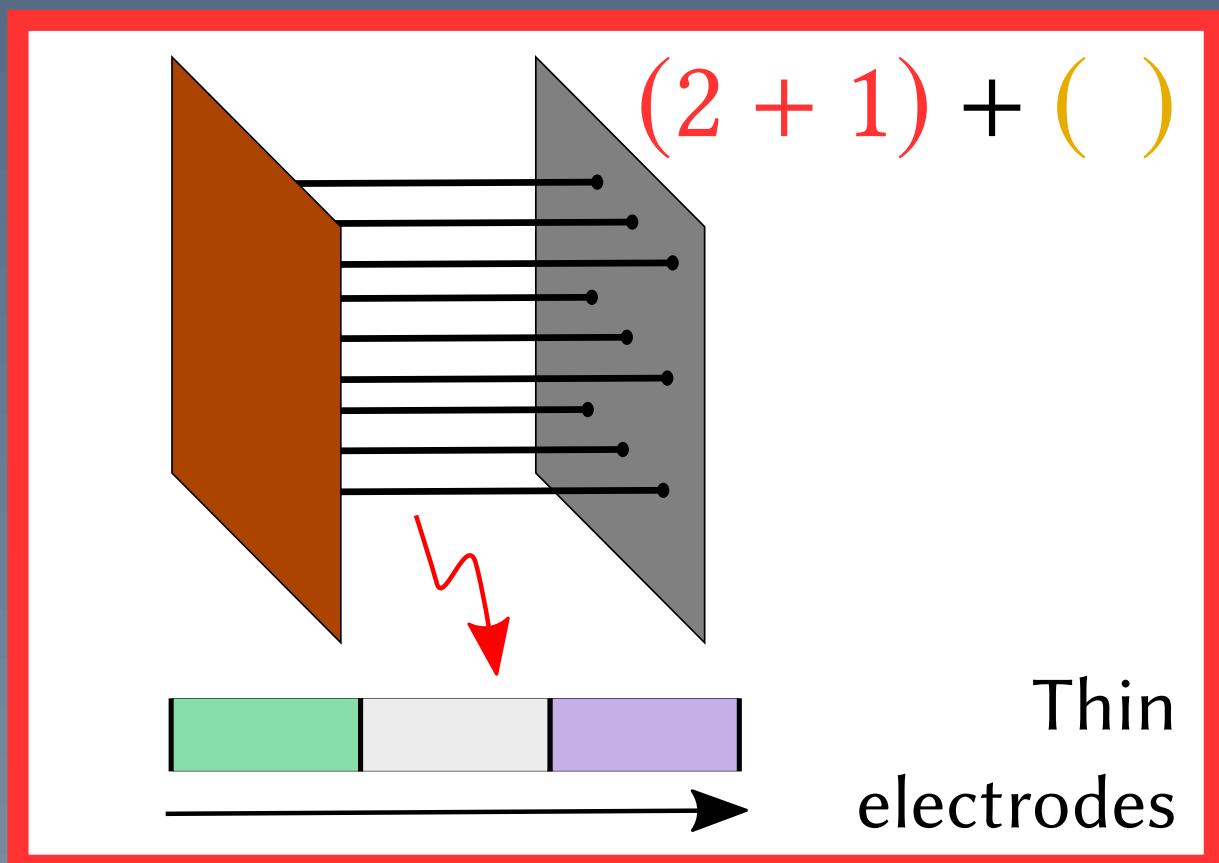
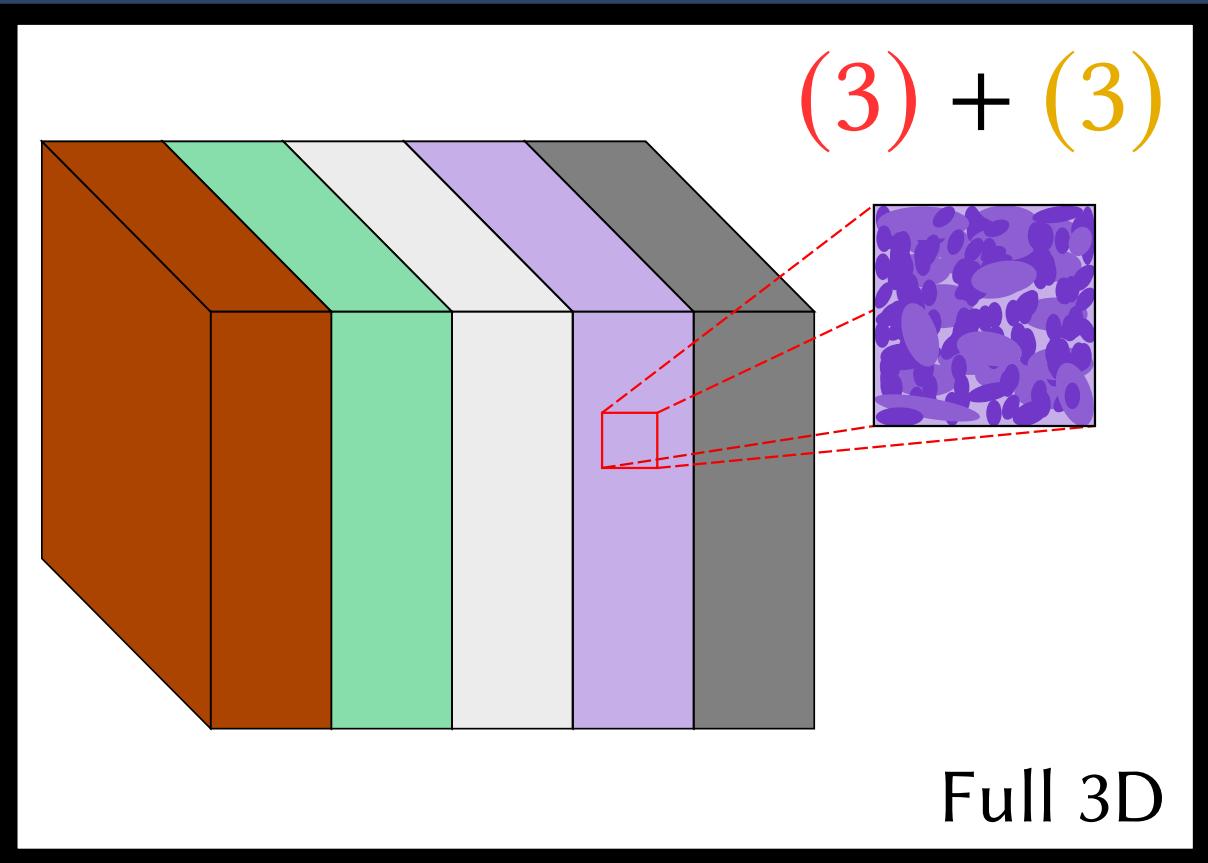
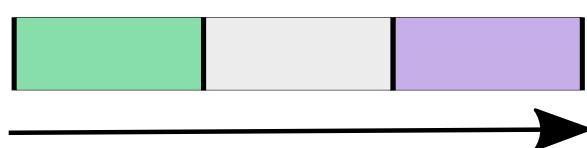
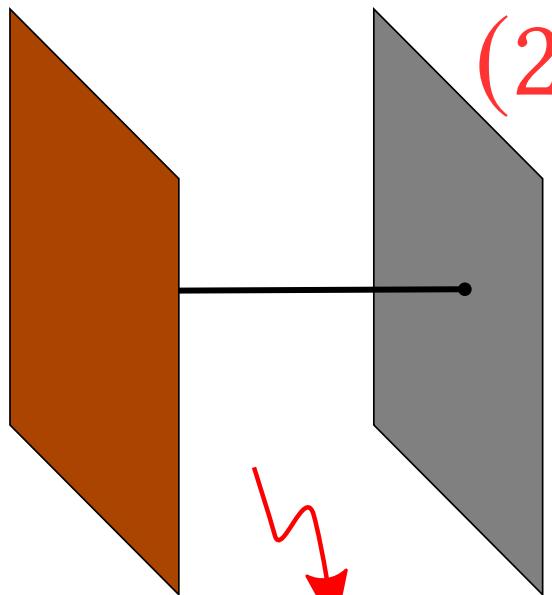


