encontrar por iteración las raíces de la función $F(Z)-1 = 0$.

$$Z_{n+1} = Z_n - F(Z_n) / F'(Z_n)$$

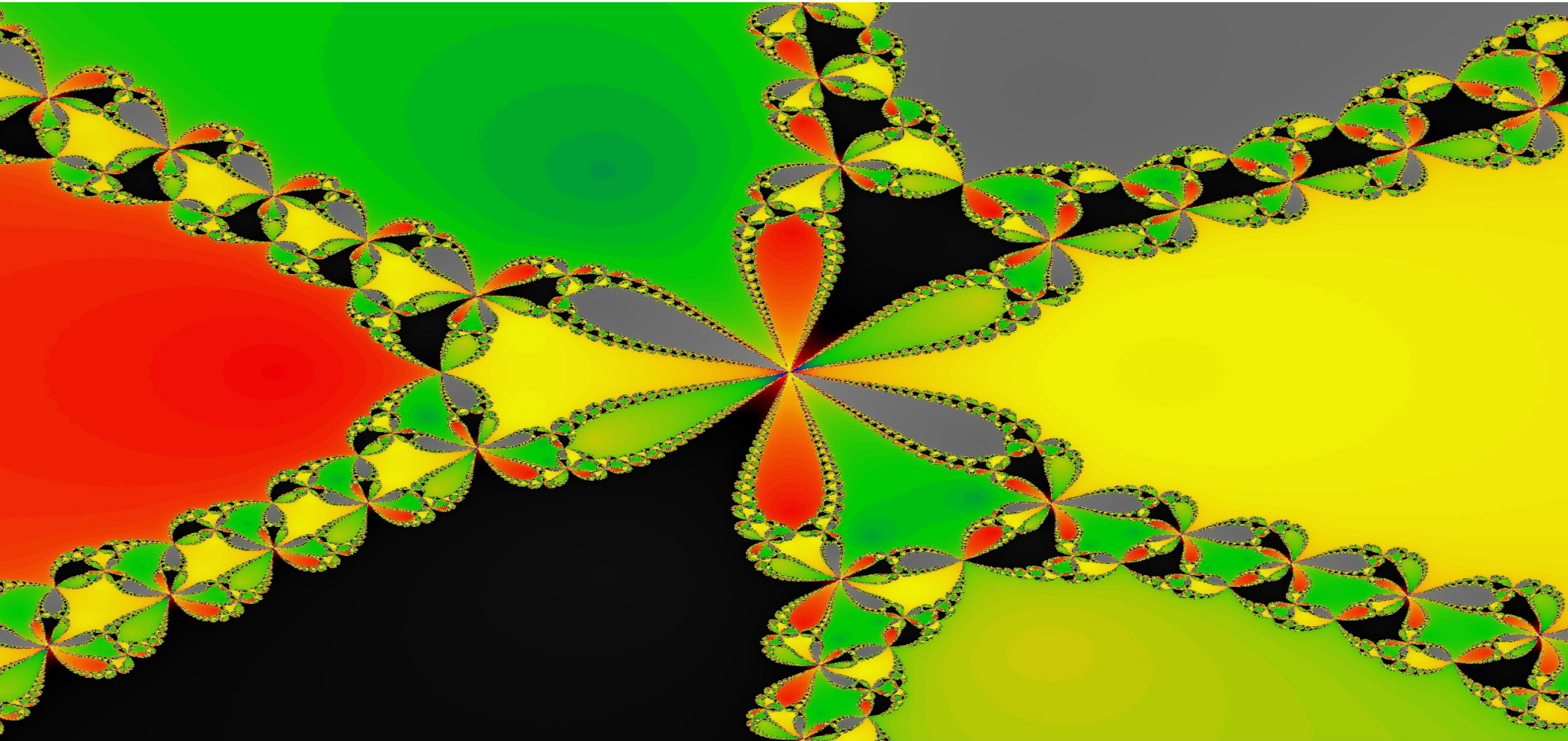
Cada pixel $z_0 = x + yi$ se colorea:

