Foundational Approaches for End-to-end Formal Verification of Computational Physics

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Challenge:

- Analytical solutions of differential equations are often **intractable**
- Numerical solvers are **unverified, yet trusted** by the scientific community for critical infrastructure
- We want to formally **verify** the correctness and accuracy of differential equations solvers

Solution:

- Formal proofs in Coq of **correctness, accuracy and convergence** results (Lax theorem, iterative solvers)
- Bounds of accuracy for **floating-point** computations
- Tighter **probabilistic** accuracy bound

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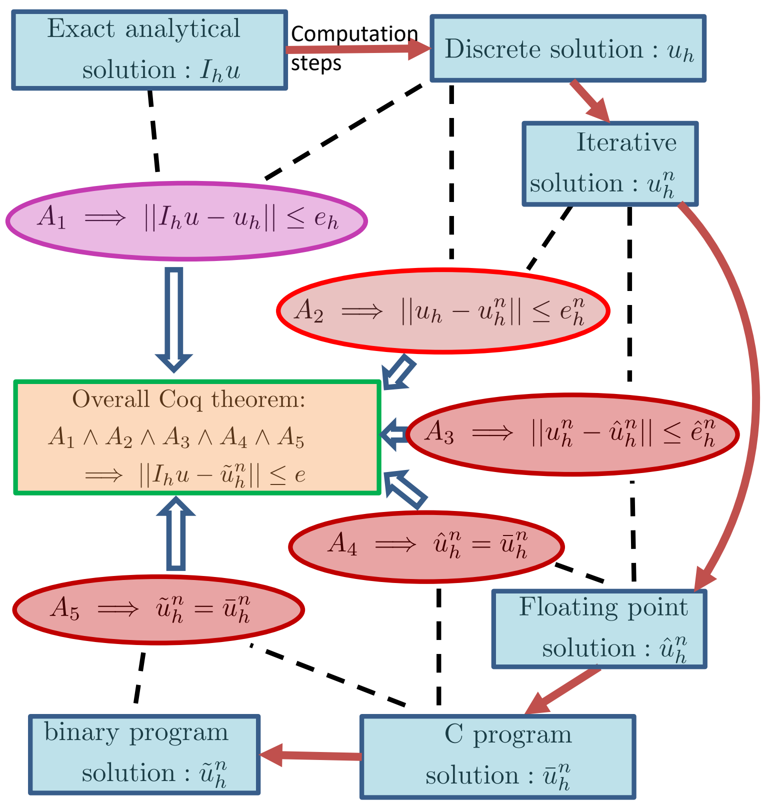

Scientific Impact:

- End-to-end formal link **from paper version to C code** and executable
- Mechanically-checked guarantees allow the computational physicist to **set and achieve a desired level of accuracy**
- Possible FMitF transfers to **embedded systems** or **machine learning** applications

Broader Impact and Broader Participation:

- Applications in many science and engineering domains (**aviation, climate modeling, nuclear powerplants**)
- Tighter rounding uncertainty enables **more efficient resource allocation**