[PRX Quantum 4, 010312]

Counterdiabatic Optimised Local Driving
(COLD)

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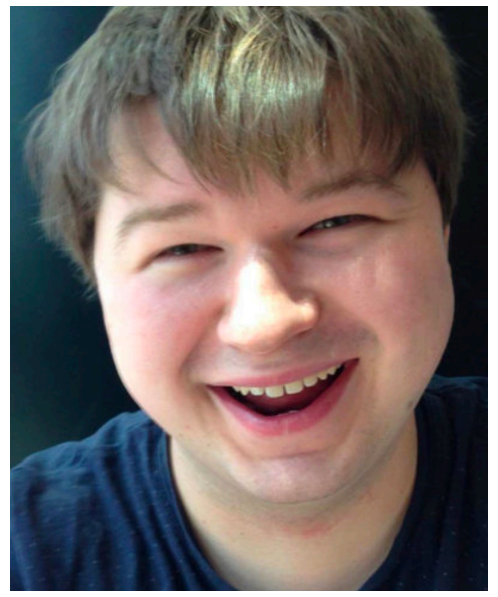
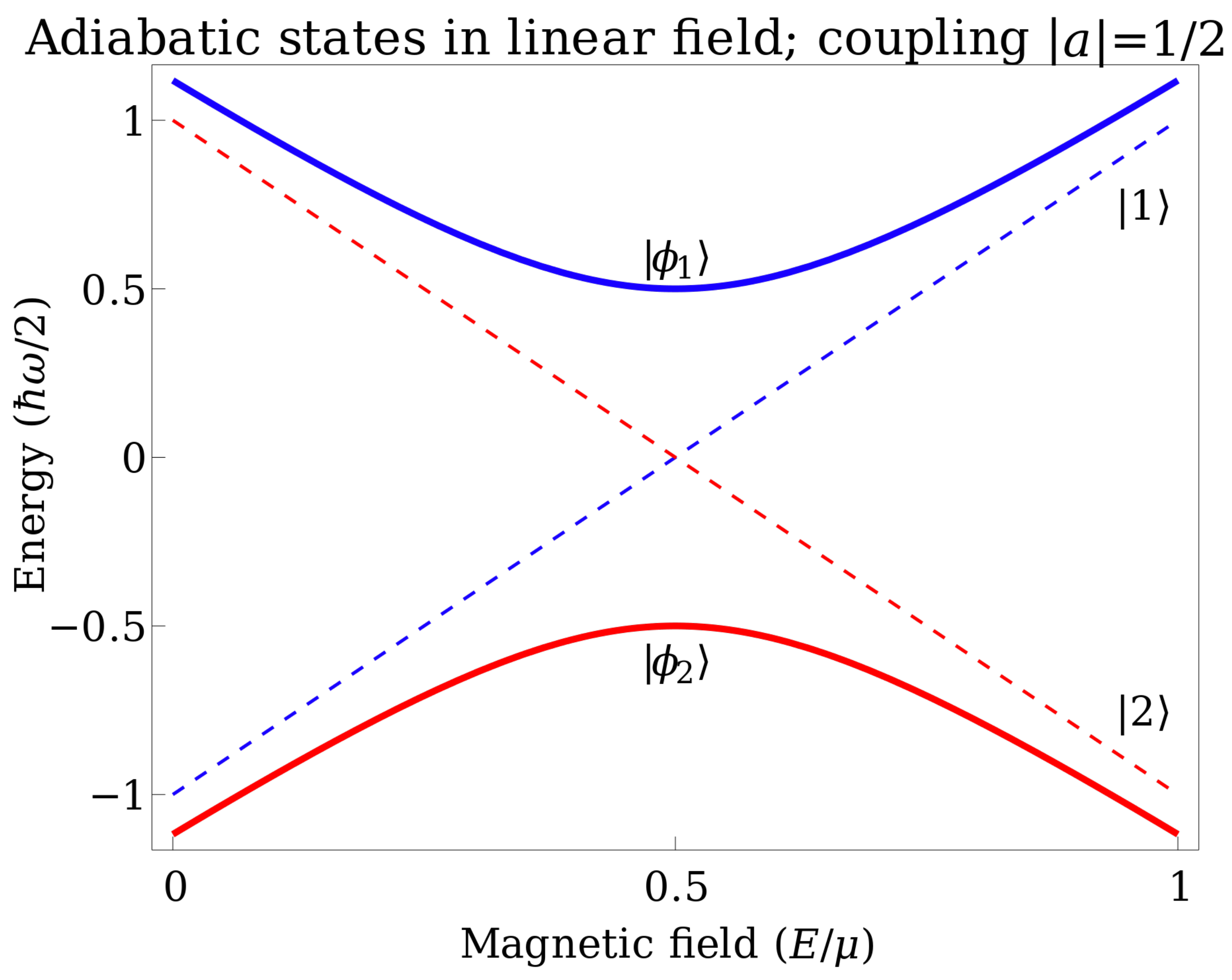



Adiabatic processes

- **Slowly** varying $H(\lambda)$ according to some $\lambda(t)$

    - System in eigenstate of $H(\lambda_0)$ $\xrightarrow{\text{(Adiabatic evolution)}}$ *corresponding* eigenstate of $H(\lambda_f)$ (**adiabatic theorem**)

- **Useful**: Adiabatic quantum computation, state preparation, quantum annealing…

