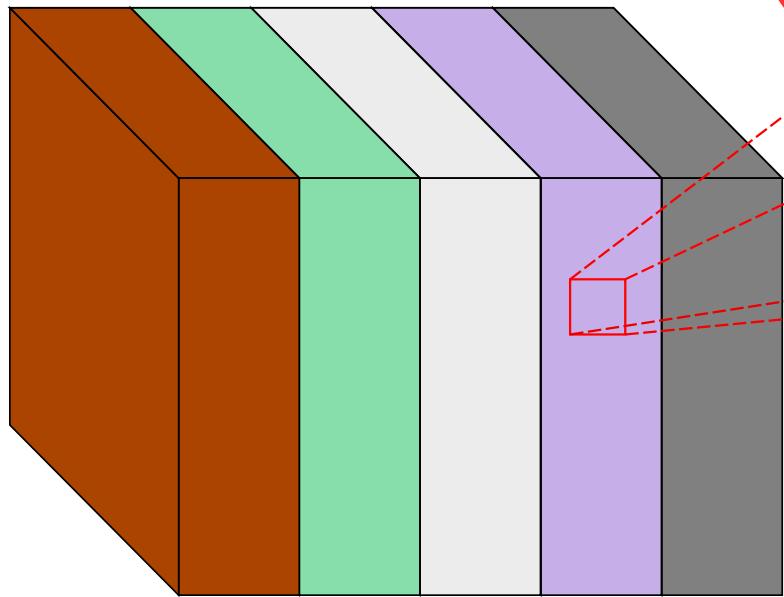




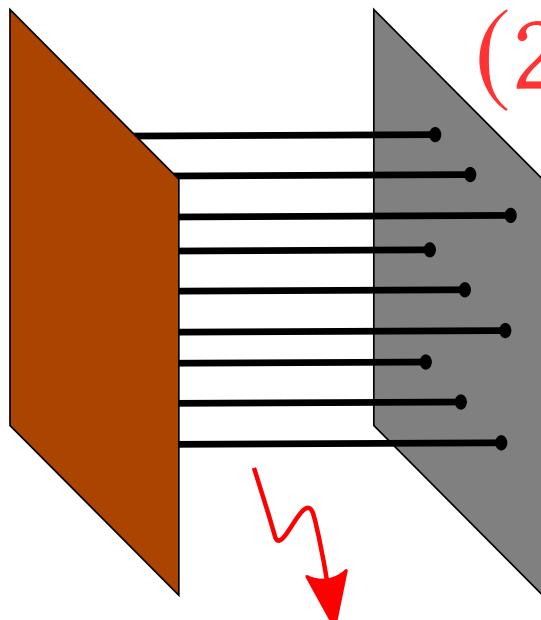
Electrochemical and equivalently expensive and the physics-based models, which design. Combinations of simplicity can be selected to best models which is independent of and degradation mechanisms

(3) + (3)



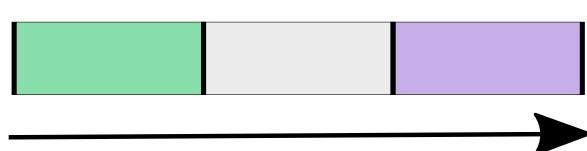
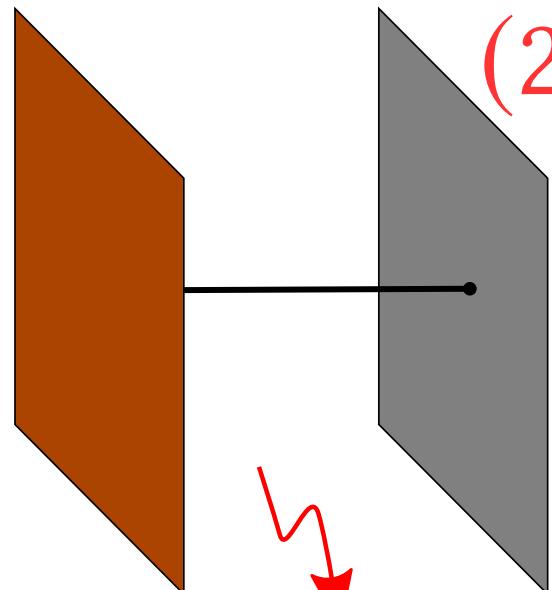
Full 3D

(2 + 1) + ()



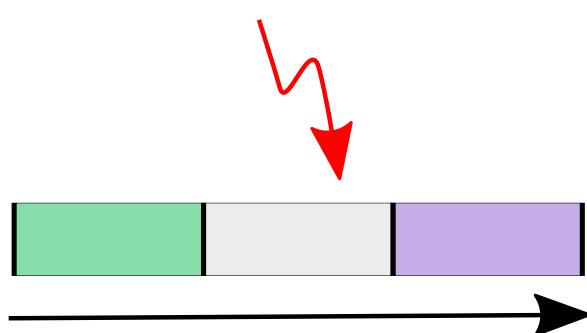
Thin
electrodes

$(2 + \bar{1}) + (\)$



Large conductivity

$(1) + (\)$



Very large conductivity

(0) + ()



Fast diffusion
in electrolyte

References

- [1] V. Sulzer, S.J. Chapman, C.P. Please, D.A. Howe
- [2] I.R. Moyles, M.G. Hennessy, T.G. Myers, and B.

