OpenDreamKit: an introduction

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Some fundamental trends

Long standing and booming role of computers in pure mathematics

- **Computer exploration** to discover and check conjectures
- **Assisted, certified, mechanized proofs**: CoQ, Isabelle, ...
- **Collaborative work**: Wikipedia, Polymath, ...
- **Mathematical Knowledge Management**: arXiv, ...
- **Education**

Open Science getting momentum

"Open science is the movement to make scientific research, data and dissemination accessible to all levels of an inquiring society, amateur or professional"

- ▶ Open Knowledge (Access, Educational Ressources)
- ▶ Open Source or, better, Free Software
- ▶ Open Data
- ▶ Open Peer Review, Methodology, ...

- ▶ At the core of science for centuries
- ▶ Finally getting recognition as **viable** and **necessary**, even by funding agencies!

Emergence of a vibrant ecosystem of free software for pure mathematics

- **Specialized systems**: LinBox, PARI/GP, MPIR, Singular, . . .
- **General purpose systems**: GAP, SageMath, . . .
- **Online databases**: OEIS, LMFDB, . . .
- **Interactive computing environments**:
  Jupyter, SageMathCloud, . . .
- Together with the wider **Scientific Python ecosystem**

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Viable alternatives to Maple, Mathematica, Matlab,. . .
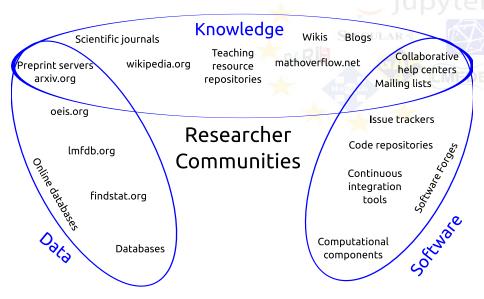For research and education (and the industry?)

Virtual Research Environments (VRE): the next frontier?

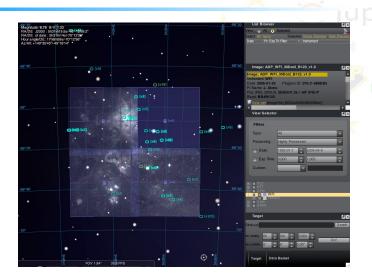### H2020 European Research Infrastructures Work Programme

"Groups of researchers, typically widely dispersed who are working together through ubiquitous, trusted and easy access to services for scientific data, computing, and networking, in a **collaborative virtual environment** *"*

A useful VRE for mathematics?

Mathematicians are already immersed in many VREs

Knowledge

Scientific journals   Wikis   Blogs

Preprint servers   wikipedia.org   Teaching   mathoverflow.net   Collaborative
arxiv.org   resource   help centers
                                          repositories   Mailing lists

oeis.org   Issue trackers

lmfdb.org   Researcher   Code repositories

                    Communities   Continuous
                                          integration
Online databases   tools
findstat.org   Software Forges

Databases   Computational
                     components

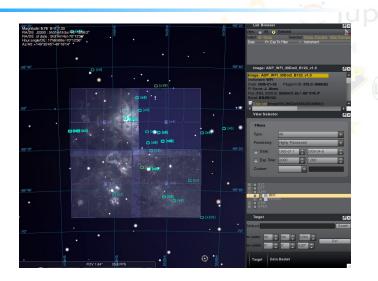Data   Software

A workflow based VRE?

