IRTG Bielefeld–Seoul Winter School - Stochastic Dynamics

Science outreach with a YouTube channel: a personal experience

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22 December 2021 (online)

A short history of a YouTube channel

Channel https://www.youtube.com/c/NilsBerglund

- Created in December 2012 to host videos used in articles of the CNRS outreach web site Images des Mathématiques
- In April 2021 : Approx 60 000 views, for 40 videos

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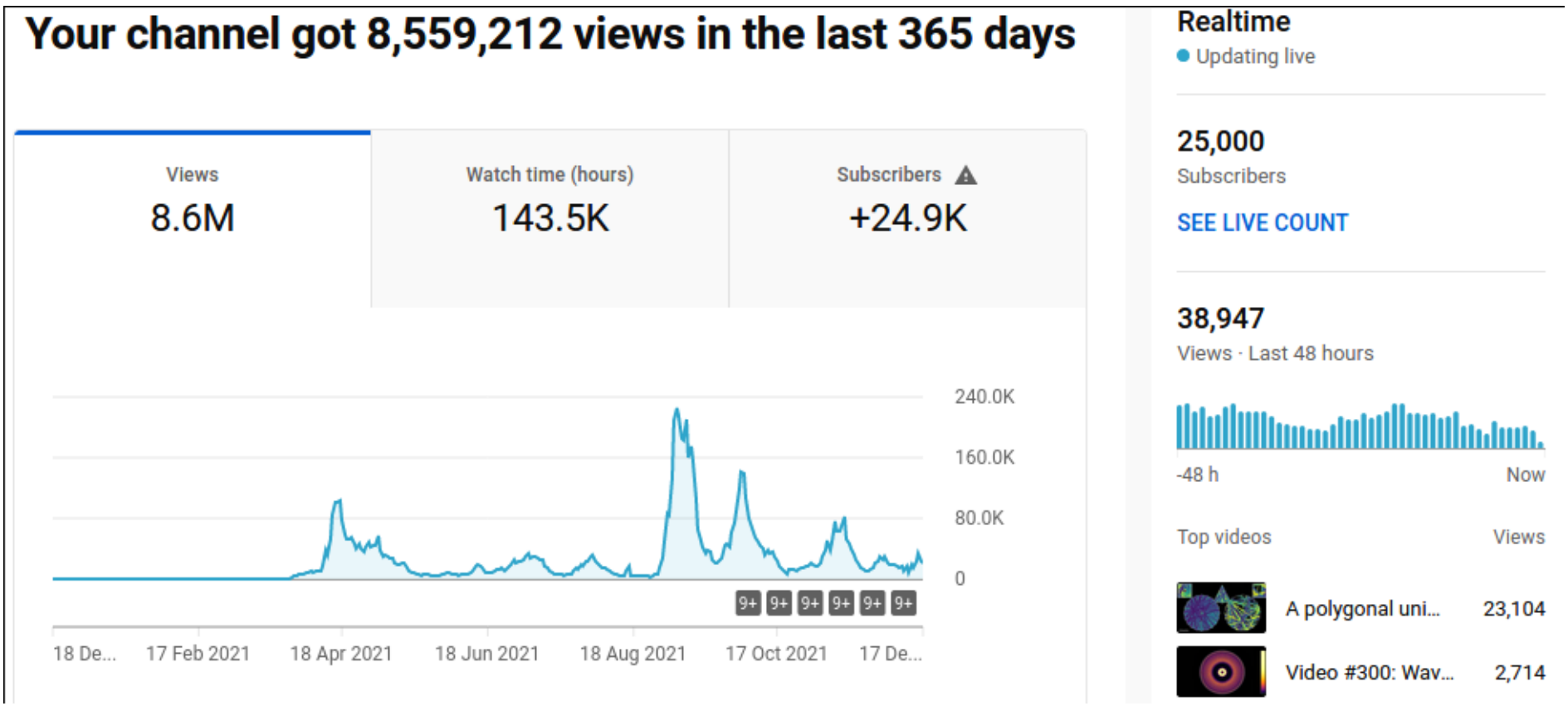
- In December 2021 : 300+ videos,



What happened???