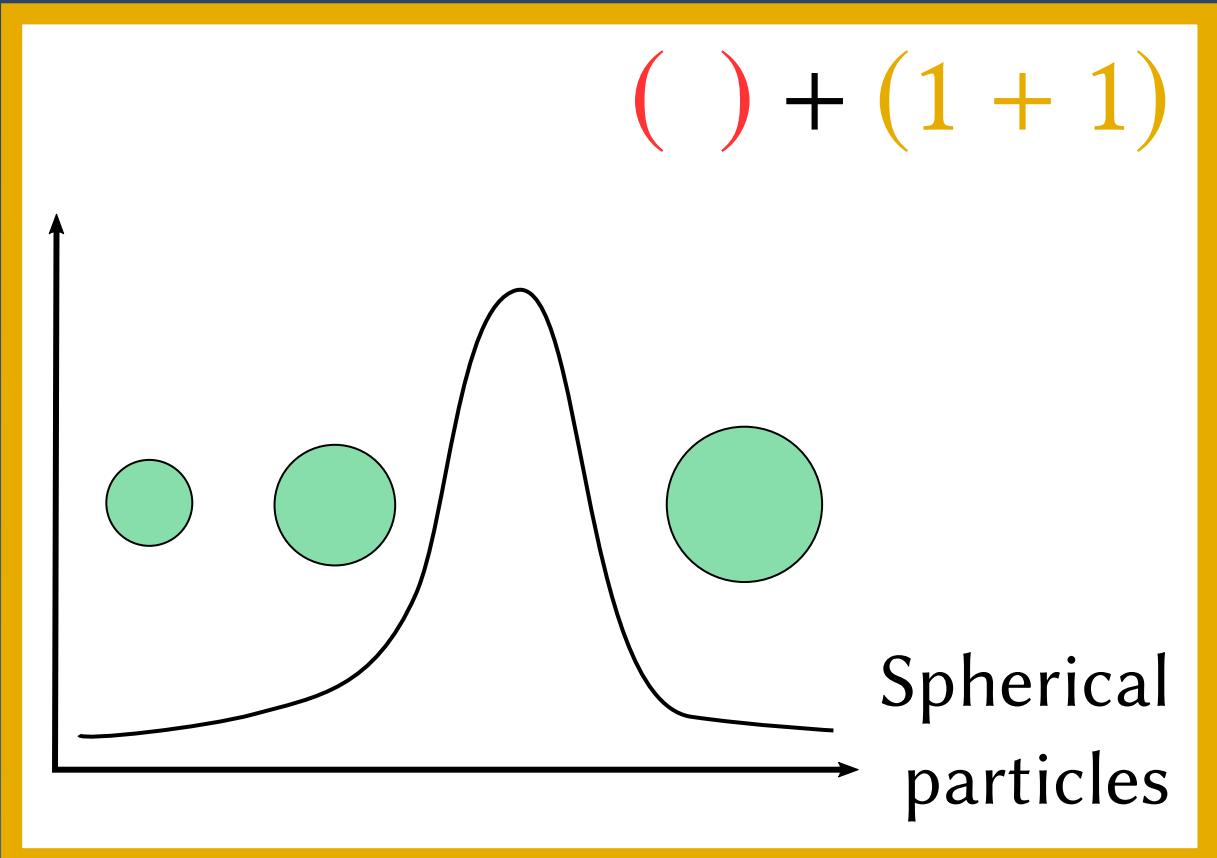


An Asymptotic for Battery

Jon Chapman, Matt Hennessy,
Colin Please, Ian Roper, Valeria

nt-circuit modelling are the two most common approaches to battery modelling. The former provides limited physical insight, while the latter can provide a useful theoretical framework. However, both approaches have their limitations and it is often necessary to make simplifications to the **macroscale** and **microscale** models in order to meet the user's needs. The approach presented here is based on a combination of chemistry, and can be extended to include other physical phenomena. We are currently developing the software to allow users to easily create and simulate their own battery models.

() + (1 + 1)