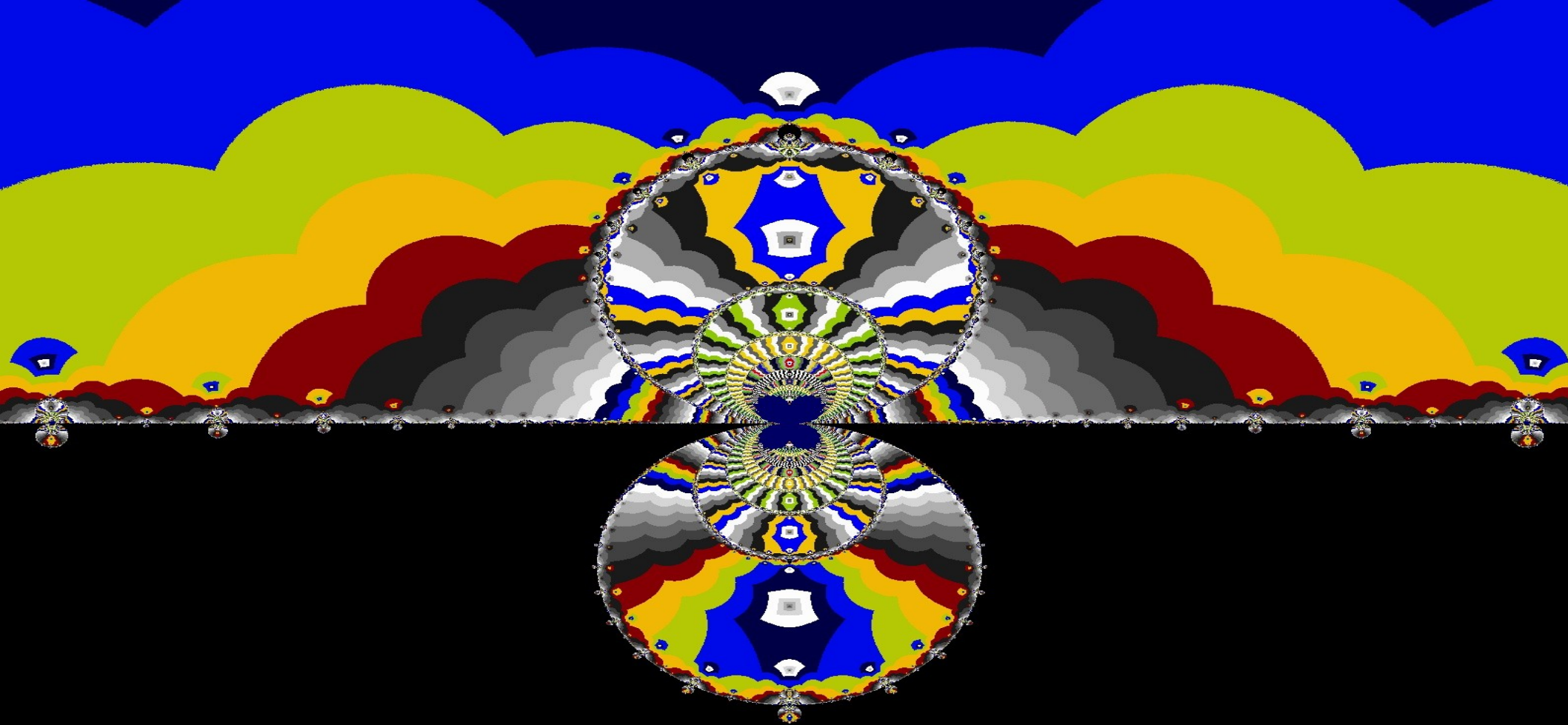
- * en función de las iteraciones necesarias para encontrar la solución





Métode de Newton. $Z^4 - 1 = 0$ $Z_{n+1} = [3 * Z_n^4 + 1] / (4 * Z_n^3)$





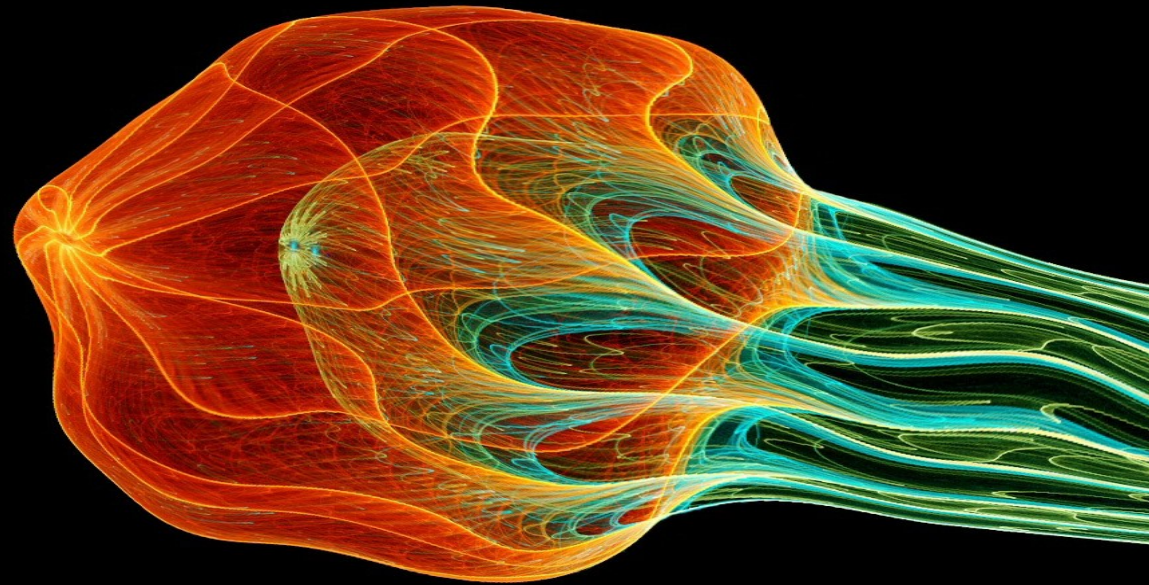
Méthode de Newton. $\text{COSH}(Z) - 1 = 0$ $Z_{n+1} = (Z_n * \text{Sinh}(Z_n) - \text{Cosh}(Z_n) + 1) / \text{Sinh}(Z_n)$