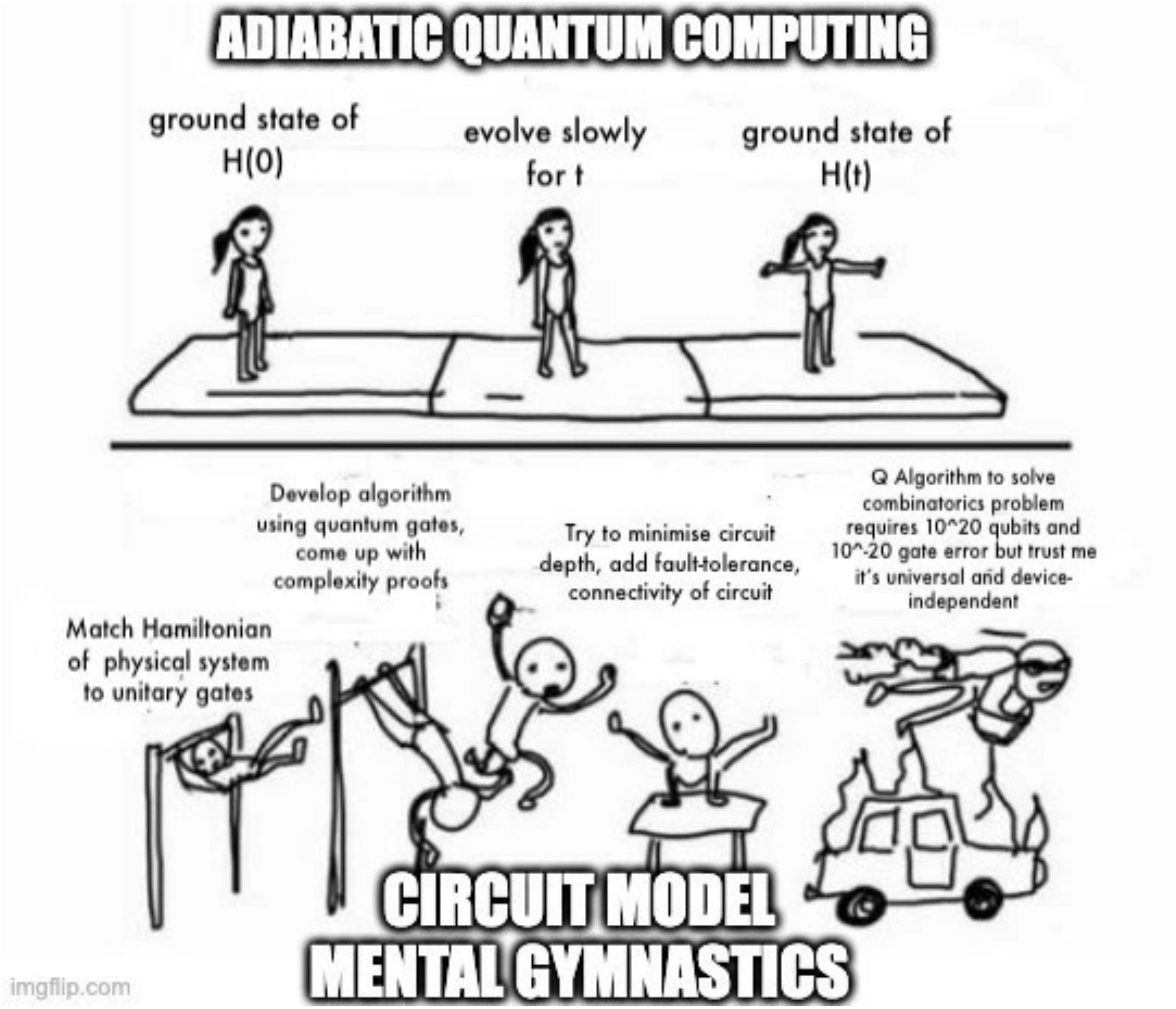


https://en.wikipedia.org/wiki/Adiabatic_theorem

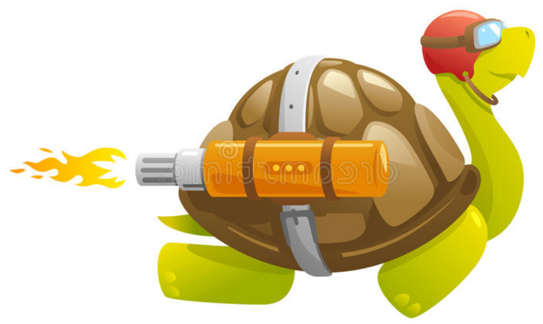
!

Trying to perform an adiabatic evolution **fast** leads to **losses**: transitions out of the required eigenstate

Adiabatic processes (extra motivation)

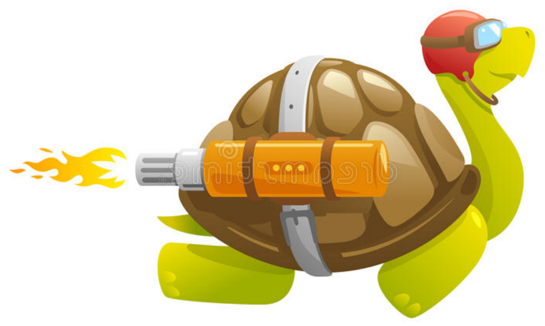


Speeding things up



- What do we want?

Speeding things up



- What do we want?
  - Adiabatic dynamics!

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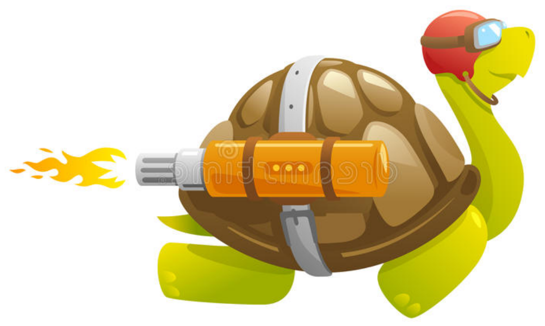

- What do we want?
    - Adiabatic dynamics!
- When do we want them?

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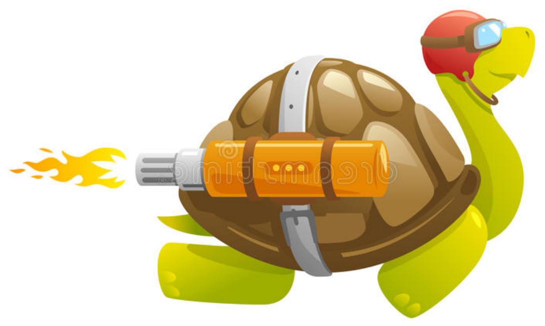

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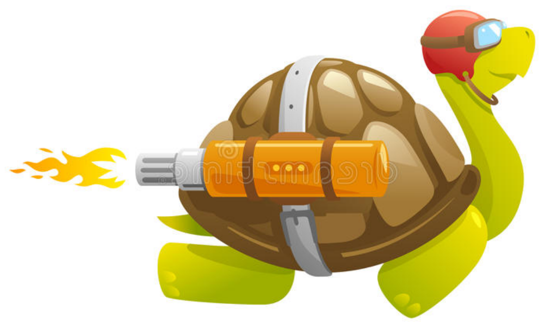

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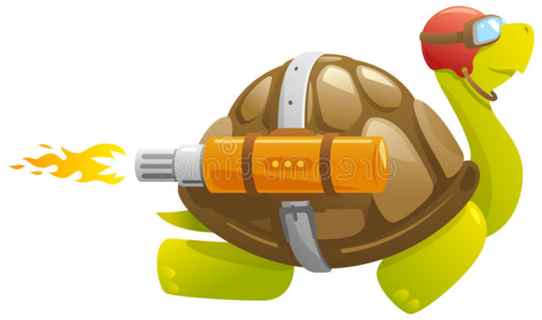

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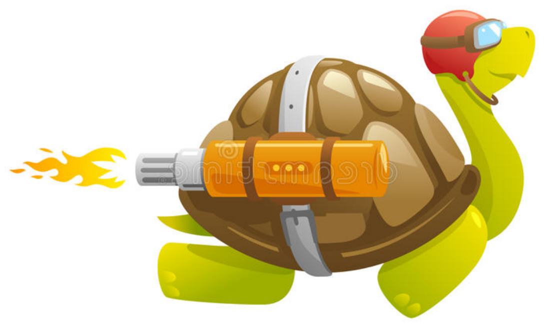
Shortcuts to adiabaticity

Rev. Mod. Phys. 91, 045001 (2019)

Optimal control methods

Eur. Phys. J. D 69, 1 (2015).

Speeding things up



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Shortcuts to adiabaticity

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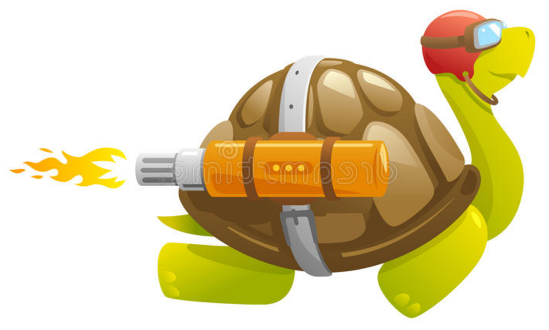
Local counterdiabatic driving

PNAS 114, E3909 (2017)

Optimal control methods

Speeding things up



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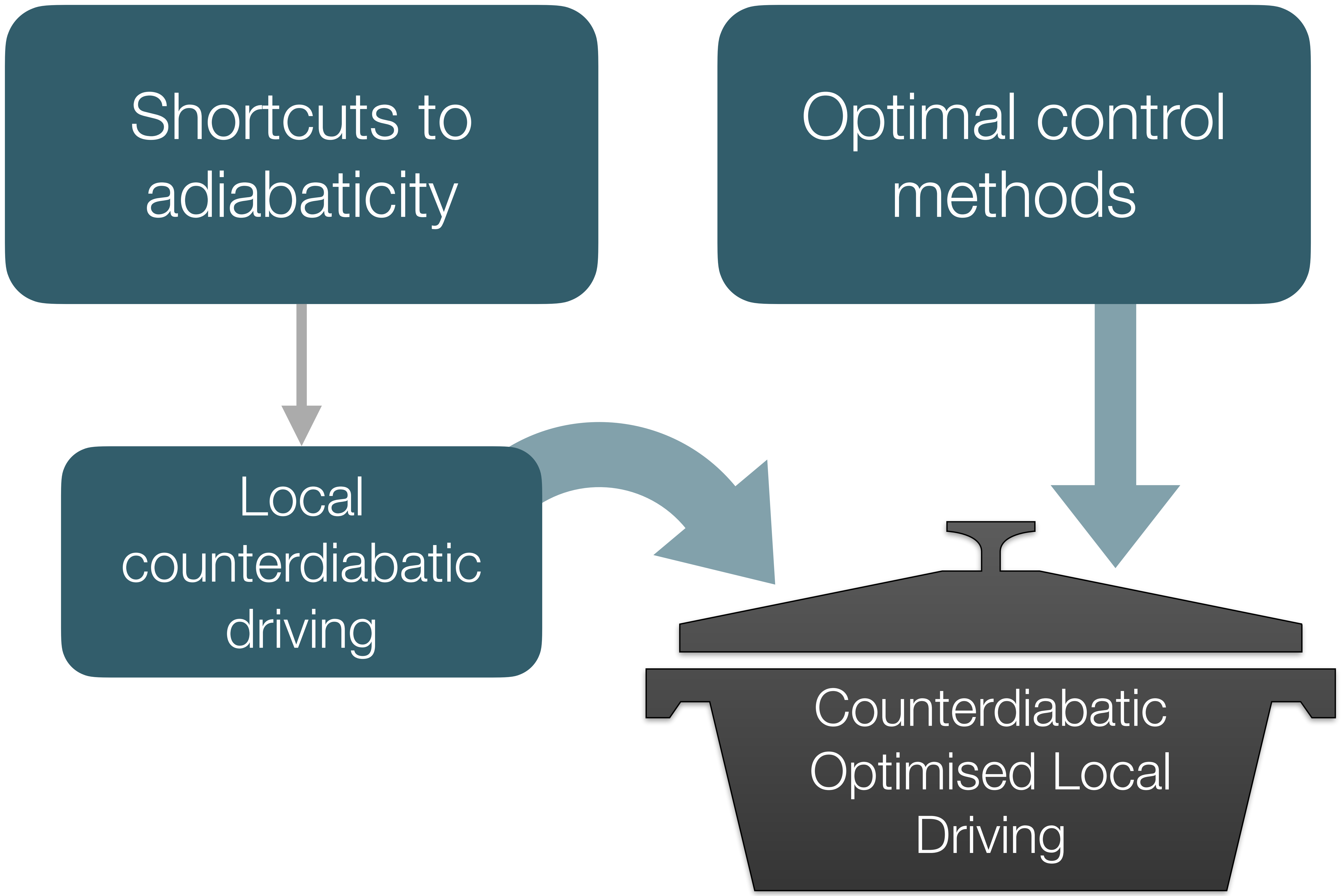

