Showcasing an educational tool for strong gravitational lensing
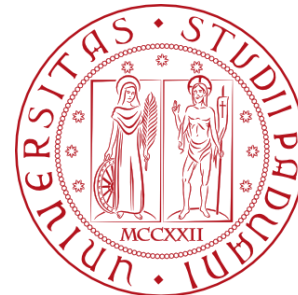
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Jena, 05/09/19

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How it all began

Last month I woke up with a brilliant idea.

«Let's simulate strong gravitational lensing.» - I said to myself
I **IMMEDIATELY** regretted it.

Outsourcing:

- Plenty of sources, plenty of github repositories.

- None simple enough to tackle in the time I had or to design what I had in mind.

- I found a 10 years old **Lensing Demo** by Adam S. Bolton, University of Utah

- It was outdated and needed some clean up, but the mathematical backbone was solid.

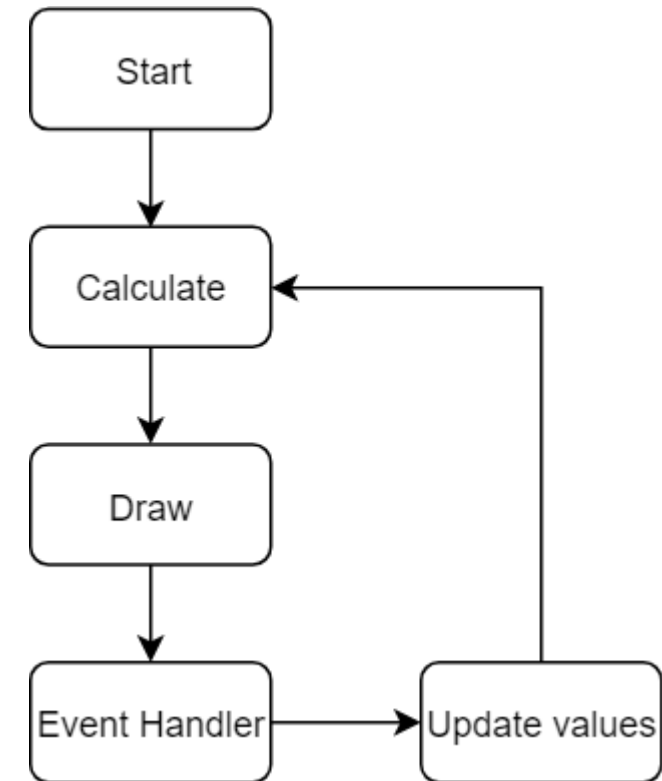**AKA «I don't really know how to program, please, help»**

How does it work?

- Multi-step process

- The basic is: do some math – draw the results

- Very simple flowchart = easier to understand

- Non-real-time updates = slow
  Please, help! I have no clue what I'm doing

```
        ┌─────────┐
        │  Start  │
        └────┬────┘
             │
             ▼
     ┌──────────────┐ ◄─────────────┐
     │  Calculate   │               │
     └──────┬───────┘               │
            │                       │
            ▼                       │
       ┌─────────┐                  │
       │  Draw   │                  │
       └────┬────┘                  │
            │                       │
            ▼                       │
 ┌──────────────┐     ┌──────────────┐
 │ Event Handler├────►│ Update values│
 └──────────────┘     └──────────────┘
```

The design Philosophy

The main designing question:

Who is the user?

A high school student or someone with limited physics knowledge

This stirred up some challenges
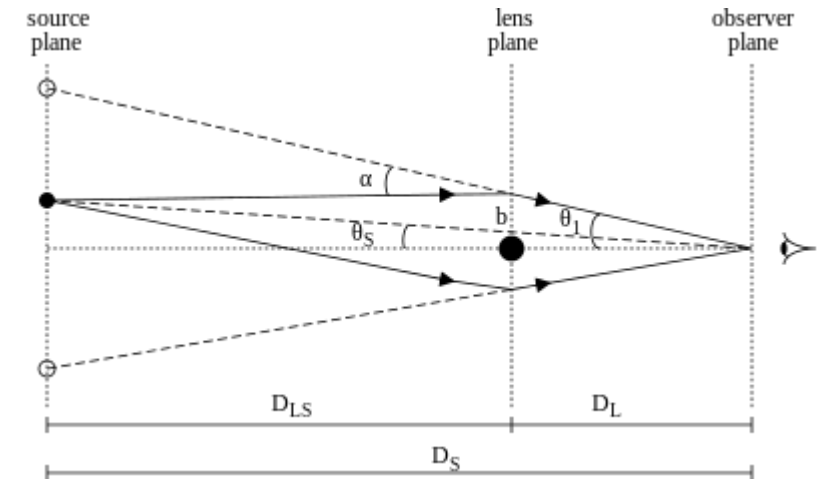
How to not overwhelm the user:

Use **concepts**, rather than **formalism**

e.g.:
Einstein Radius: the idea is to hide all physical properties behind a single variable

$$\theta_E = \left(\frac{4GM}{c^2}\frac{d_{LS}}{d_L d_s}\right)^{1/2}$$

The physics can be explained on the side, a normal user is not forced to know the meaning of it all to enjoy the effects it has.

The challenges

How to spark interest in the user:

- No messing with the code for the user.

- User friendly interface and an interactive, hands-on, experience.

A user interface is like a joke.
If you have to explain it,
it's not that good.
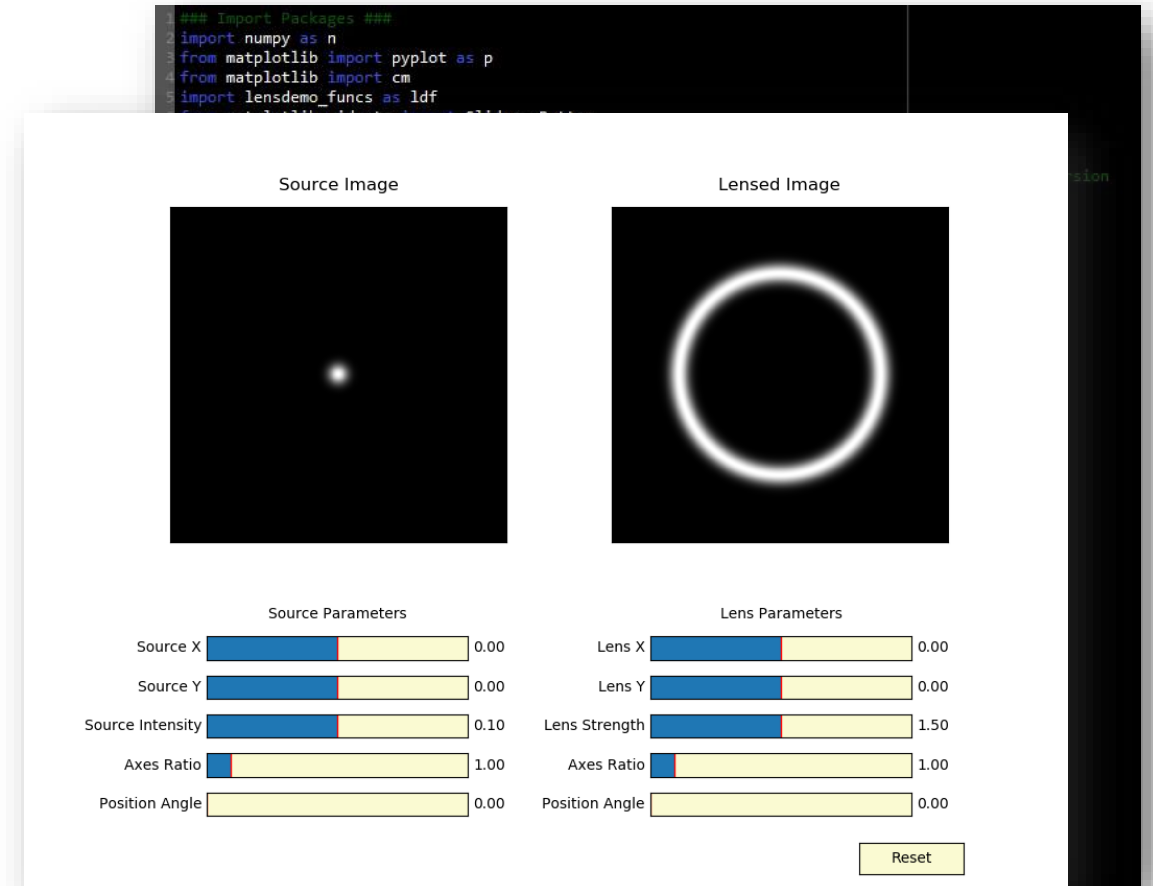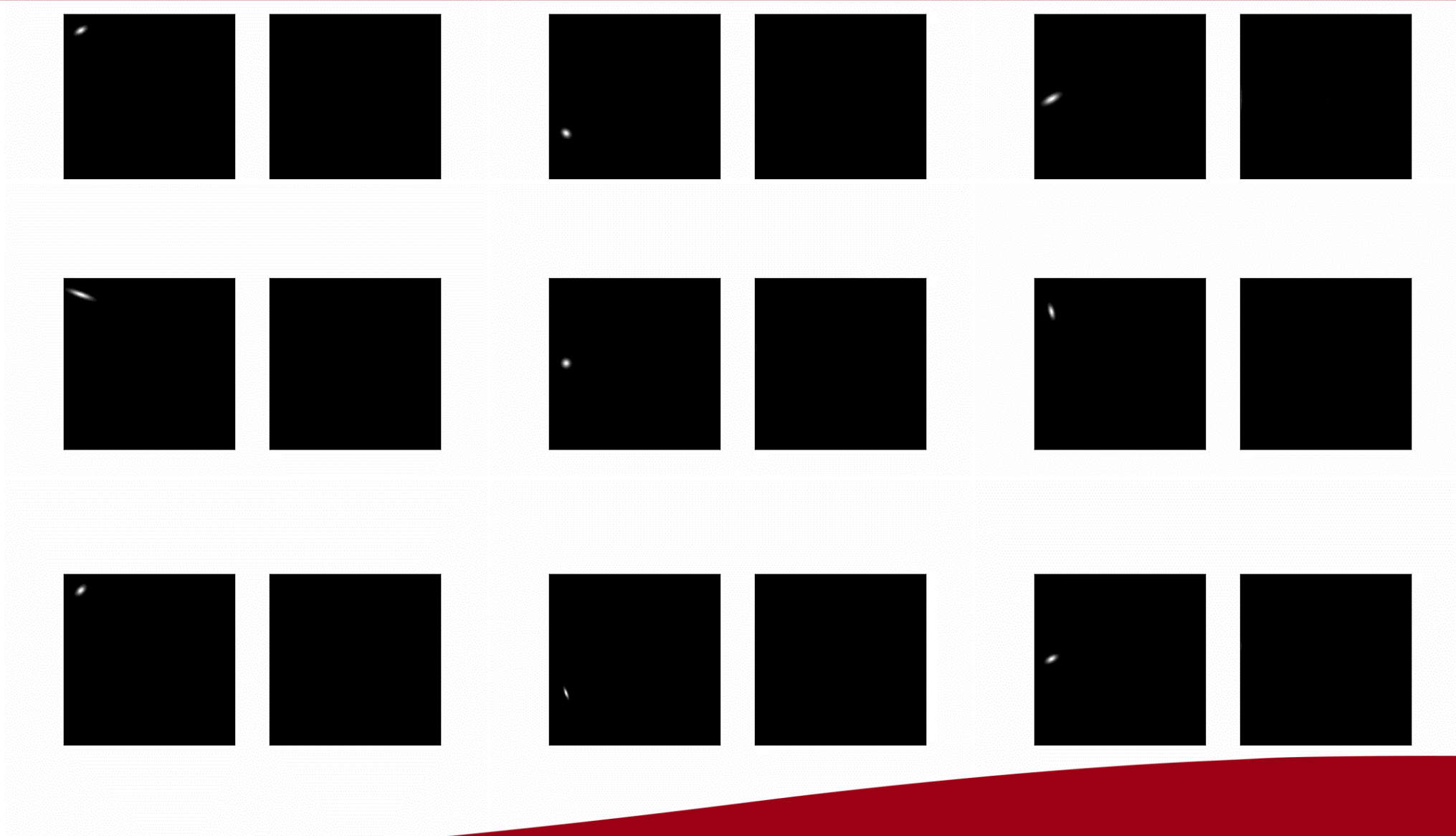
What can it do?

Some simple results:

- Simulate basic lensed images.

- Recreate complex single lens multiple images situations.

