

# Research projects – Numerical Analysis & Scientific Computing

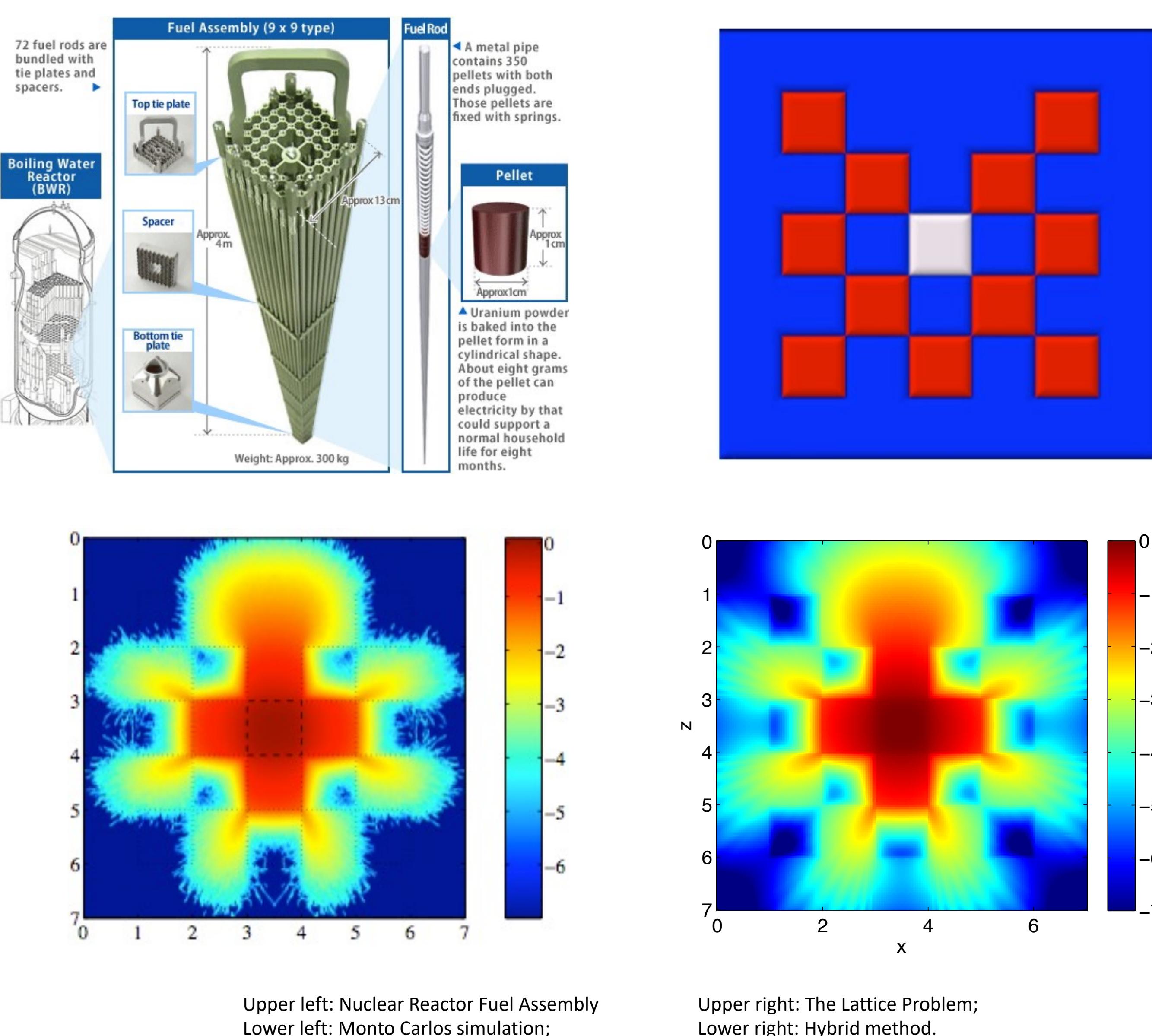
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## Research Interests

- Numerical analysis, scientific computing, high-performance computing
- Machine learning, neural networks
- Kinetic problems, multi-scale computational methods
- Numerical methods for problems with singularities, fractional-order partial differential equations, post-processing techniques, image processing
- Uncertainty quantification