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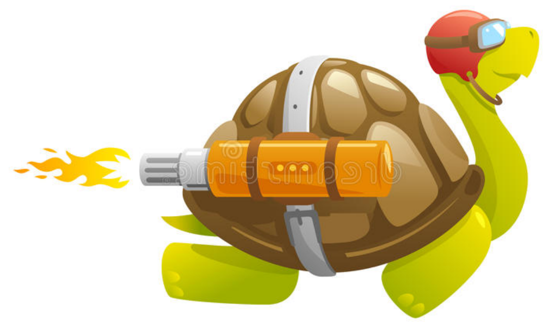

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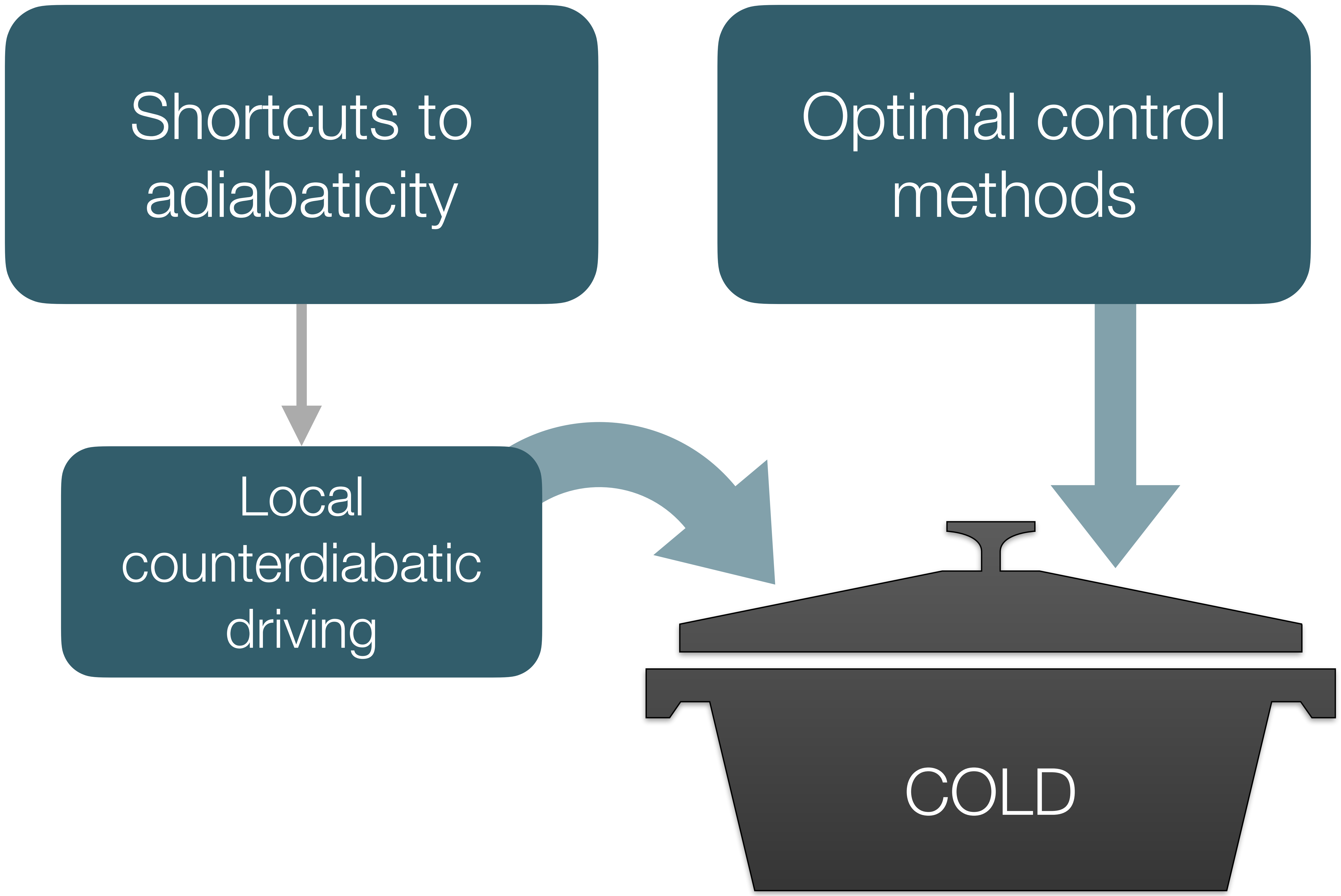

Counterdiabatic optimised local driving (COLD)

