OpenDreamKit: an introduction

Nicolas M. Thiéry

April 24, 2017

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**

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**

Viable alternatives to Maple, Mathematica, Matlab,...

For research and education (and the industry?)

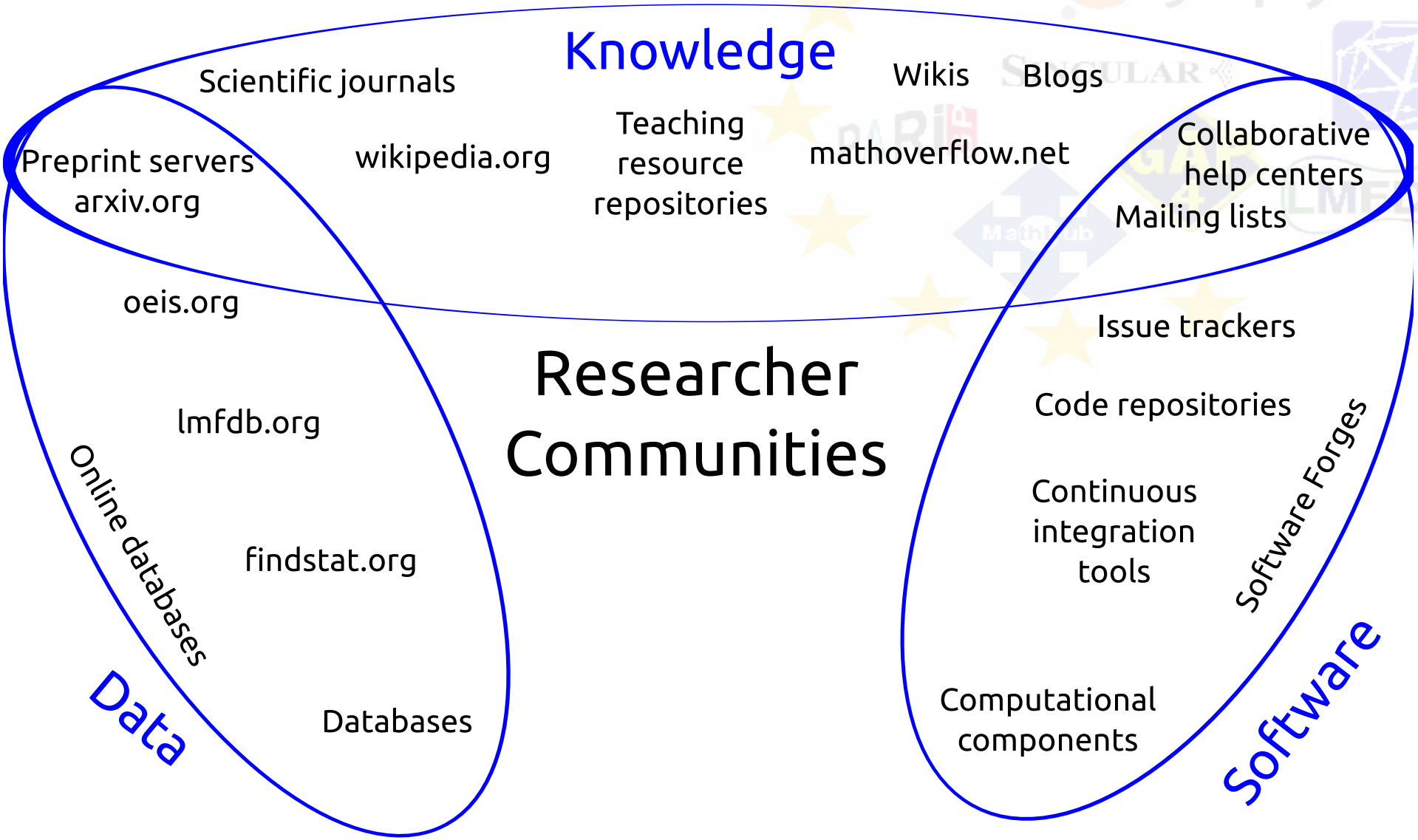
Virtual Research Environments (VRE): the next frontier?

