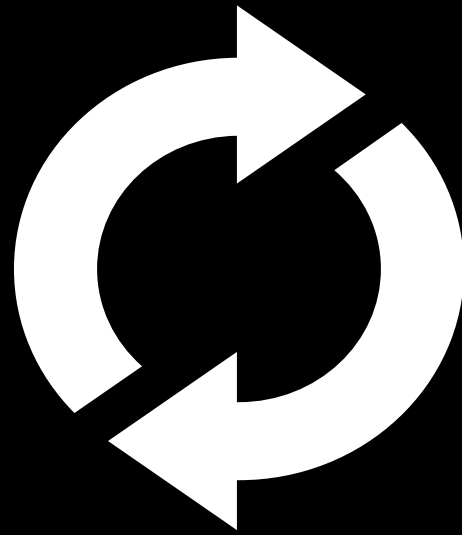


# AI + SCIENCE

Anima Anandkumar

# HOW IS ENGINEERING AND SCIENTIFIC RESEARCH DONE TODAY?

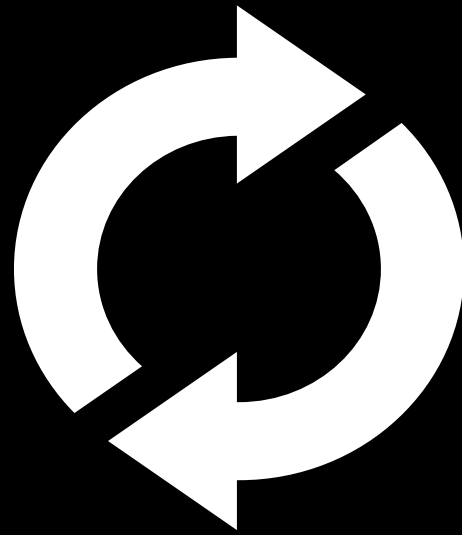
Human intuition



Bottleneck: simulation/physical experiments  
(weeks - months)

# THE FUTURE OF ENGINEERING AND SCIENTIFIC RESEARCH

Human intuition + AI

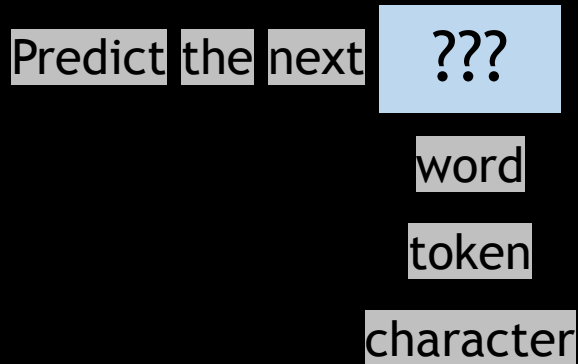


Can AI simulate, experiment and design?