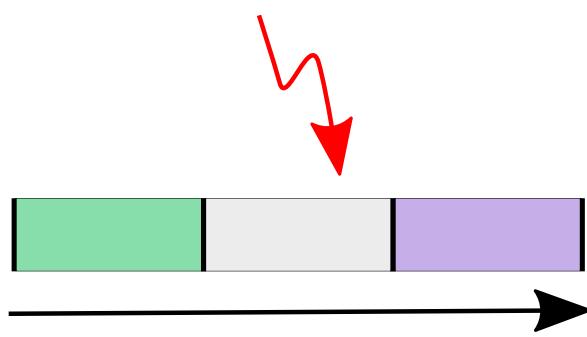


Electrochemical and equivalently expensive and the physics-based models, which design. Combinations of simplicity can be selected to best which is independent of chemical degradation mechanisms. We



$(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.



Engineering and Physical Sciences
Research Council

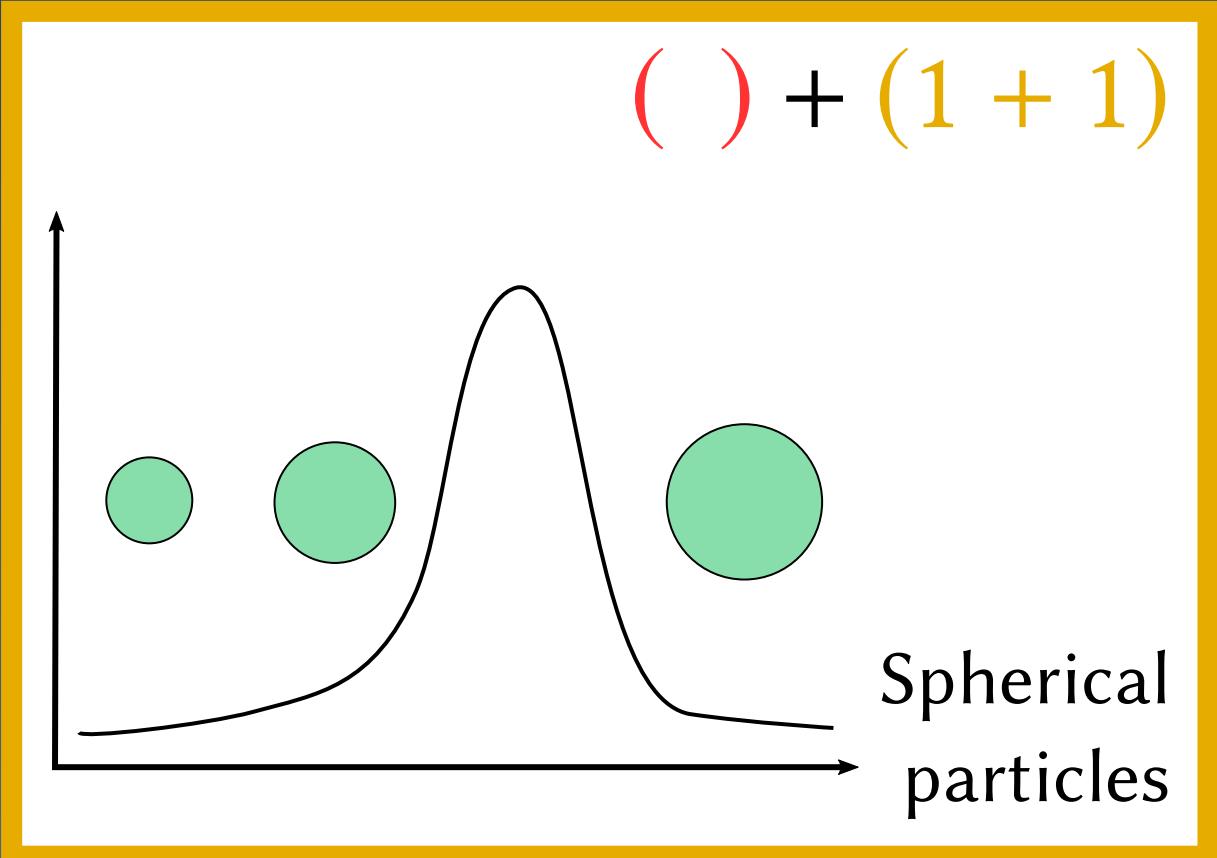


An Asymptotic for Battery

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 provide a useful theoretical middle ground. Both approaches have their own qualifications to the **macroscale** and **microscale**. In this paper we propose a new approach that can best meet the user's needs. The approach is based on a combination of asymptotic methods and chemistry, and can be extended to incorporate more complex phenomena. The results presented here are currently developing the software package.