H2020 European Research Infrastructures Work Programme

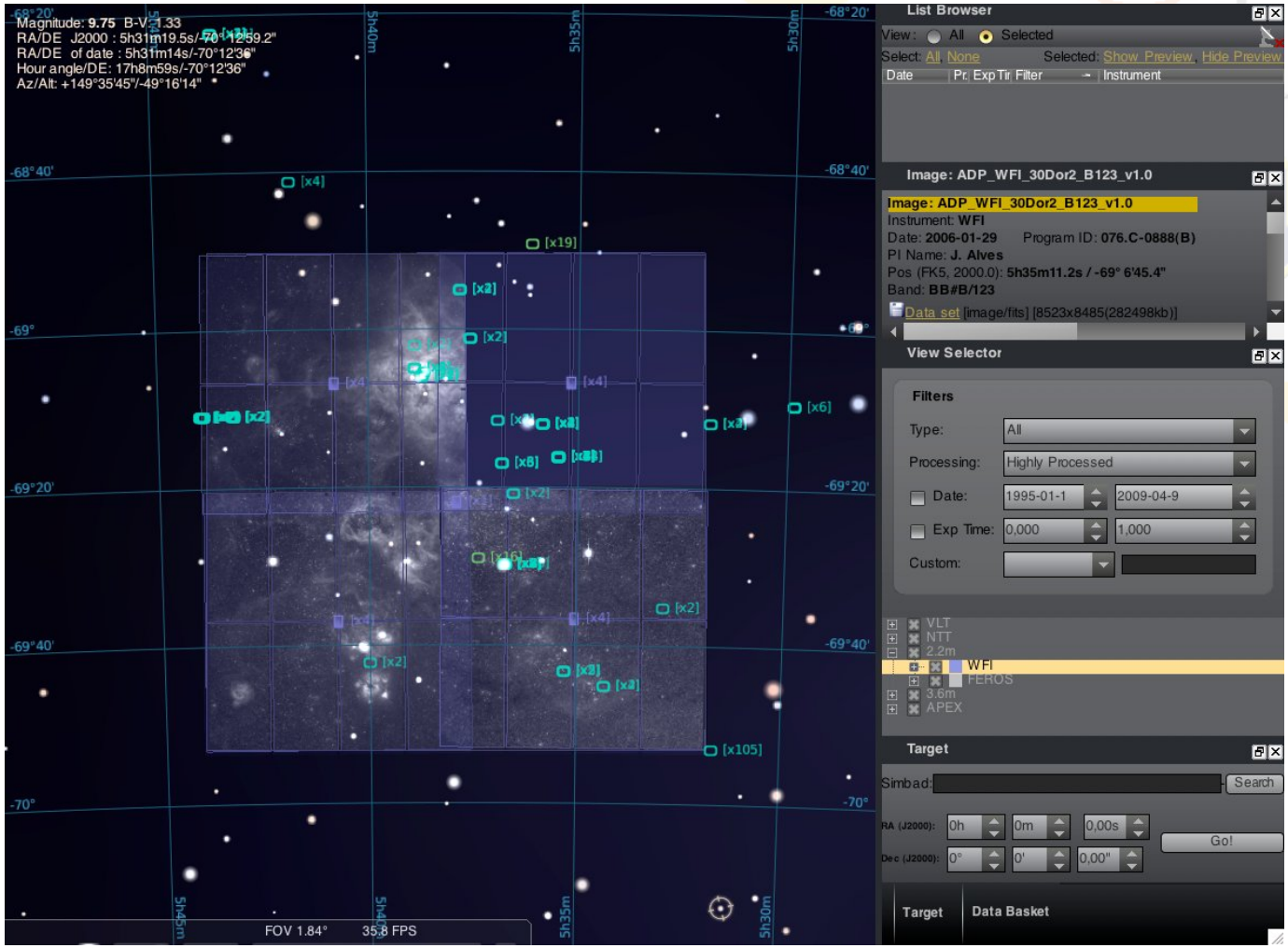
> *"Groups of researchers, typically widely dispersed who are working together through ubiquitous, trusted and easy access to services for scientific data, computing, and networking, in a* **collaborative virtual environment** *"*

A useful VRE for mathematics?