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(Link to simulation)

Some viewer comments :

- `Small physics simulations are really getting popular aren't they?`
- `now I not only understand entropy, but also how videocompression works.`

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(Link to simulation) (Link to simulation)

Some viewer comments :

- Small physics simulations are really getting popular aren't they?
- now I not only understand entropy, but also how videocompression works.
- The algorithm has chosen you!
- youtube has thrown me into a pit and told me to learn science and physics
- Dang it, I wanted to see it go full circle
- God I wanted that to form a complete ring more than I wanted the DVD logo to hit the corner
- WHERE'S THE FULL CIRCLE DARNIT!

What happened next?

Improvements based on suggestions made in comments:

- Make longer version

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- Higher resolution

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- Add music

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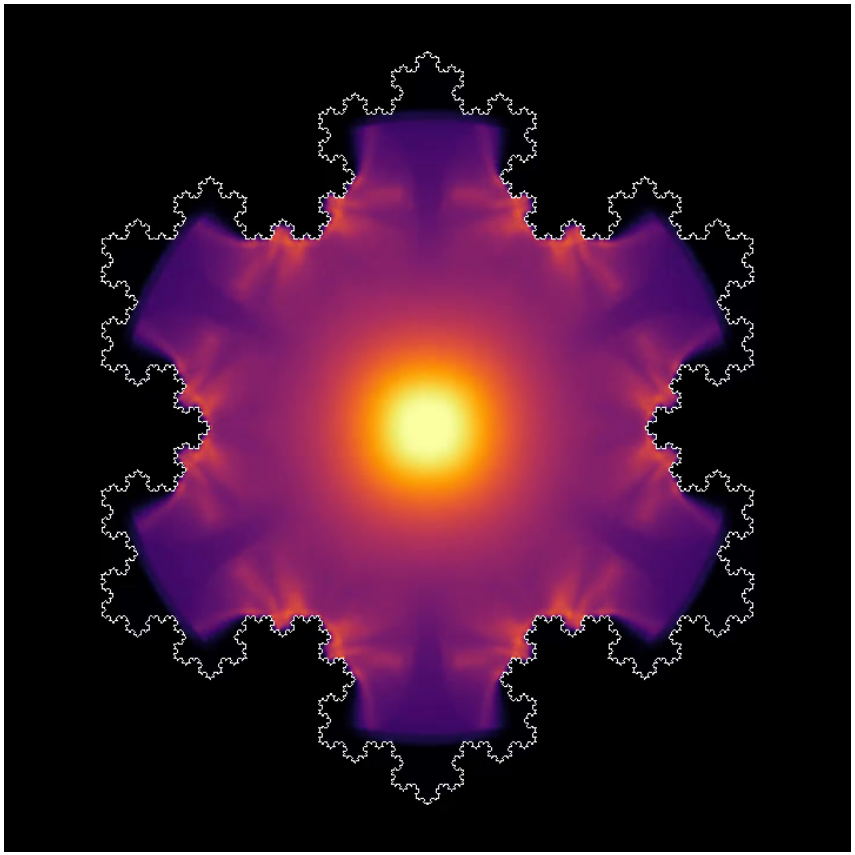
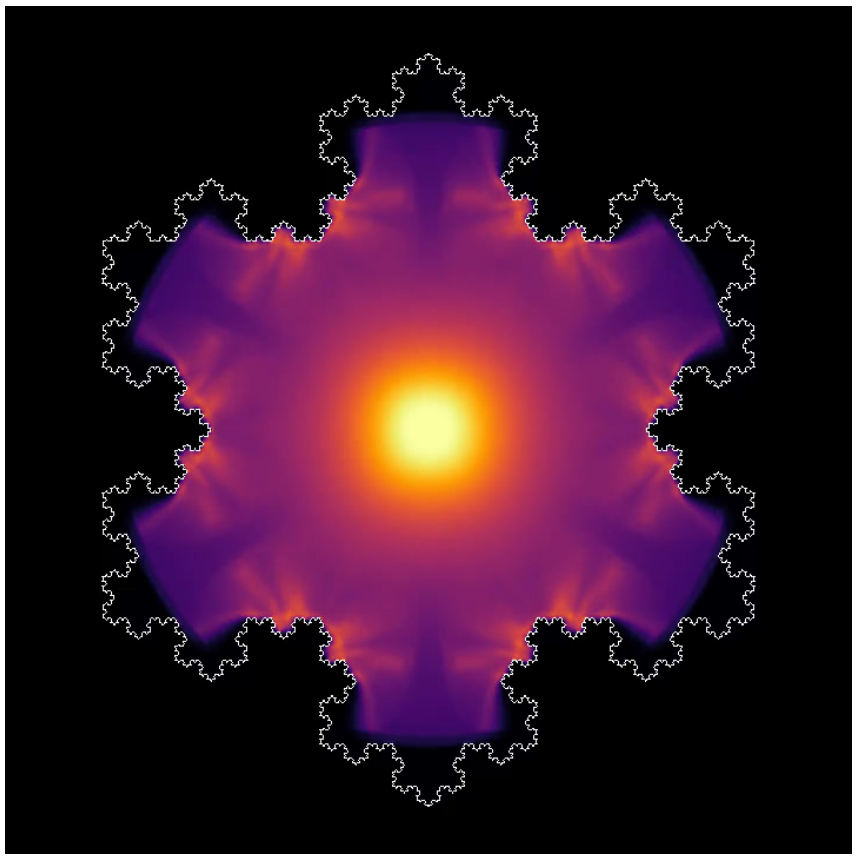
- Higher resolution
- Add music
- Make "shorts"
- Improve color schemes