() + (1 + 1)

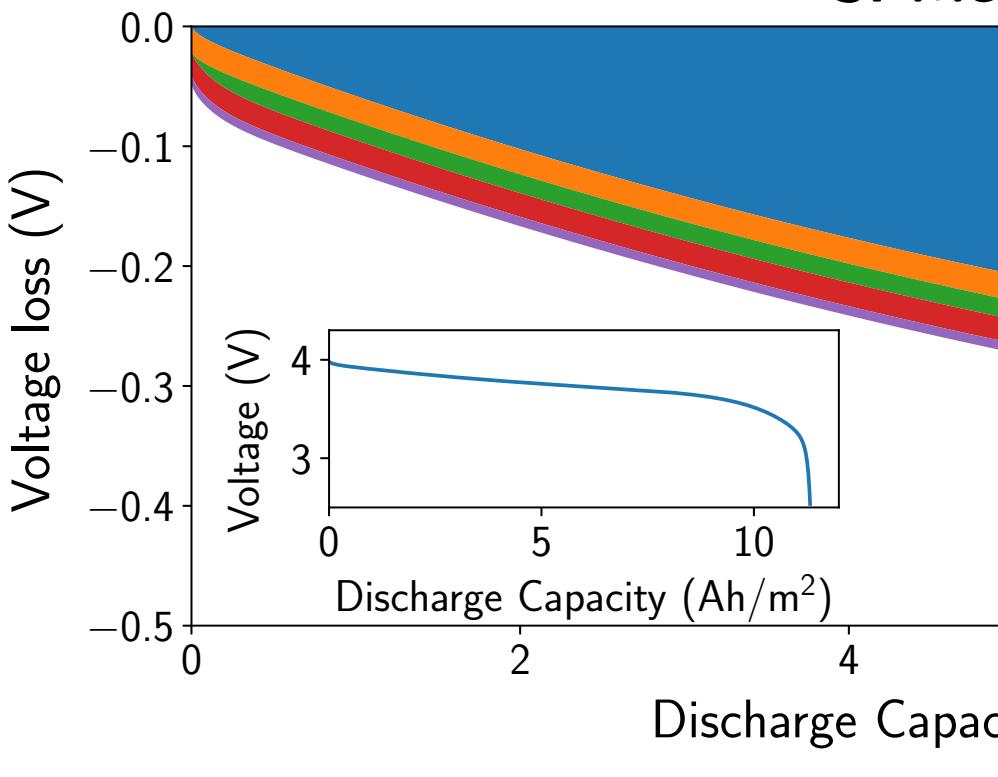


Complex

+



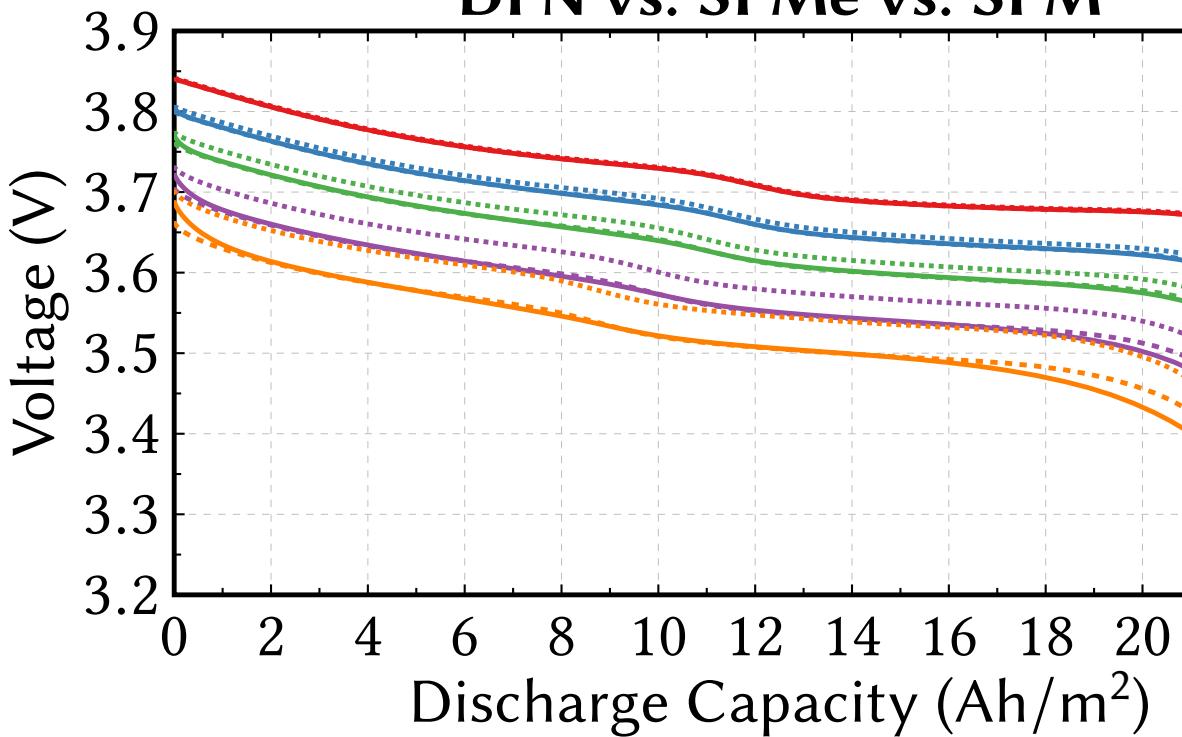
Complex



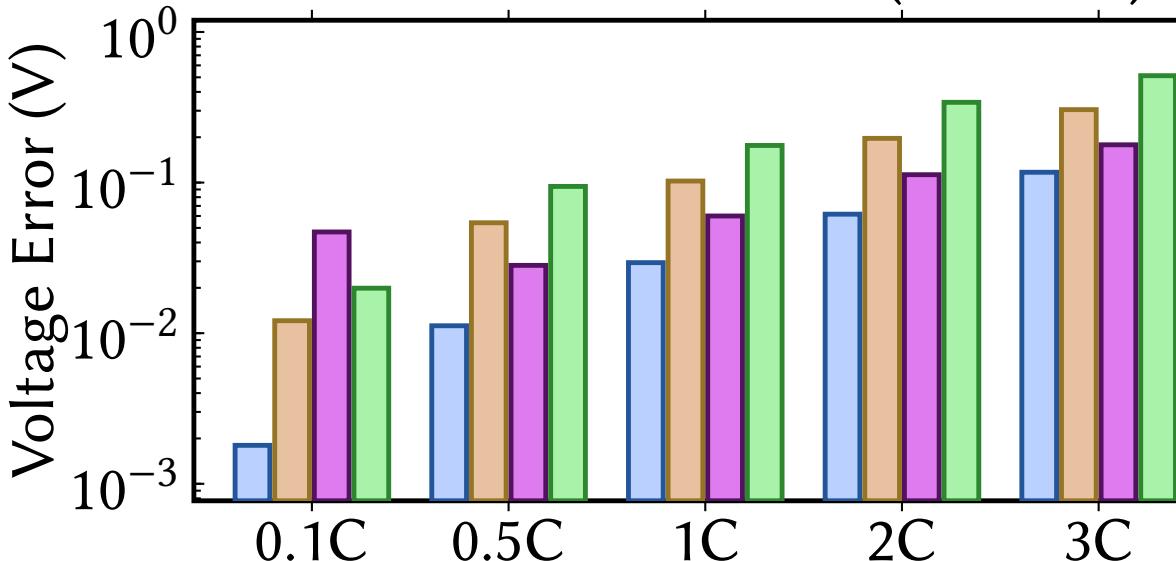
MACROSCALE

Lithium Cobalt Oxide

DFN vs. SPMe vs. SPM



Versions of the SPMe (vs. DFN)

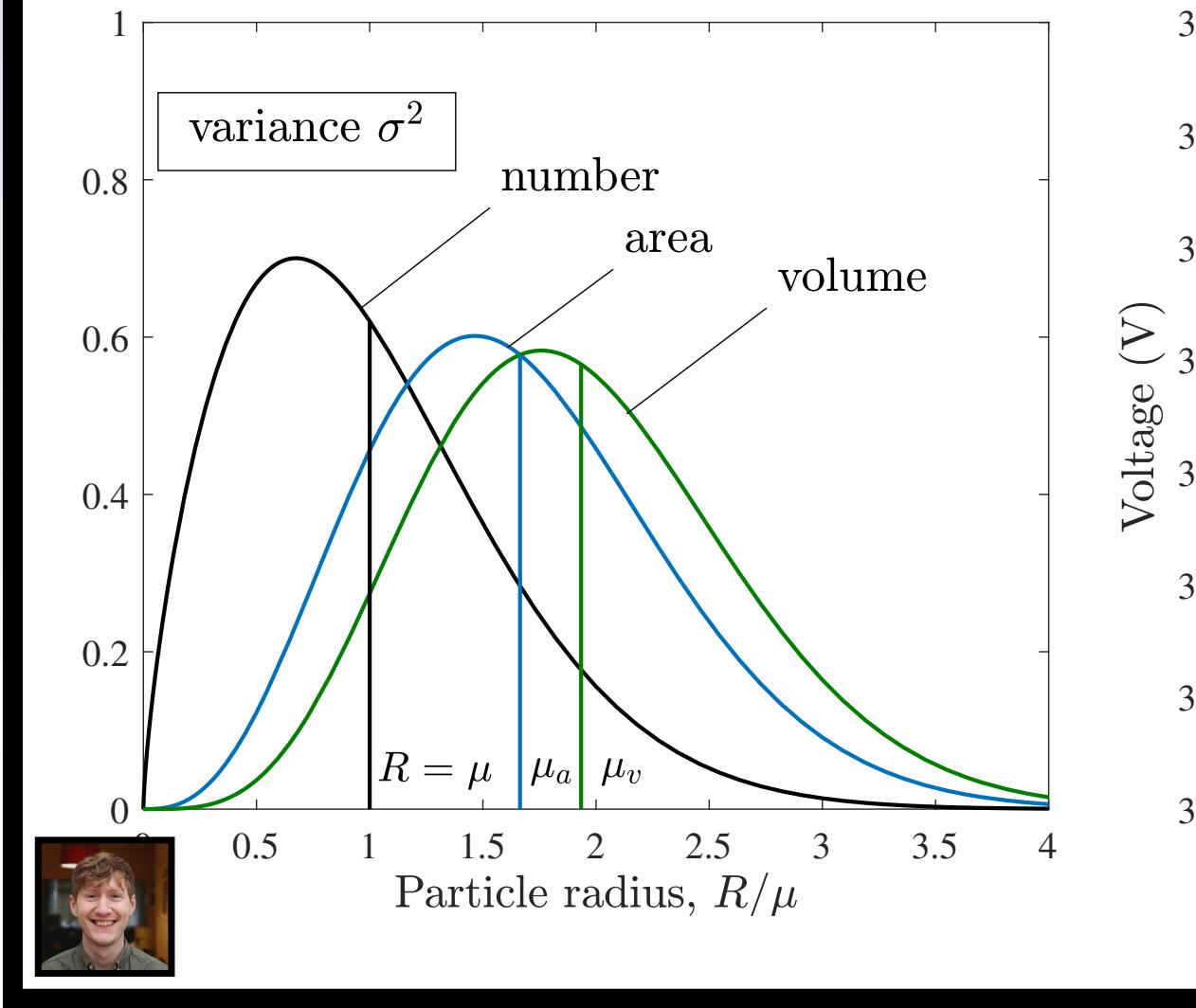


DPM

Distributed Particle Model

Lithium Cobalt Oxide

Simple



y, and C.W. Monroe. Faster Lead-Acid Battery Simulations from Porous Media Models. *J. Comput. Phys.*, 340:1–16, 2017.
R. Wetton. Asymptotic reduction of a porous electrode model for lithium-ion batteries. *SIAM J. Appl. Math.*, 77(3):1030–1052, 2017.