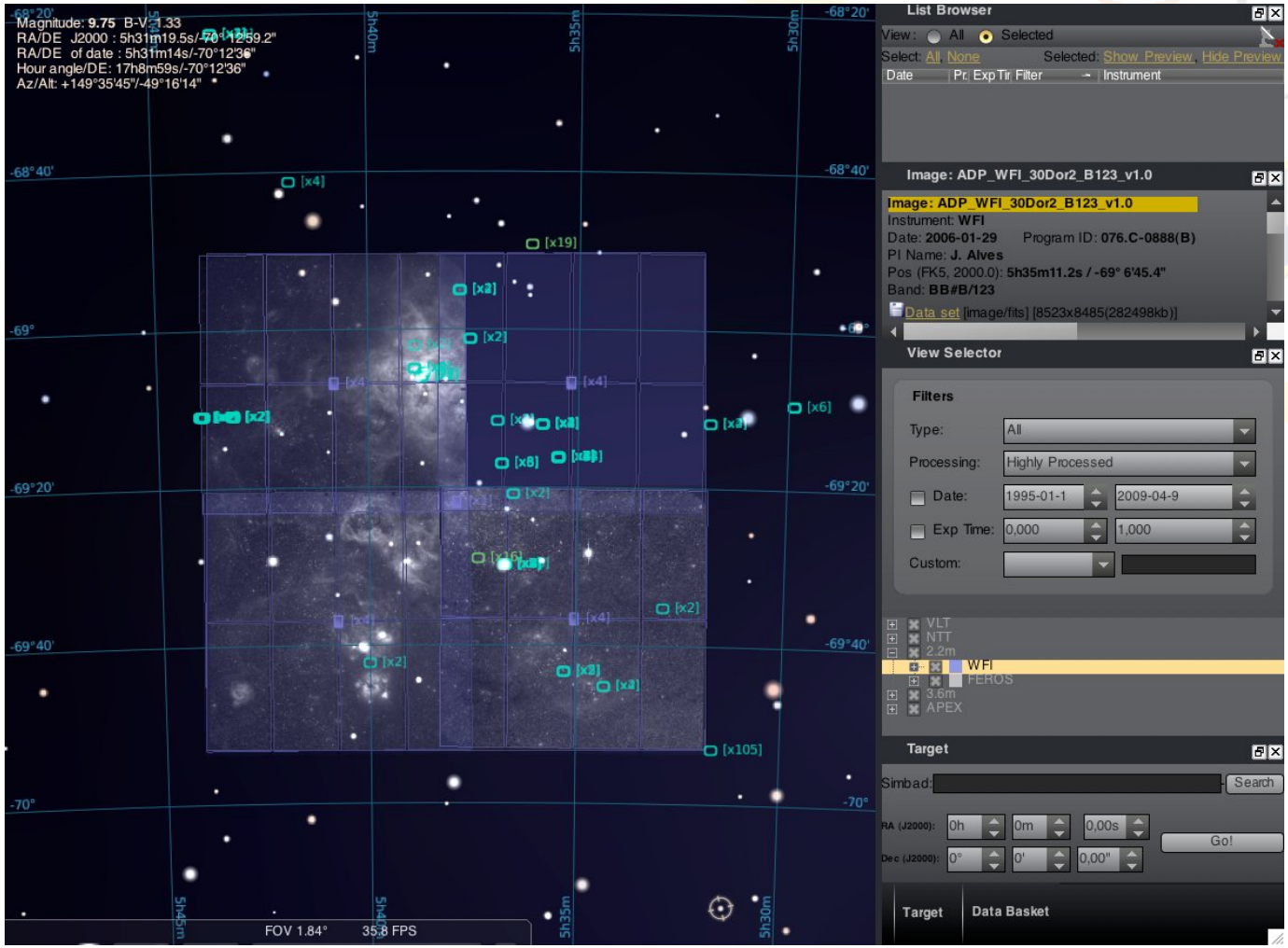
Mathematicians are already immersed in many VREs



A workflow based VRE?



A workflow based VRE?