What happened next?

Improvements based on suggestions made in comments:

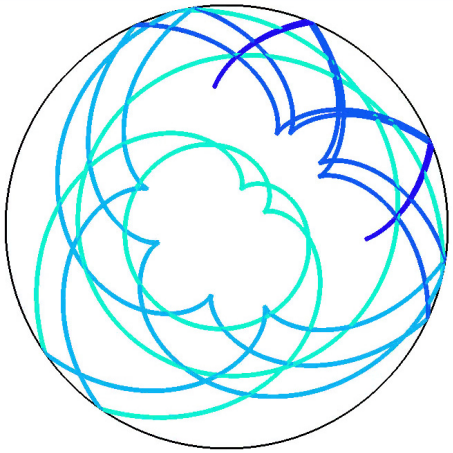
- Make longer version
- Higher resolution
- Add music
- Make "shorts"
- Improve color schemes
- Plus lots of suggestions: other domains/ equations/effects to simulate



What are the themes?

▷ Particle simulations :

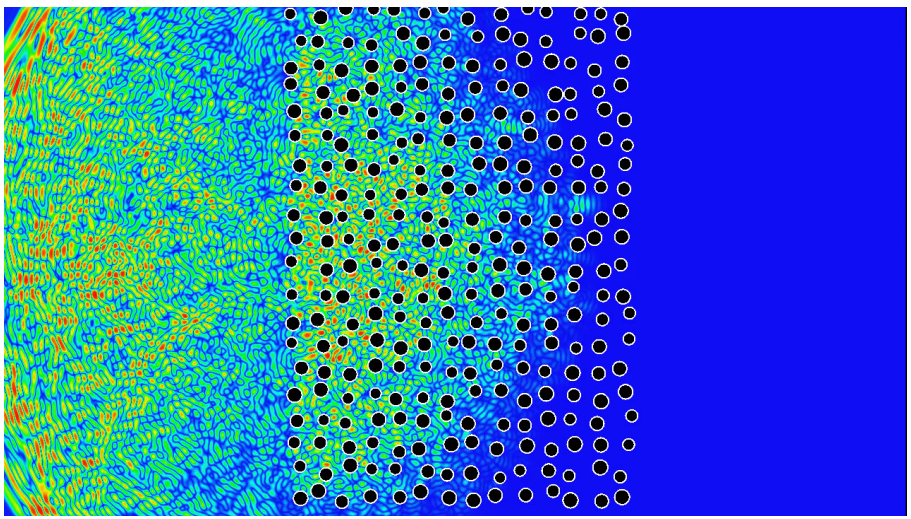
- ◇ Regular/chaotic billiards
- ◇ The illumination problem
- ◇ Translation surfaces
- ◇ Statistics (collisions, free path) for Sinai billiards (Lorentz gas)
- ◇ Molecular dynamics