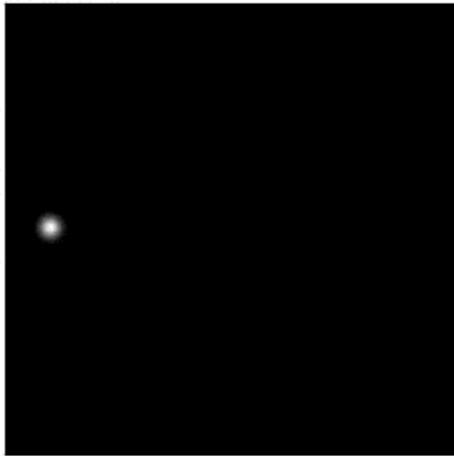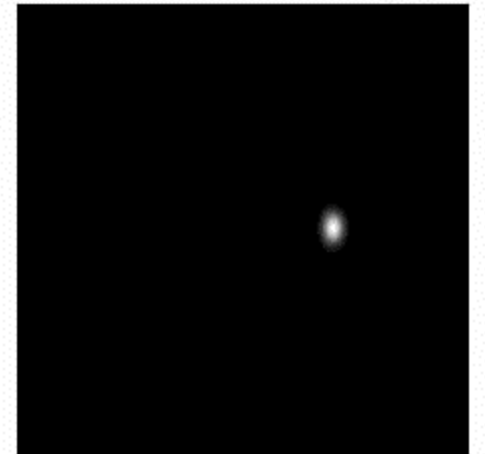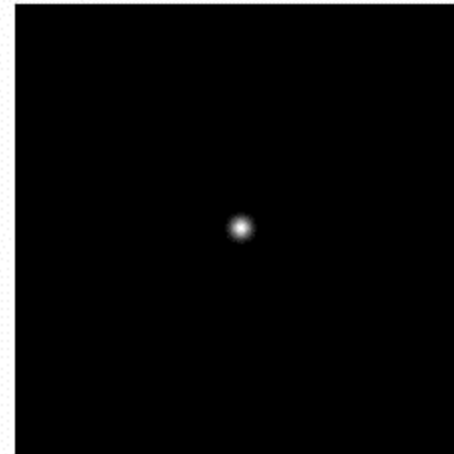- With a bit of creativity, something like this

Endless possibilities

An example of the practical uses

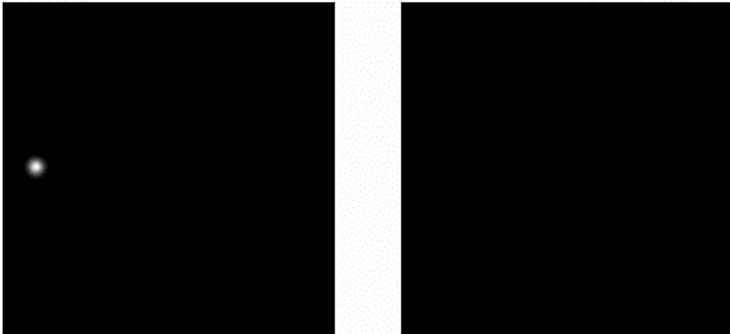We can have a Source passing behind a Lens **BUT** What if the Lens passed in front of a Source?
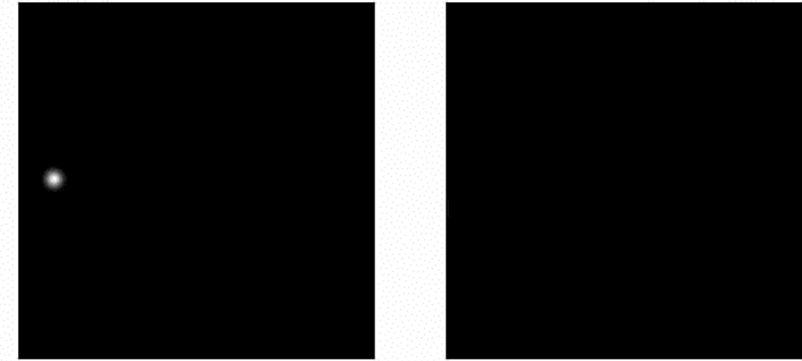
What can we do with it?

Explain how different Lens symmetries work

Sferical Lens in the center

Non Sferical Lens in the center: a/b = 2
P.A. = 60°

This project is meant to be Open Source and available

Give it a try yourself!

Thank your for your attention!

Jena, 05/09/19