APLICACIONES DE LOS FRACTALES



MODELOS GENÉTICOS



BIOLOGIA



SISTEMAS MONTAÑOSOS



MEDICION DE COSTAS Y FRONTERAS



QUIMICA



FENOMENOS NATURALES



ASTRONOMIA



MECANICA DE FLUIDOS



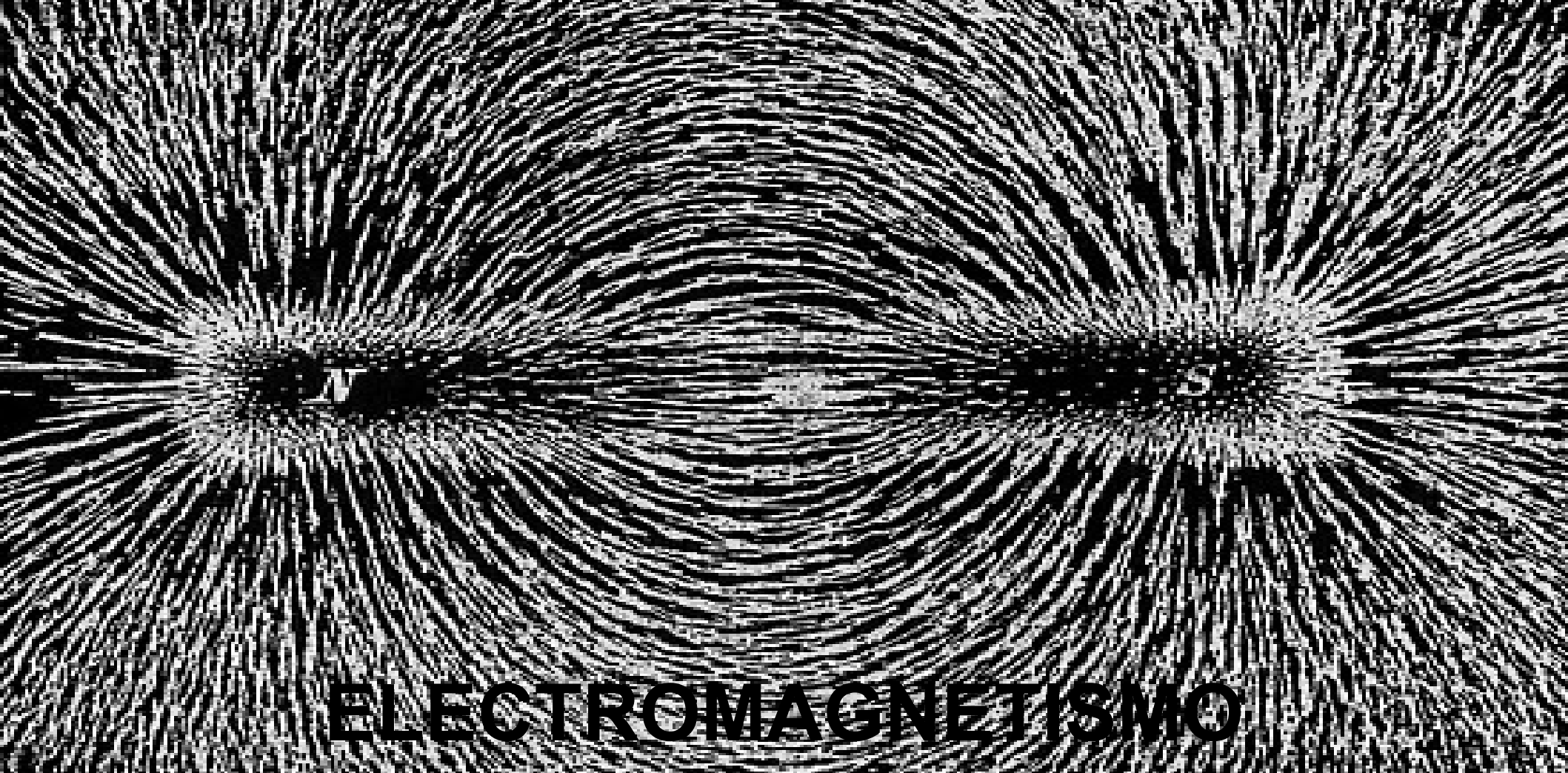
SISTEMAS CAÓTICOS



El aleteo de una mariposa puede sentirse al otro lado del mundo



FISICA DE PARTICULAS



ELECTROMAGNETISMO



MEDICINA



ARTE

66330 bytes



24619 bytes



2852 bytes



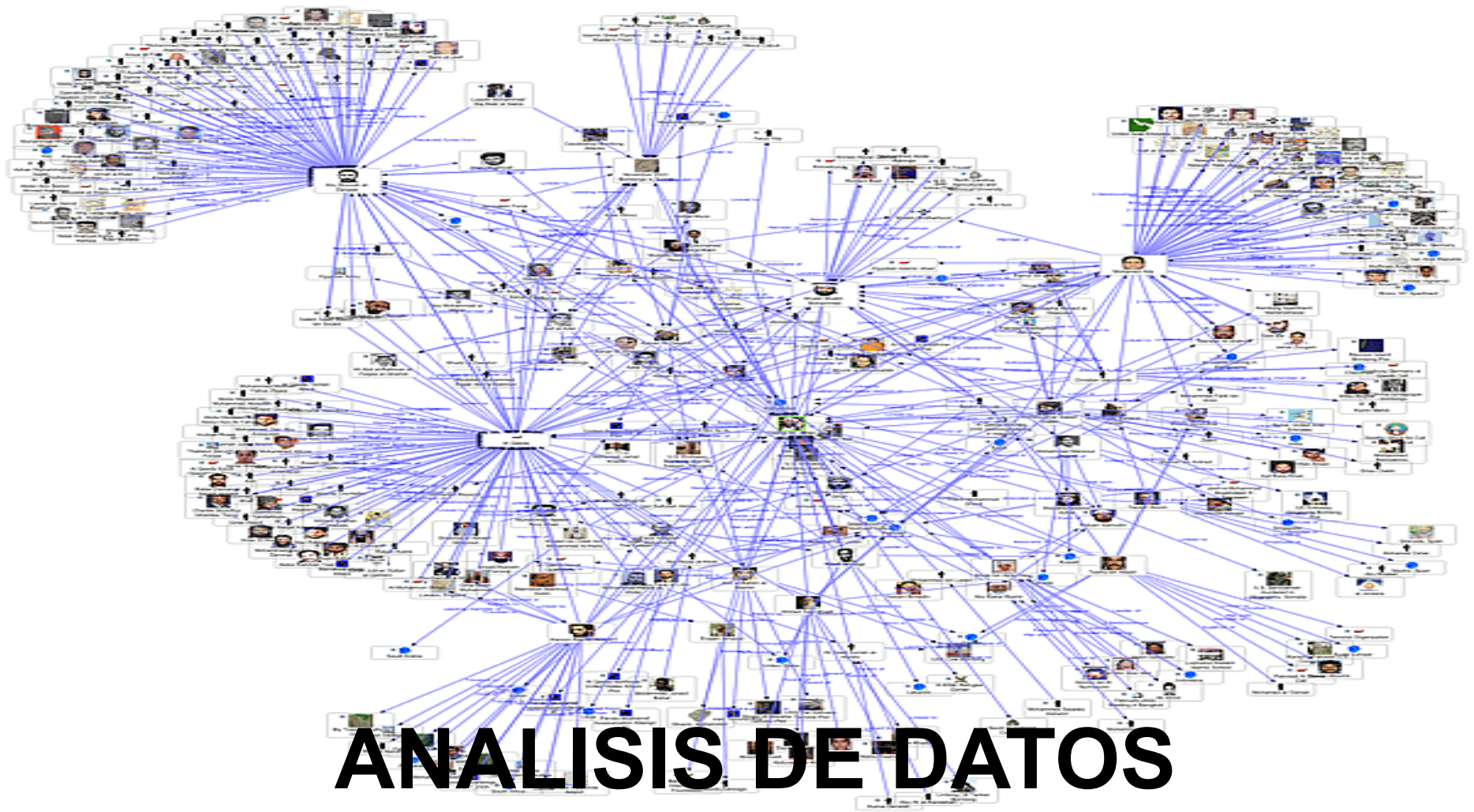
INFORMATICA: COMPRESION FICHEROS



BLOCKCHAIN
TECHNOLOGY



VIDEOJUEGOS

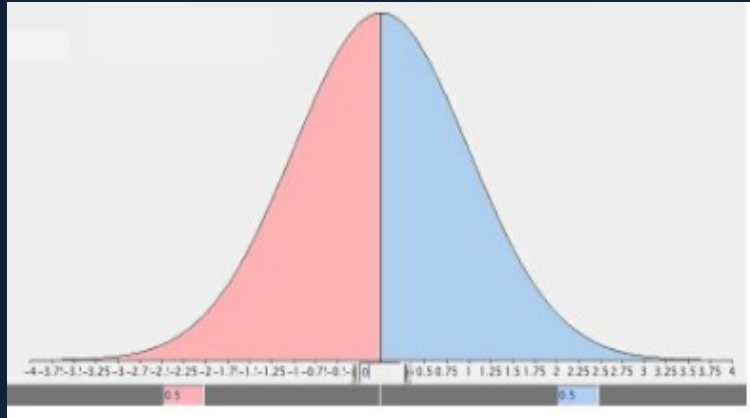


ANALISIS DE DATOS

EVOLUCIÓN DEL IBEX 35 DESDE 1987



SERIES TEMPORALES – ANALISIS BURSATIL



```

require('TEMPLATE_PATH/js/jquery/jquery.stylenav.php')
jQuery(document).ready(function($){
  $options = {
    'array' : 'style' => 'nav',
    'module' => 'ModuleNav',
    'topmenu' => 'ModuleNav',
    'mod_name' => ''
  };
  Main Menu
  if ($default_menu_style == 1 or $default_menu_style == 2) {
    $module->params = 'moduletype=form_name/subnav/children/links.php';
    $topmenu = $renderer->render($module, $options);
    $menuclass = 'horizontal';
    $topmenuclass = 'top menu';
  }
  elseif ($default_menu_style == 3 or $default_menu_style == 4) {
    $module->params = 'moduletype=menu_name/subnav/children/links.php';
    $topmenu = $renderer->render($module, $options);
    $menuclass = 'horizontal d';
    $topmenuclass = 'top menu d';
  }
  SPI.IT MENU NO SUCH
  elseif ($default_menu_style == 5) {
    $module->params = 'moduletype=menu_name/subnav/children/links.php';
    $topmenu = $renderer->render($module, $options);
    $menuclass = 'horizontal';
    $topmenuclass = 'top menu';
  }
}
  
```

GRADO EN ESTADISTICA EMPRESARIAL

<http://estadistica.edu.umh.es/>





RECURSOS ONLINE

Select a fractal and click "Reset":

Newtonian fractal ▼

Polynomial terms:

1,0,0,-1

Relaxation parameter:

1

Minimum real value:

-2,8

Maximum real value:

2,8

Maximum imaginary value:

2,1

Minimum imaginary value:

-2,1

Scale:

1:1

Render time:

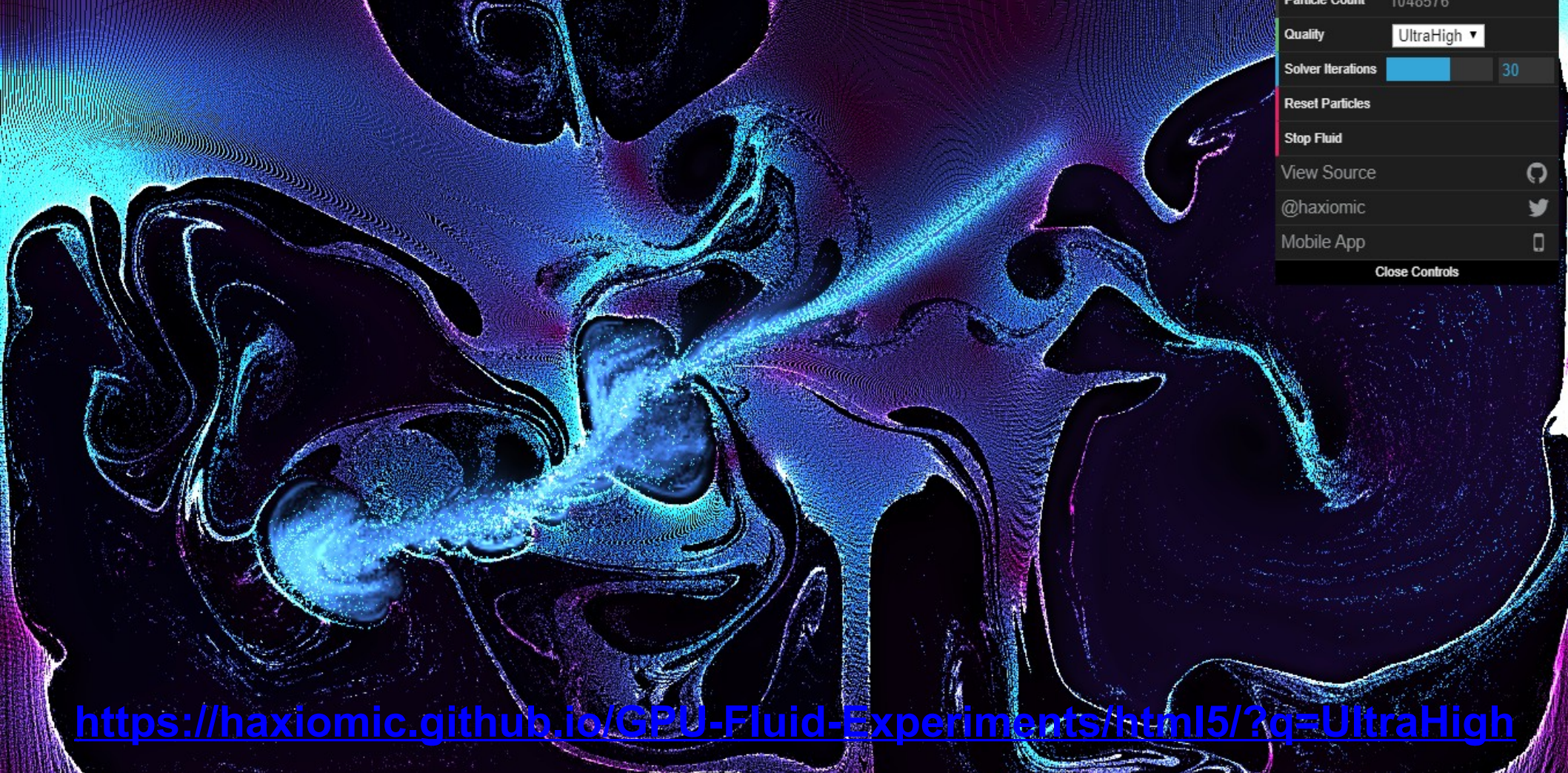
896 ms

<http://usefuljs.net/fractals/>

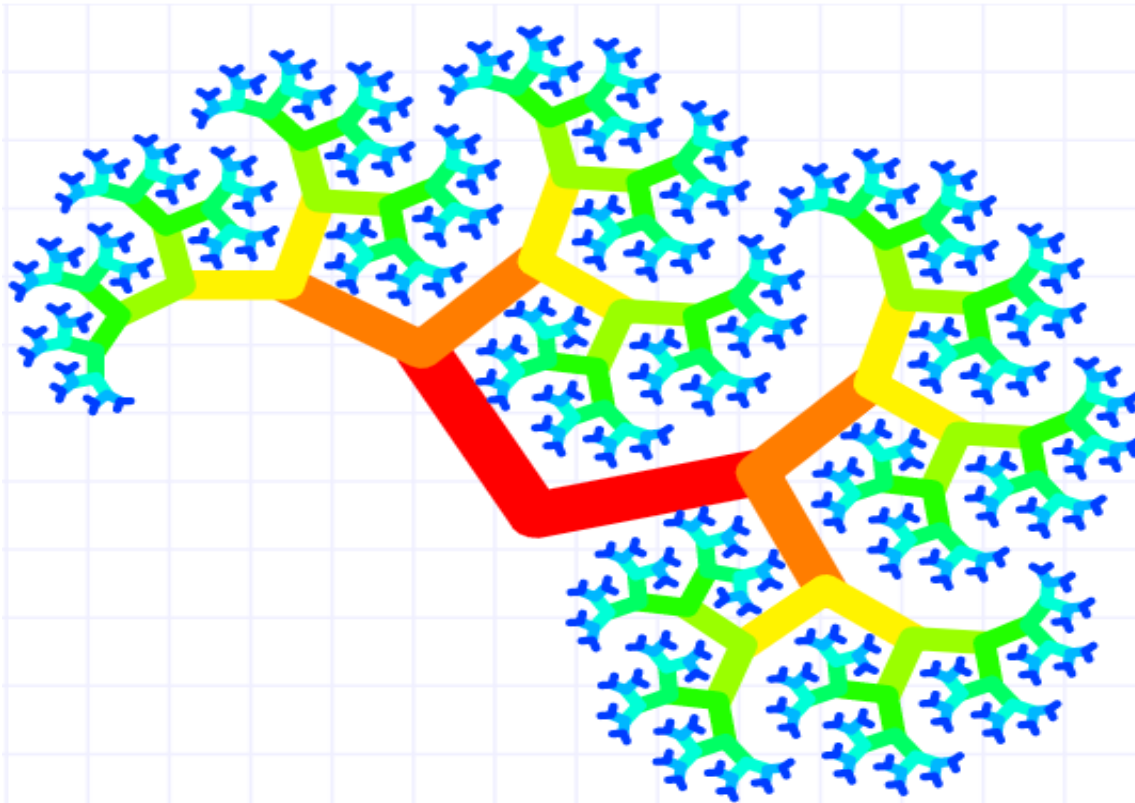
< Back



Reset



<https://haxiomic.github.io/GPU-Fluid-Experiments/html5/?q=UltraHigh>



variables	style
angle1 :	<input type="text" value="107"/> °
angle2 :	<input type="text" value="283"/> °
iterations :	<input type="text" value="9"/>
branches :	<input type="text" value="2"/>
start length :	<input type="text" value="2,8"/>
length multiplier :	<input type="text" value="0,68"/>
start width :	<input type="text" value="0,67"/>
width multiplier :	<input type="text" value="0,8"/>

<https://www.visnos.com/demos/fractal>

Now with kerring. And faster.

