AGH Modelling of Physical Systems 2025: projects

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May 6, 2025

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- grading:
  5×5% for presentations;
  25% for PR;
  25% for code review;
  25% for test coverage.

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Jun 17: code review summary

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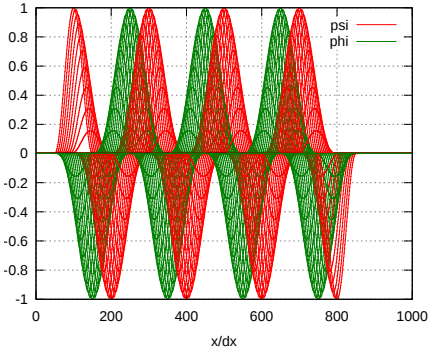
... merge (add your names to .zenodo.json!)

Project idea 1: tutorial for source-term handling in PyMPDATA

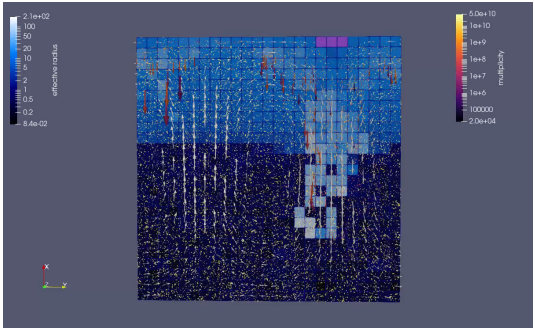
Prototype source-term-handling example for PyMPDATA using the coupled-oscillator test case from Fig. 8-9 in Smolarkiewicz 2006 (doi:10.1002/fld.1071) (and Fig. 15 in Jaruga et al. 2015, doi:10.5194/gmd-8-1005-2015)

$$\partial_t \psi + \partial_x(u_o \psi) = \omega\phi$$
$$\partial_t \phi + \partial_x(u_o \phi) = -\omega\psi$$



Project idea 2: Monte-Carlo particle transport scheme for PySDM

(PySDM uses deterministic transport so far, test case(s) inspiration: figures in Curtis et al. 2024, doi:10.5194/gmd-17-8399-2024)



Project idea 3: Burgers equation solution using MPDATA

(e.g., based on the tutorial here: `https://people.sc.fsu.edu/~jburkardt/classes/math1091_2020/burgers/burgers.pdf`)

$$\partial_t u + u \partial_x u = 0$$

The Burgers Equation

MATH1091: ODE methods for a reaction diffusion equation

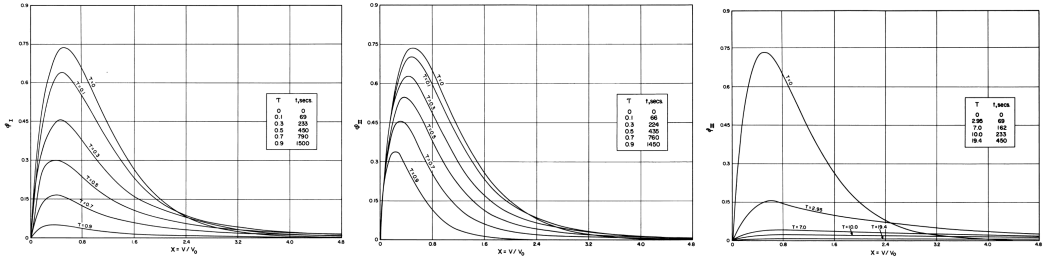
http://people.sc.fsu.edu/~jburkardt/classes/math1091_2020/burgers/burgers.pdf

A follower who's faster will cause a disaster!