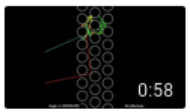
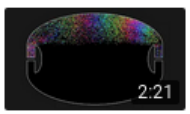
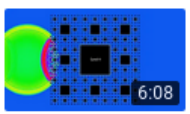
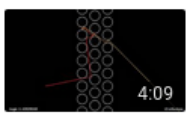
▷ Simulations of partial differential equations :

- ◇ Wave equation (linear, hyperbolic)

  Refraction, diffraction, fractal domains, Anderson localisation, wave protection, invisibility cloak, resonators
- ◇ Heat equation
- ◇ Schrödinger's equation



Which videos have the most views?

☐	 3:01	A wave traveling between two parabolic a... This simulation was suggested by several viewers, following the simpler version...	Public	None	27 Aug 2021 Published	1,877,515	1,741	98.4% 29,048 likes
☐	 0:58	Illustrating the butterfly effect with a laser This new #shorts episode shows how sensitive dependence on initial conditions,...	Public	None	26 Aug 2021 Published	673,377	1,036	97.1% 52,129 likes
☐	 1:22	Drop in an elliptic pond Evolution of the wave front created by a drop of water in an elliptic container filled with...	Public	None	11 Apr 2021 Published	428,790	682	99.4% 10,894 likes
☐	 2:21	A particle version of Penrose's unillumina... This simulation is a particle equivalent of the video https://youtu.be/DUF95VJQ2Uc that...	Public	None	25 Sept 2021 Published	342,195	525	98.2% 6,153 likes
☐	 6:08	Waves hitting a Sierpinski carpet After having done a number of simulations solving the heat equation in fractal domains,...	Public	None	16 Jun 2021 Published	331,915	622	98.0% 10,103 likes
☐	 1:21	Drop in an elliptic pond Evolution of the wave front created by a drop of water in an elliptic container filled with...	Public	None	11 Apr 2021 Published	257,741	262	99.2% 7,048 likes
☐	 4:09	Illustrating the butterfly effect with a laser,... This is a longer version of the video https://youtu.be/ls_66dIM9-4 without pause...	Public	None	3 Sept 2021 Published	241,011	341	98.7% 3,488 likes
☐	 1:04	Irreversibility - Ehrenfest's model For better resolution, see http://www.youtube.com...	Public	None	27 Dec 2012 Published	214,873	302	98.8% 1,843 likes
☐	 0:49	Squaring the circle and circling the square... This #short animation shows what a resonator made of four confocal parabolas...	Public	None	23 Sept 2021 Published	212,361	319	98.5% 7,900 likes
☐	 3:05	Mixing in an Ehrenfest-type pinball This simulation illustrates a property called "mixing", that many chaotic dynamical...	Public	None	29 Aug 2021 Published	192,167	157	98.2% 1,361 likes

Which videos have the most views?