Complex

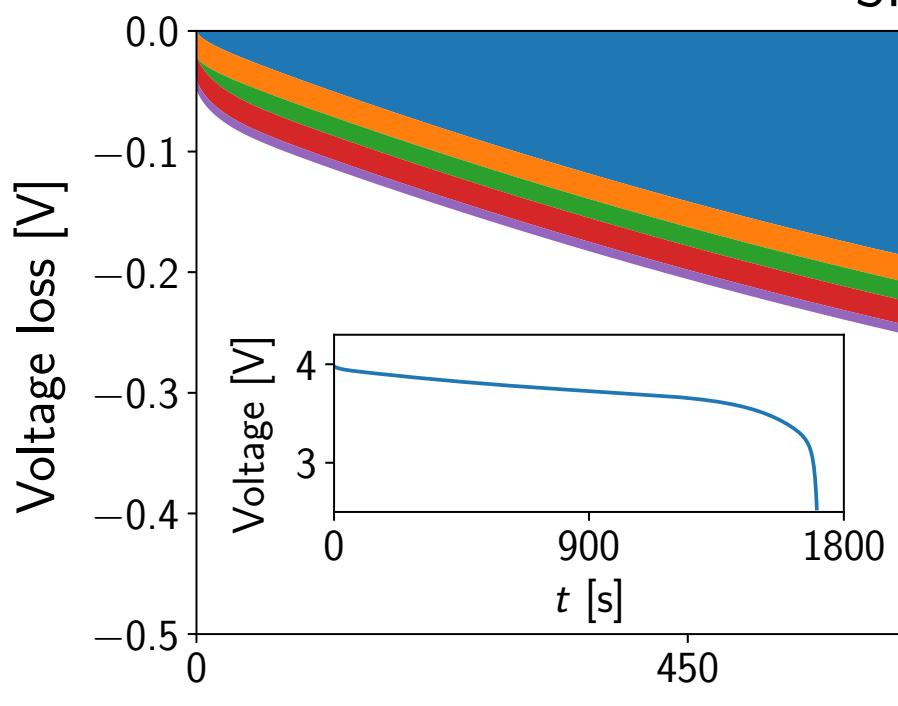
+



Complex

Lithium Cobalt Oxide

SPMeC

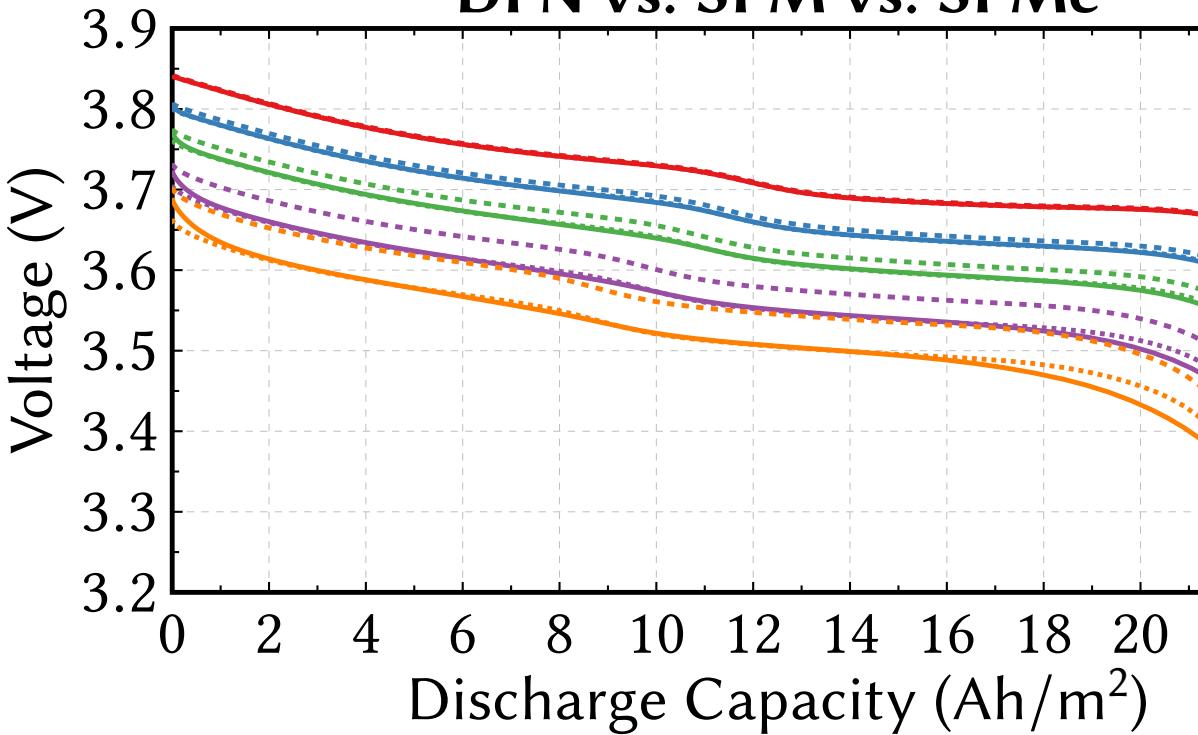


t [s]

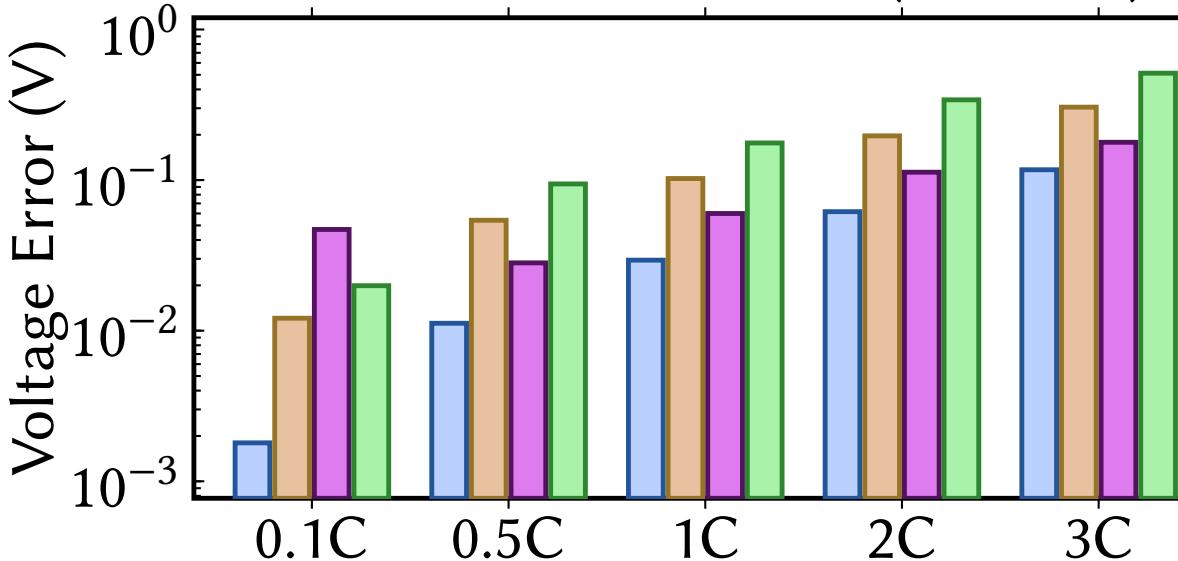
MACROSCALE

Lithium Cobalt Oxide

DFN vs. SPM vs. SPMe



Versions of the SPMe (vs. DFN)