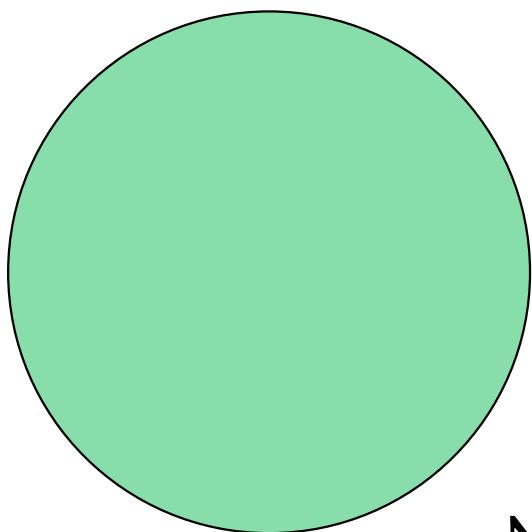


ic Framework Modelling

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

popular approaches to battery simulation. Through asymptotic analysis, we systematically reduce the number of variables required to support battery management, which can scale result in a suite of reduced-order models. This provides a general framework for developing additional physical effects such as mechanical behaviour. We have developed a package PyBaMM to implement the submodels and solve the resulting system of differential equations.

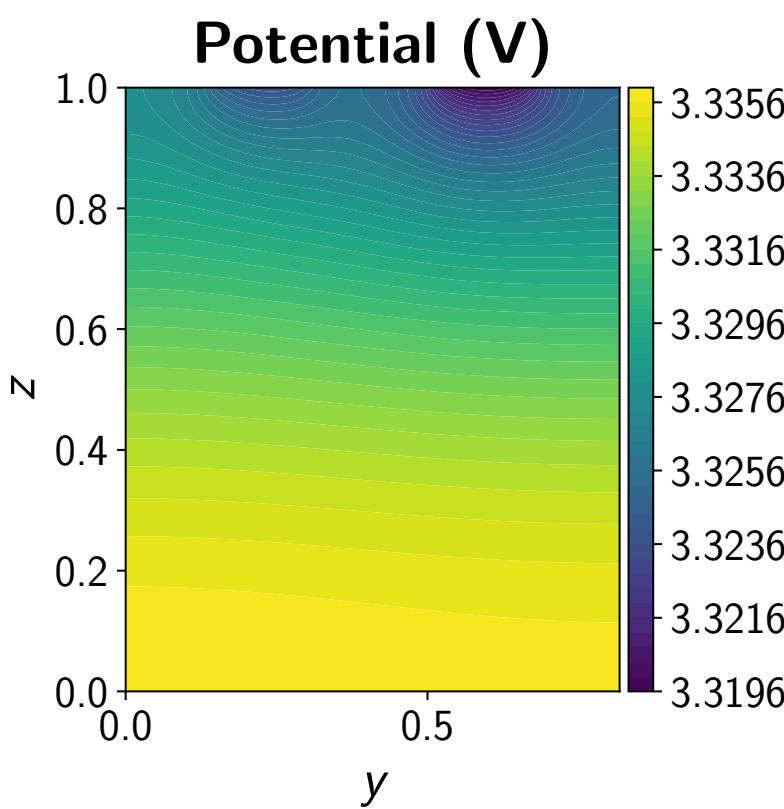
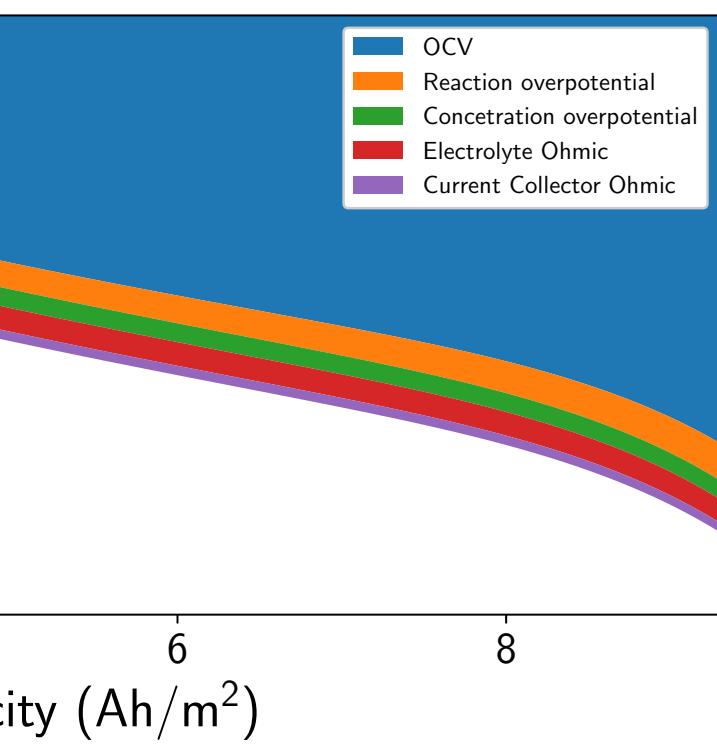
() + (1)

