

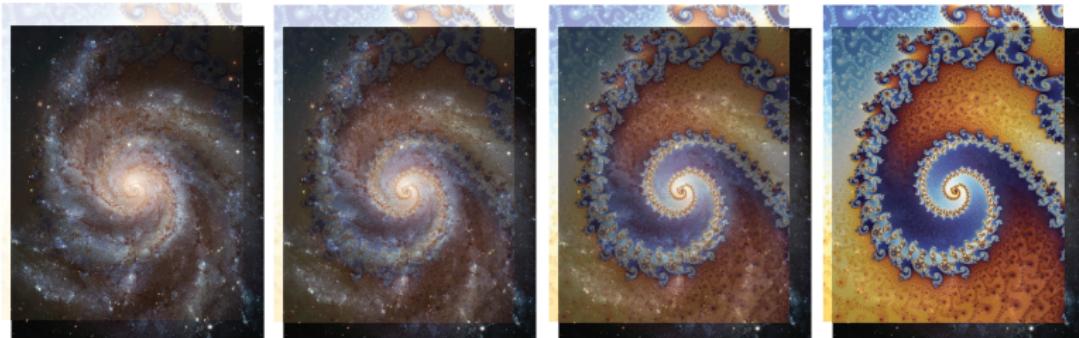
Pattern



Stefan Forcey, University of Akron

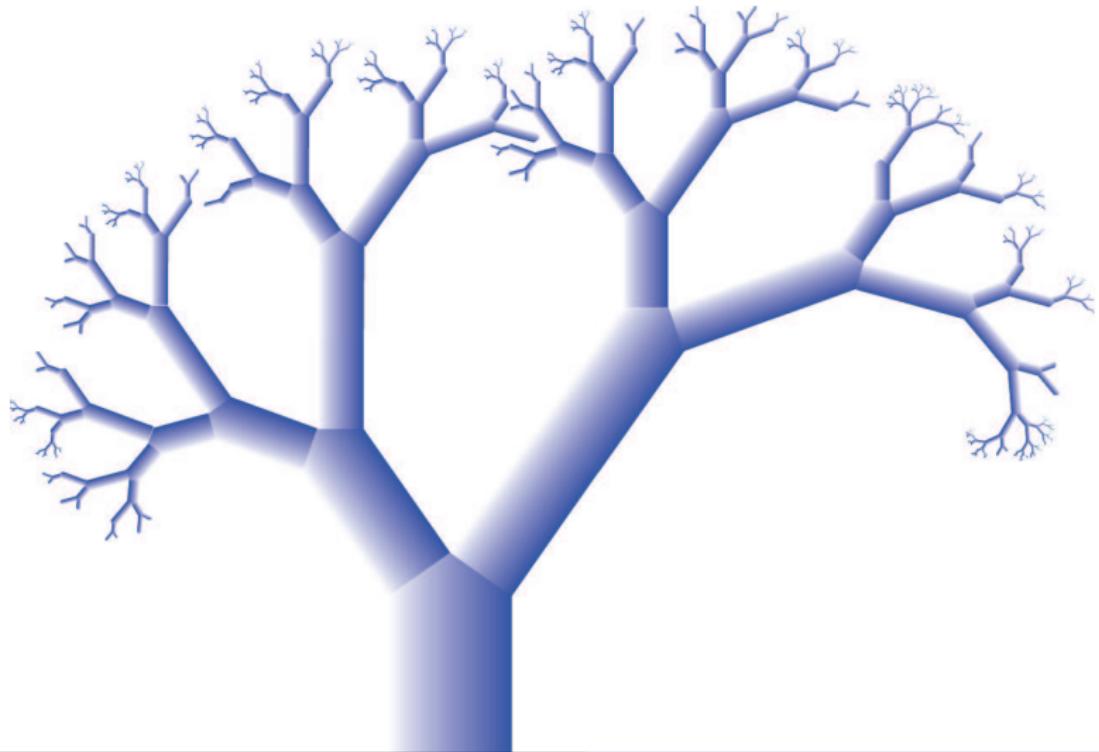


January 9, 2013



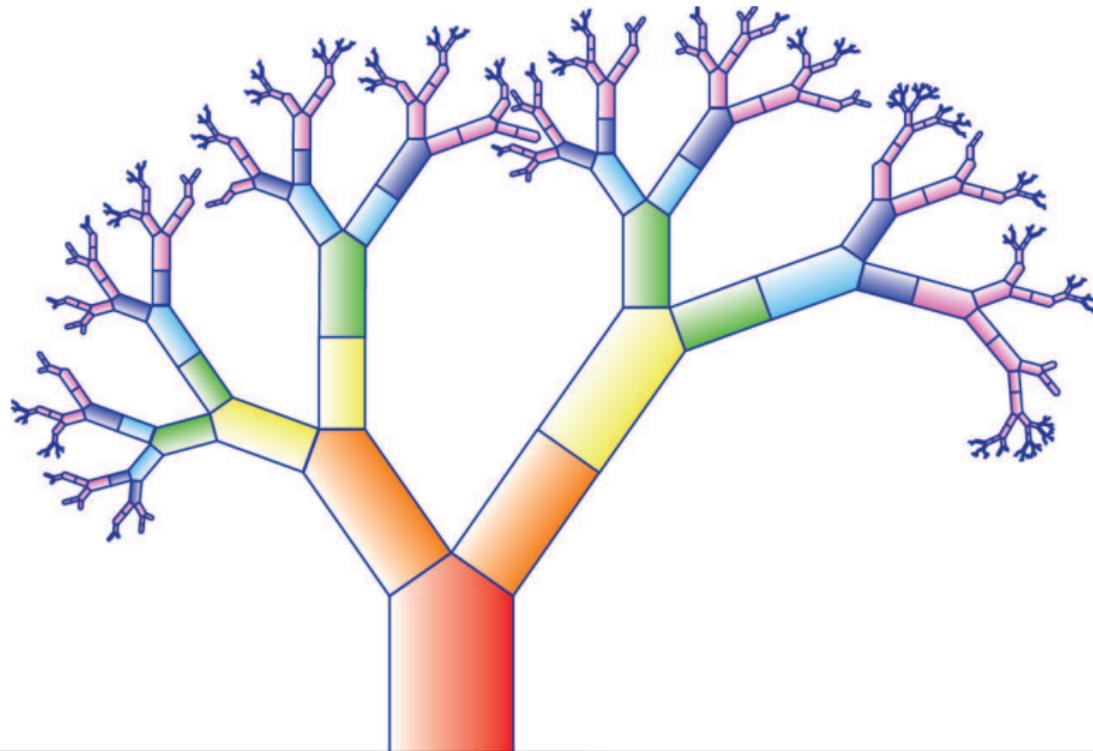
_____ sequence.

1, 1, 2, 3, 5, 8, 13, ?

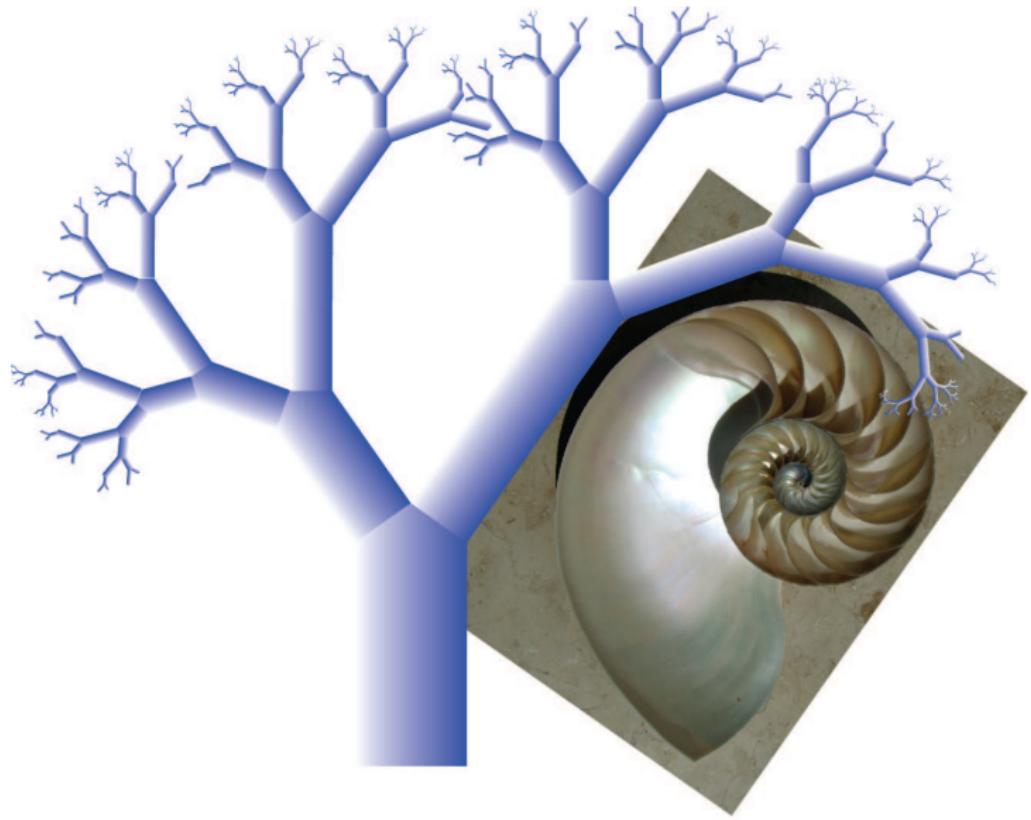


Fibonacci tree.

1, 1, 2, 3, 5, 8, 13, 21, 34, ...



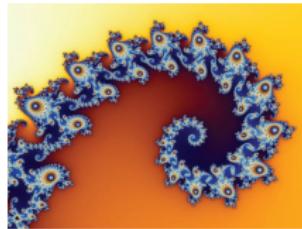
Logarithmic spiral.



Logarithmic spiral.

Image credits: McSweeney's (first two) Wikimedia (last two).

$$r = e^{\theta}.$$



Mandelbrot sequences.

Definition

Mandelbrot sequences: Take a complex number z and add it to its square. Repeat, by squaring your result and adding the same original z .

$$\begin{aligned} z \\ \mapsto z + z^2 \end{aligned}$$

Mandelbrot sequences.