Video	Views	Watch time (hours)	Subscribers	Impressions	Impressions click-through rate
Total	**8,559,349**	**143,529.5**	**24,884**	**48,706,363**	**7.1%**
A wave traveling between two parab...	1,877,948 21.9%	36,274.9 25.3%	3,145 12.6%	10,318,142	5.0%
Illustrating the butterfly effect with a...	678,881 7.9%	7,918.4 5.5%	1,085 4.4%	4,475,593	9.9%
Drop in an elliptic pond	429,014 5.0%	6,135.0 4.3%	667 2.7%	2,940,705	7.4%
A particle version of Penrose's unillu...	342,844 4.0%	5,780.7 4.0%	829 3.3%	1,317,636	9.5%
Waves hitting a Sierpinski carpet	332,070 3.9%	10,378.4 7.2%	755 3.0%	1,928,494	9.9%

Success story 1: elliptical pools

(Link to simulation)

429 000 views

Based on works by Yves Colin de Verdière and David Vicente

Success story 1: elliptical pools

(Link to simulation)

112 000 views

Success story 2: waves & a Sierpinsky carpet

(Link to simulation)

332 000 views

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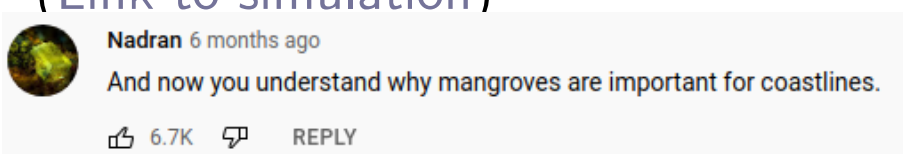

Led to “Mangrove vs tsunami” series, wave protection comparisons

Success story 3: parabolic antennae

(Link to simulation)

Original version: 1 878 000 views

Led to “parabolic resonators”series

Success story 4: the butterfly effect with a laser

(Link to simulation)

679 000 views

Implemented IRL on the The Action Lab

Success story 5: the illumination problem

(Link to simulation)

Most viewed in series: 342 000 views

Related: "Laser fight"problem (blocking property), Tokarsky rooms

How do I make these videos?

- Coded in `C`, using `OpenGL` for the graphics
  About 30-40 geometries, 4 boundary conditions, 7 colour schemes
  Code available on `GitHub`

  `https://github.com/nilsberglund-orleans/YouTube-simulations`

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  Code available on `GitHub`
  `https://github.com/nilsberglund-orleans/YouTube-simulations`
- Particle simulations usually computed in real time
- Wave simulations slower by a factor 5-20

$$\frac{\partial^2}{\partial t^2} u(x,t) = c^2 \Delta u(x,t) \qquad \text{+ initial cond , boundary cond}$$

  Solved with finite differences (discretisation)
- Code accelerated with the help of Marco Mancini, a few other contributions via `GitHub`

Who are the viewers of the channel?

Geography	Views ↓	Watch time (hours)	Average view duration
Total	**8,559,272**	**143,527.9**	**1:00**
United States	2,608,156 30.5%	46,392.7 32.3%	1:04
Germany	558,142 6.5%	9,529.2 6.6%	1:01
United Kingdom	460,653 5.4%	7,887.2 5.5%	1:01
Brazil	332,701 3.9%	5,575.6 3.9%	1:00
France	327,868 3.8%	5,663.2 4.0%	1:02
India	308,670 3.6%	4,274.5 3.0%	0:49
Canada	284,771 3.3%	4,957.2 3.5%	1:02
Italy	282,108 3.3%	4,300.7 3.0%	0:54