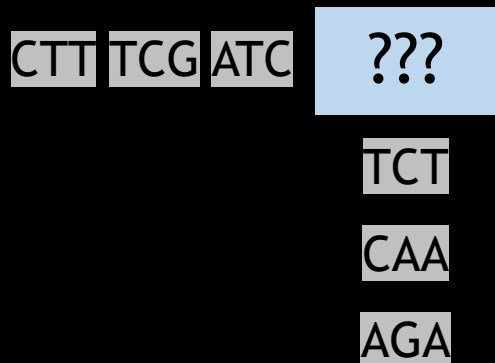
Ideally real-time

# IDEA GENERATION WITH AI

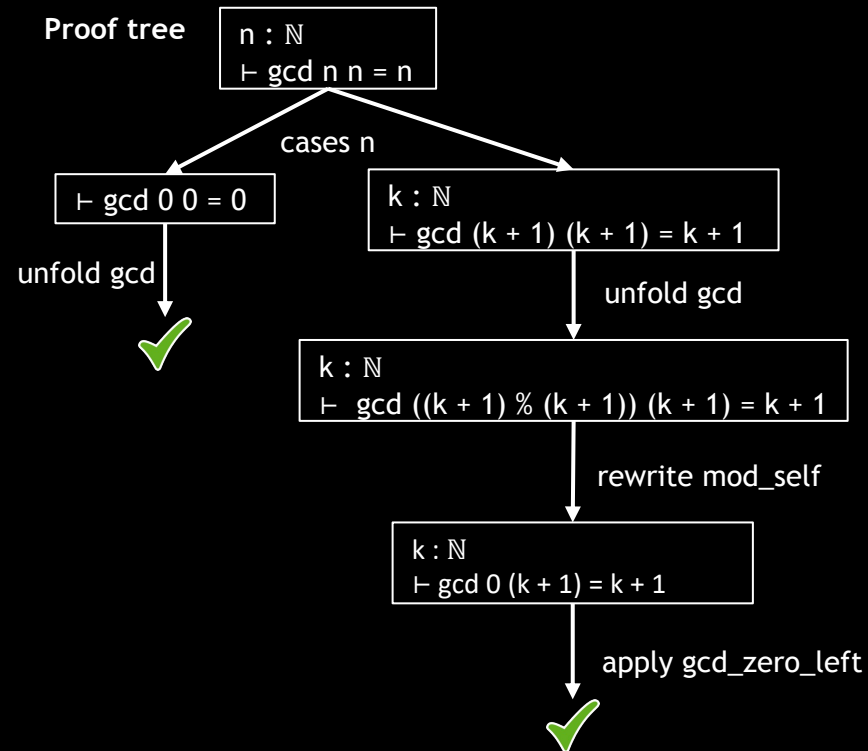
## TEXT



## GENOMES



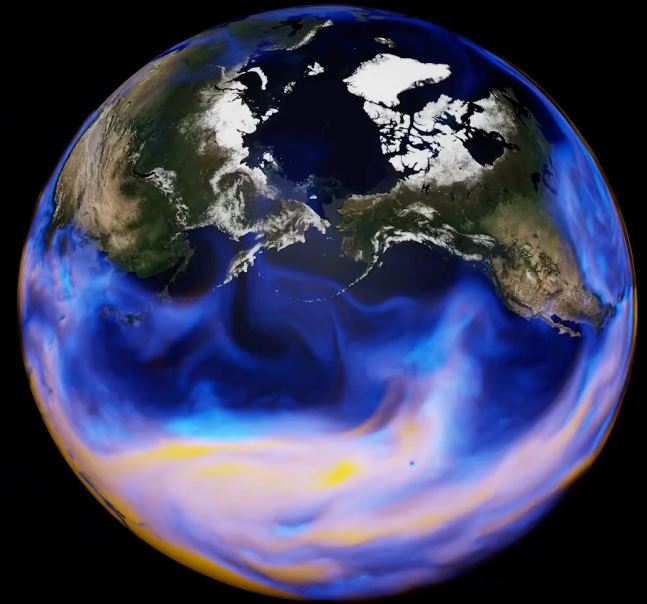
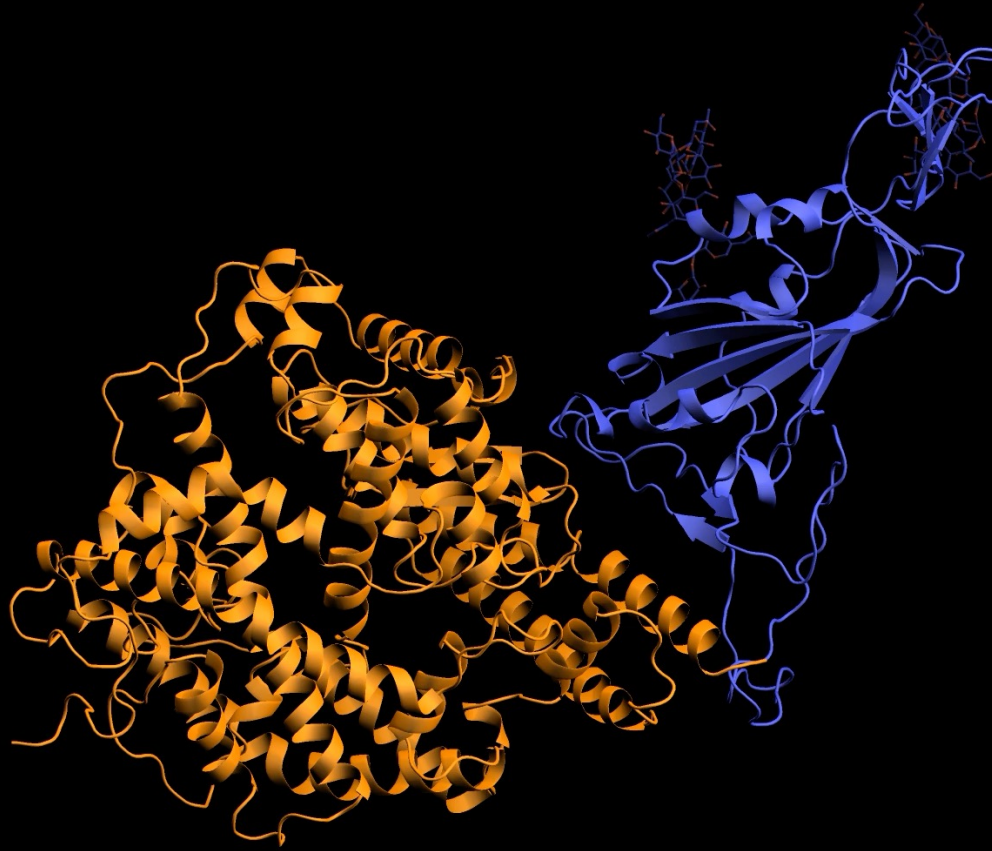
## THEOREMS