Definition

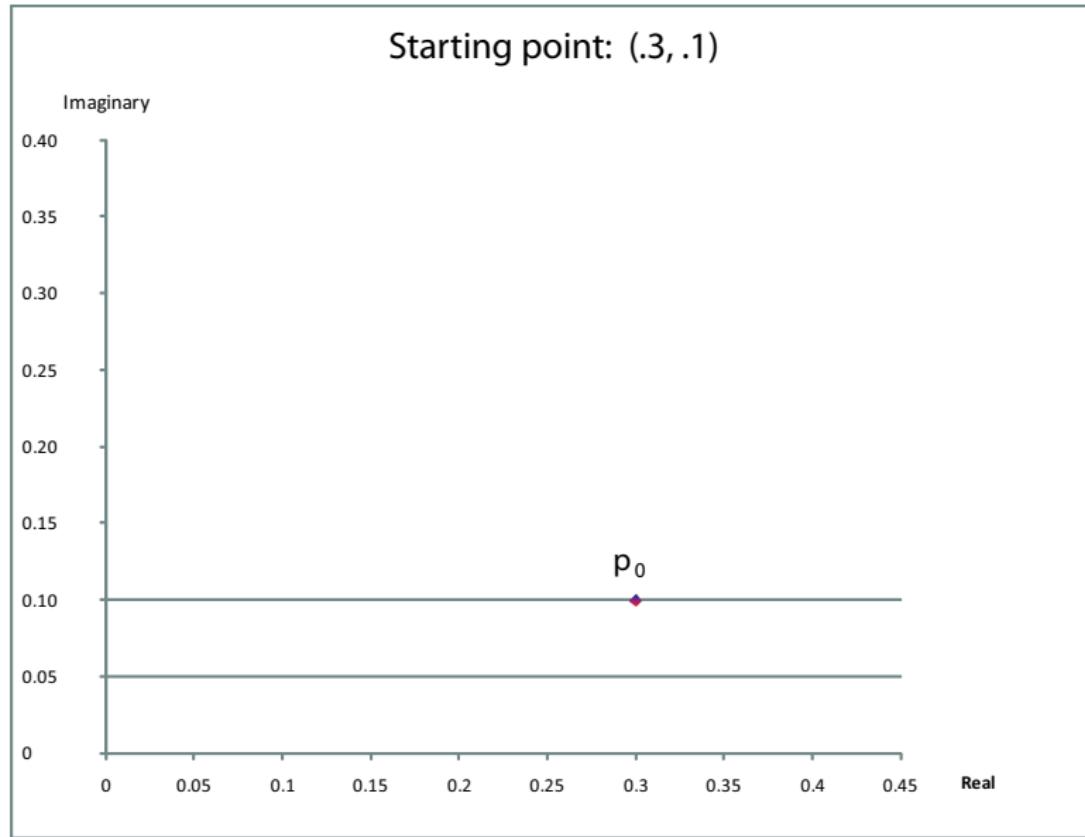
Mandelbrot sequences: Take a complex number z and add it to its square. Repeat, by squaring your result and adding the same original z .

z

$$\mapsto z + z^2$$

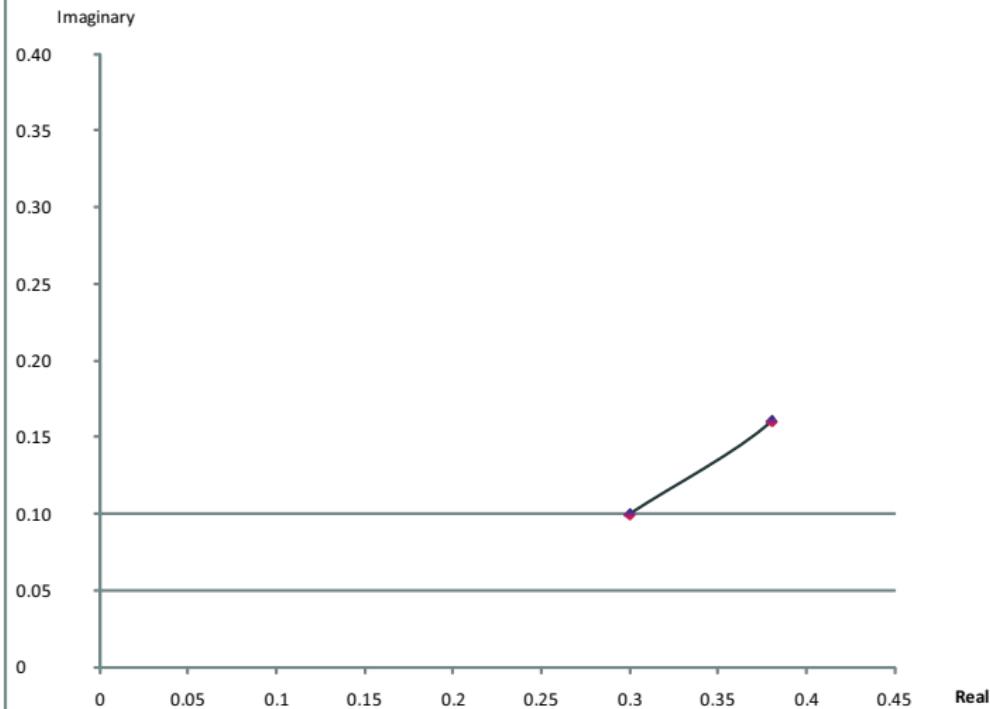
$$\mapsto z + (z + z^2)^2$$

Example Mandelbrot sequence: $z \mapsto z + z^2$



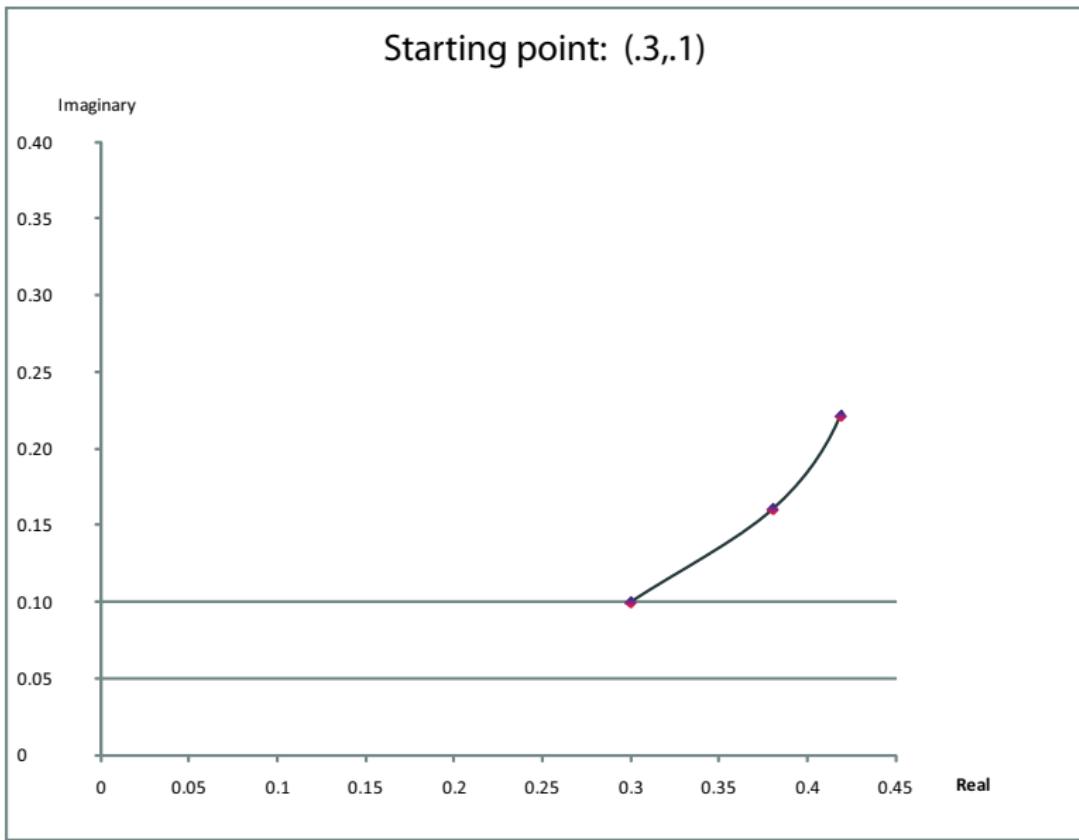
Mandelbrot $z \mapsto z + z^2$

Starting point: (.3,.1)



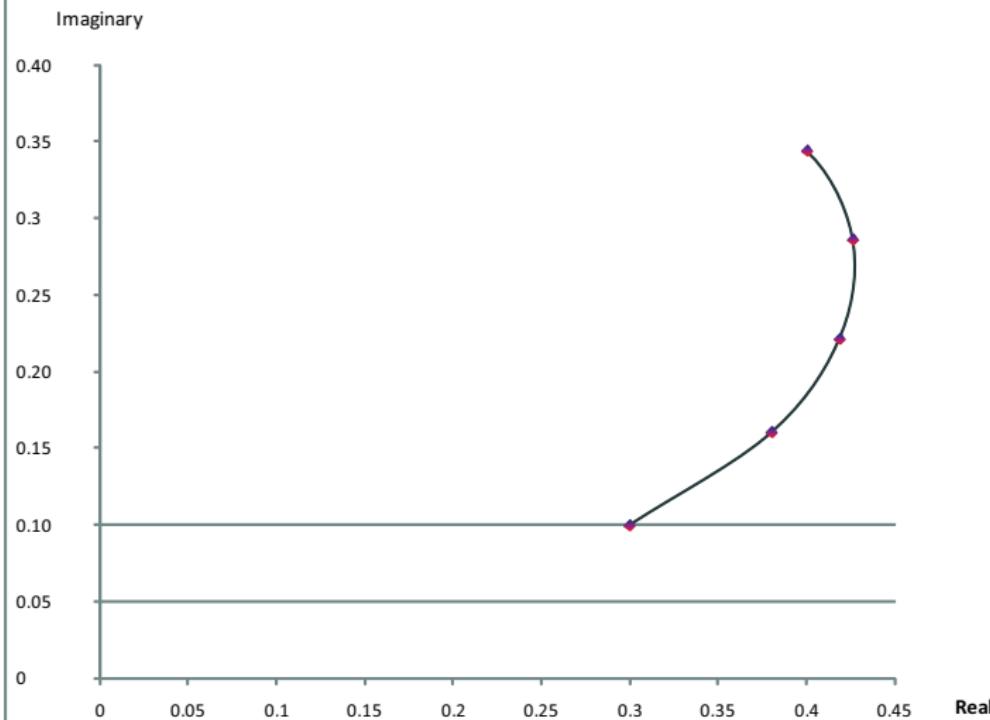
Mandelbrot $z \mapsto z + z^2$

Starting point: (.3,.1)