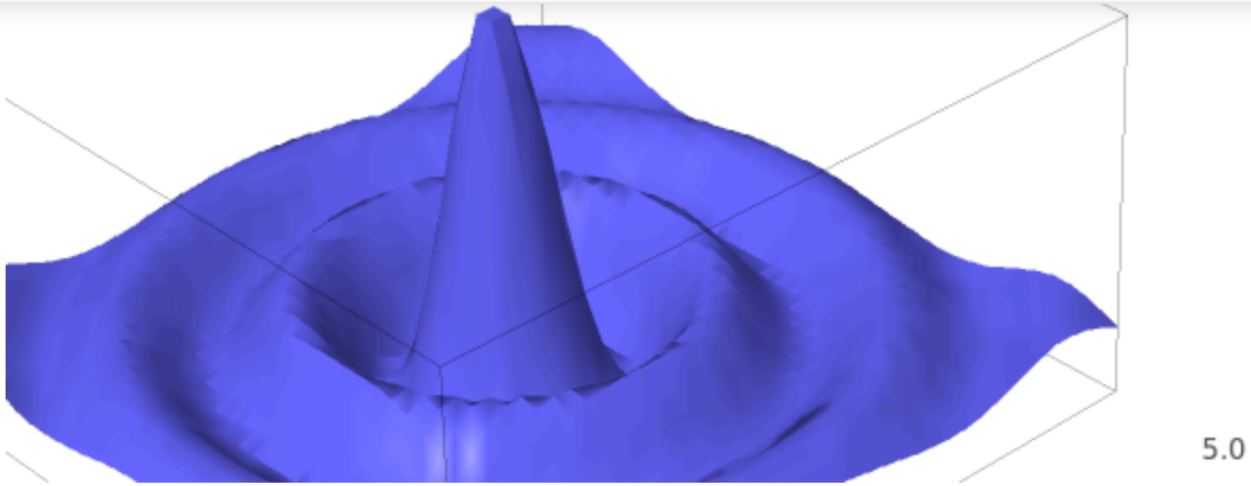


Could cover only a tiny fragment of mathematics

The Read-Eval-Print loop and notebook metaphors

jupyter une feuille de travail (unsaved changes) Logout

File Edit View Insert Cell Kernel Widgets Help SageMath 7.6.rc1



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:

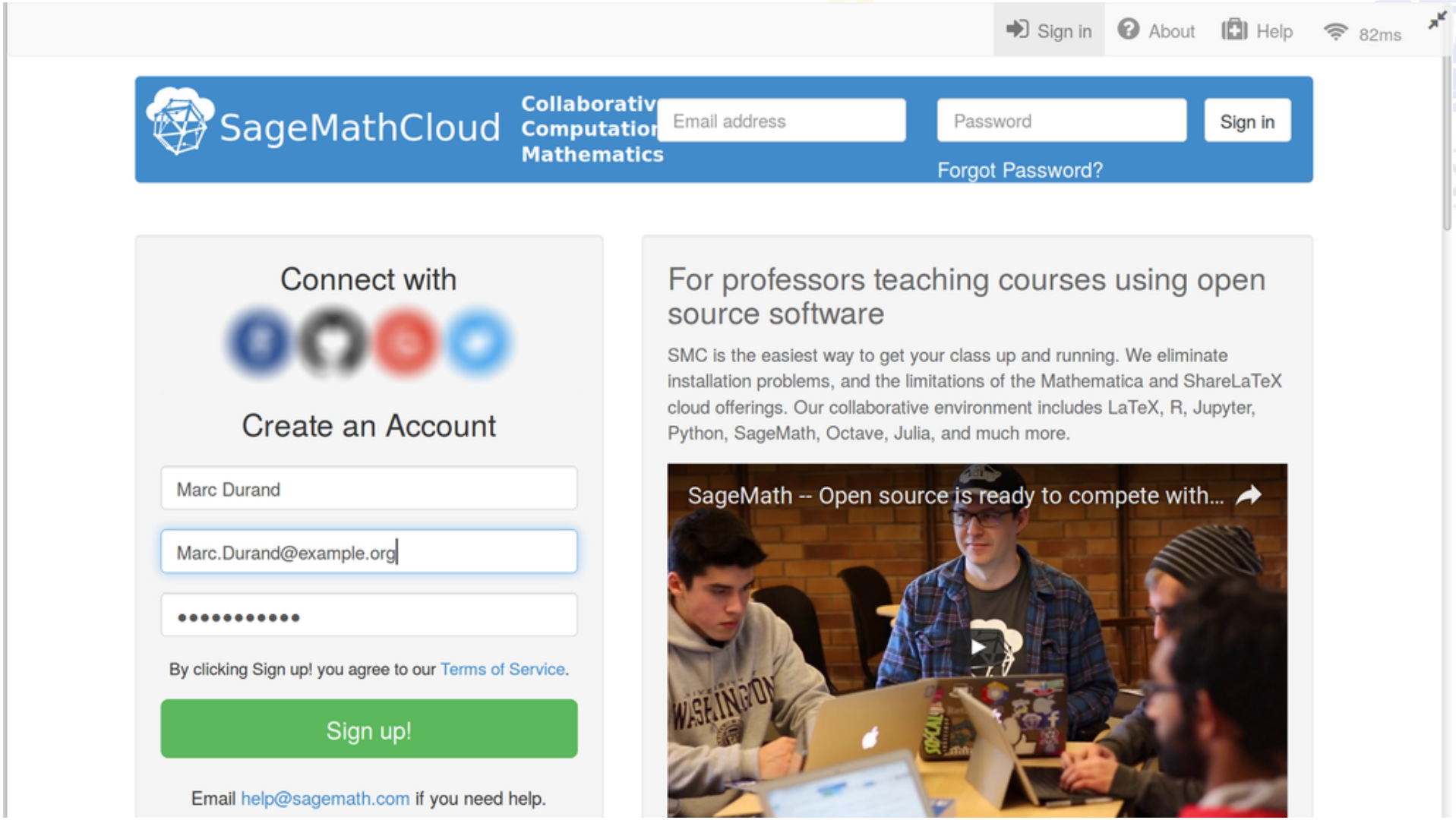
```
In [5]: plot3d?
```

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

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

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

A proof of concept VRE: SageMathCloud



A one-size-fits-all VRE?

A one-size-fits-all VRE?

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

A one-size-fits-all VRE?

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

Supporting many computational components

A one-size-fits-all VRE?

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

Supporting many computational components

Supporting many data bases

A one-size-fits-all VRE?

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

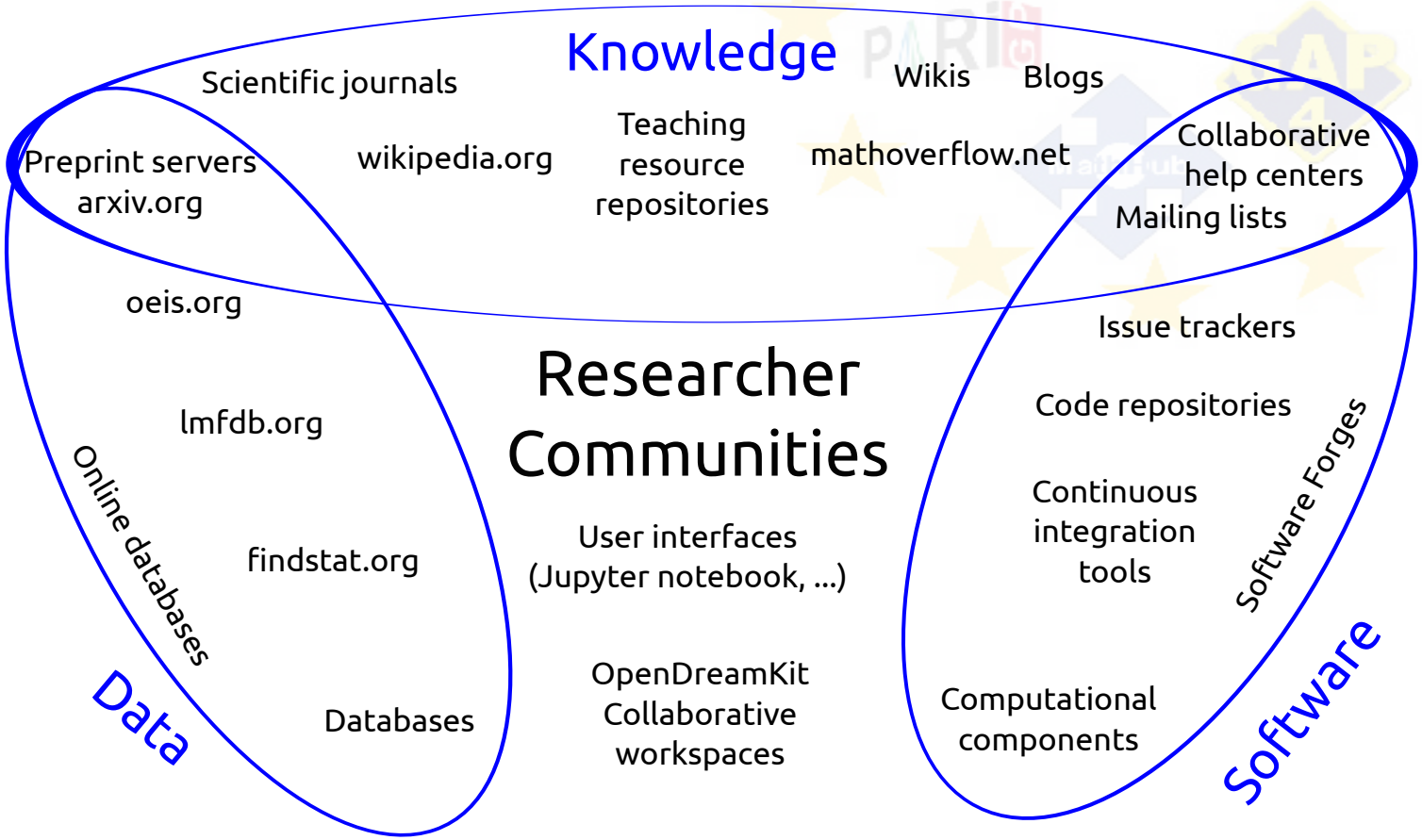
Supporting many computational components

Supporting many data bases

Way too many use cases!