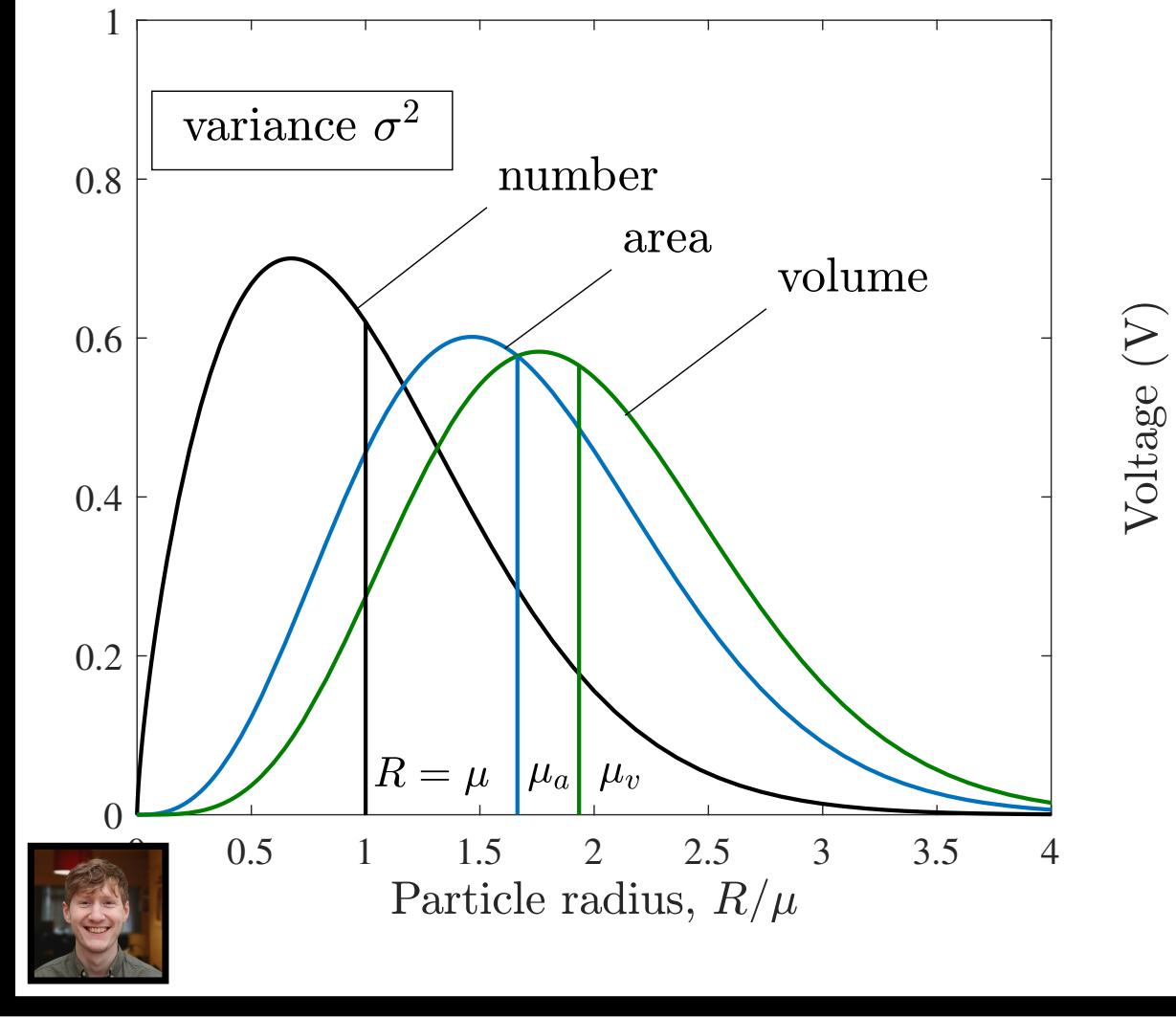


DPM

Distributed Particle Model

Lithium Cobalt Oxide

Simple



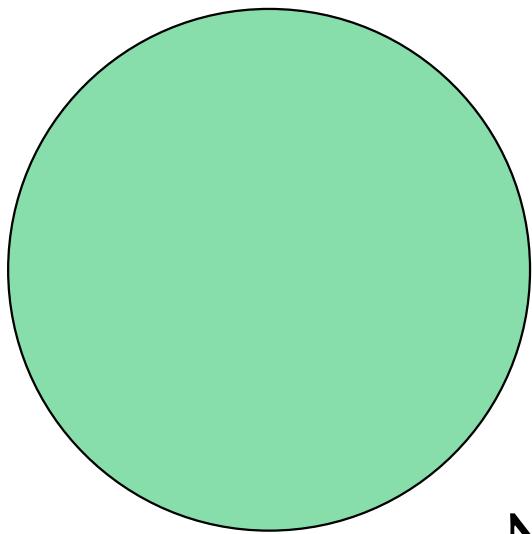
y, and C.W. Monroe. Faster Lead-Acid Battery Simulations from Porous Media Models. *J. Comput. Phys.*, 2013, 250, 1–12.
R. Wetton. Asymptotic reduction of a porous electrode model for lithium-ion batteries. *SIAM J. Appl. Math.*, 2013, 73(3), 1030–1052.

ric Framework Modelling

sy, Toby Kirk, Scott Marquis,
entin Sulzer, Robert Timms.

popular approaches to battery simulation. Through asymptotic analysis, we systematically reduce the complexity of the model to support battery management, and as a **large-scale** result in a suite of reduced-order models. This taken provides a general framework for which additional physical effects such as heat transfer can be incorporated. We have implemented this framework in a software package PyBaMM to implement the models and simulations.