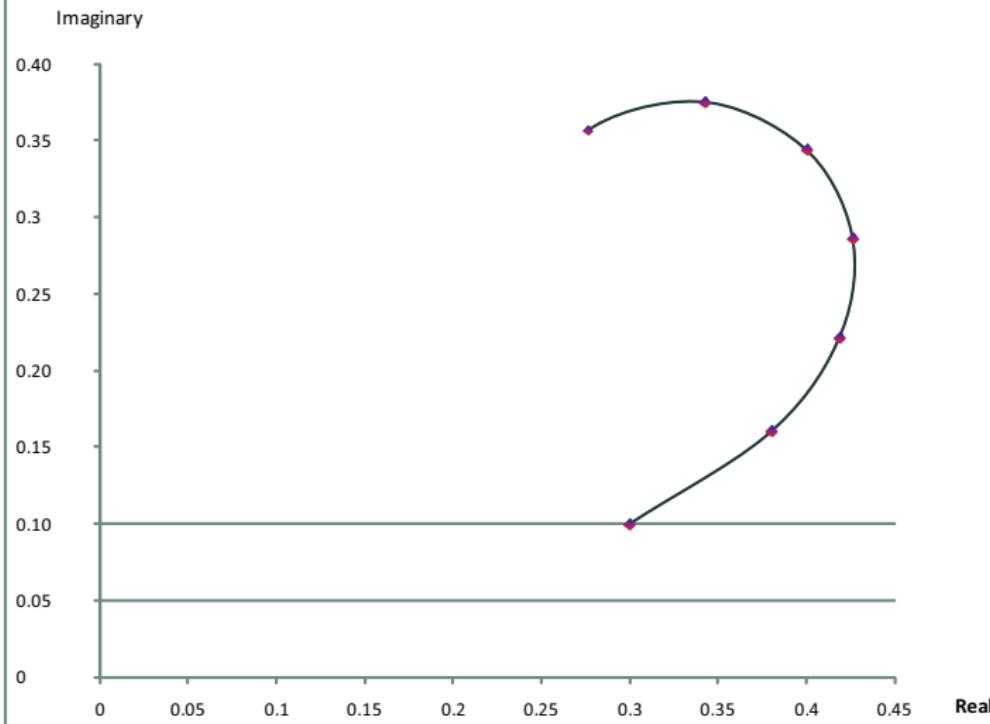
Mandelbrot $z \mapsto z + z^2$

Starting point: (.3,.1)



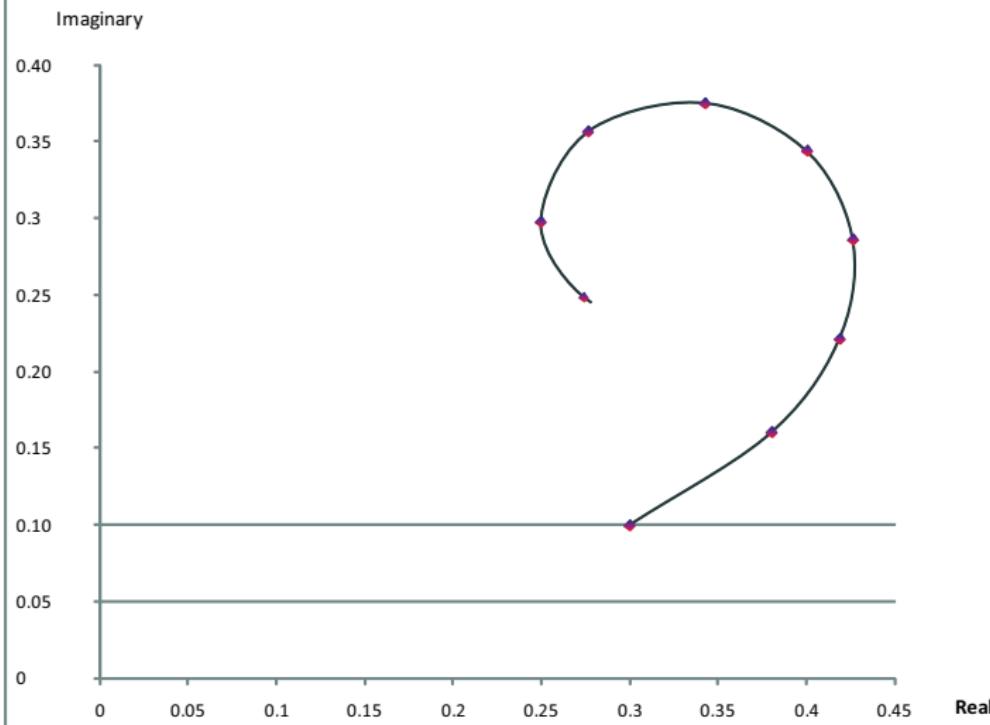
Mandelbrot $z \mapsto z + z^2$

Starting point: (.3,.1)



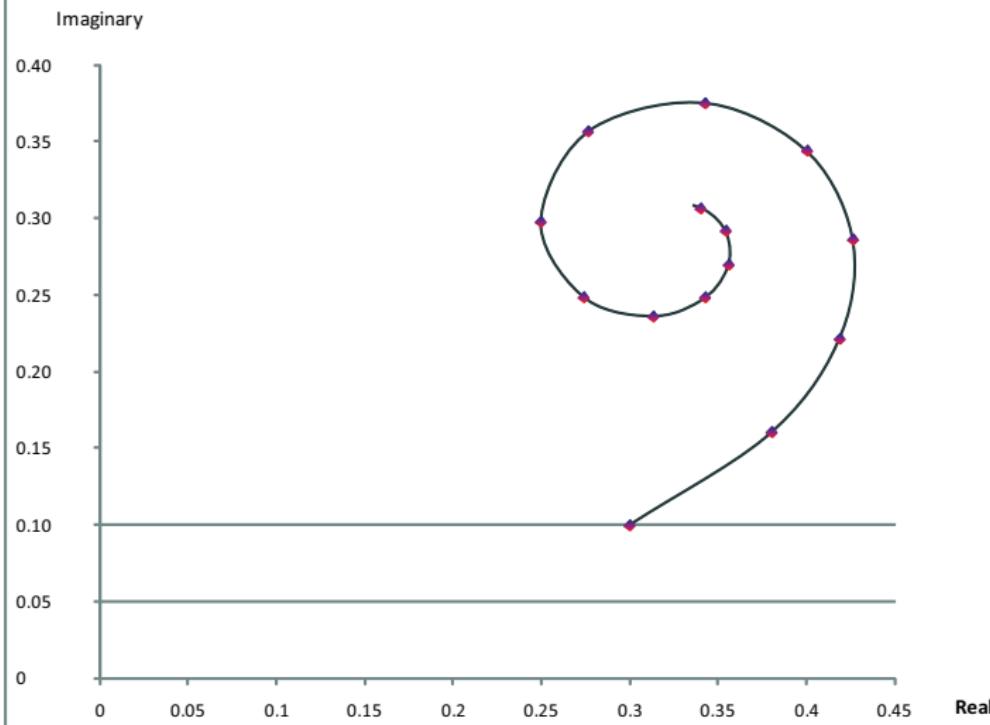
Mandelbrot $z \mapsto z + z^2$

Starting point: (.3,.1)



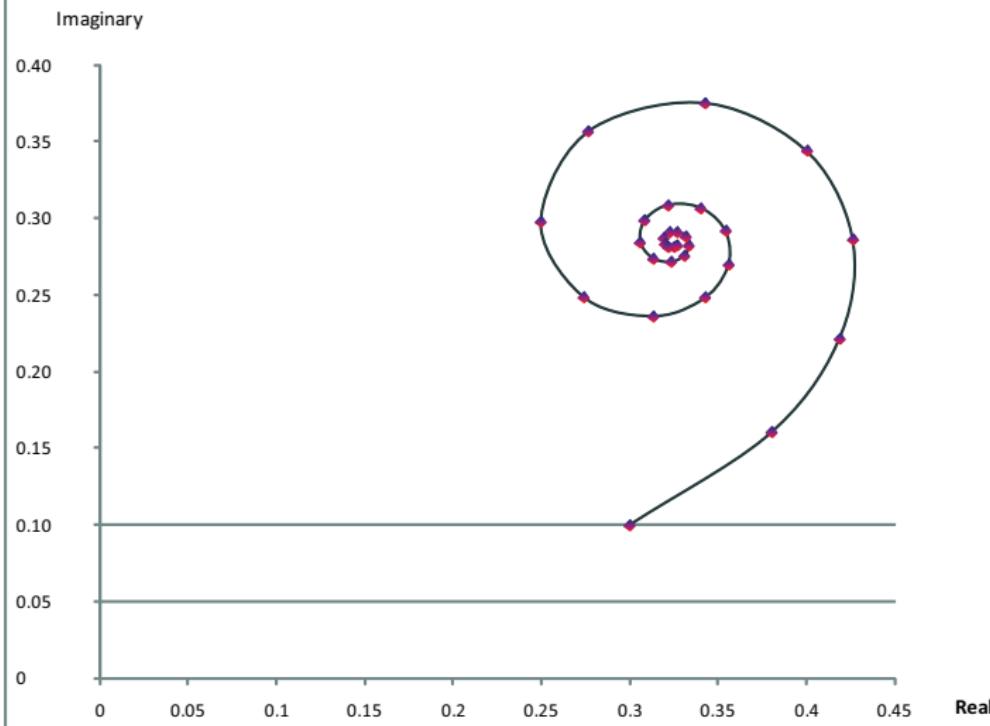
Mandelbrot $z \mapsto z + z^2$

Starting point: (.3,.1)



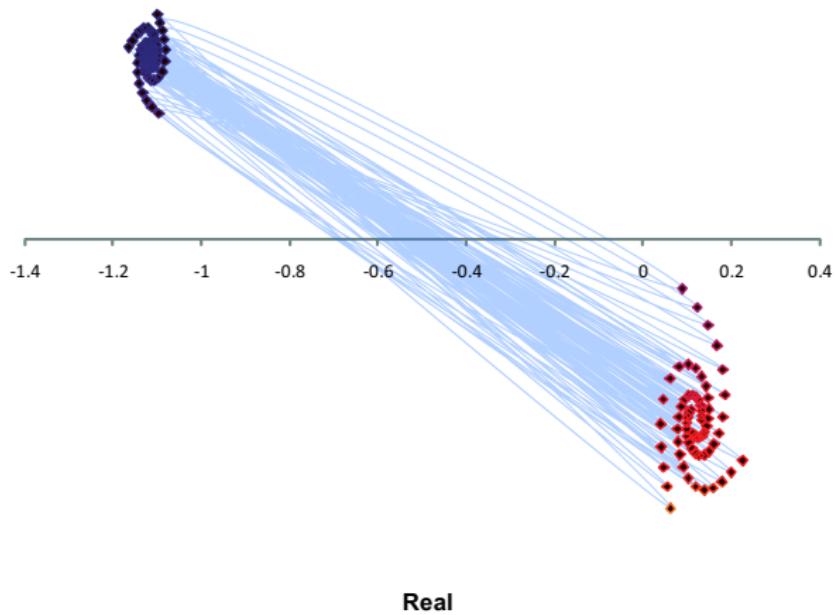
Mandelbrot $z \mapsto z + z^2$

Starting point: (.3,.1)