OpenDreamKit's proposal

Building a **VRE Toolkit for Mathematics**



Added values of the toolkit approach

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

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)

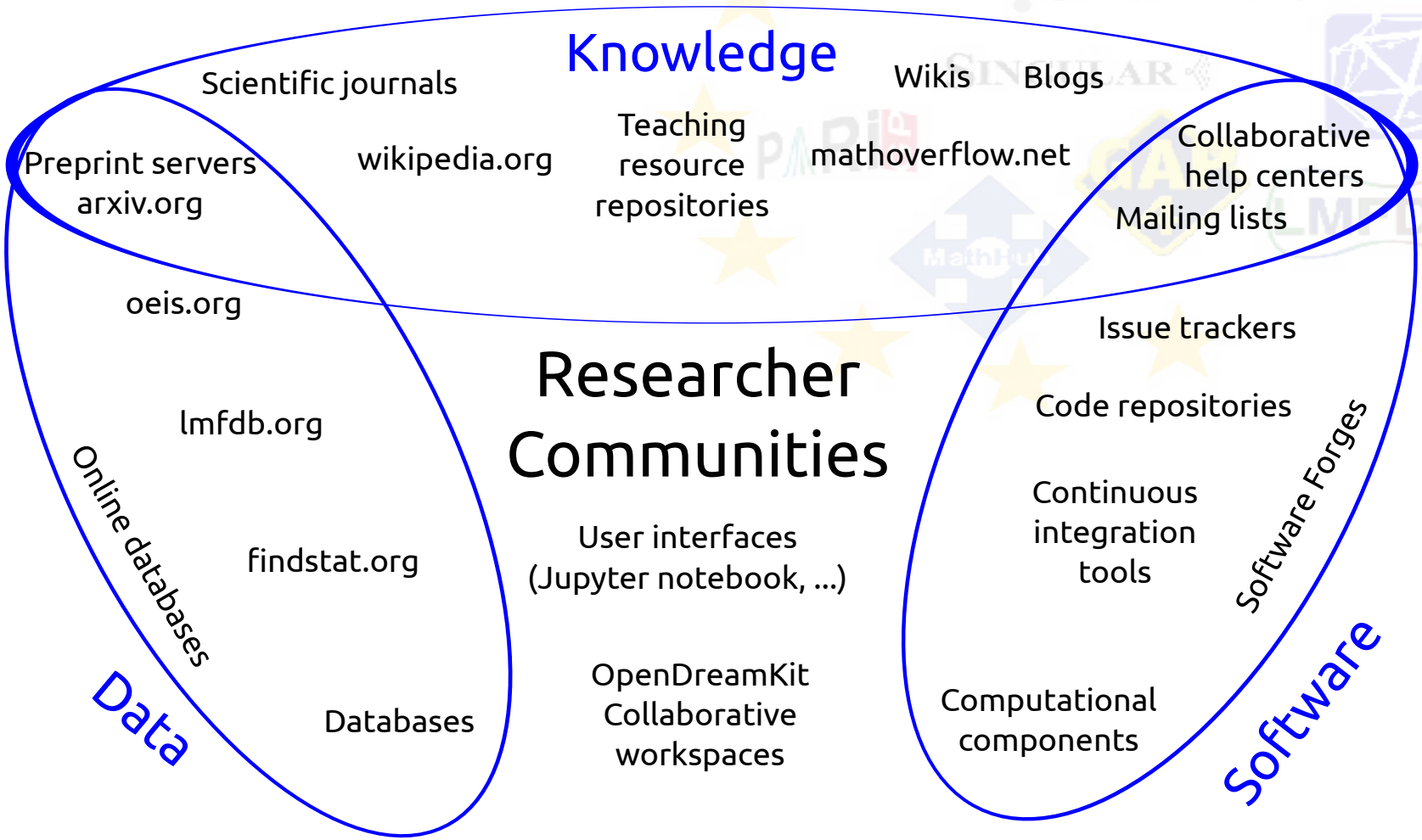
Supported by:

- 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?



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