## EMBODIED AGENTS



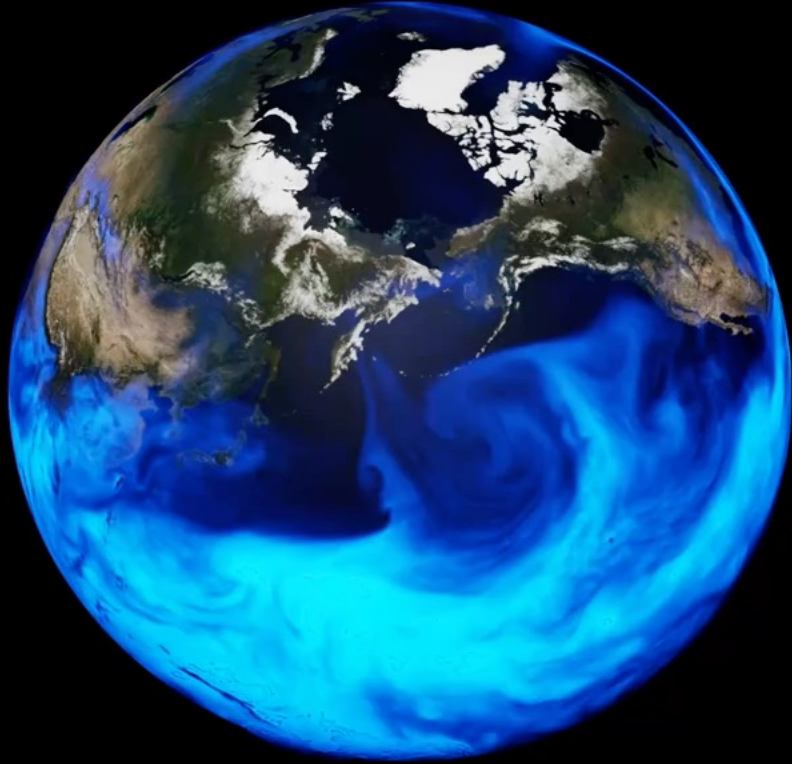
# MULTI-SCALE PROCESSES IN NATURE



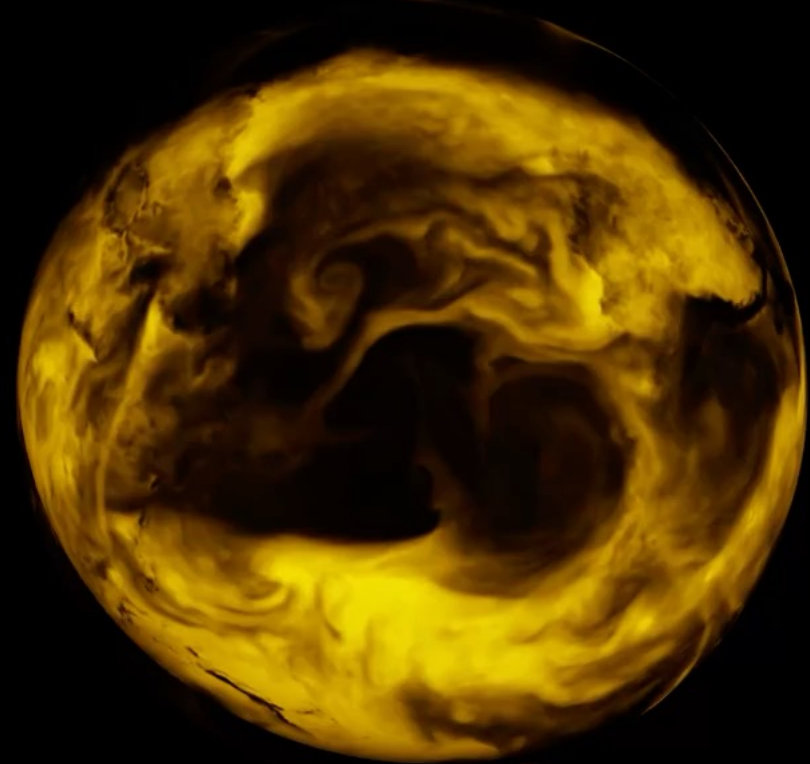
Mathematical equations govern the world at all scales

# AI ACCELERATES WEATHER FORECASTING

Ground Truth



FourCastNet



Our AI (FNO) is 45,000 times faster than current weather models

# AI ACCELERATES WEATHER FORECASTING

The screenshot displays the ECMWF Charts catalogue interface. At the top, the ECMWF logo and 'Charts' are visible on the left, and 'Help' and 'Log in' on the right. The main content area shows search results for 'FourCastNet'. On the left, a search bar contains 'FourCastNet' and a list of filters is visible, including 'Range' (Medium, Extended, Long), 'Type' (Forecasts, Verification), 'Component' (Surface, Atmosphere), 'Product type' (High resolution, Ensemble, Combined, Extreme, Point-based, Experimental: AIFS, Experimental: Machine learning models), and 'Parameters' (Wind). The search results are presented in a grid of six cards, each featuring a weather map and a description of an experimental FourCastNet ML model. The models include: 1) Mean sea level pressure and 850 hPa wind speed; 2) 500 hPa geopotential height and 850 hPa temperature; 3) Mean sea level pressure and 200 hPa wind; 4) Temperature and geopotential at various pressure levels; 5) 2 m temperature and 10 m wind; 6) Wind and geopotential heights at various pressure levels; 7) Total column water. Each card includes a 'Latest forecast' link and a brief description of the model's development and resolution.