Mandelbrot $z \mapsto z + z^2$

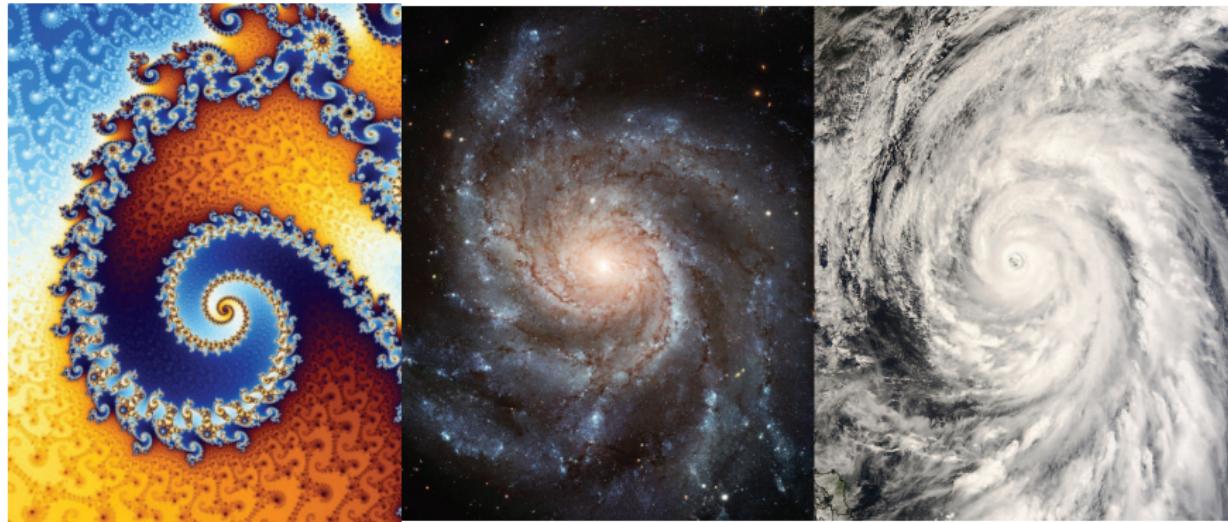
Starting point: (-1.1, .22)



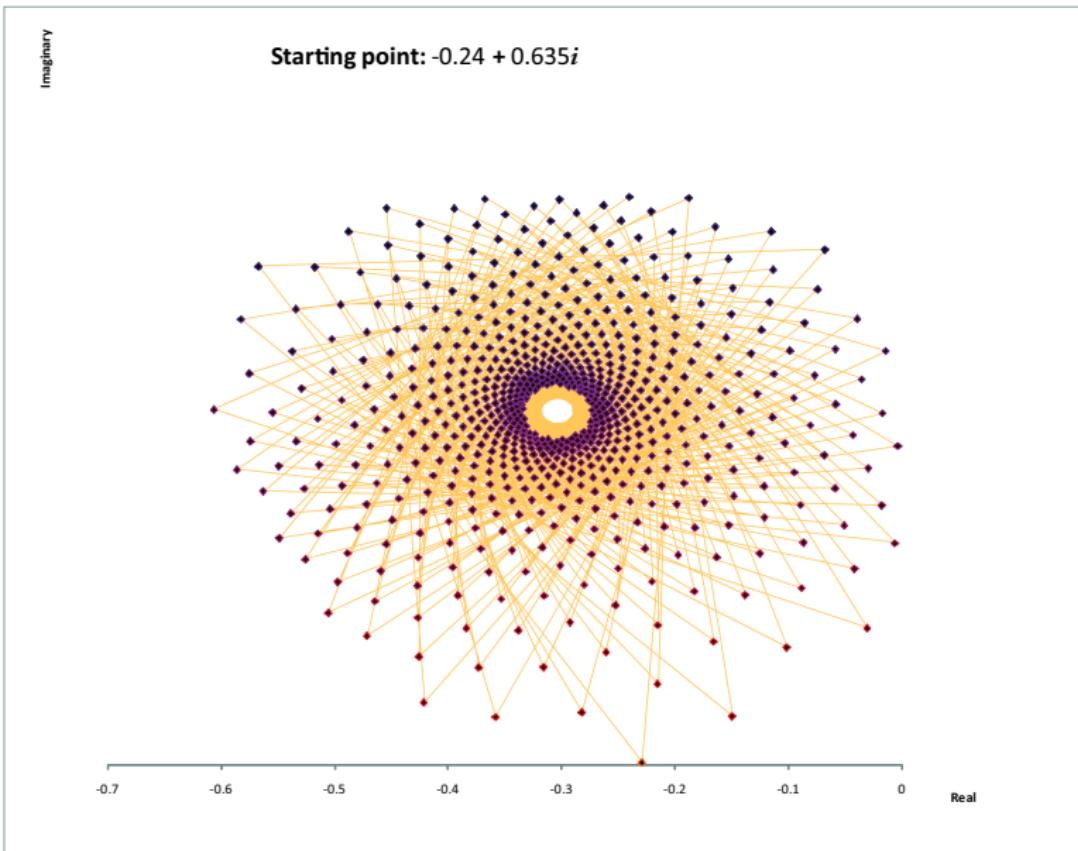
Logarithmic spiral.

Image credits: Wikimedia (first), NASA (second two).

$$\ln r = \theta.$$



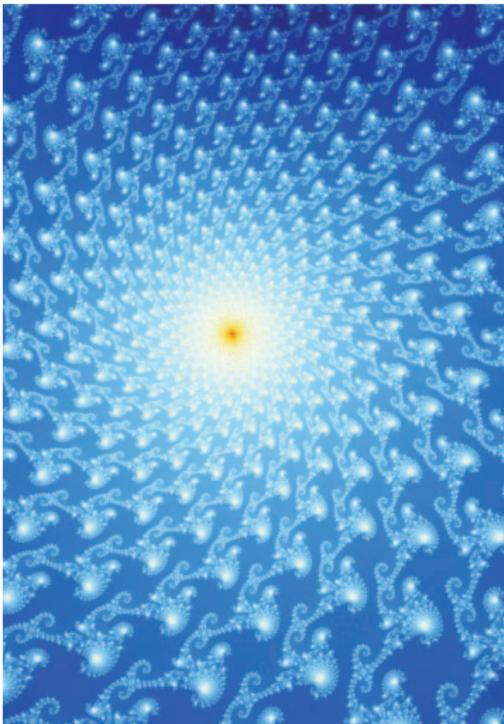
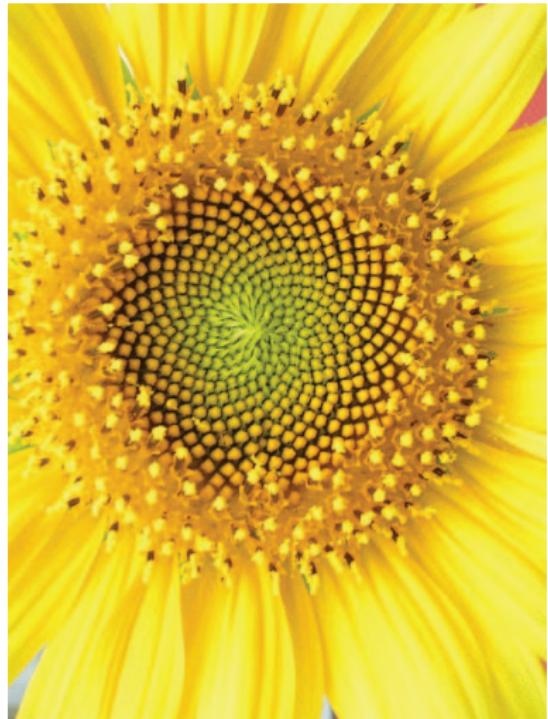
Mandelbrot $z \mapsto z + z^2$



Logarithmic spiral.

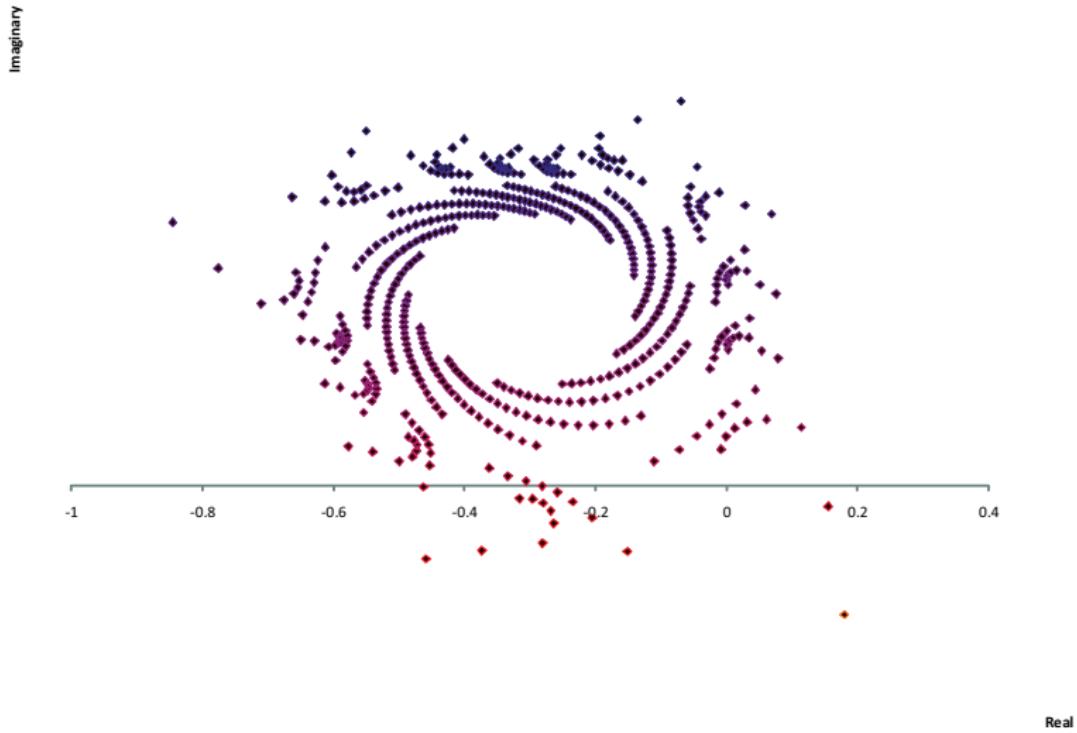
Image credits: Wikimedia.