Number of dots:



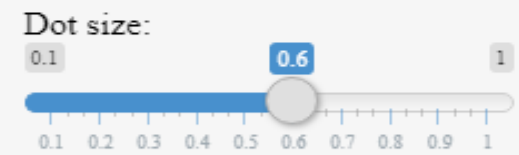
Text:

Number of iterations:



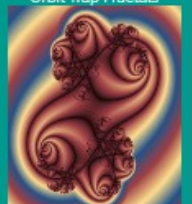




- 1
- 2
- 3
- 4
- 5
- 6

Text color:

Background color:



<https://rpubs.com/ismaelsb/FractalText>

- 
- Make Fractals of Images

- Orbit Trap Fractals**

- Animate Julia Sets

- Möbius Transformation of a Doyle Spiral

- Rolling Hypocycloids and Epicycloids

- Focal Points, Ellipses and Ovals


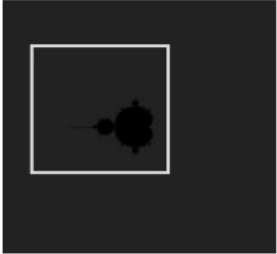
Change the palette

Pattern repetitions:

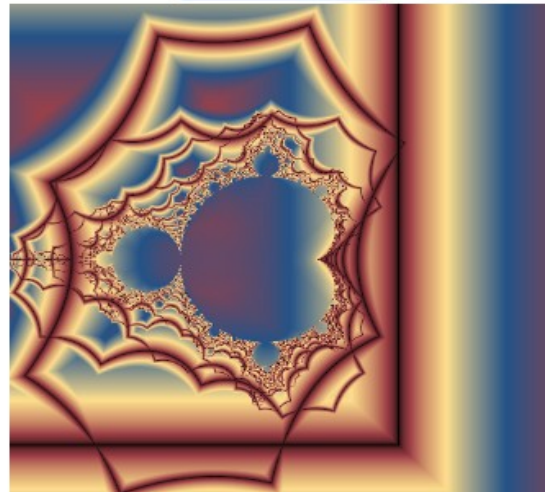
Pick orbit trap

Orbit trap size 2

Orbit trap position



Generate new fractals



<http://www.malinc.se/m/OrbitTraps.php>

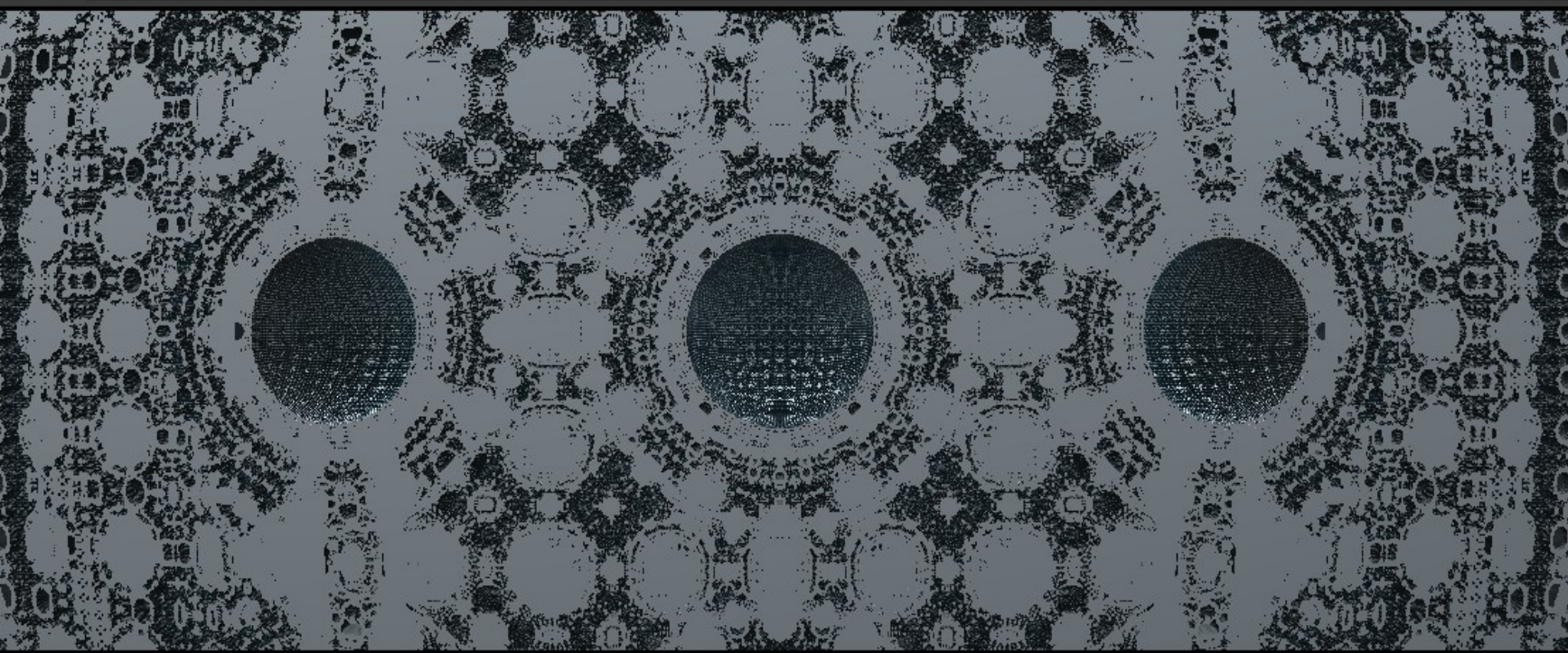
Fractal Lab

Interactive WebGL fractal explorer.