Home / Charts catalogue

Search: FourCastNet

Range

- Medium (15 days)
- Extended (42 days)
- Long (Months)

Type

- Forecasts
- Verification

Component

- Surface
- Atmosphere

Product type

- High resolution forecast (HRES)
- Ensemble forecast (ENS)
- Combined (ENS + HRES)
- Extreme forecast index
- Point-based products
- Experimental: AIFS
- Experimental: Machine learning models
- Atmospheric composition

Parameters

- Wind

[https://charts.ecmwf.int/products/fourcast\\_medium-z500-t850](https://charts.ecmwf.int/products/fourcast_medium-z500-t850)

Latest forecast

**Experimental: FourCastNet ML model: Mean sea level pressure and 850 hPa wind speed**

FourCastNet v2-small: a deep learning-based system developed by NVIDIA in collaboration with researchers at several US universities. It is initialised with ECMWF HRES analysis. FourCastNet operates at 0.25° resolution.

Latest forecast

**Experimental: FourCastNet ML model: 500 hPa geopotential height and 850 hPa temperature**

Experimental: FourCastNet ML model: 500 hPa geopotential height and 850 hPa temperature

FourCastNet v2-small: a deep learning-based system developed by NVIDIA in collaboration with researchers at several US universities. It is initialised with ECMWF HRES analysis. FourCastNet operates at 0.25° resolution.

Latest forecast

**Experimental: FourCastNet ML model: Mean sea level pressure and 200 hPa wind**

FourCastNet v2-small: a deep learning-based system developed by NVIDIA in collaboration with researchers at several US universities. It is initialised with ECMWF HRES analysis. FourCastNet operates at 0.25° resolution.

Latest forecast

**Experimental: FourCastNet ML model: Temperature and geopotential at various pressure levels**

FourCastNet v2-small: a deep learning-based system developed by NVIDIA in collaboration with researchers at several US universities. It is initialised with ECMWF HRES analysis. FourCastNet operates at 0.25° resolution.

Latest forecast

**Experimental: FourCastNet ML model: 2 m temperature and 10 m wind**

FourCastNet v2-small: a deep learning-based system developed by NVIDIA in collaboration with researchers at several US universities. It is initialised with ECMWF HRES analysis. FourCastNet operates at 0.25° resolution.

Latest forecast

**Experimental: FourCastNet ML model: Wind and geopotential heights at various pressure levels**

FourCastNet v2-small: a deep learning-based system developed by NVIDIA in collaboration with researchers at several US universities. It is initialised with ECMWF HRES analysis. FourCastNet operates at 0.25° resolution.