$$\ln r = \theta.$$



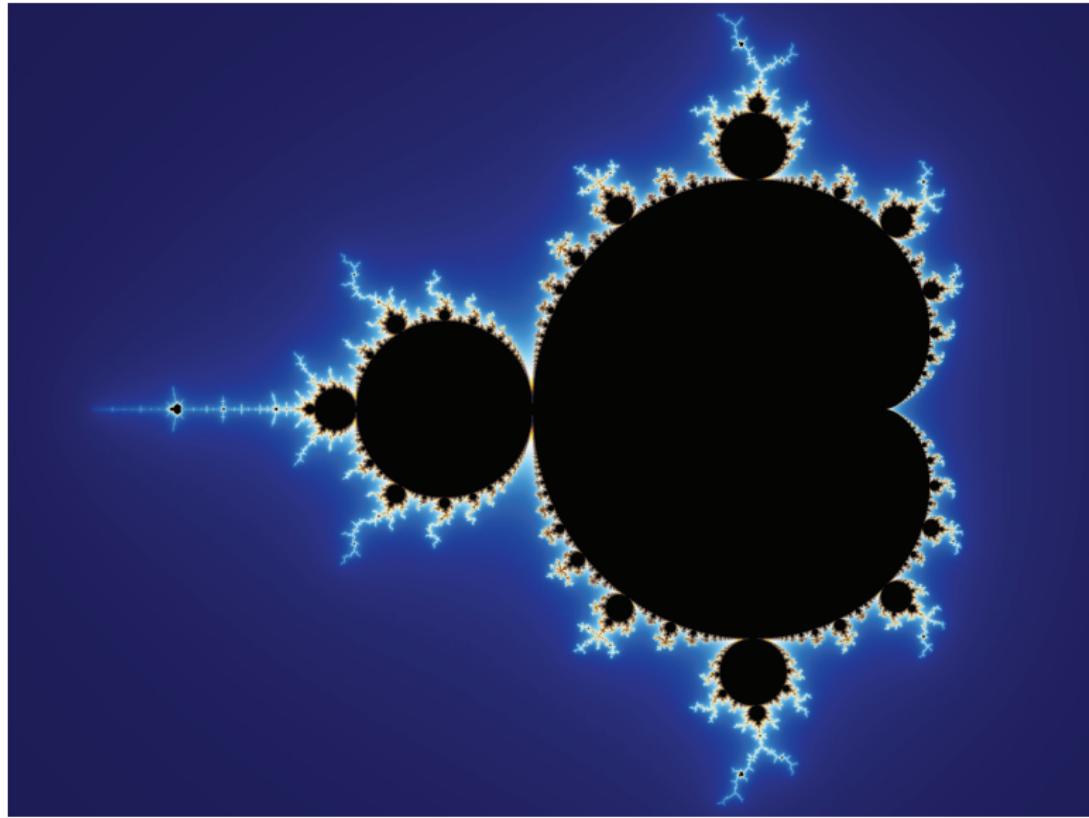
Mandelbrot $z \mapsto z + z^2$

Starting point: $-0.26 + 0.635i$

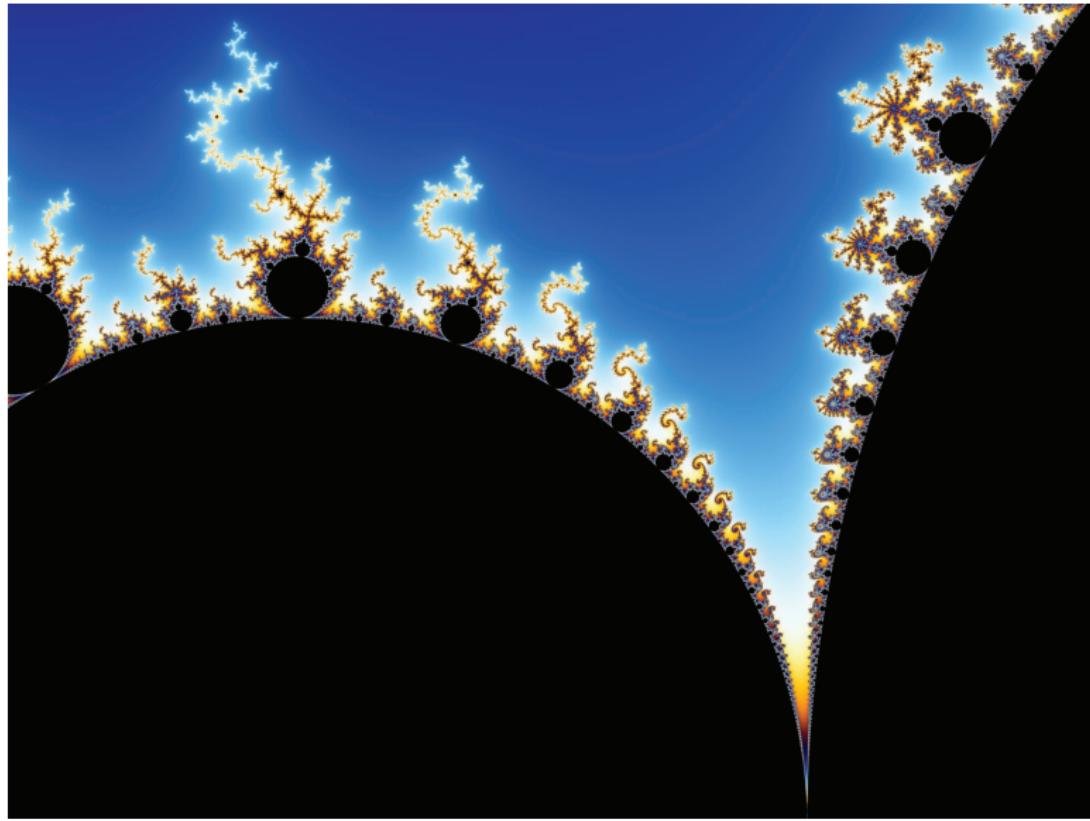


Mandelbrot set.

Image credits (all following Mandelbrot slides): Wikimedia, W. Beyer.



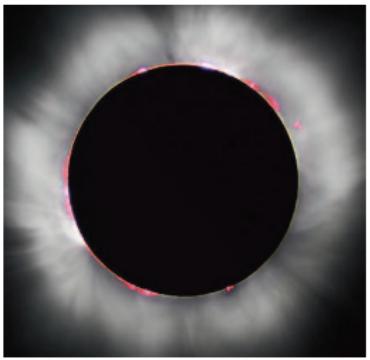
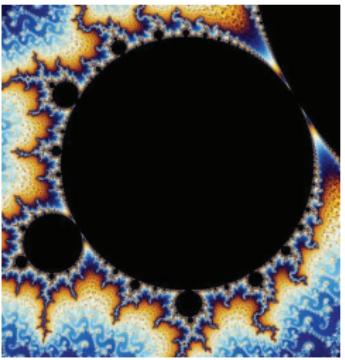
Mandelbrot set.



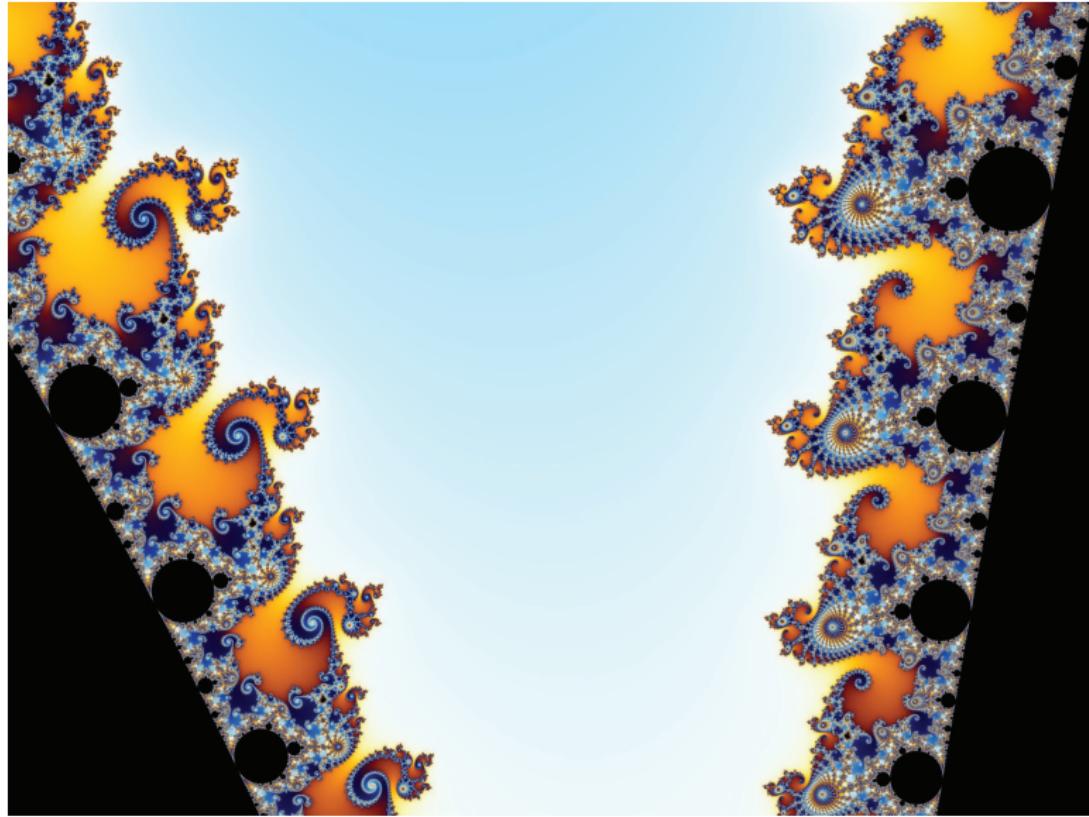
Fractal

Image credit: NASA.