1. Start with adiabatic protocol: $H(\lambda)$

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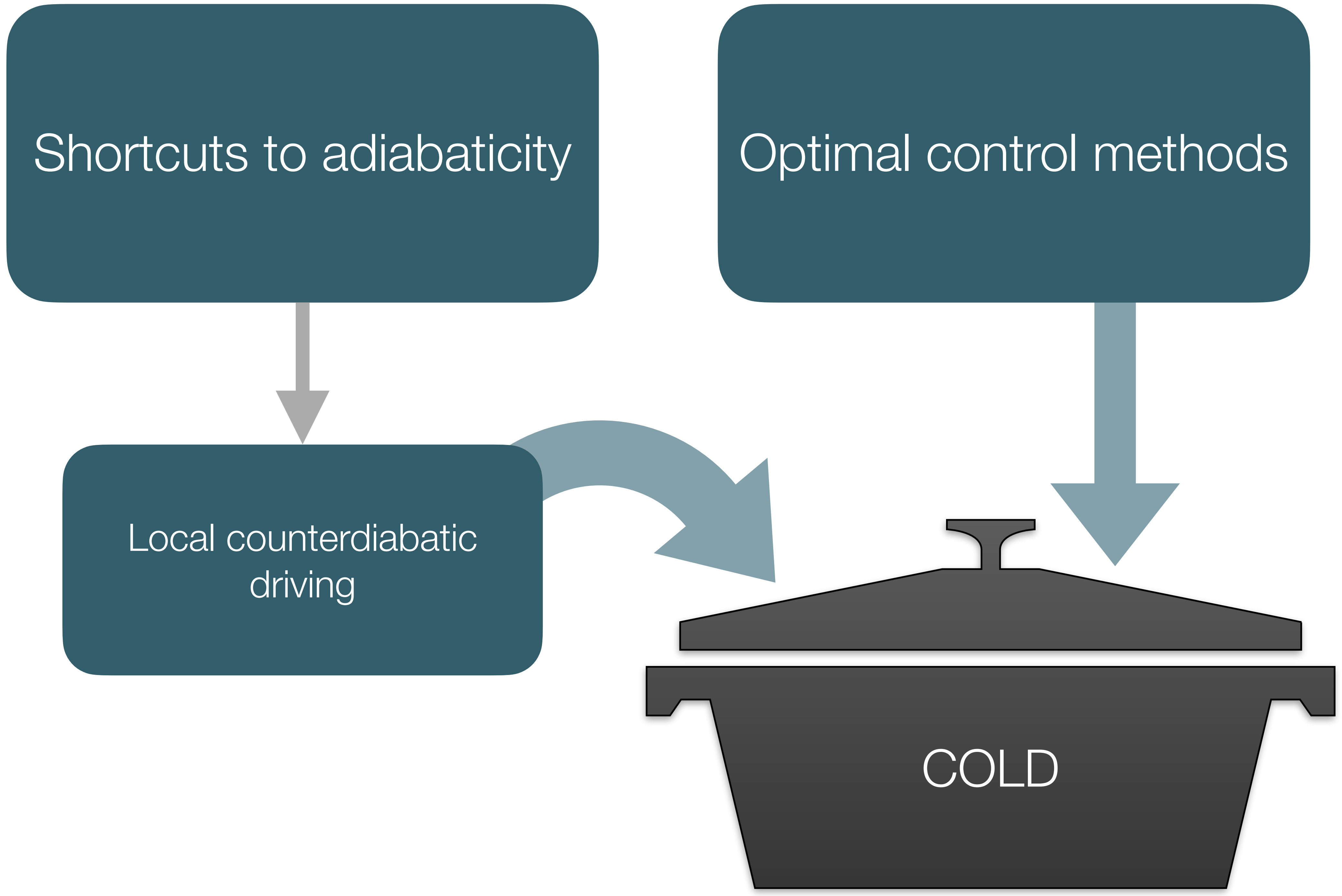
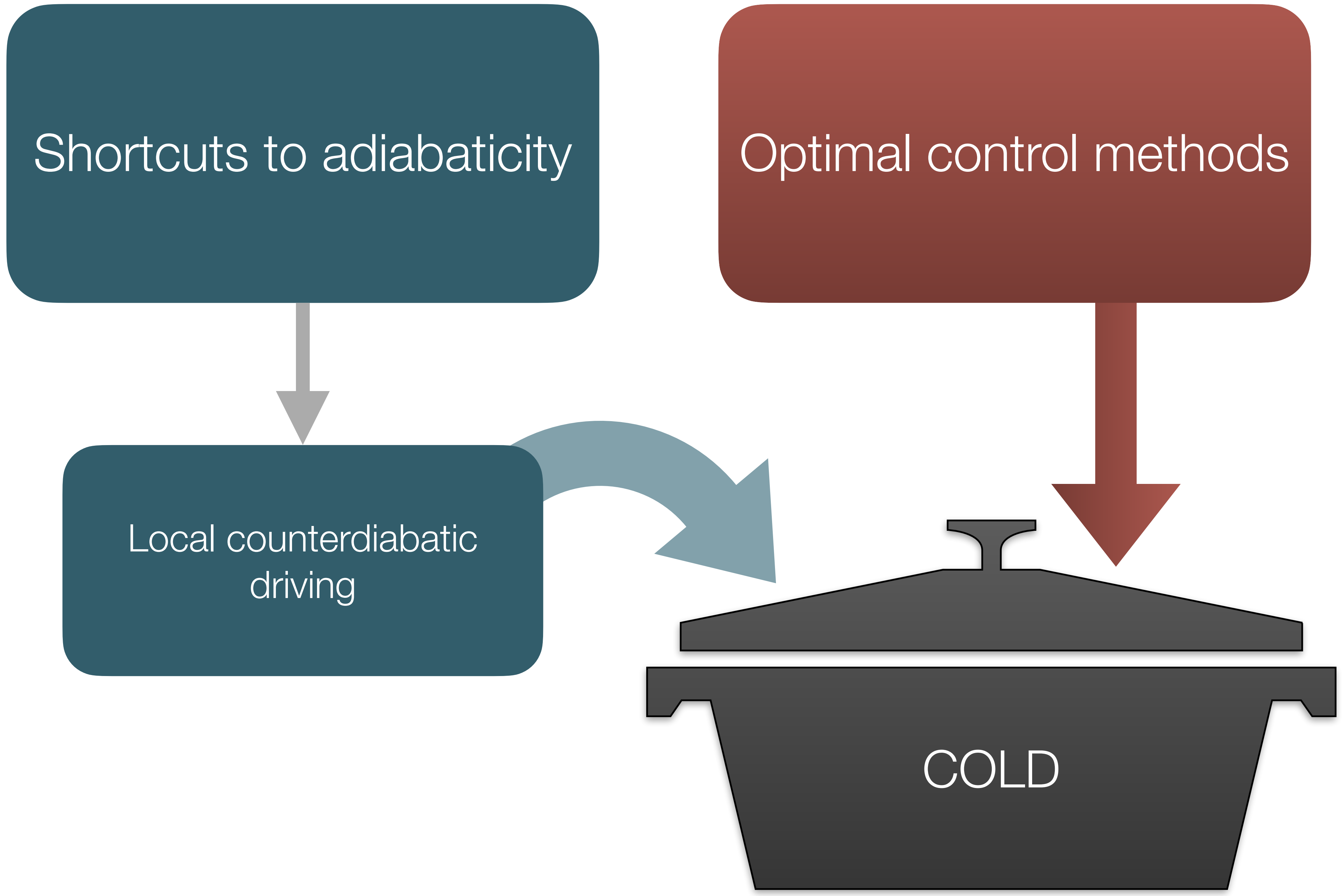


Counterdiabatic optimised local driving (COLD)

1. Start with adiabatic protocol: $H(\lambda)$

2. Add control pulse:

$$H_\beta(\lambda, \beta) = H(\lambda) + \beta \mathcal{O}_{\text{opt}}$$



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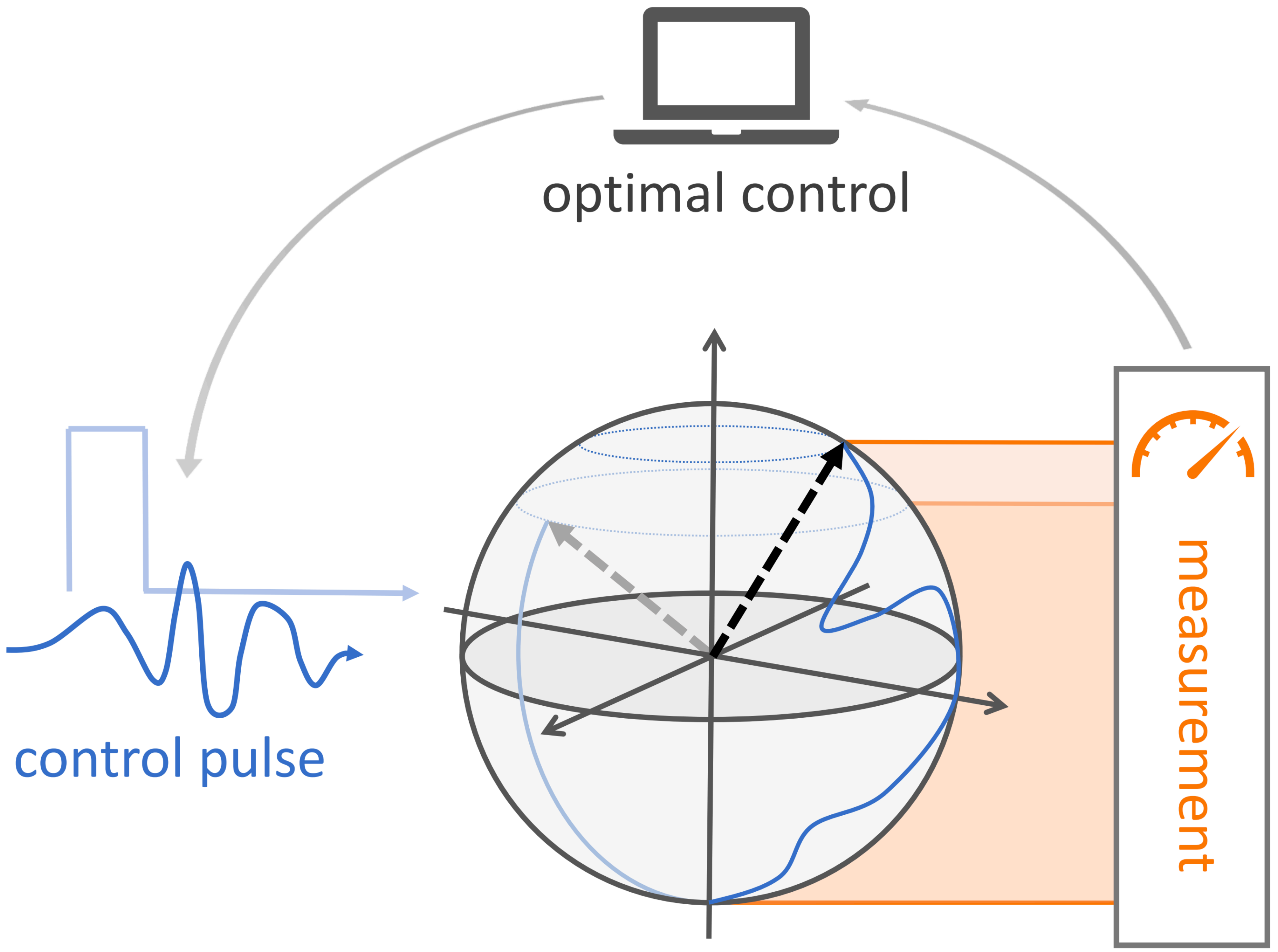