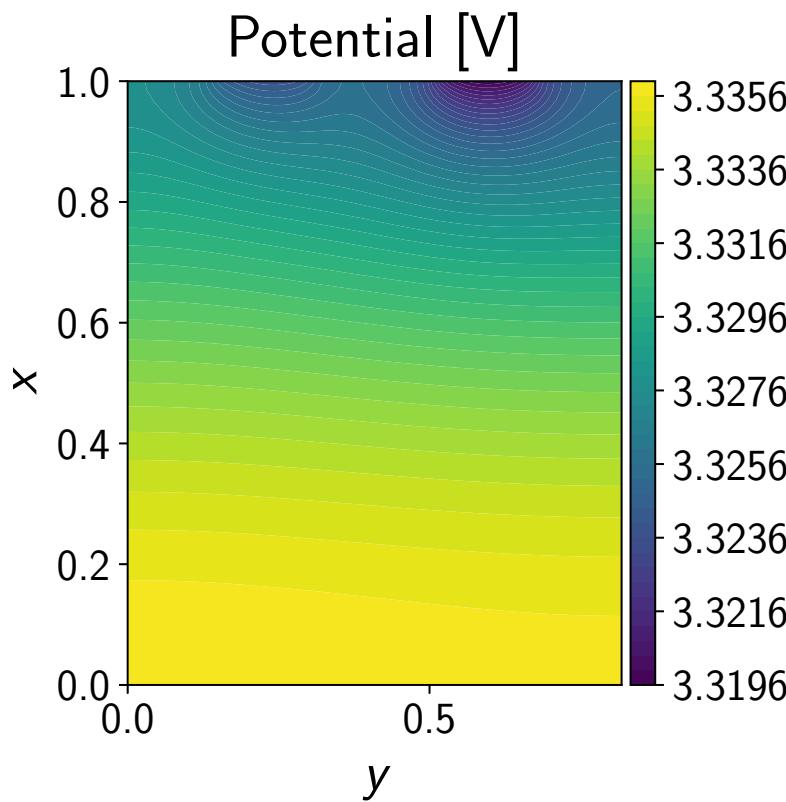
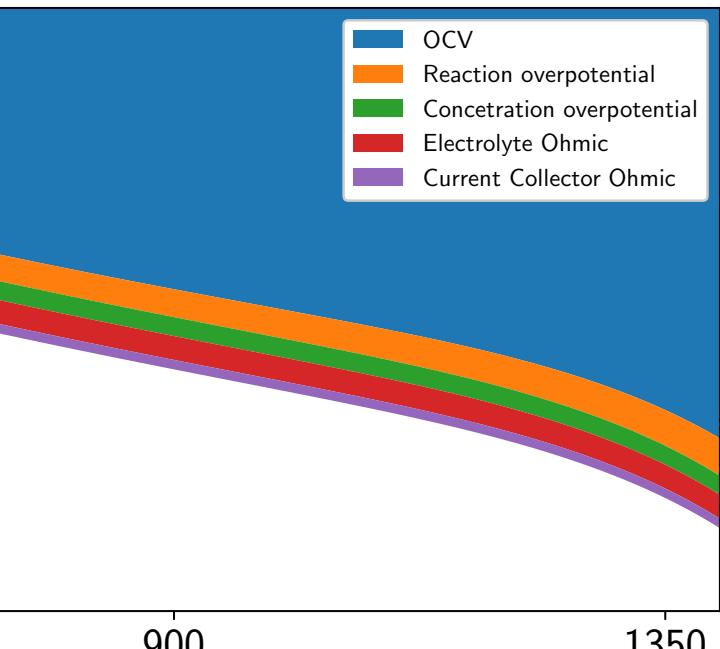
() + (1)