Fullscreen Save fractal Fractal library Help

Fractal Saved images Vertex Fragment Log

Recompile Save image 2D 3D Reset



Constants Fractal type
Mandelbox

Fractal parameters

Iterations 8

Max steps 60

Camera AO iterations 4

Render quality

Anti-aliasing

Shading

<http://hirnsohle.de/test/fractalLab/>

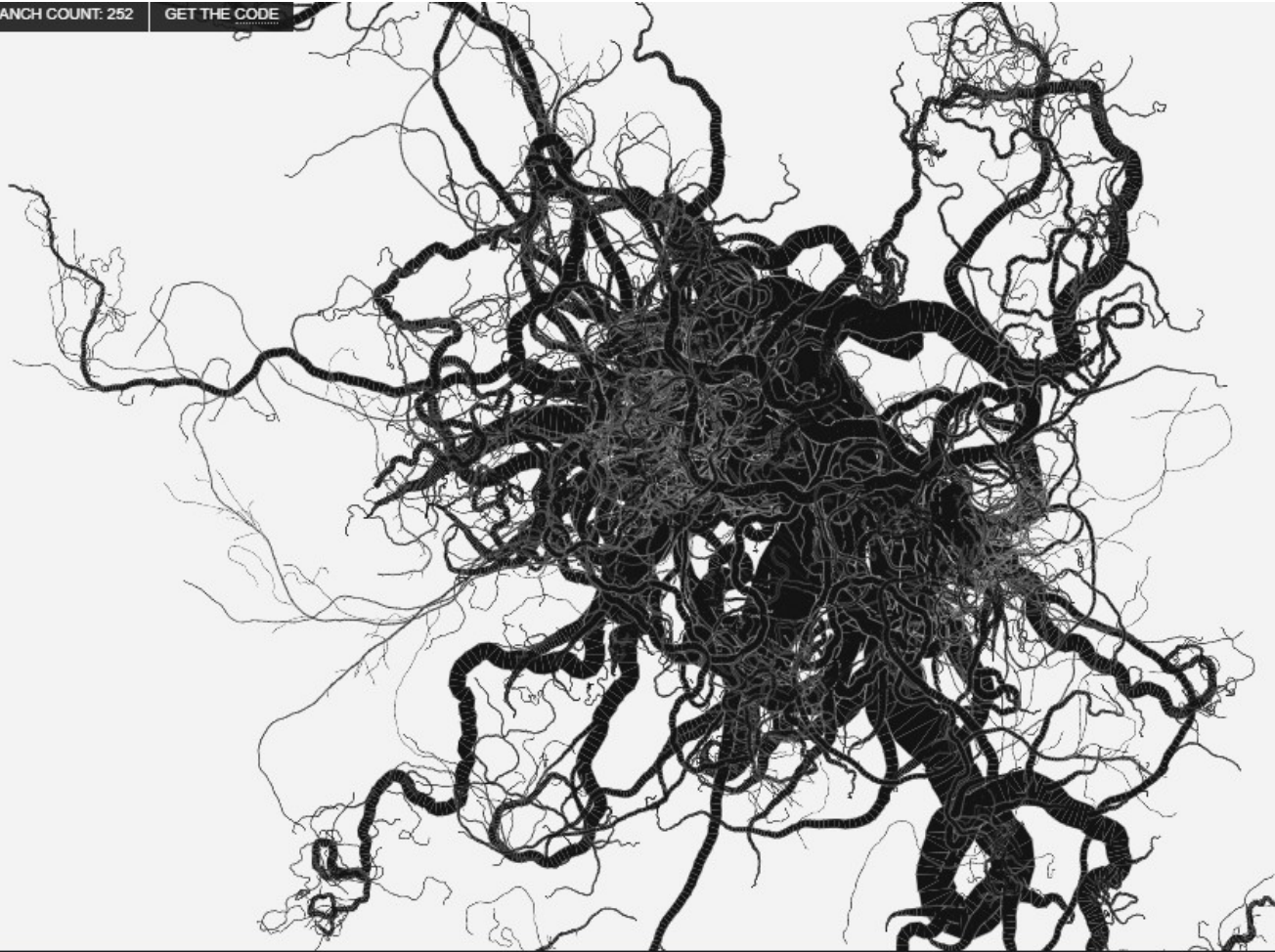
1114x436 px Auto preview ▾

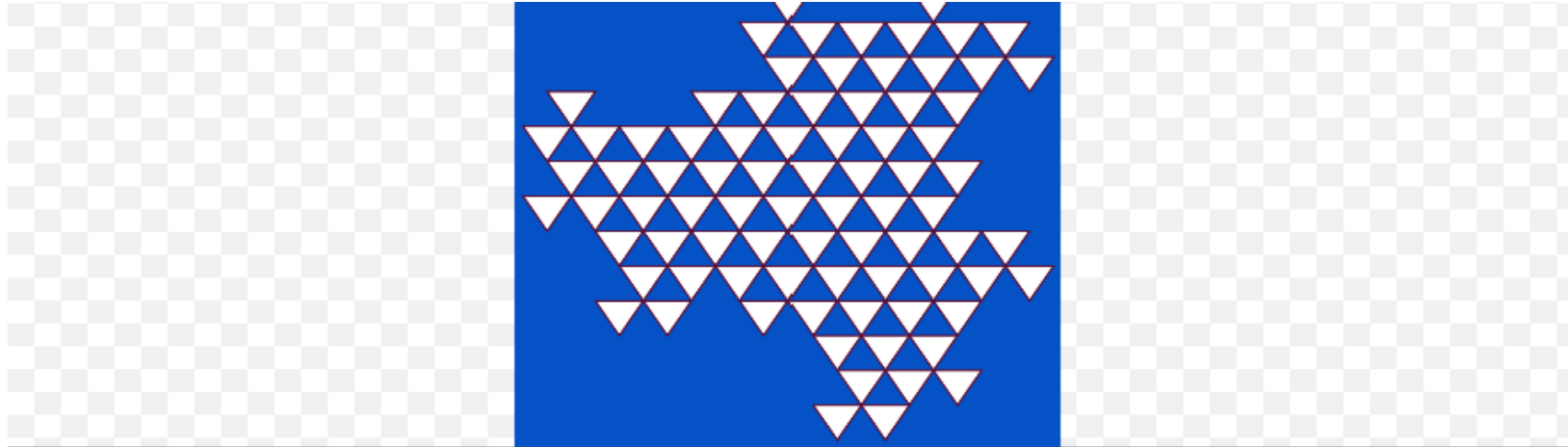
CLICK TO SPAWN

BRANCH COUNT: 252

GET THE CODE

Recursion Settings





Chain with... Save as... Copy to clipboard

triangle dragon fractal options

Iterations and Dimensions	Fractal's Color Palette	Space Options and Rotation
Iterations Iterations Fractal order. (Number of iterations.) 5	#034cc2 Background color.	10 Space (in pixels) between the fractal and the frame.
800 800 Fractal width. Fractal height.	rgb(255, 255, 255) Triangle's interior color.	Right Rotate initial triangle to this direction.
3 Fractal order.	#570c2f Triangle's border color.	

<https://onlinefractaltools.com/draw-triangle-dragon-fractal>

VIDEOS SOBRE FRACTALES

La paradoja de la costa ROMPE la REALIDAD | Fractales:

<https://www.youtube.com/watch?v=uK1unoVNtMs>

Concepto de dimensión fractal:

<https://www.youtube.com/watch?v=db8NMrqrrd0>

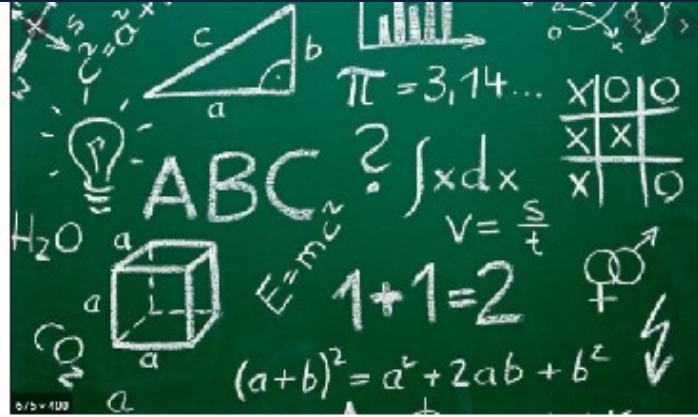
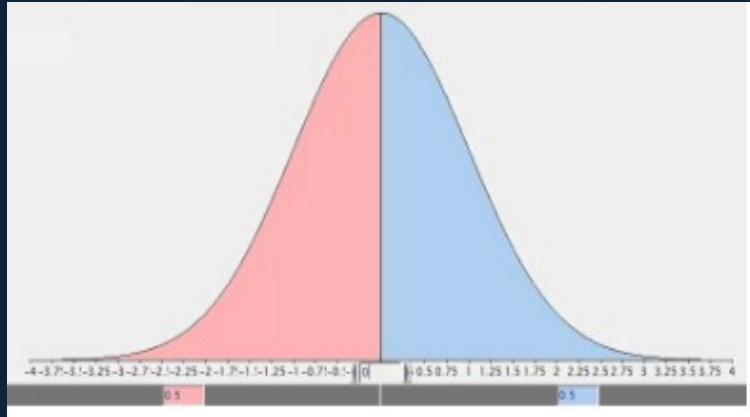