Project idea 4: Multiplicative kernel solutions using SDM

$$K(x, y) = a \cdot x \cdot y$$

- validated against analytic solution (see Drake 1972 for an overview, doi:10.1175/1520-0469(1972)029%3C0537:TSTEOC%3E2.0.CO;2)



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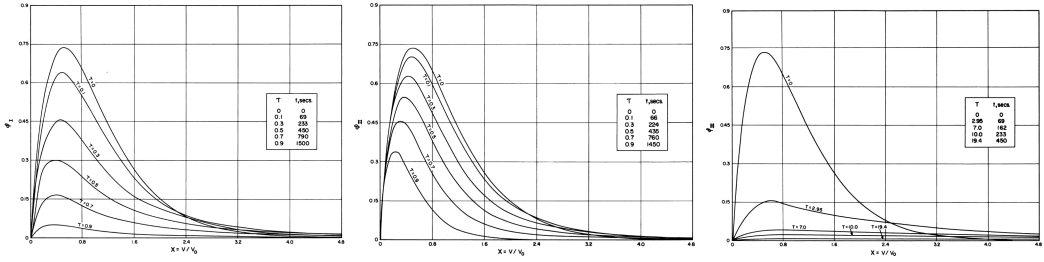
- reproduce Figs 6-8 from Scott 1965 (`https://books.google.com/books?id=fqNQAAAAYAAJ`)



Project idea 5: Prototype drop radiative heat exchange effects

(e.g. based on Fig. 2 from Roach 1976, doi:10.1002/qj.49710243207)

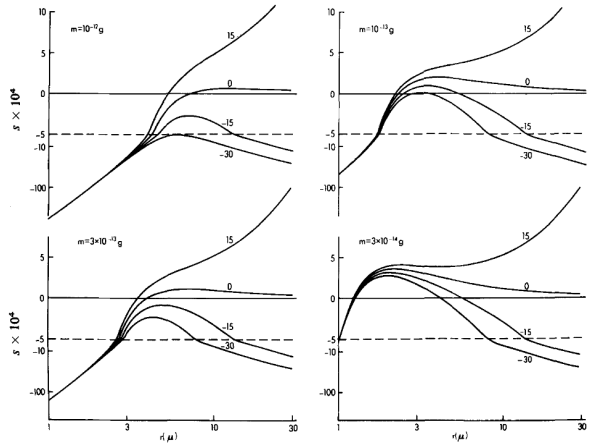
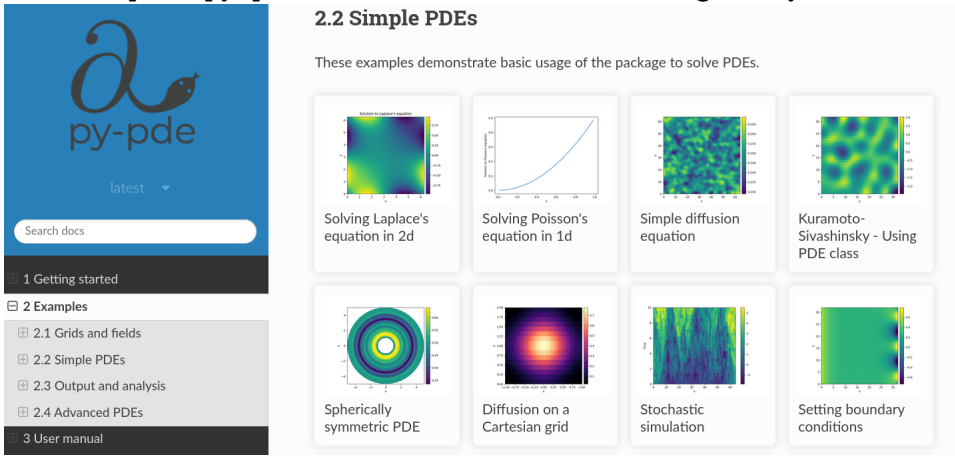