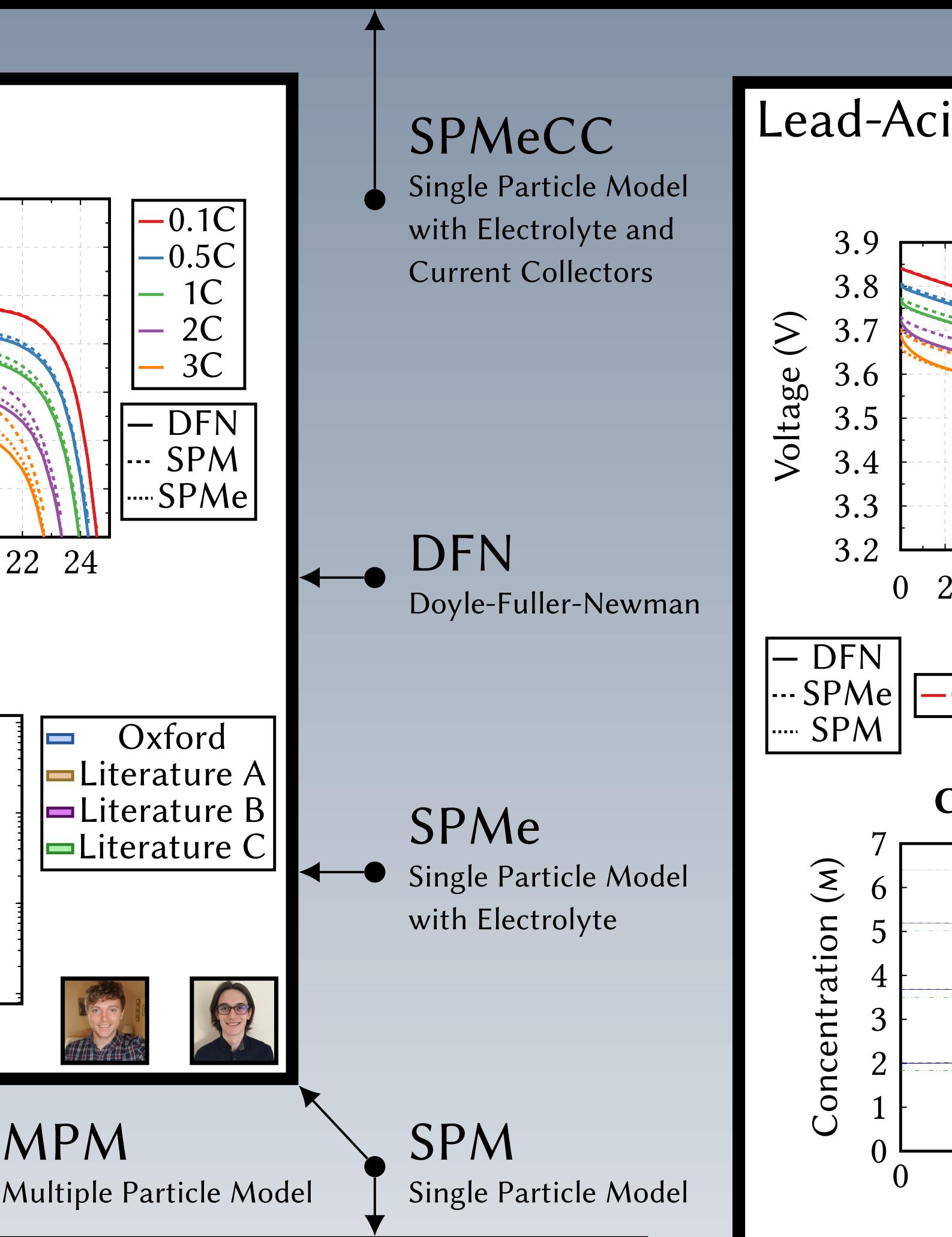


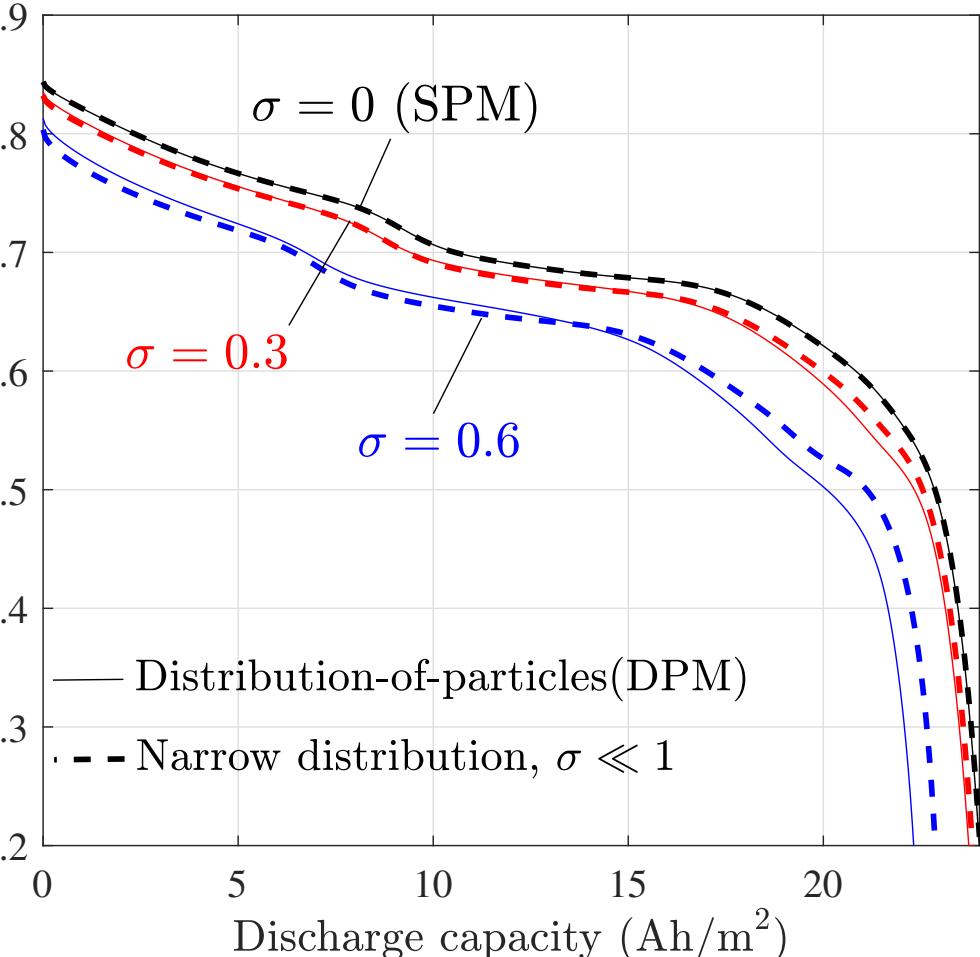
Narrow particle
distribution

MICROSCALE

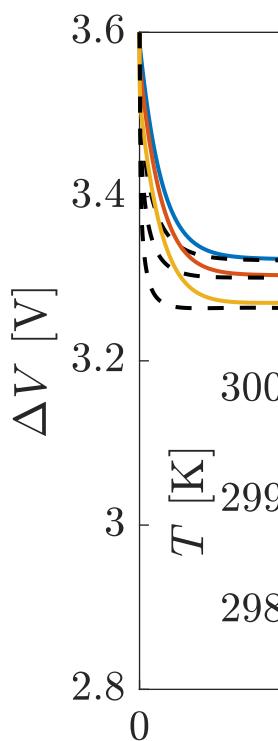
CC







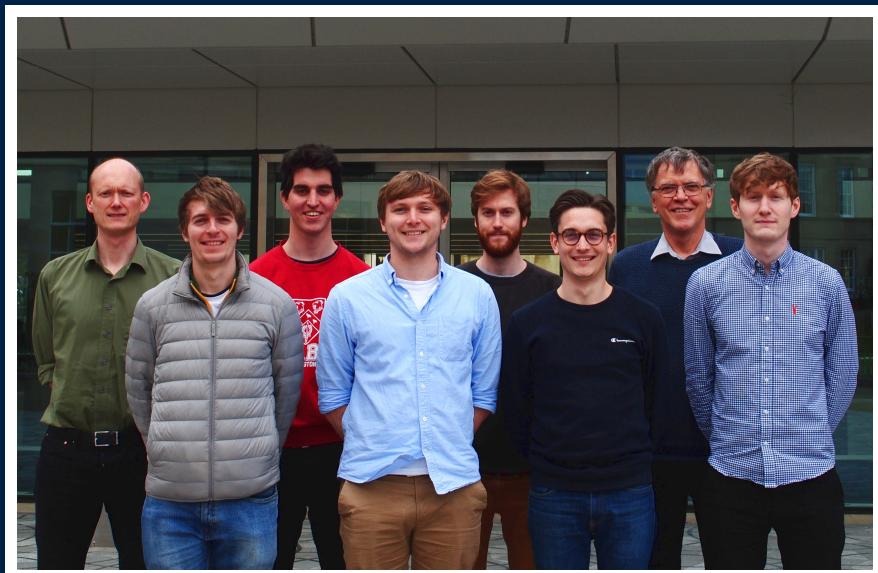
Lithium



Various-Electrode Theory: II. Asymptotic Analysis. *Submitted*, 2019. *arXiv preprint arXiv:1805.07099*
 Various-Electrode Theory: I. Numerical Solution. *Submitted*, 2018. *arXiv preprint arXiv:1805.07099*

SIEMENS

nexeo



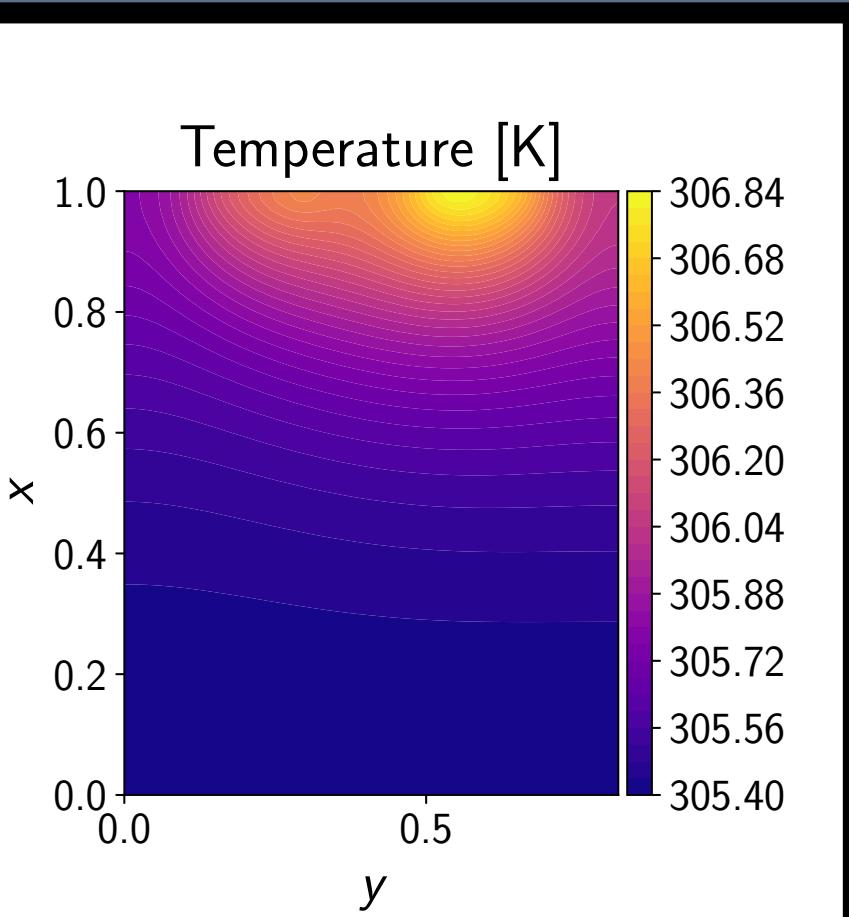
on, but the former is computationally more expensive. We systematically derive simplified models for the simulation of complex systems, such as on-line diagnostics, and cell models, whose complexity and behaviour can be controlled by the user. This allows for developing reduced-order models for complex systems, such as mechanics, side reactions and chemical kinetics, which can be solved numerically. The resulting suite of models numerically.

() + (0)