Origami. Construye tus propios fractales:

<https://www.youtube.com/watch?v=dnuFRjDr-KI>



PELICULAS SOBRE MATEMATICAS





```
require('TEMPLATE_PATH/js/jquery/jquery_stylenav.php');
jQuery(document).ready(function() {
    $options = {
        'array' : 'style' => 'nav',
        'module' => 'ModuleManager',
        'topmenu' => false, $submenu => false, $sideNav => false;
    };
    Main Menu
    if ($default_menu_style == 1 or $default_menu_style == 2) {
        $module->params = 'moduletype=<form_name>/subnavAllChildItem/outline.php';
        $topmenu = $router->render($module, $options);
        $menuclass = 'horiznav';
        $topmenuclass = 'top menu';
    }
    elseif ($default_menu_style == 3 or $default_menu_style == 4) {
        $module->params = 'moduletype=<form_name>/subnavAllChildItem/outline.php';
        $topmenu = $router->render($module, $options);
        $menuclass = 'horiznav d';
        $topmenuclass = 'top menu d';
    }
    SPLIT MENU NO SUBM
    elseif ($default_menu_style == 5) {
        $module->params = 'moduletype=<form_name>/subnavAllChildItem/outline.php';
        $topmenu = $router->render($module, $options);
        $menuclass = 'horiznav';
        $topmenuclass = 'top menu';
    }
});
```

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