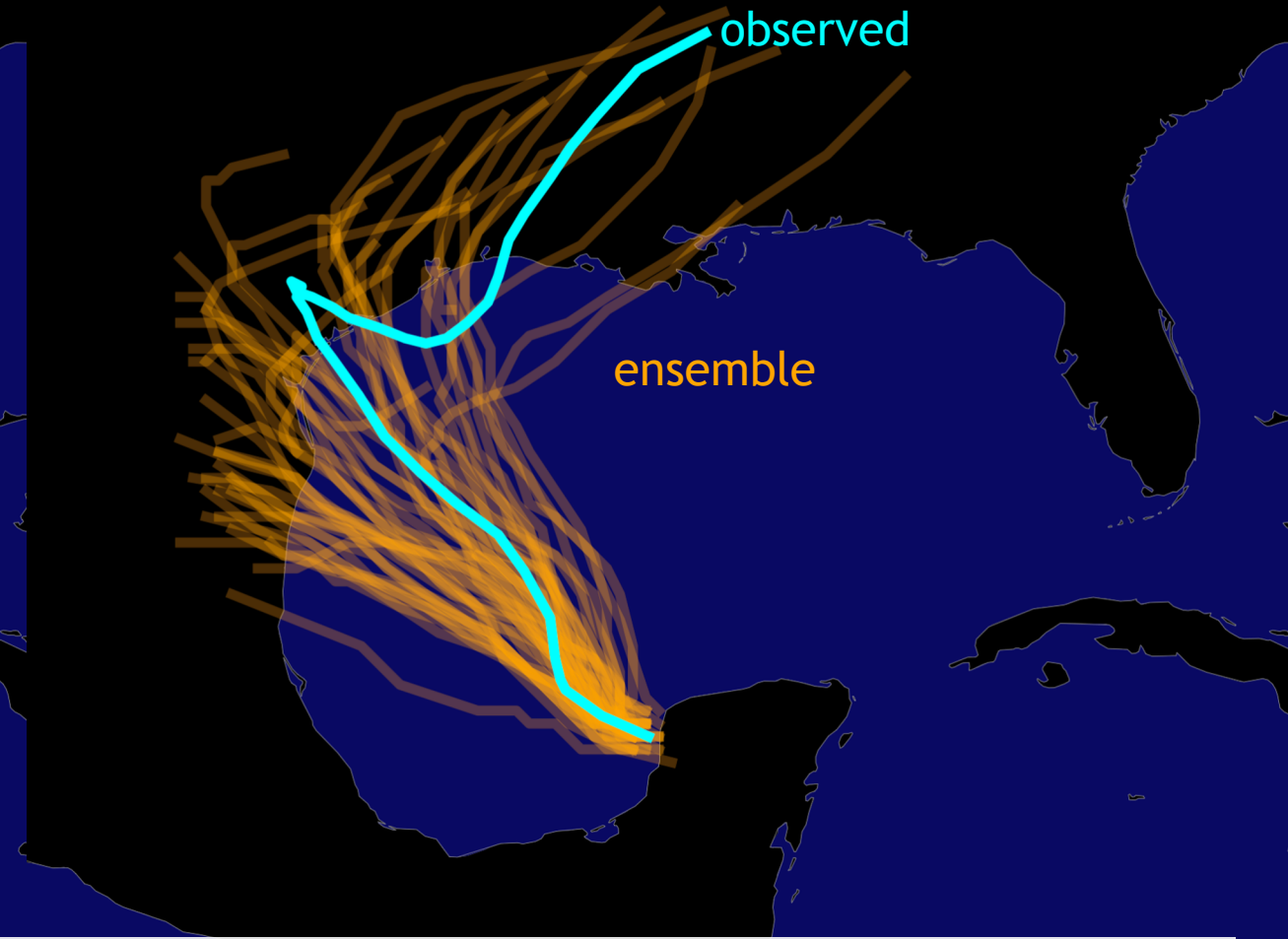
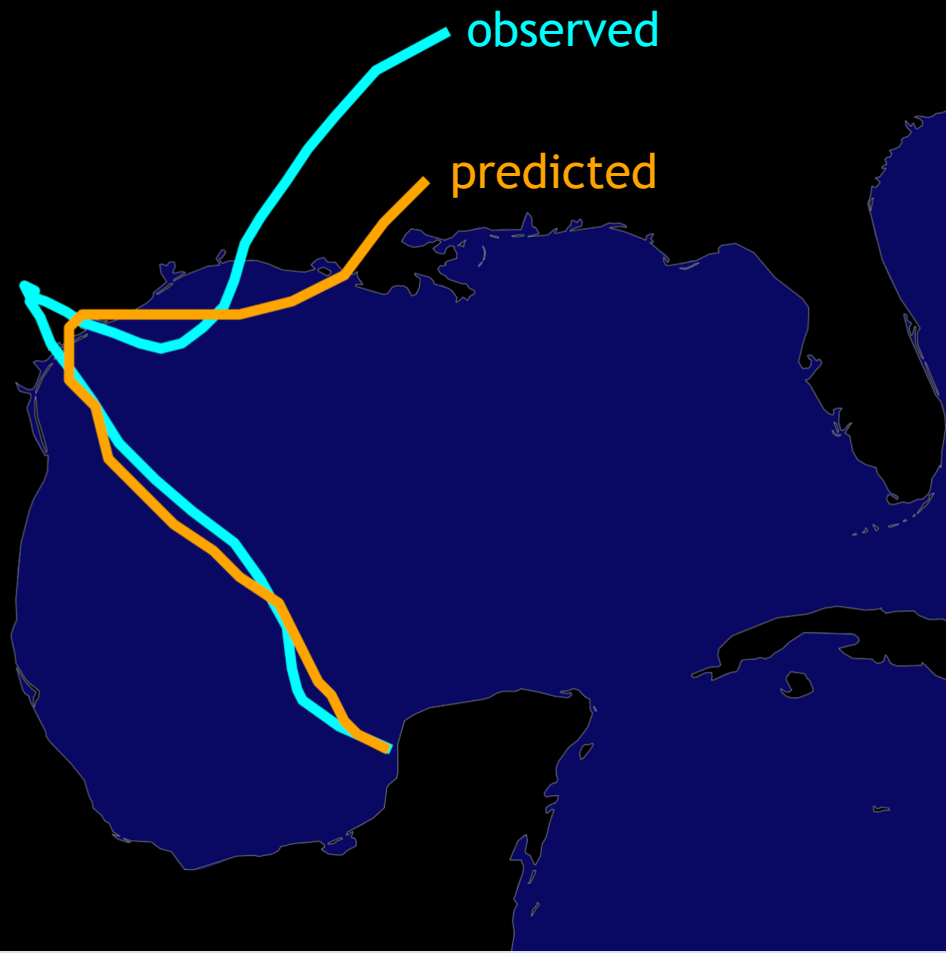
Latest forecast

**Experimental: FourCastNet ML model: Total column water**

FourCastNet v2-small: a deep learning-based system developed by NVIDIA in collaboration with researchers at several US universities. It is initialised with ECMWF HRES analysis. FourCastNet operates at 0.25° resolution.