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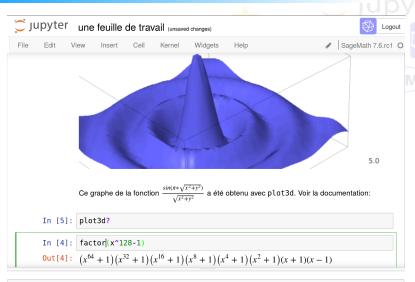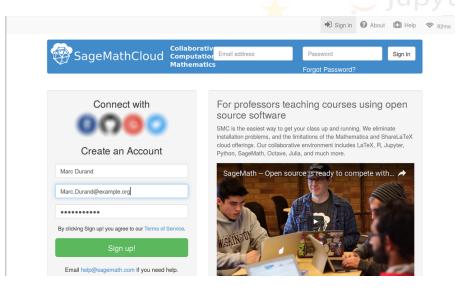

Could cover only a tiny fragment of mathematics

The Read-Eval-Print loop and notebook metaphors

Ce graphe de la fonction $\frac{sin(\pi * \sqrt{x^2+y^2})}{\sqrt{x^2+y^2}}$ a été obtenu avec `plot3d`. Voir la documentation:

```
In [5]:  plot3d?
```

```
In [4]:  factor(x^128-1)
```

Out[4]: $\left(x^{64}+1\right)\left(x^{32}+1\right)\left(x^{16}+1\right)\left(x^8+1\right)\left(x^4+1\right)\left(x^2+1\right)(x+1)(x-1)$

```
Signature:      plot3d(f, urange, vrange, adaptive=False, transformation=None, **kwds)
```

A proof of concept VRE: SageMathCloud

A one-size-fits-all VRE?

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Supporting many scales

- A single person installation on a laptop
- A collaborative VRE between three researchers, running on their lab's server
- A university wide VRE for teaching
- A service provided by a European grid infrastructure

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Supporting many computational components

Supporting many data bases

<p style="text-align:center; color:red;">Way too many use cases!</p>

Building a **VRE Toolkit for Mathematics**
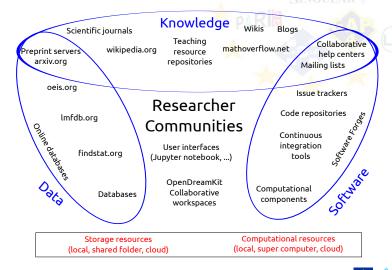
OpenDreamKit's proposal

Building a **VRE Toolkit for Mathematics**

Added values of the toolkit approach

- **Modularity**, **sustainability**
- Joining forces with the wider scientific computing community
- Lowering the software barrier between pure and applied maths

Open Digital Research Environment Toolkit for the Advancement of Mathematics

- OpenDreamKit.org
- H2020 European Research Infrastructures Work Programme
  Call: Virtual Research Environments
- Budget: 7.6M€
- 18 sites, 50 participants
- In close collaboration with the international community!

A user-driven consortium

European power users and core developers of the ecosystem of open source software for Mathematics:

▶ GAP (St Andrews, Oxford)
▶ Linbox (Grenoble)
▶ PARI/GP (Bordeaux, Versailles)
▶ SageMath (Bordeaux, Grenoble, Paris Sud, Oxford, Versailles)
▶ Singular (Kaiserslautern)
▶ LMFDB (Warwick, Zürich)
▶ MathHub, MMT/OpenMath (Bremen)
▶ Jupyter (Simula)
▶ Scientific Python (SouthHampton, Sheffield, Silesia)

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Supported by:

- Research Software Engineers
- An open source based company (Logilab)

OpenDreamKit's aims

- ▶ Improve the productivity of researchers in pure mathematics and applications by further promoting collaborations on **Data**, **Knowledge**, and **Software**

- ▶ Make it easy for teams of researchers of any size to set up custom, collaborative **Virtual Research Environments** tailored to their specific needs, resources and workflows

- ▶ Support the entire life-cycle of computational work in mathematical research, from **initial exploration** to **publication**, **teaching**, and **outreach**

How to get there?

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findstat.org   User interfaces   integration
Online databases   (Jupyter notebook, ...)   tools

Databases   OpenDreamKit   Computational
Data   Collaborative   components   Software
                   workspaces

Software Forges

| Storage resources | Computational resources |
| (local, shared folder, cloud) | (local, super computer, cloud) |