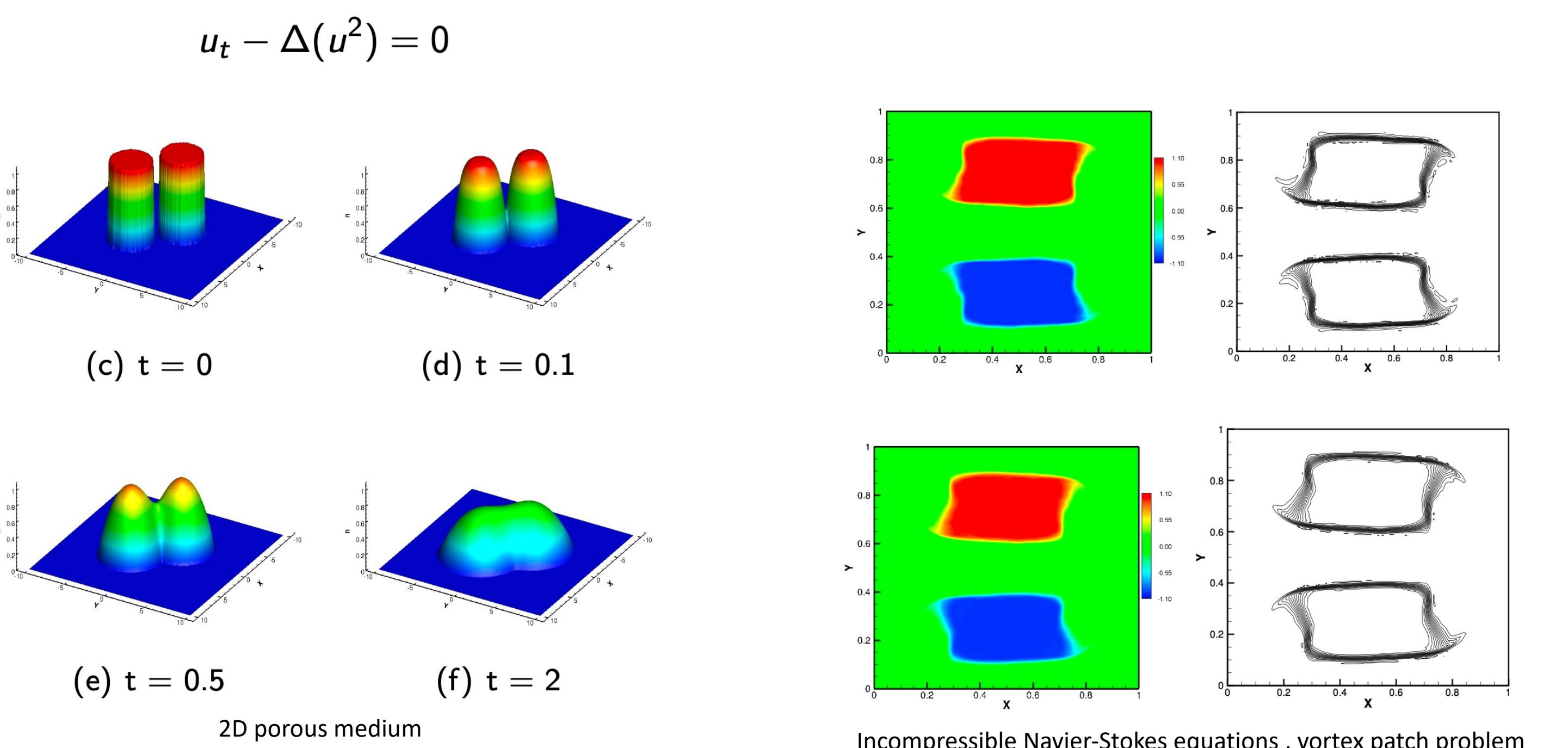
## Numerical simulations on kinetic models

- Kinetic models:** kinetic particles (e.g., neutrons, electrons, photons, photons, and charged particles) traveling through a surrounding material medium.
- Applications:** Semiconductor devices, thermodynamic systems, etc.
- Challenges:** high dimensional curse, huge computational cost, slow simulations, negative density, asymptotic limits, multiscale problems, etc.
- High-efficiency simulations:** Monte Carlo, Spectral Methods, Discontinuous Galerkin methods, hybrid methods, etc.