Our AI weather model is deployed at ECMWF, giving real-time forecasts

# AI FOR EXTREME WEATHER FORECASTING

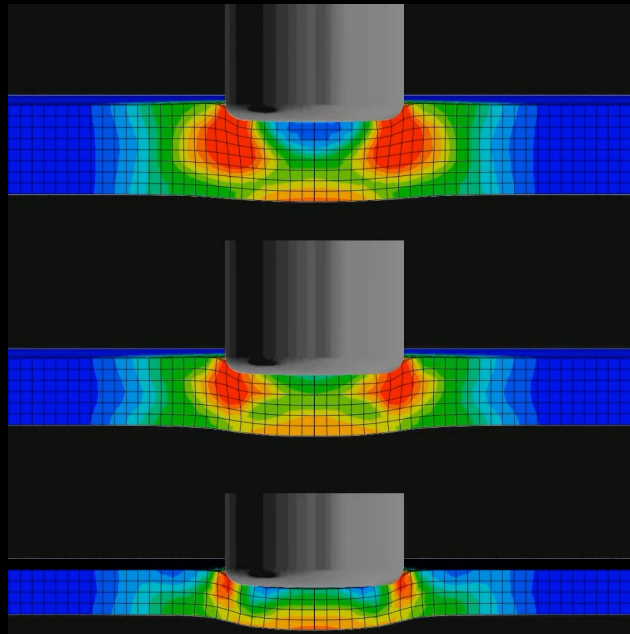


Our AI (FNO) enables larger ensembles and **better risk assessment**

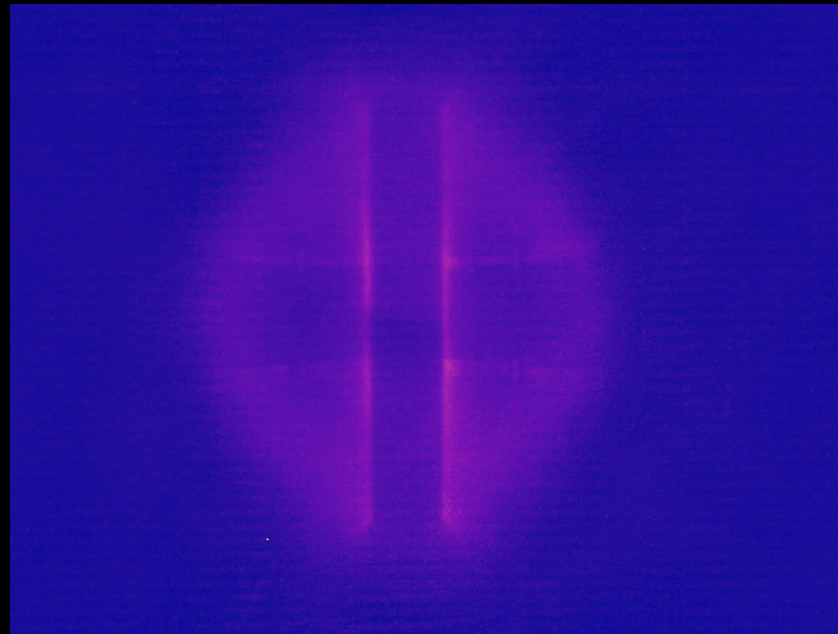


# NEURAL OPERATORS (FNO) - SIMULATION

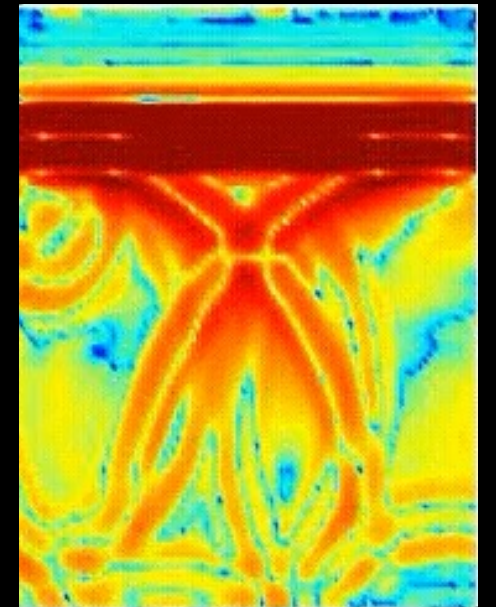
Deformation



Fusion



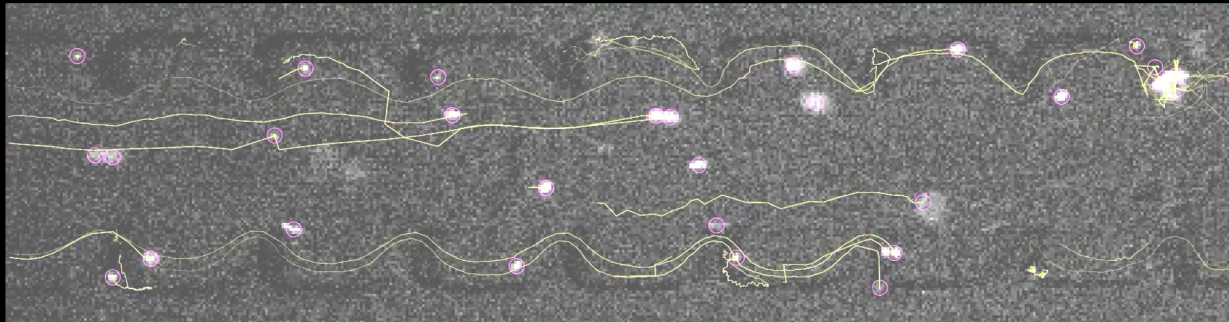
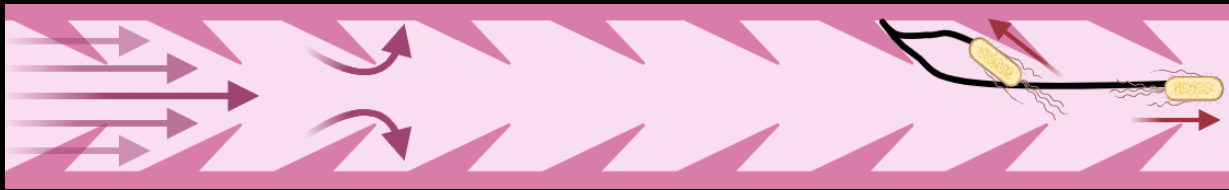
Ultrasound