https://qusco-itn.eu/2020/06/19/intro_nvc/

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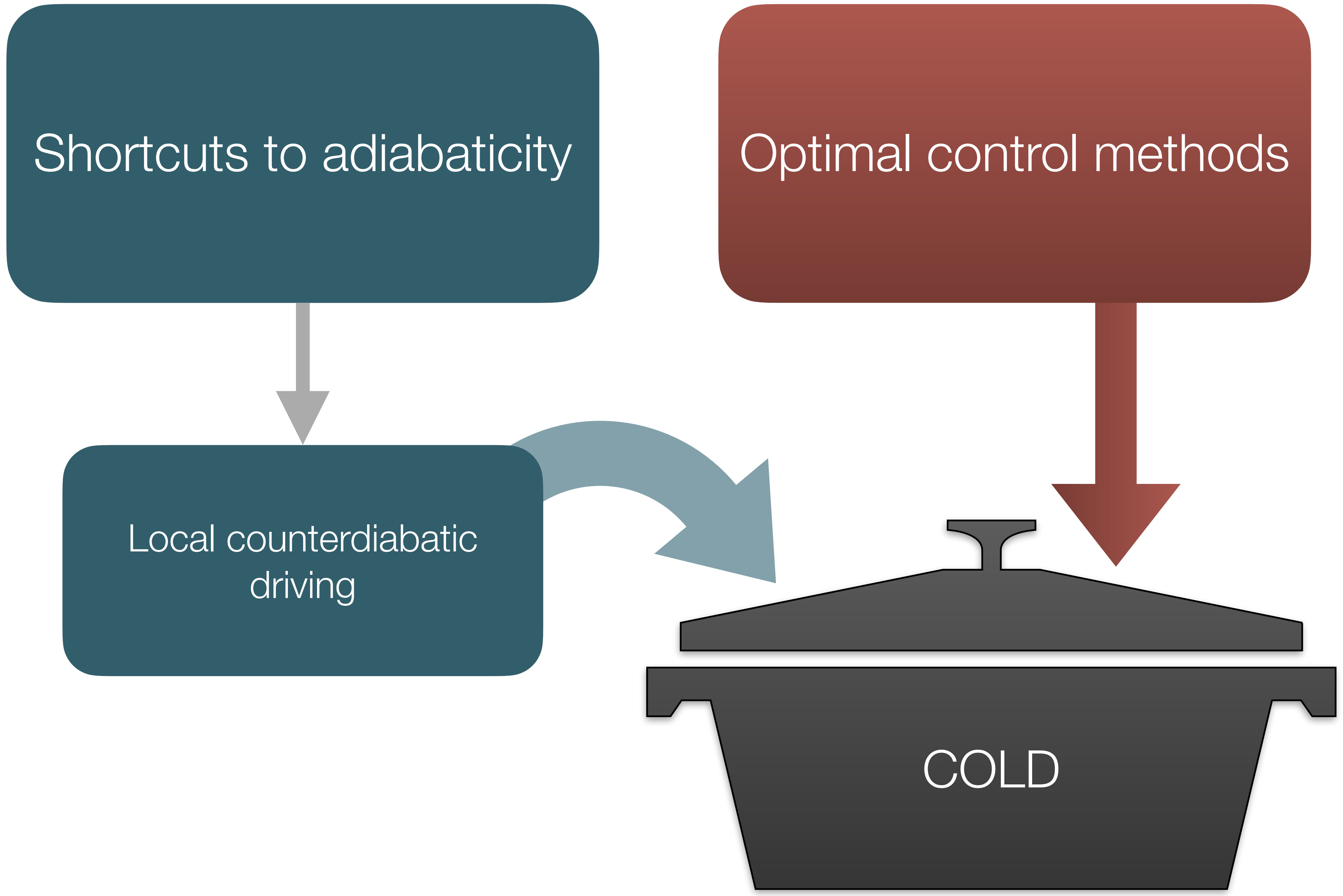

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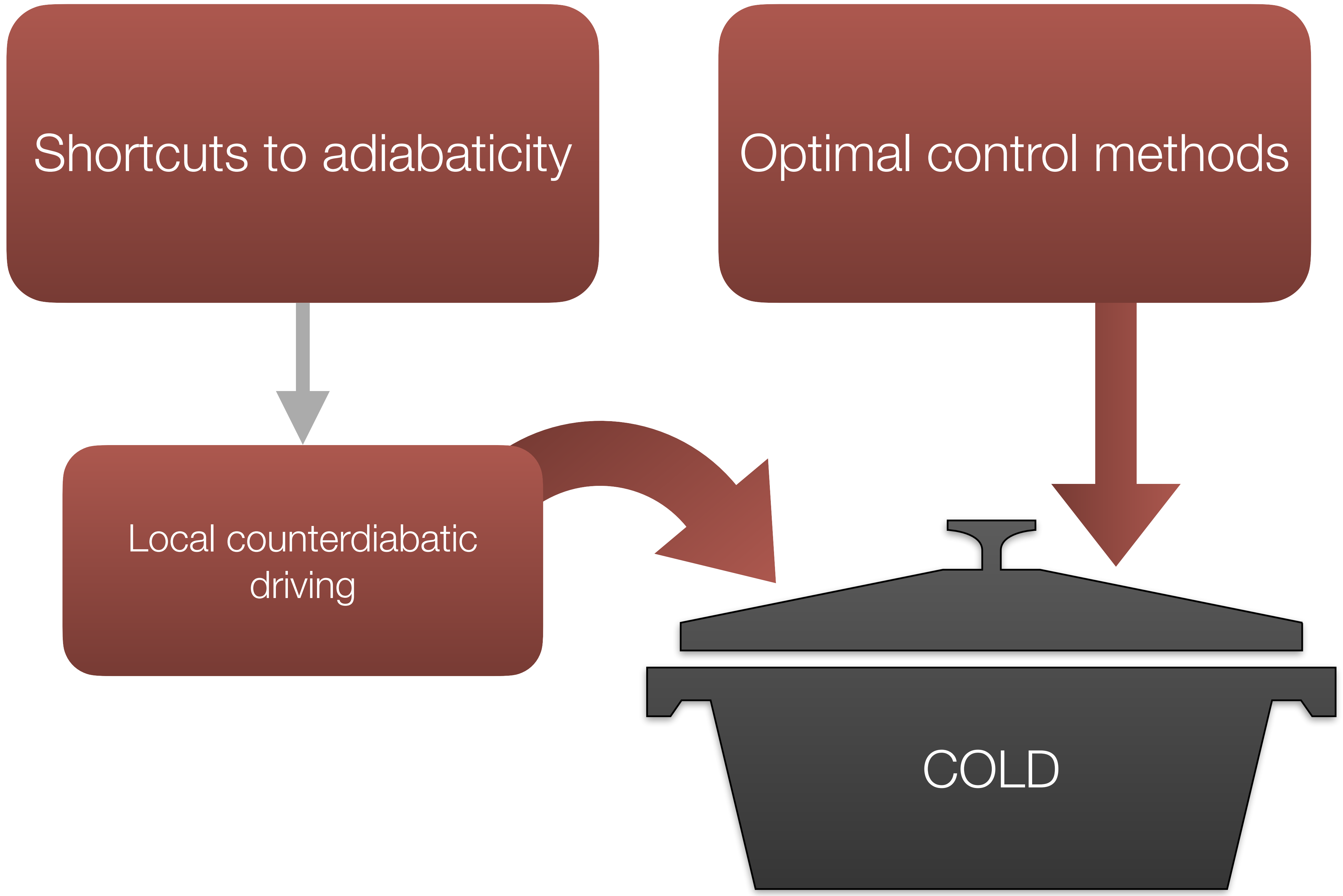