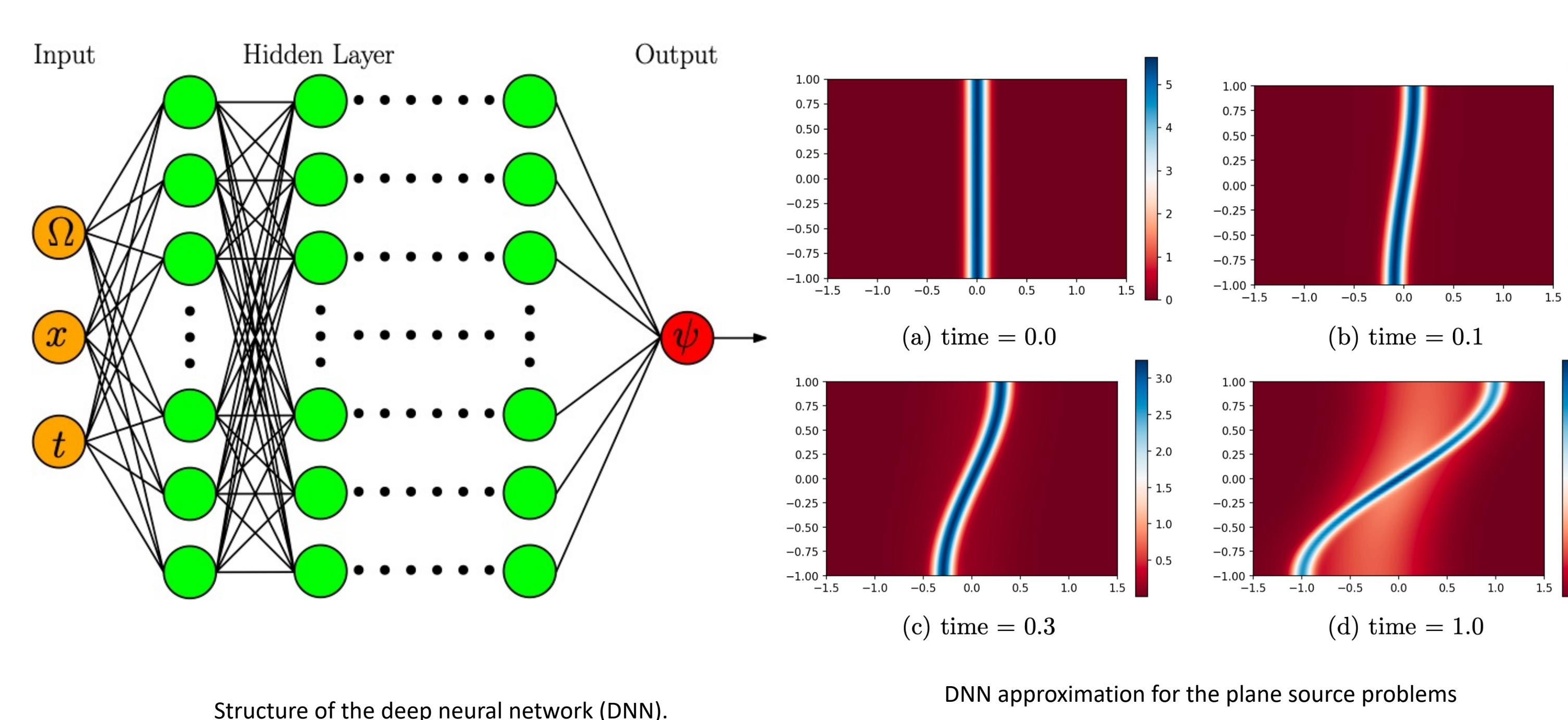
## High-order numerical simulations

- Motivation:** huge computational costs, long time, energy, machine, maintenance
- Advantages of High-order numerical methods:** efficient, fast, low energy, platform-friendly, portable
- Challenges:** physical characteristics (e.g., positivity), stability, high dimension, lack of smoothness, accuracy degradation
- Special properties:** positivity-preserving, stability-preserving, etc.
- Applications:** physics, biology, material science, finance, etc.



## Machine Learning

- Rising popular tools in scientific computing, esp. for numerical simulations on partial differential equations (PDEs)
- Alternative methods for traditional numerical methods:
- PDE solvers:** training to find solutions for some PDE problems
- Detectors:** training to predict some specific locations (e.g., trouble cells, jumps, singularities)



## Data post-processing techniques

- Trouble:** Bad presentations with raw Spectral data (e.g., Fourier data)
- Reasons:** noise, lack of smoothness, incompleteness
- Methods:** post-processing to extract accurate information from inaccurate raw data (e.g., filters, Gegenbauer reconstructions)