Our AI (FNO) is ~100,000 times faster

# NEURAL OPERATORS (FNO) - DESIGN

Catheter



Lithography

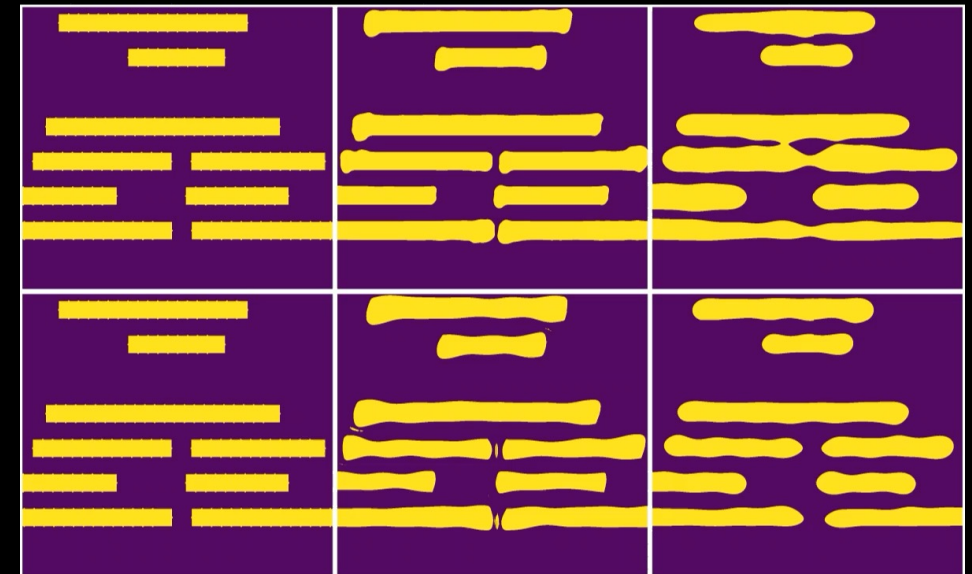
Epoch 1

AI: MSE 920798 EPE 382  
ILT: MSE 717711 EPE 123

Design

Mask

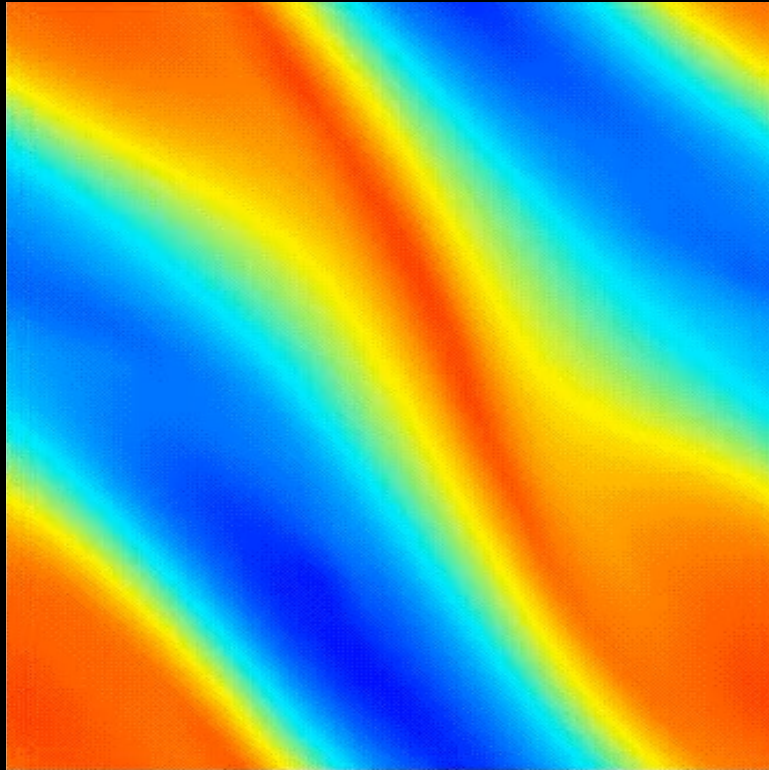
Resist



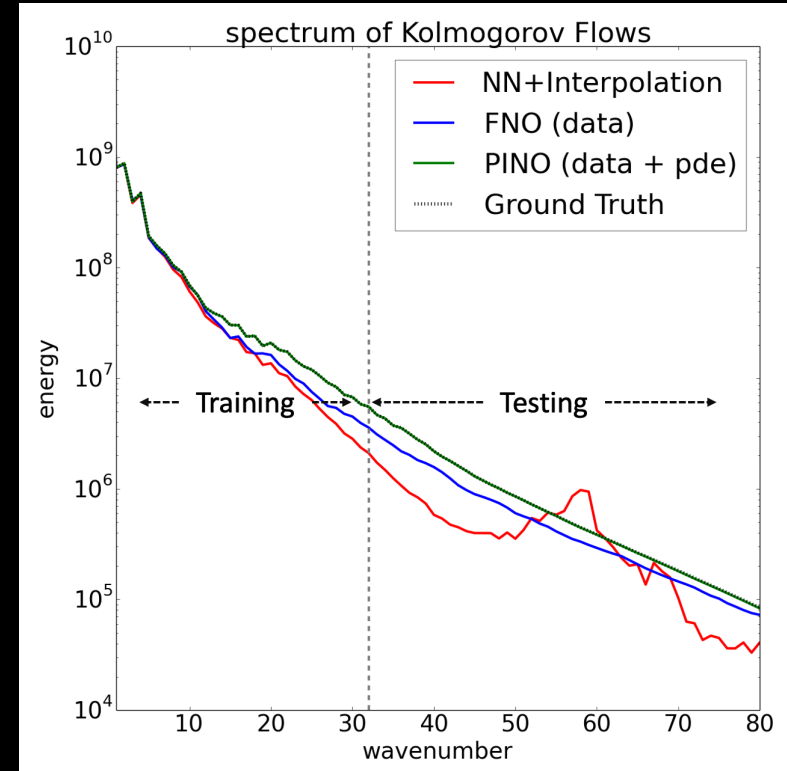
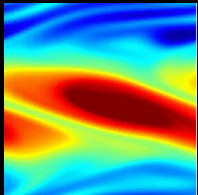