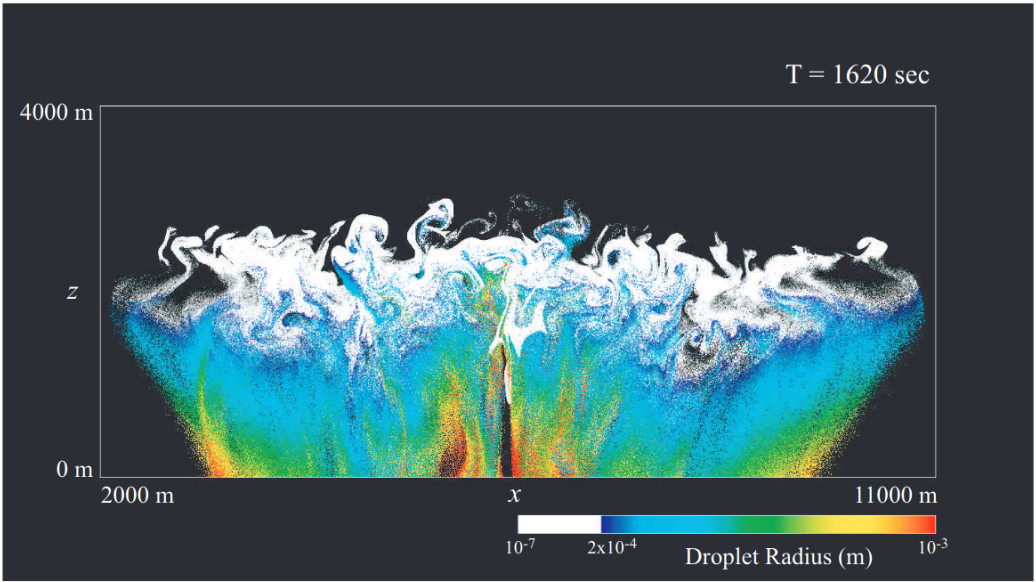
Figure 2. Equilibrium values of droplet radius as a function of supersaturation (s) for different values of solute mass (m) and radiative exchange (F). Each curve is labelled with F in W m^{-2}.

Project idea 6: Comparison of PyMPDATA solution against py-pde solution for one of problems from py-pde example gallery

https://py-pde.readthedocs.io/en/latest/gallery.html



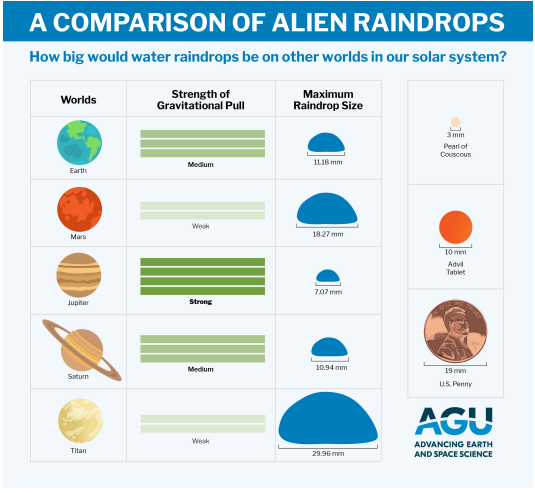
Project idea 7: PySDM + PyMPDATA warm-bubble simulation



Project idea 8: Physics of Falling Raindrops in Diverse Planetary Atm.

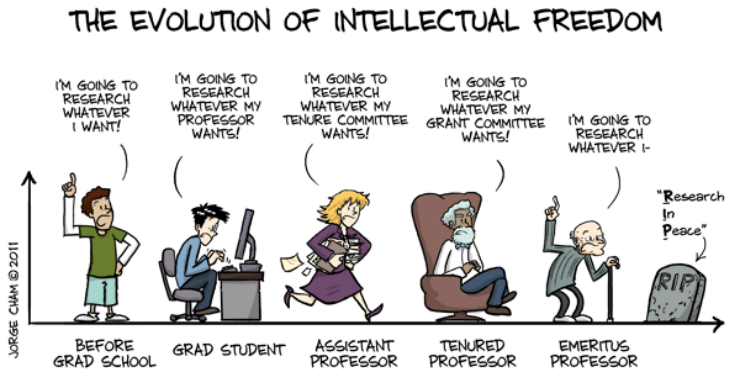
by Loftus & Wordsworth 2021 (doi:10.1029/2020JE006653)

`https://news.agu.org/press-release/alien-raindrops-surprisingly-like-rain-on-earth/`



Project idea X: your idea!

Piled Higher and Deeper ***by Jorge Cham*** **www.phdcomics.com**



title: "Intellectual Freedom" - originally published 7/20/2011