Fast diffusion
in particles

Simple

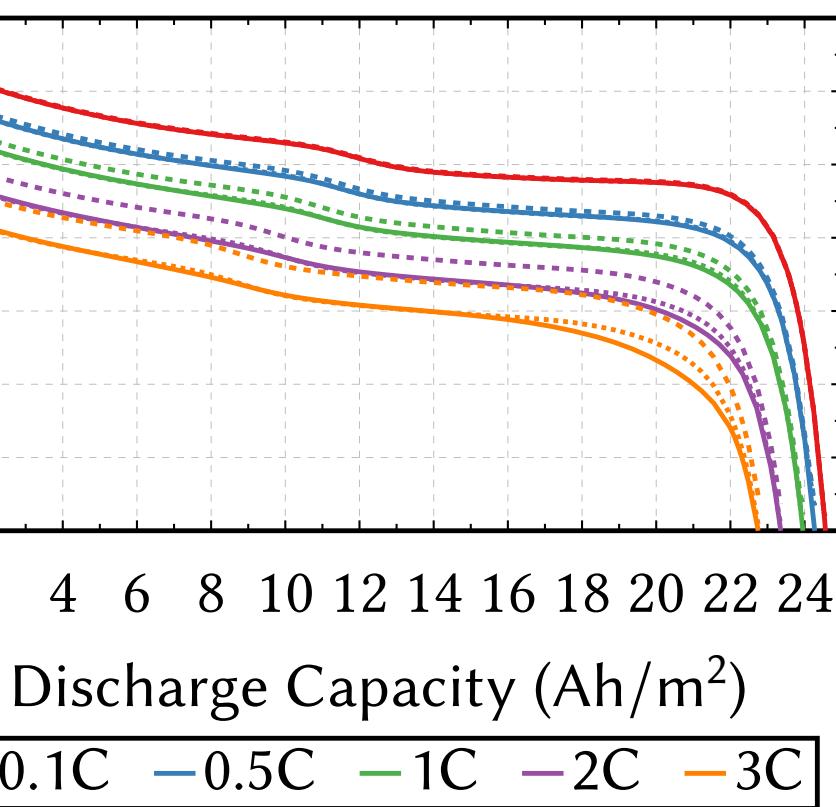


↔ ●
EPPM
Electrolyte
with
Potential
Pair Model

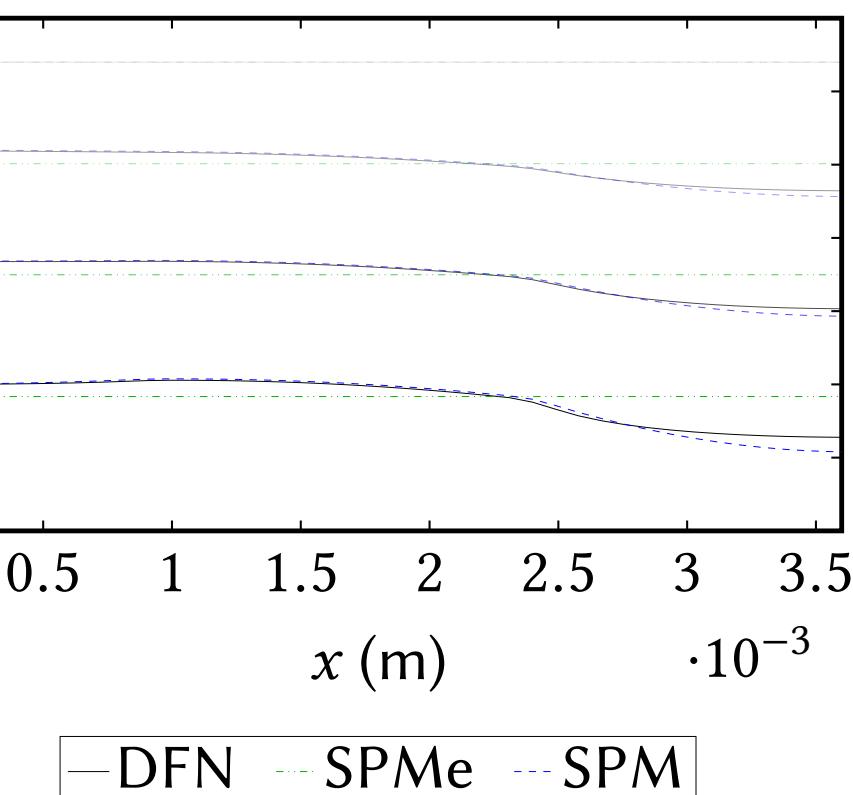
d



Lead-acid models



Concentration change (0.5C)



ECCM

Electrolyte
with Current
Collectors
Model

EM

Electrolyte
Model

REM

Reduced
Electrolyte
Model

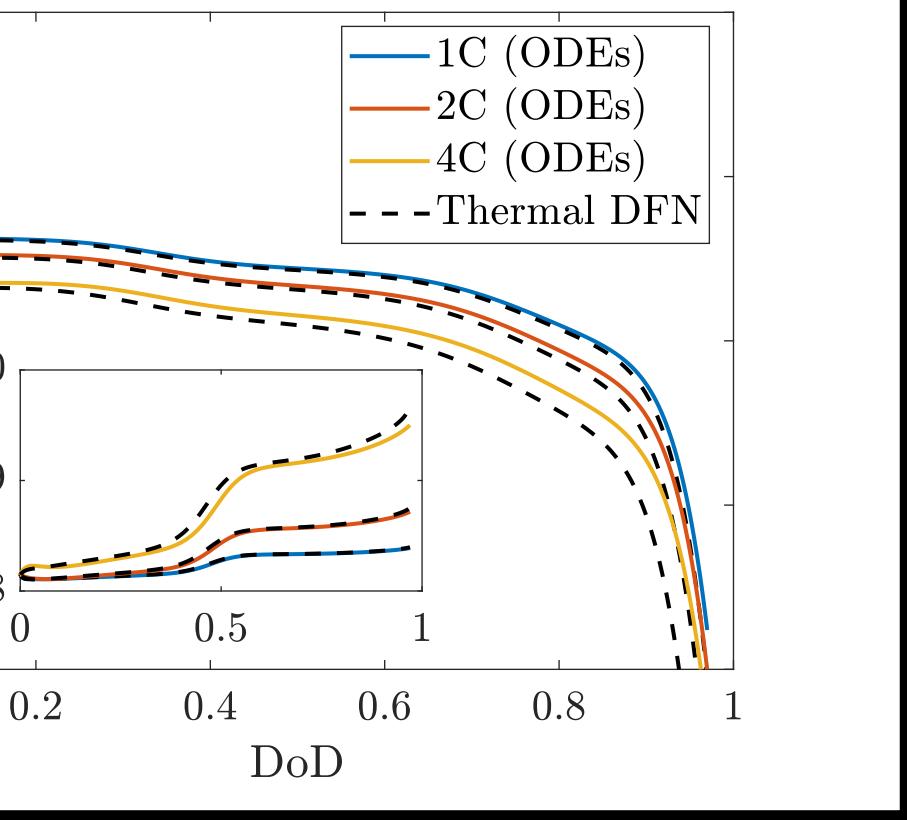
ODEM

Ordinary
Differential

Iron Phosphate



Differential
Equation
Model



arXiv preprint arXiv:1902.01774

v3v2

n