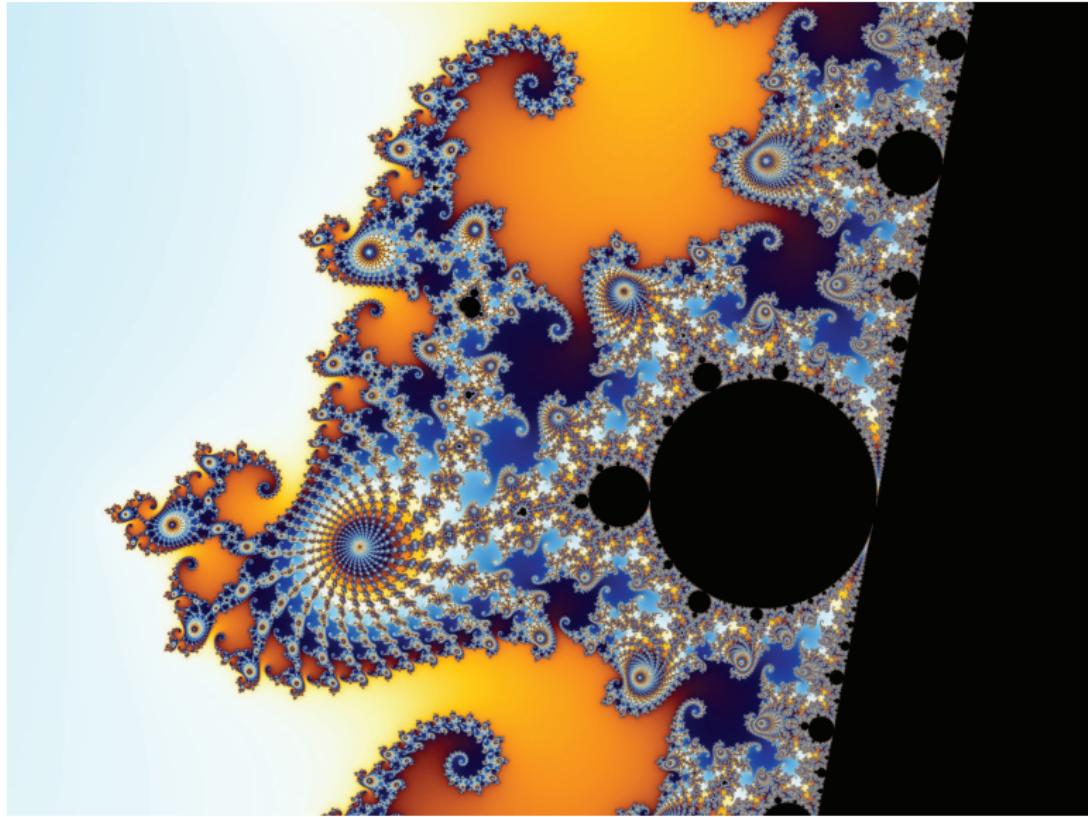
Victoria crater.



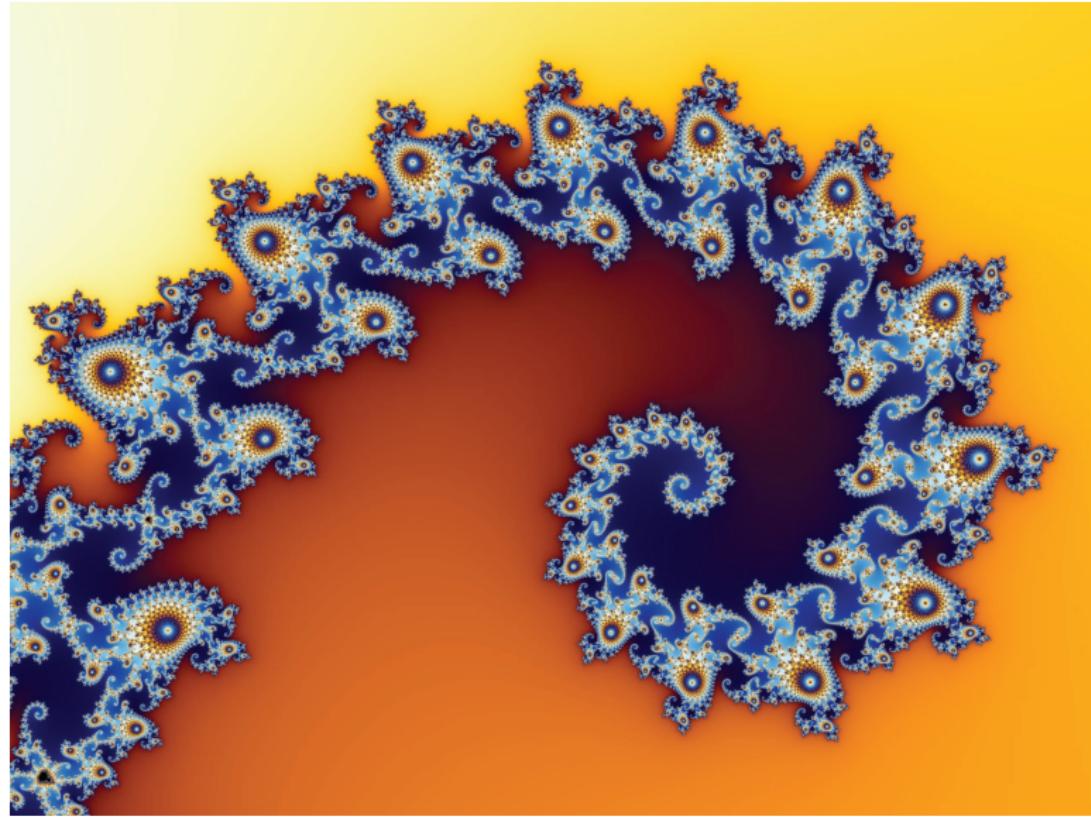
Mandelbrot set.



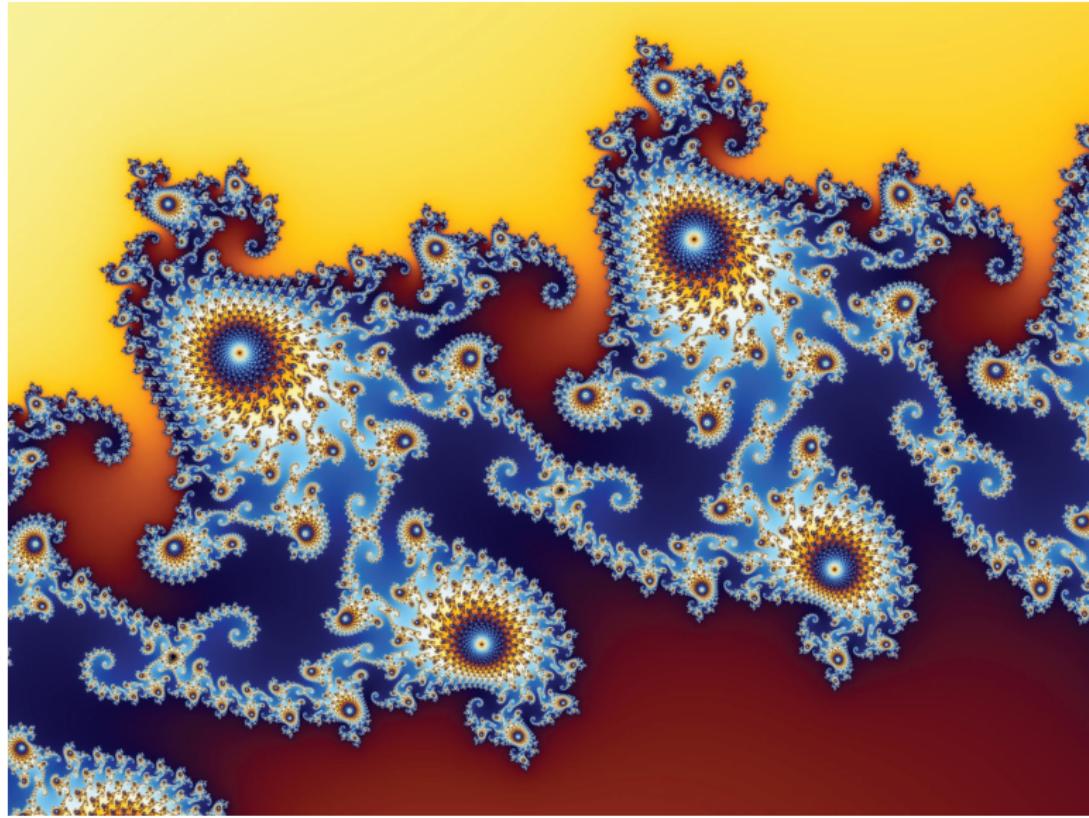
Mandelbrot set.



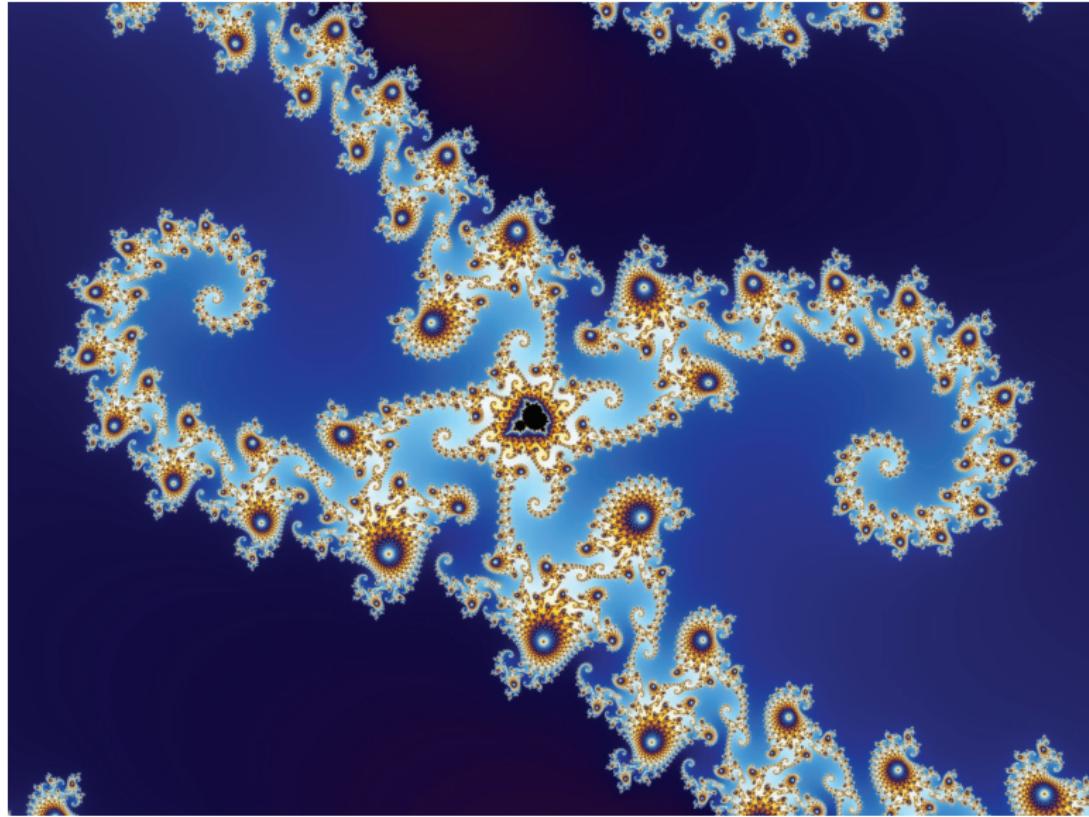
Mandelbrot set.