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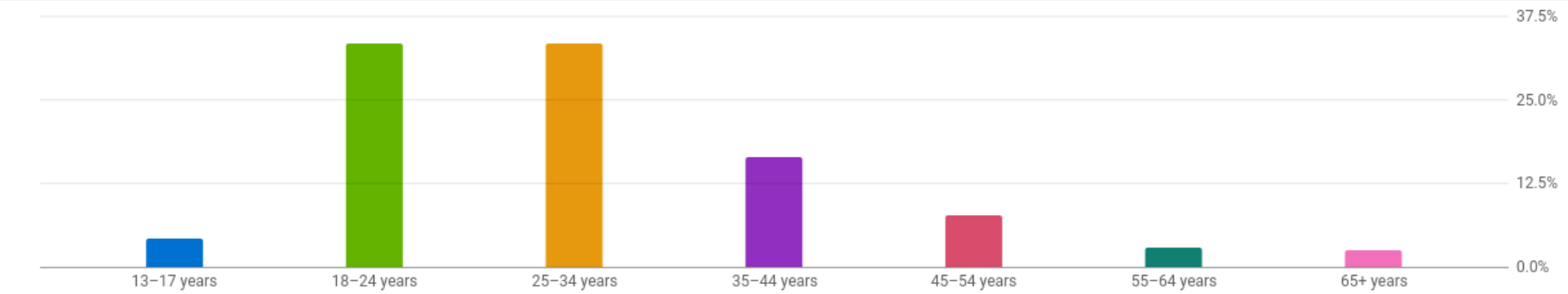

Viewer age	Views	Average view duration	Average percentage viewed	Watch time (hours)
13–17 years	4.2%	0:54	36.7%	3.8%
18–24 years	33.3%	0:57	36.2%	32.2%
25–34 years	33.3%	1:00	35.0%	33.8%
35–44 years	16.3%	1:01	34.4%	16.6%
45–54 years	7.7%	1:01	35.3%	8.0%
55–64 years	2.9%	1:04	35.7%	3.1%
65+ years	2.4%	1:02	35.4%	2.5%

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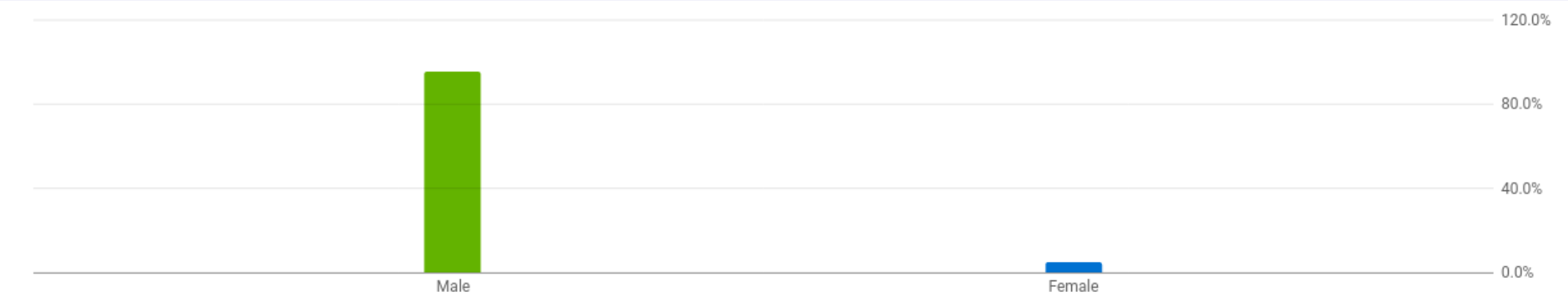

Viewer gender	Views	Average view duration	Average percentage viewed	Watch time (hours)
Female	4.5%	0:55	36.9%	4.2%
Male	95.5%	0:59	35.2%	95.8%

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- I noticed that at 1:28 ... happens!
- This is what happens in that particular physical/chemical process.
- This video has made me think...
  What is great about good scientific divulgation, is not the answers, but the questions that I never thought about.

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- ...and it's fun!

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- When coding: make baby steps
- Last but not least: produce quality content...
- Important to keep in mind when doing outreach:

> *Give a man a fish, he will eat for a day. Teach a man to fish, he will eat for a life time.* — Chinese Proverb

Future projects

- Non-linear PDEs (Allen–Cahn, FitzHugh–Nagumo, Keller–Segel, Euler...)

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Thanks for your attention!

https://www.youtube.com/c/NilsBerglund
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