Our AI (FNO) is differentiable and can do inverse design

# PHYSICS INFORMED NEURAL OPERATORS

prediction  
(256x256)

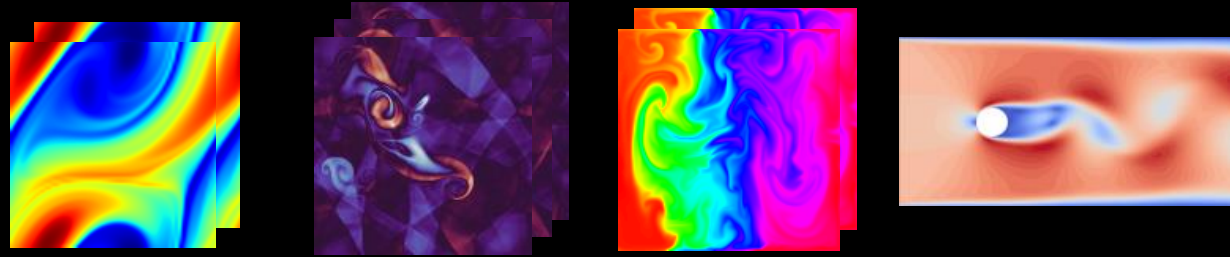


training data  
(64x64)



Our AI model (PINO) perfectly learns physical effects at all scales

# FOUNDATION MODEL FOR SCIENCE AND ENGINEERING



Foundation Model

Universal understanding of multi-scale multi-physics processes