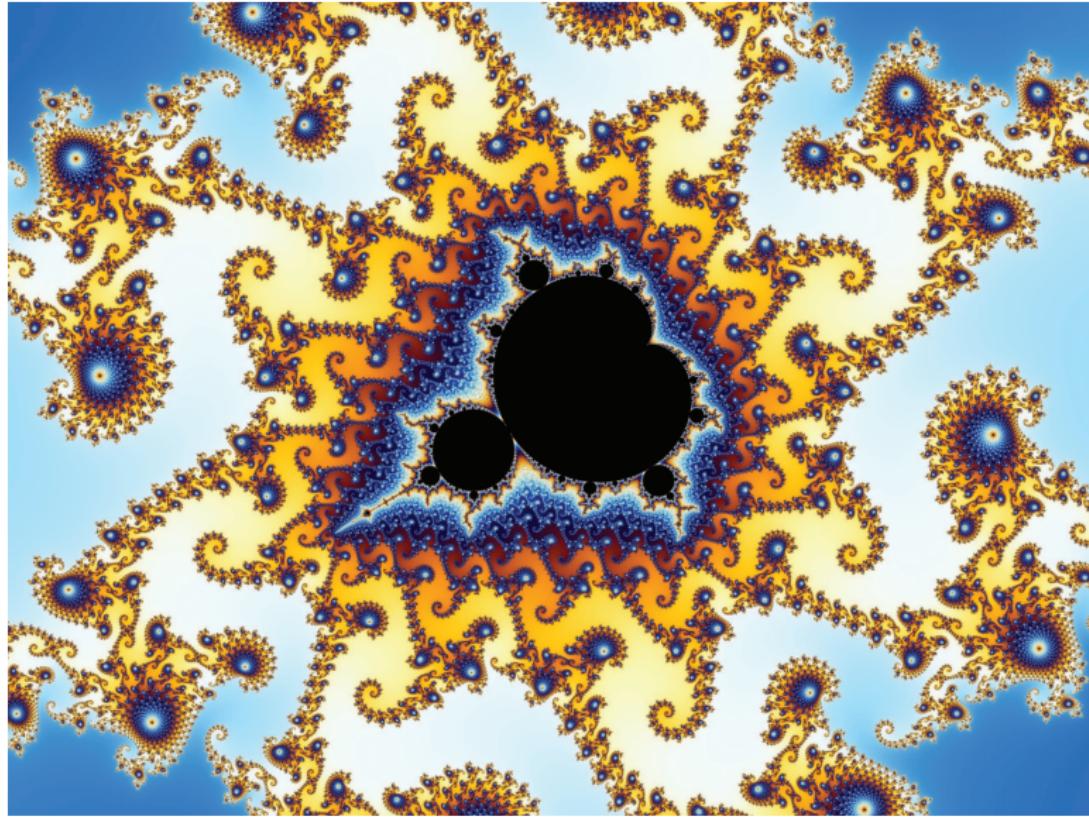
Mandelbrot set.



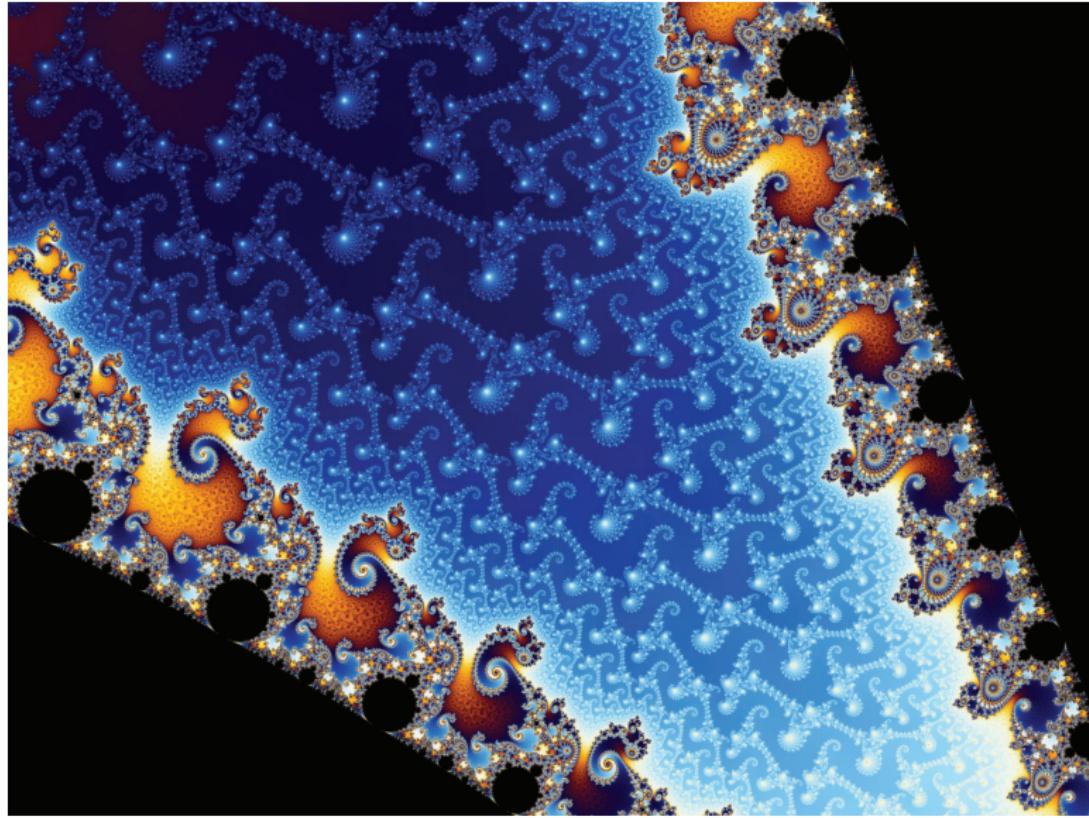
Mandelbrot set.



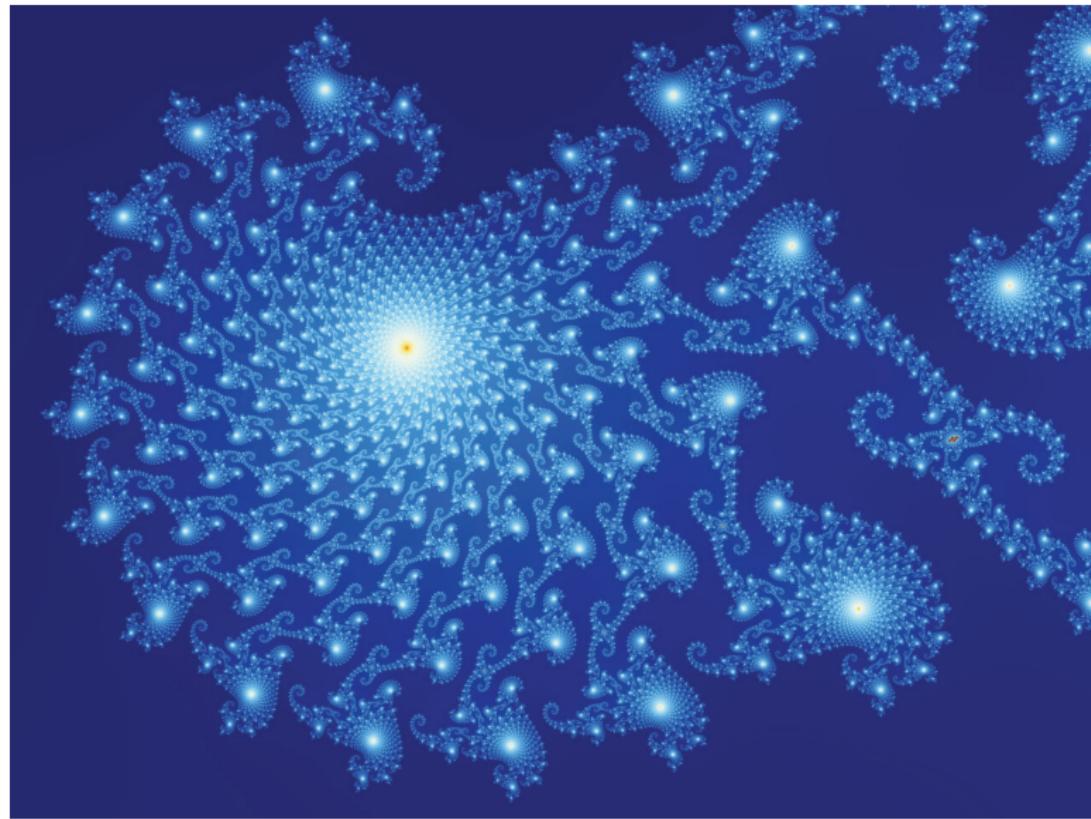
Mandelbrot set.