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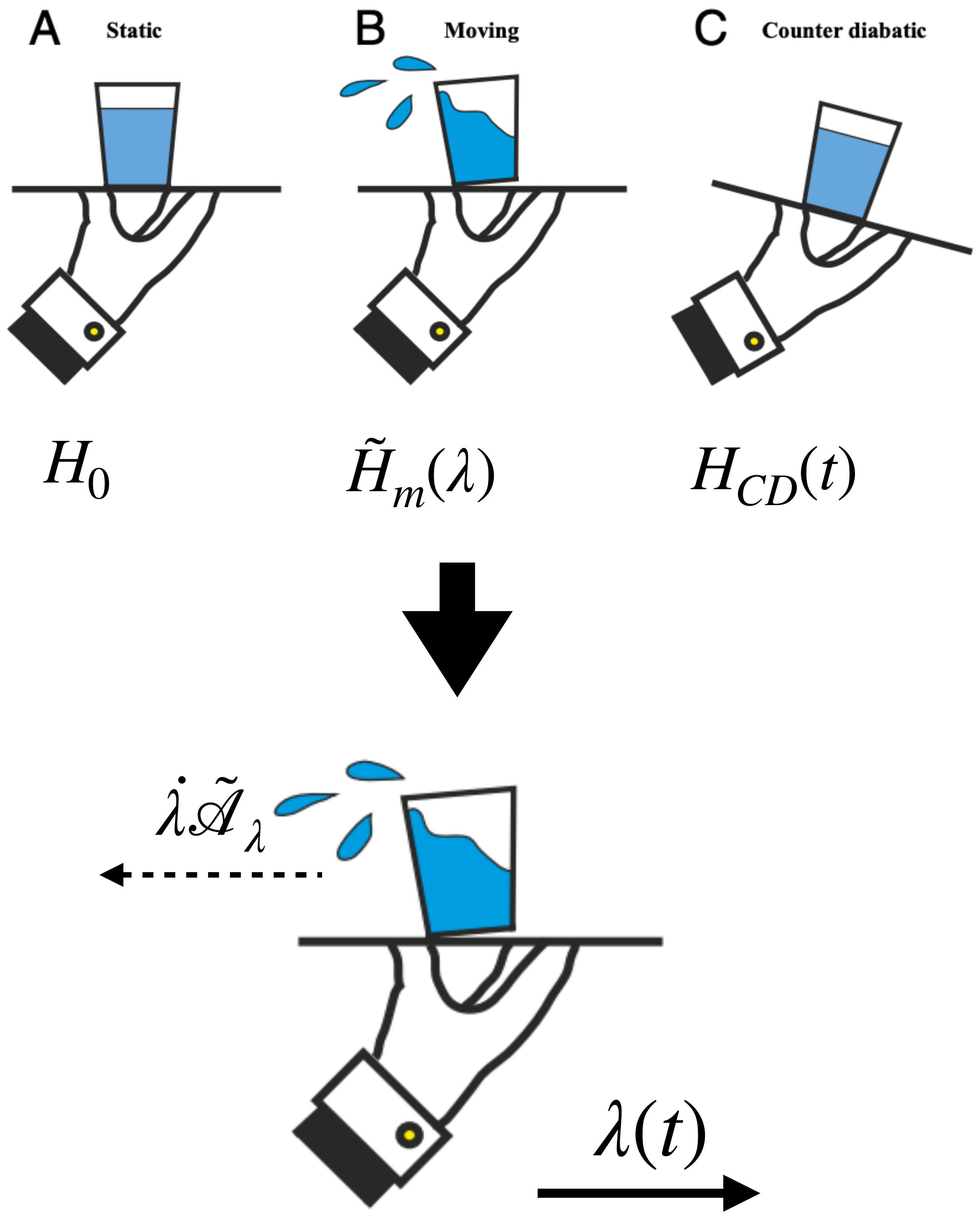

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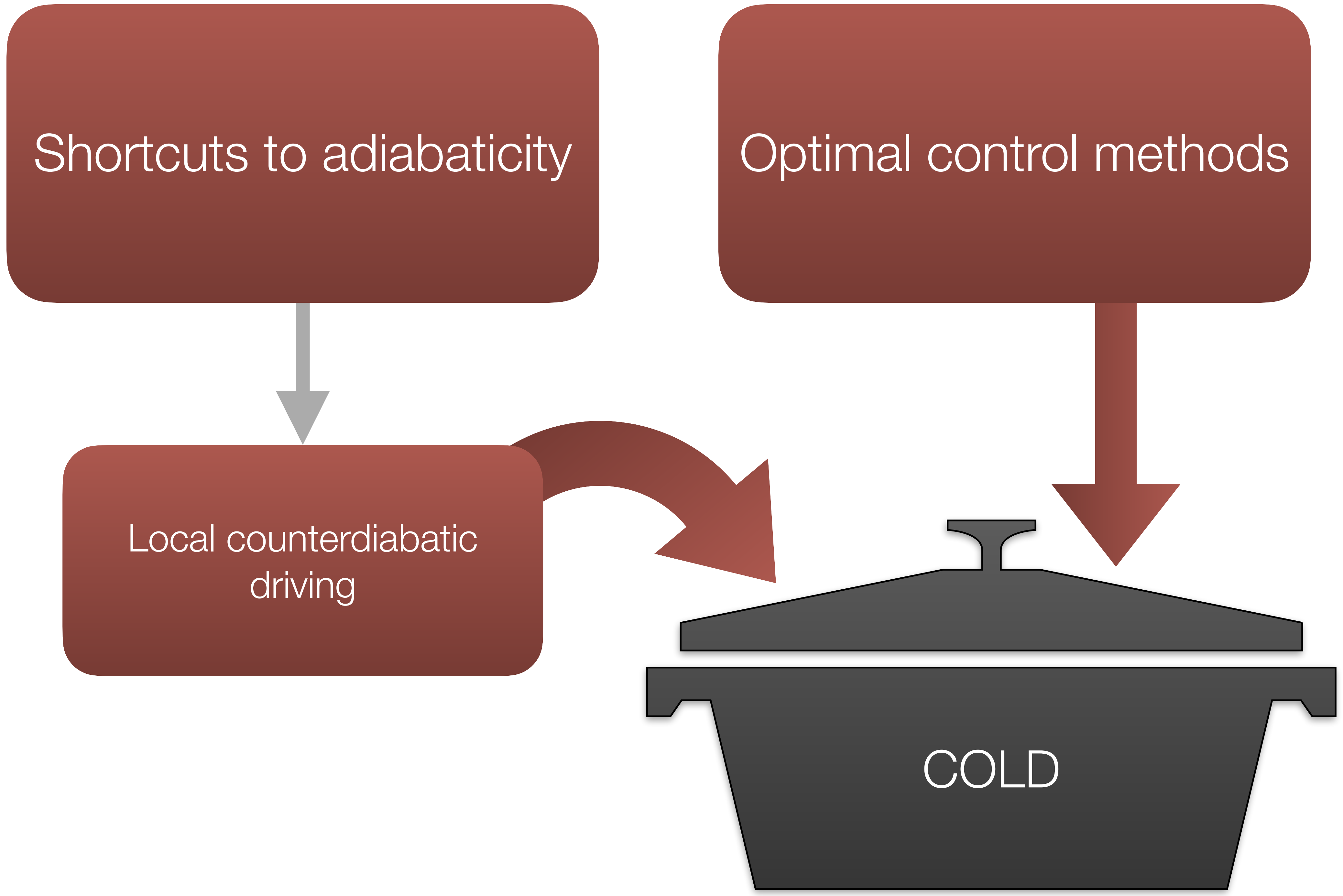