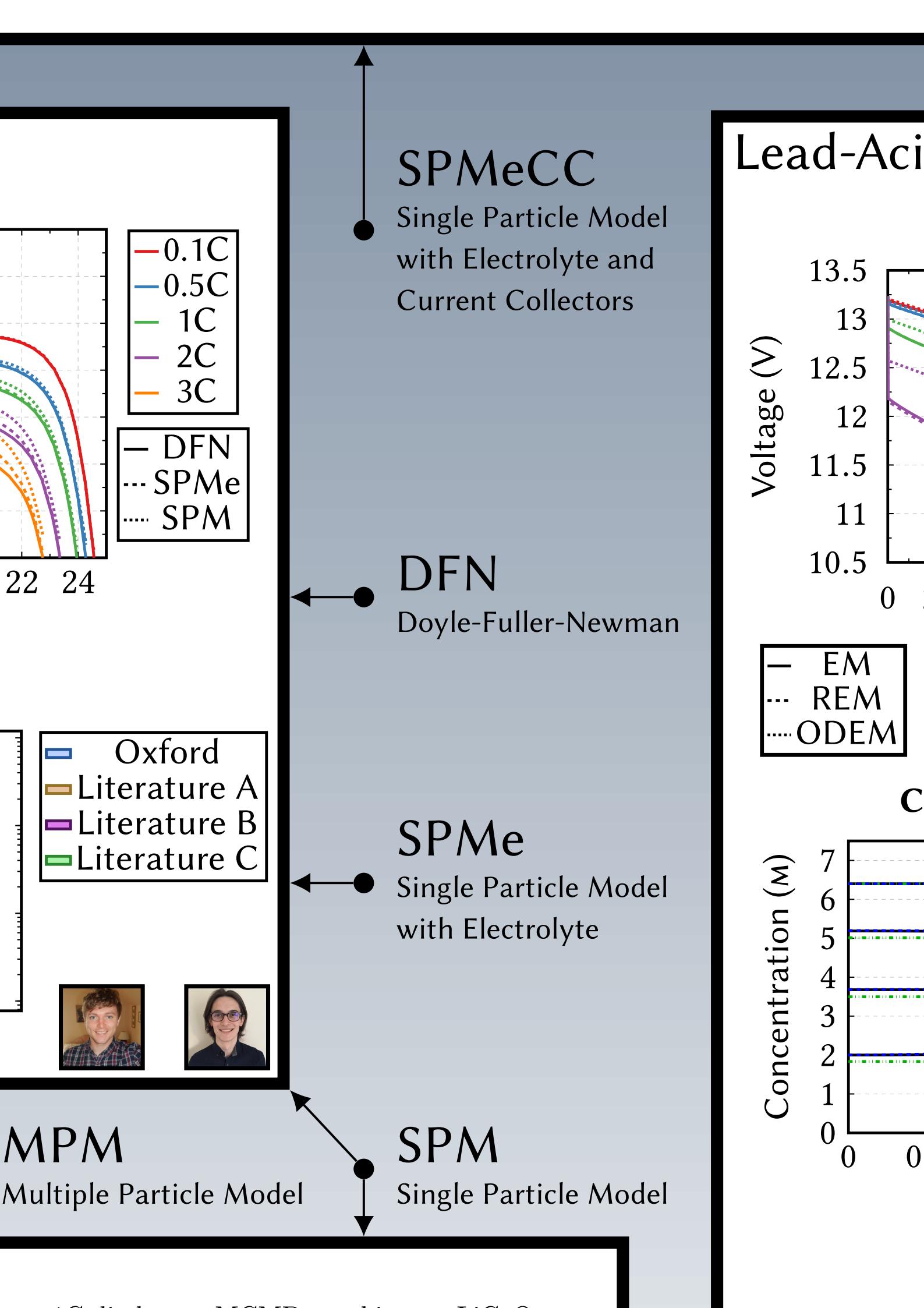


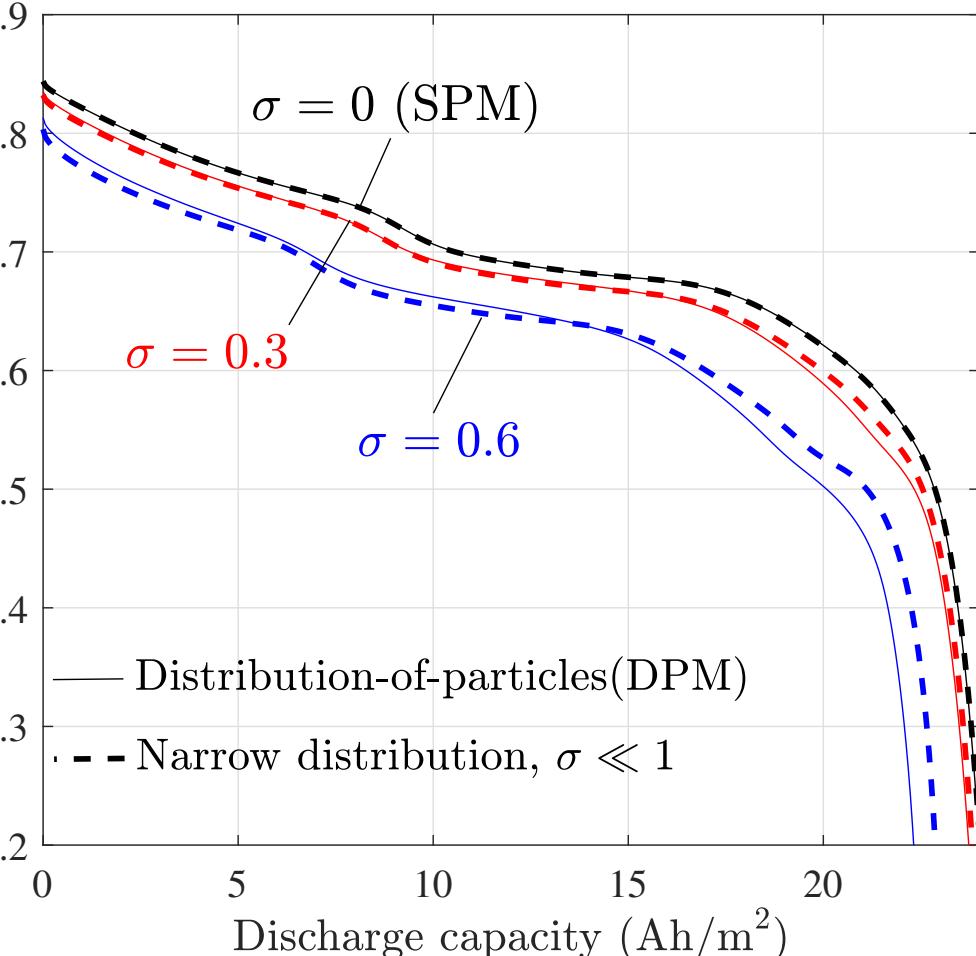
Narrow particle
distribution

MICROSCALE

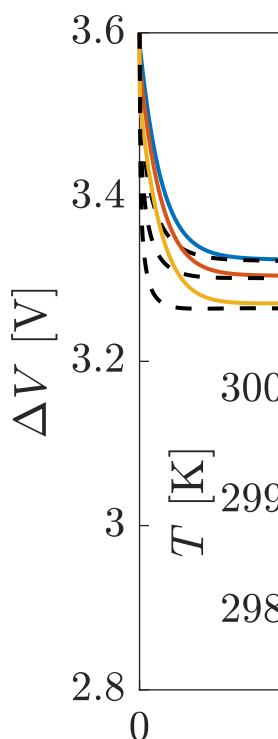
CC







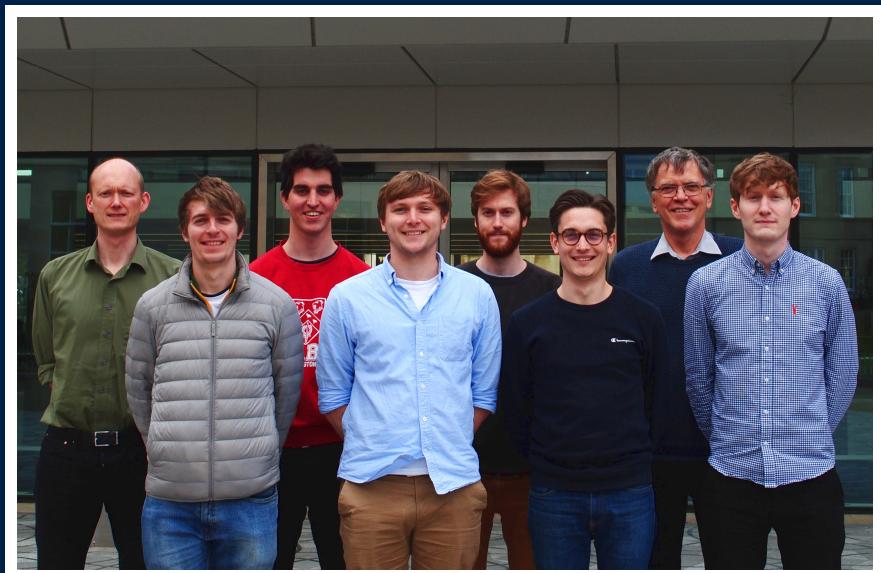
Lithium



Electrode Theory: II. Asymptotic Analysis. *Submitted*, 2019. *arXiv preprint arXiv:1805.07099*
 hium-ion batteries. *Submitted*, 2018. *arXiv preprint arXiv:1805.07099*

SIEMENS

nexeo



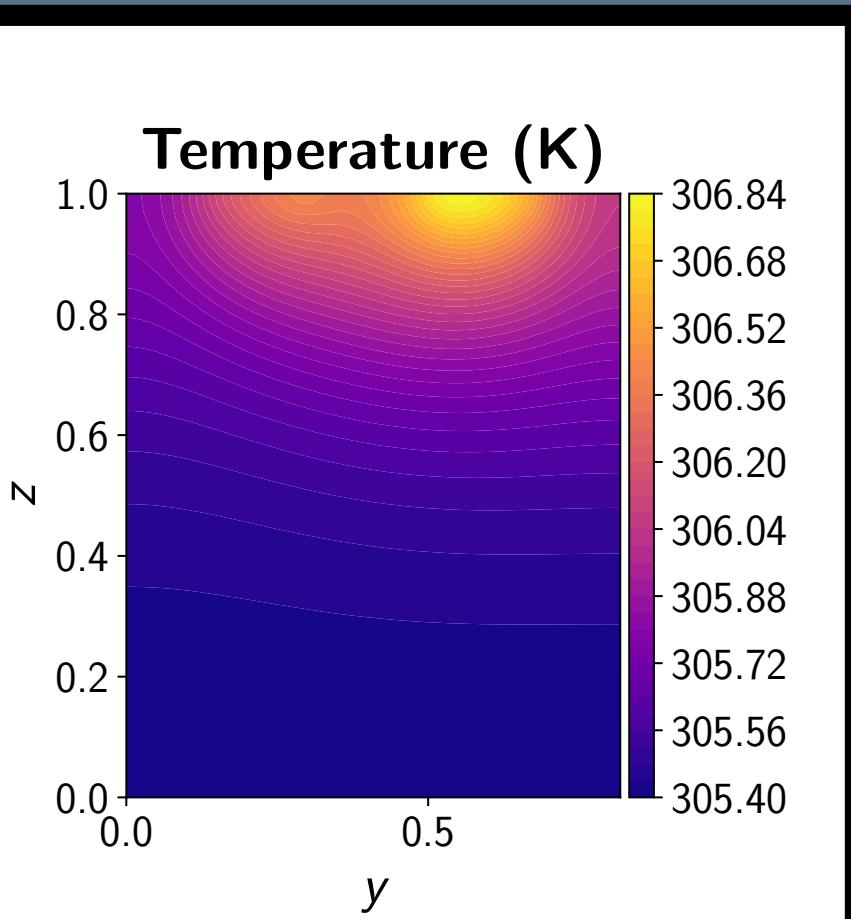
on, but the former is computationally more expensive. We systematically derive simplified models for the simulation of complex systems, such as on-line diagnostics, and cell models, whose complexity and size are reduced by developing reduced-order models that capture the main features of the system. These models can be used to study the effect of different parameters on the system's behavior, without the need to solve the full set of differential equations. The reduced-order models can also be used to predict the system's response to different inputs, and to identify the most important variables that affect the system's behavior. This approach can be applied to a wide range of applications, such as chemical engineering, biotechnology, and materials science.

() + (0)