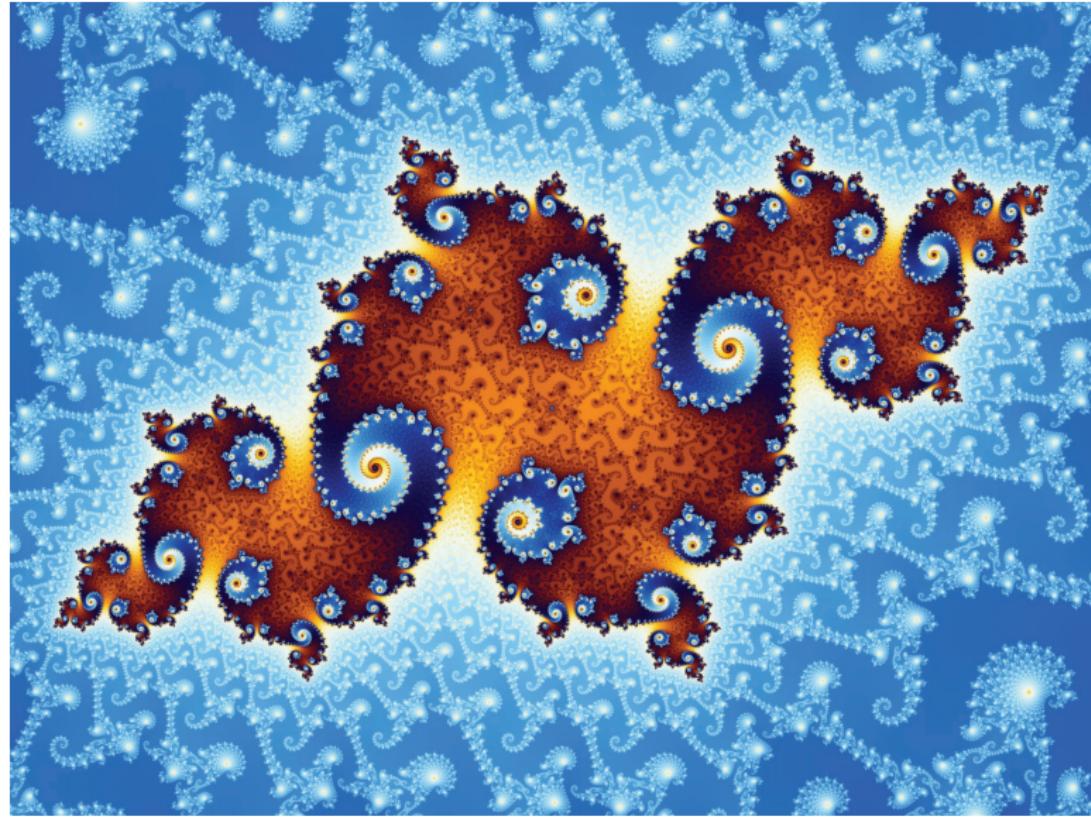
Mandelbrot set.



Mandelbrot set.

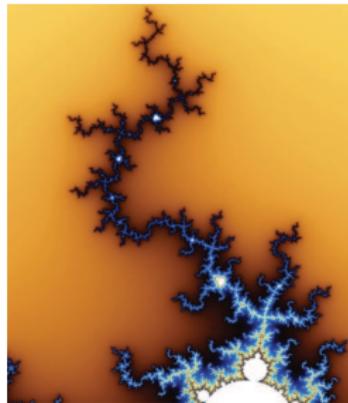
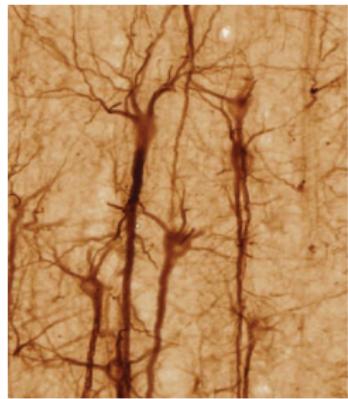


Mandelbrot set.

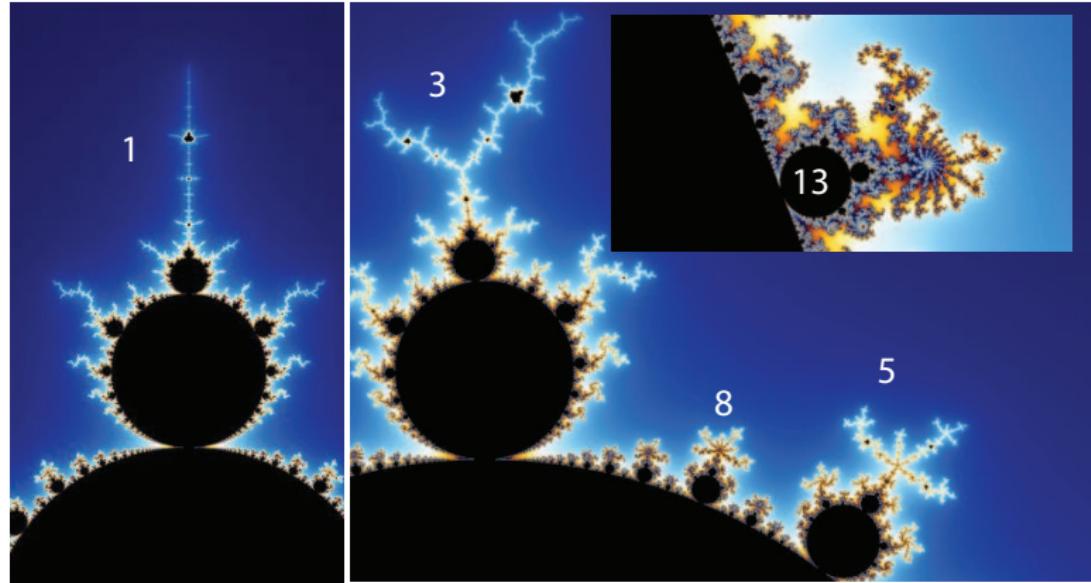


Trees

Image credits: Wikimedia.



Fibonacci again!



Trees

Image credits: Google Earth, Wikimedia.

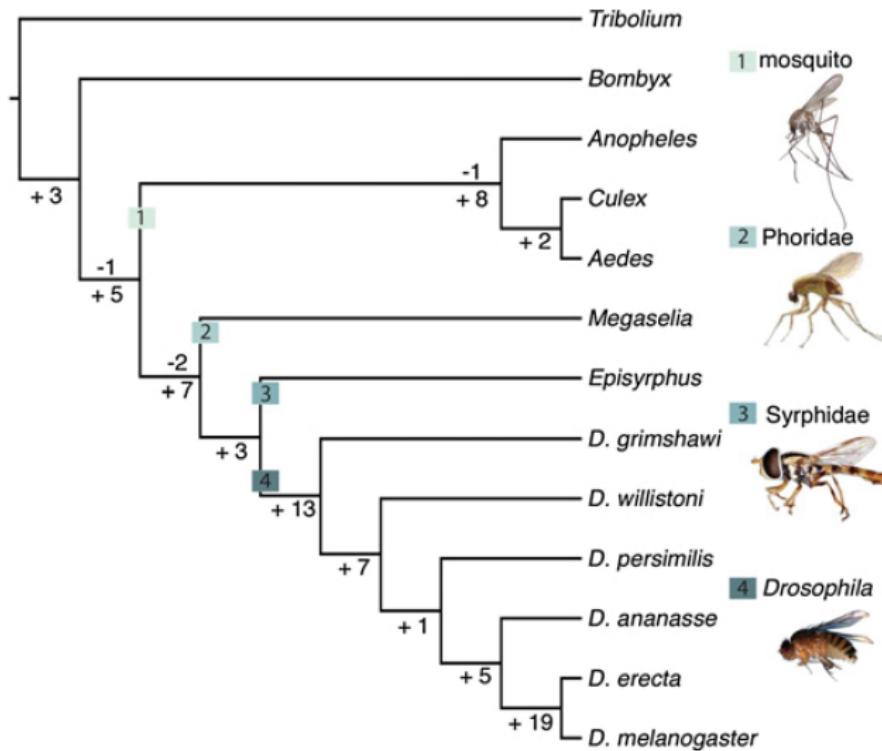


Trees

Image credits: Google Earth, Wikimedia (you may guess which!).



Trees

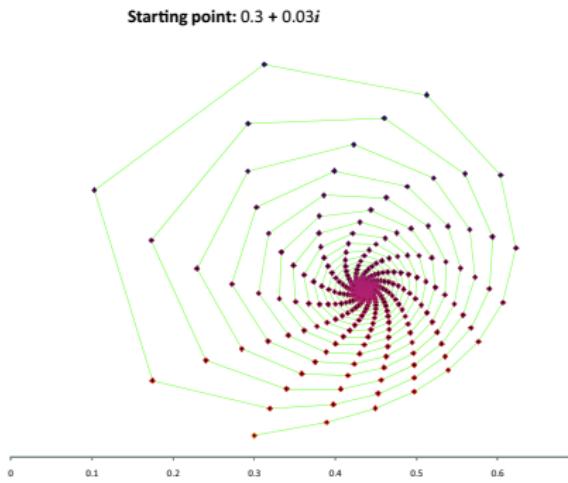


Episodic radiations in the fly tree of life, Wiegmann et.al. PNAS 2011

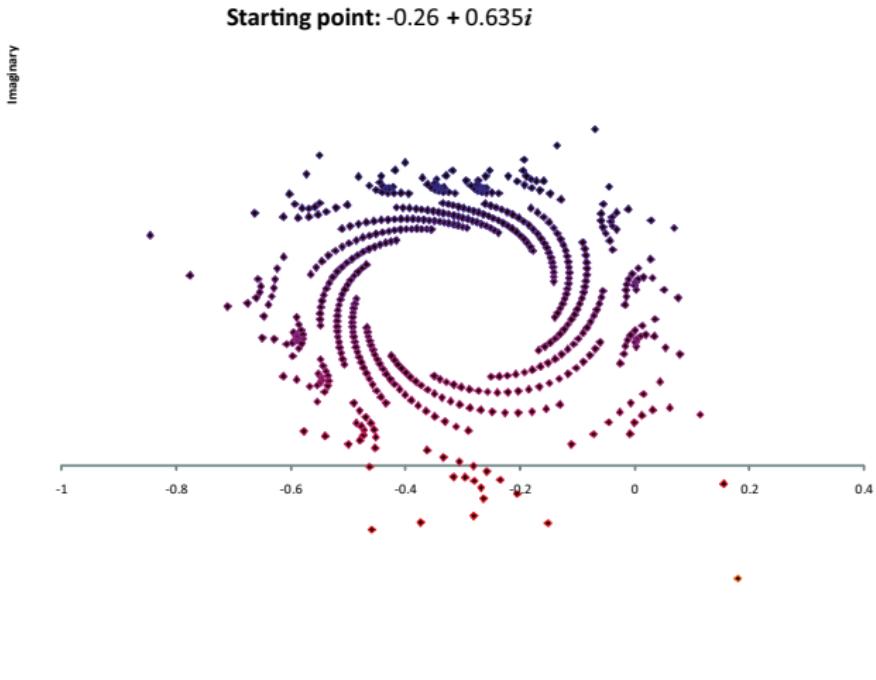
Spirals

Image credit: Wikimedia.

Imaginary



Thanks!



There are many more patterns to be discovered than there are
already known...