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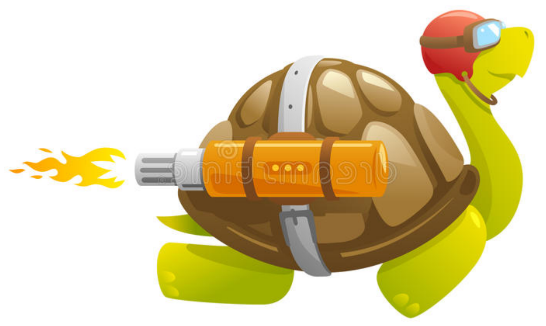
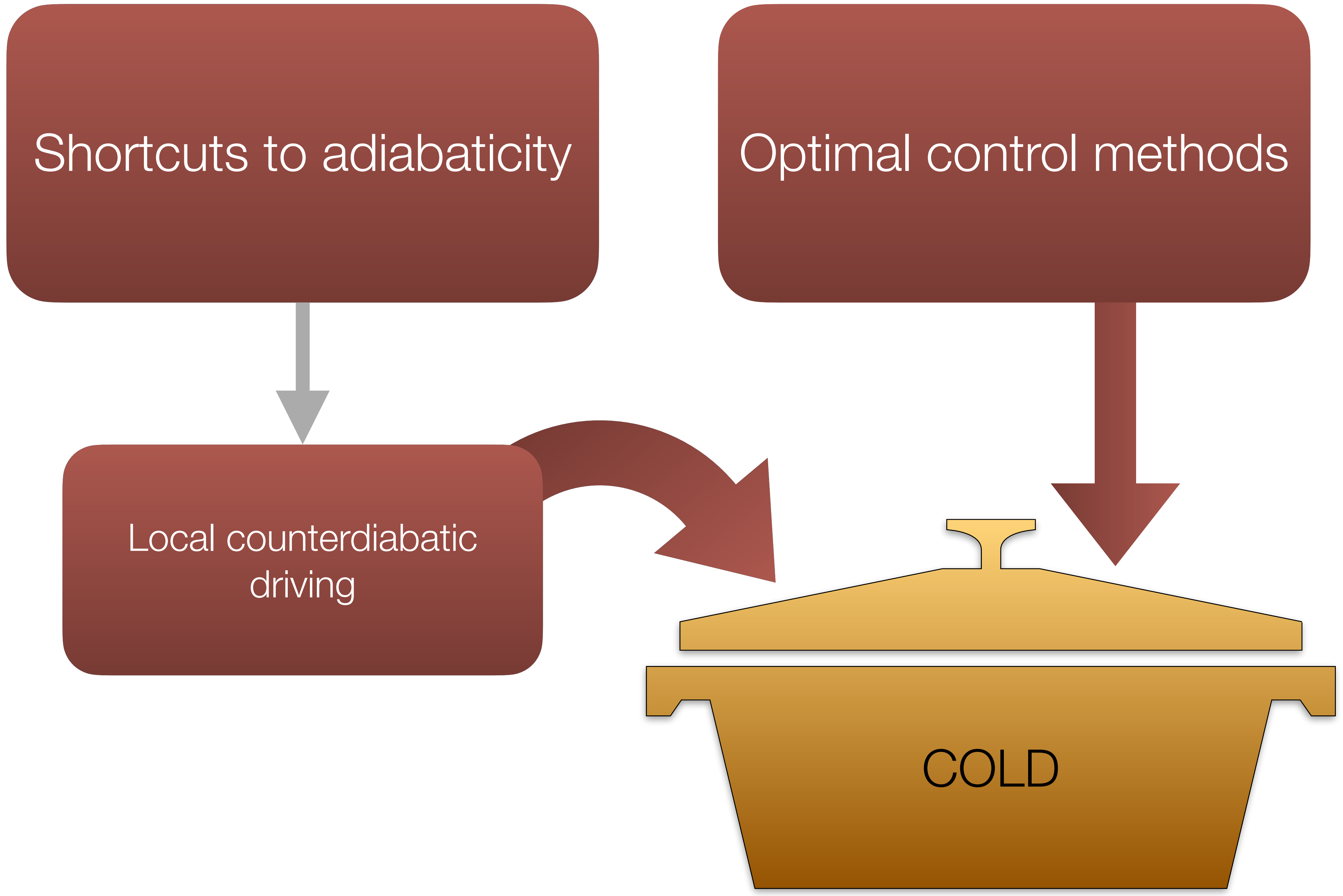
4. Optimise parameters $\boldsymbol{\beta}$





Result: 2-spin annealing

$$H(\lambda) = -2J\sigma_1^z\sigma_2^z - h(\sigma_1^z + \sigma_2^z) + 2h\lambda(t)(\sigma_1^x + \sigma_2^x)$$

- 1st order LCD:

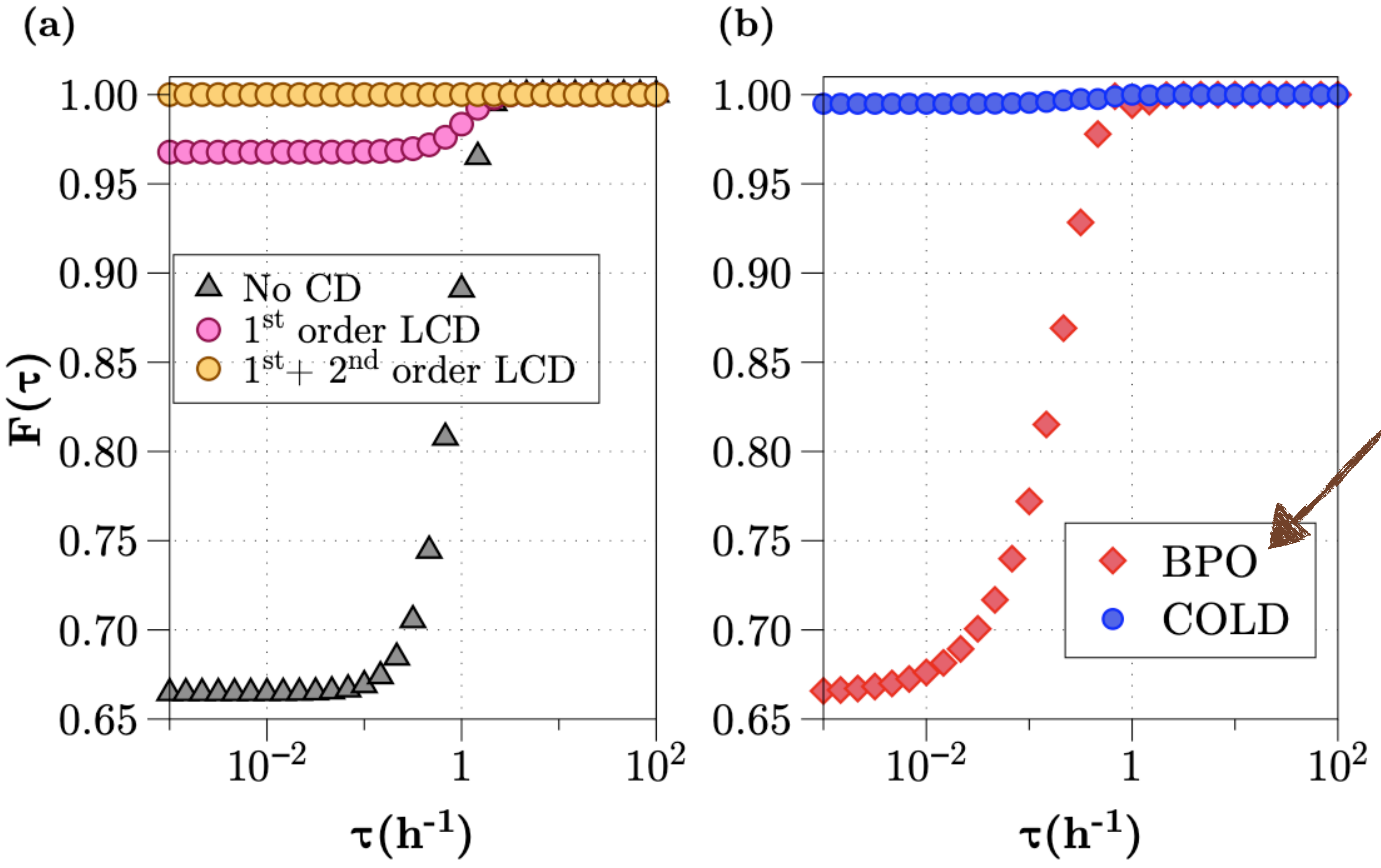
$$\alpha \sum_i \sigma_i^y$$

- 2nd order LCD:

$$\gamma \sum_{i,j} \sigma_{i(j)}^x \sigma_{j(i)}^y + \zeta \sum_{i,j} \sigma_{i(j)}^z \sigma_{j(i)}^y$$