Fast diffusion
in particles

Simple

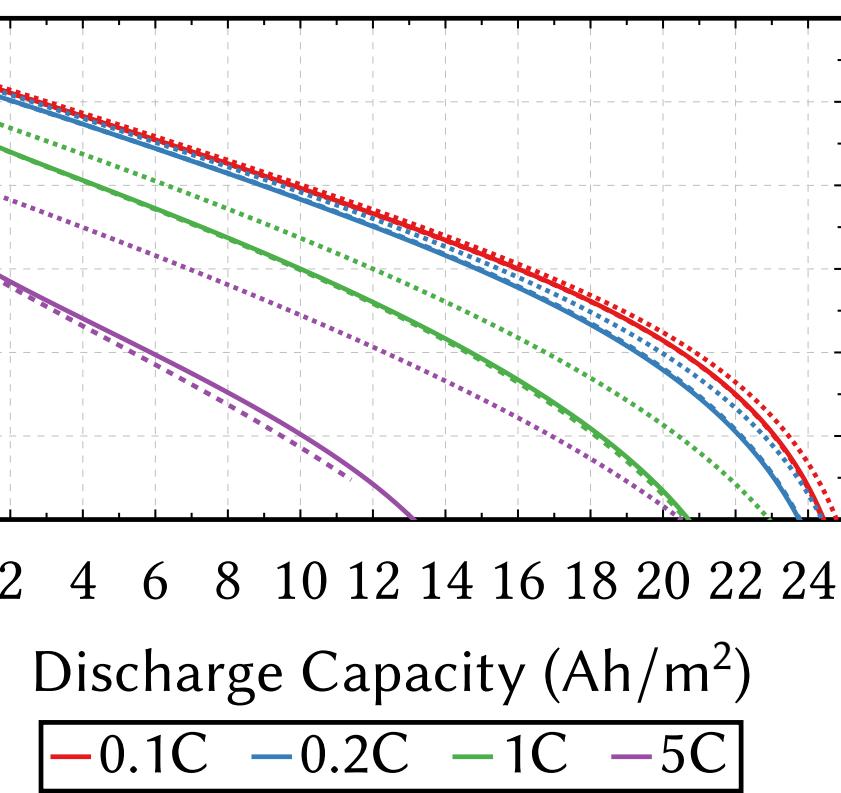


↔ ●
EPPM
Electrolyte
with
Potential
Pair Model

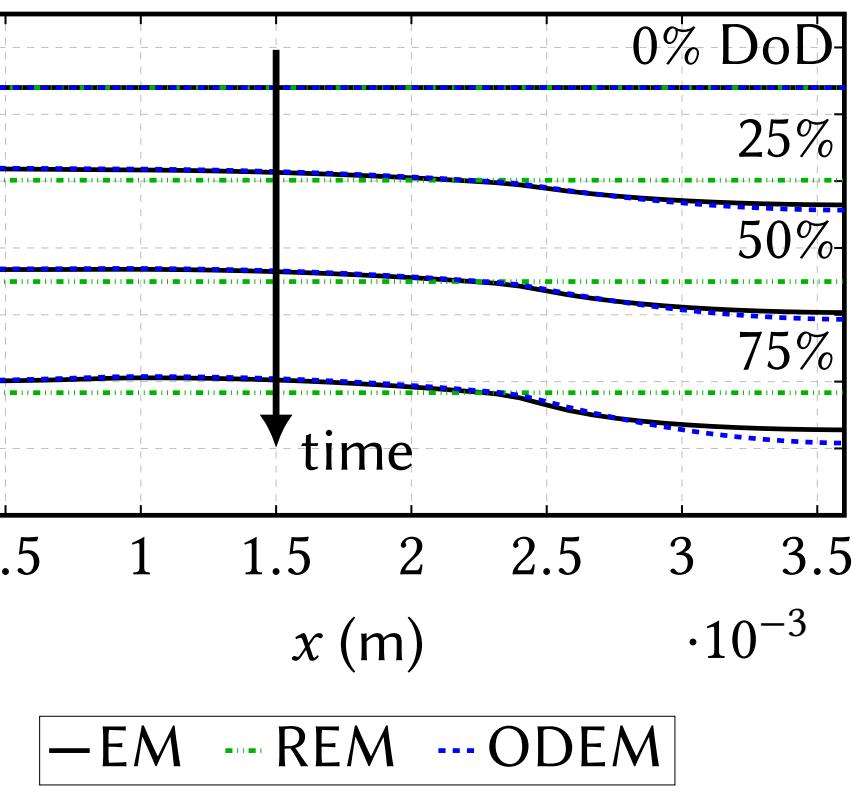
d



Lead-acid models



concentration change (0.5C)



ECCM

Electrolyte
with Current
Collectors
Model

EM

Electrolyte
Model

REM

Reduced
Electrolyte
Model

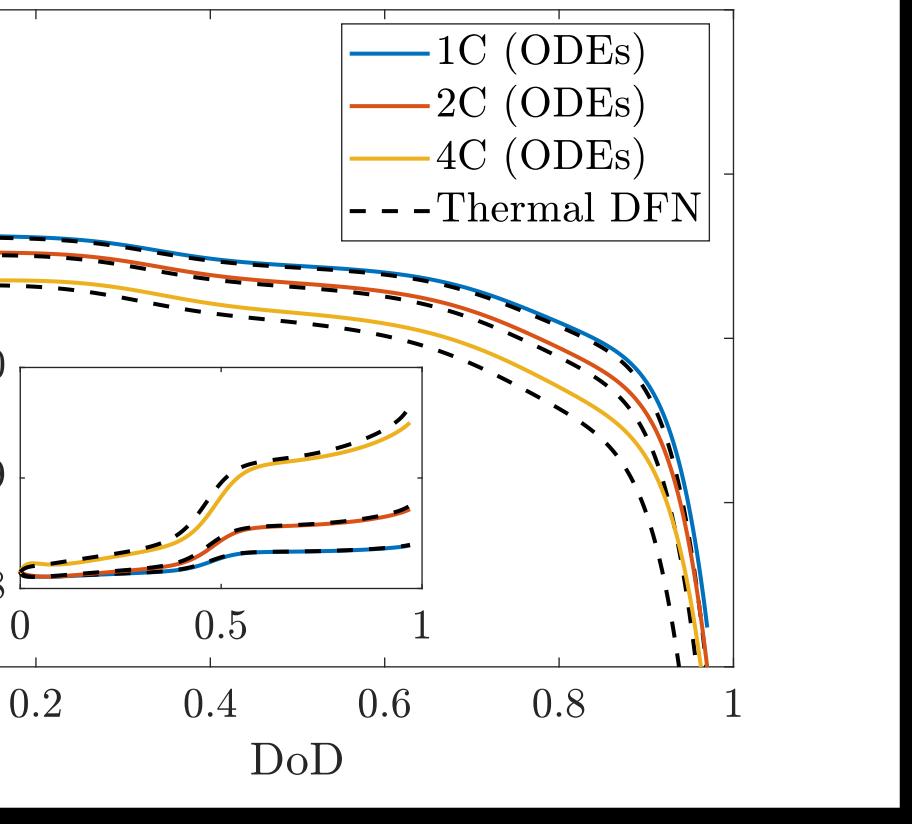
ODEM

Ordinary
Differential

Iron Phosphate



Differential Equation Model



arXiv preprint arXiv:1902.01774
v2



n