- Control field:

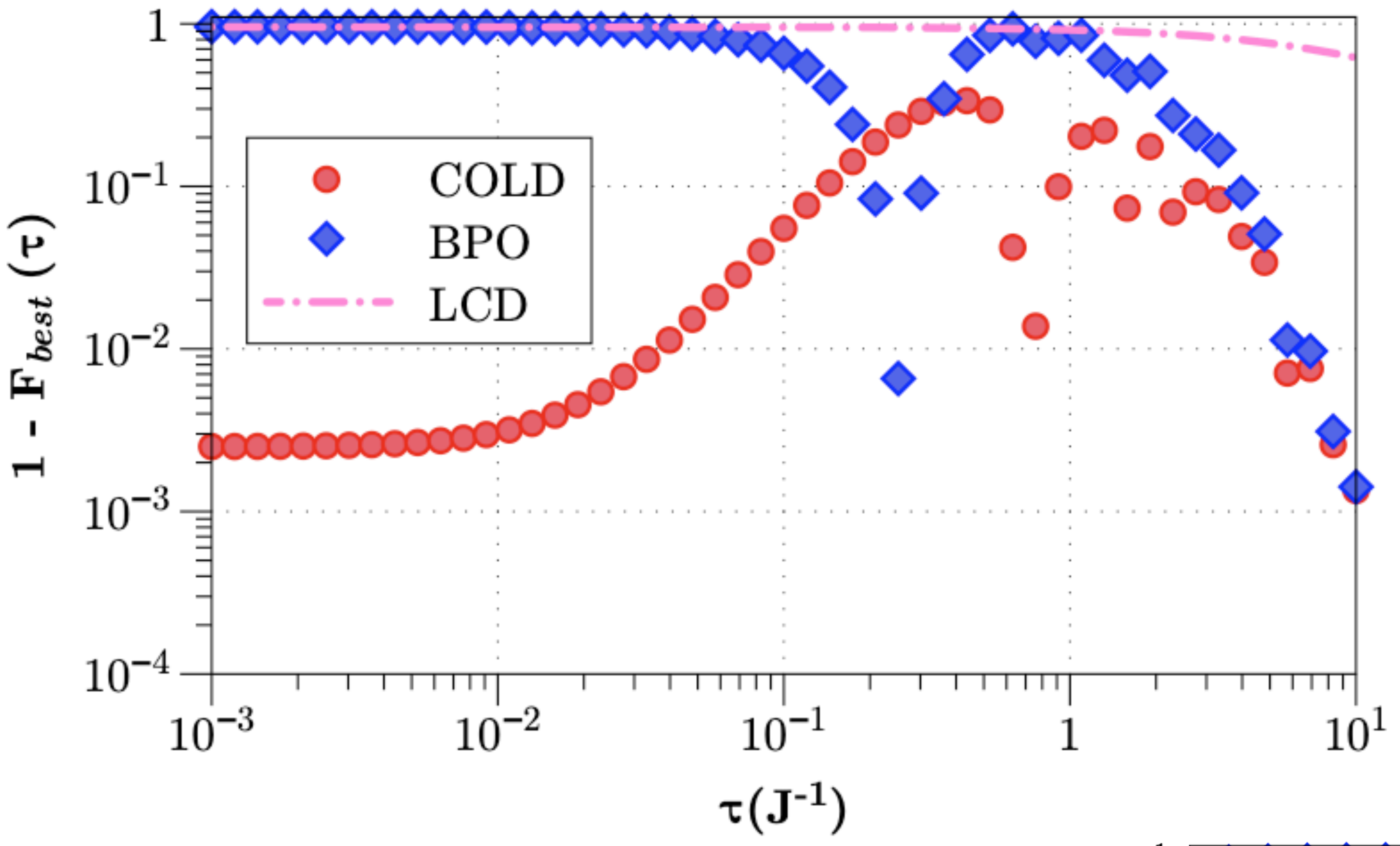
$$f(\lambda, \beta) \sum_i \sigma^z$$



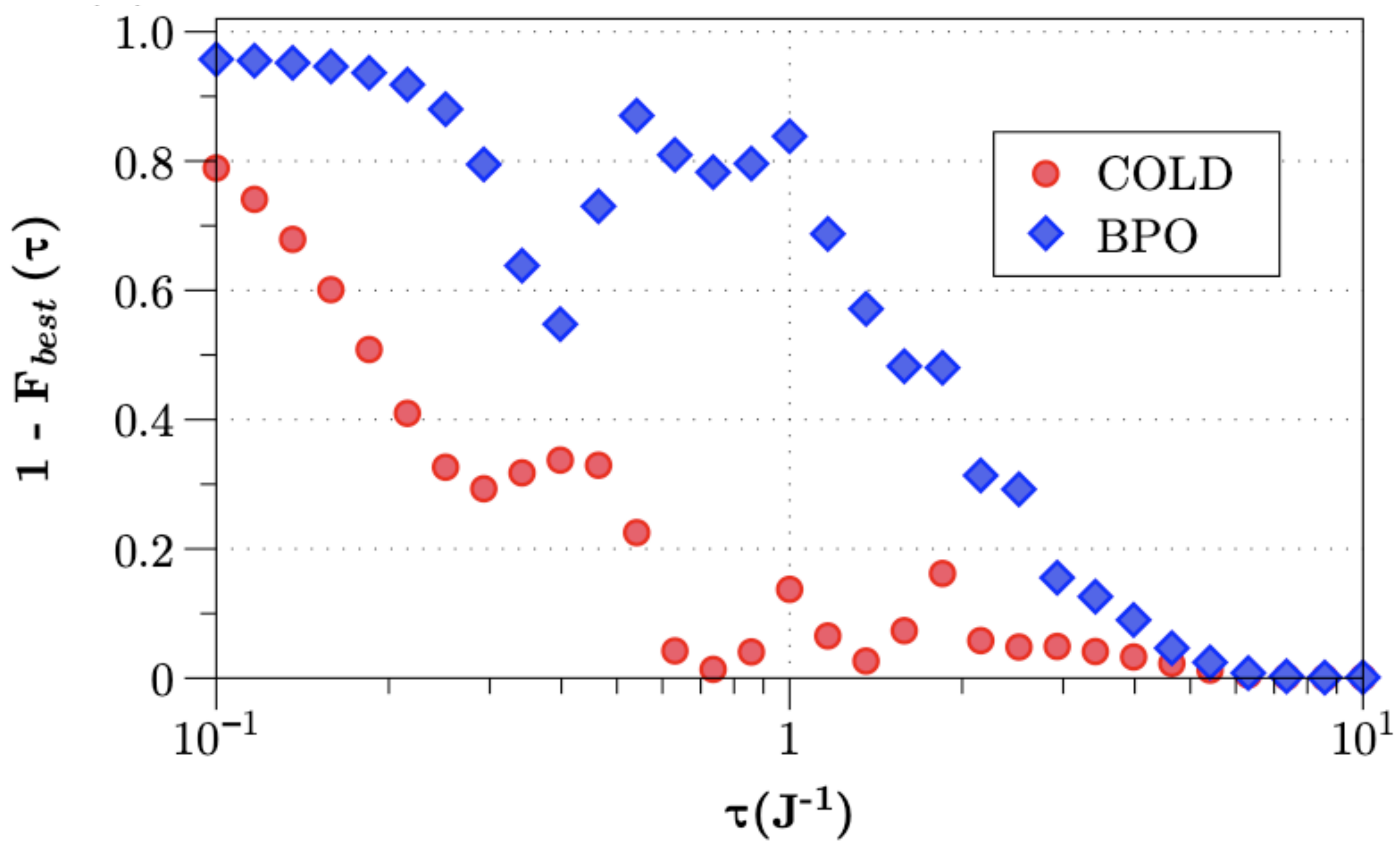
Optimal control only

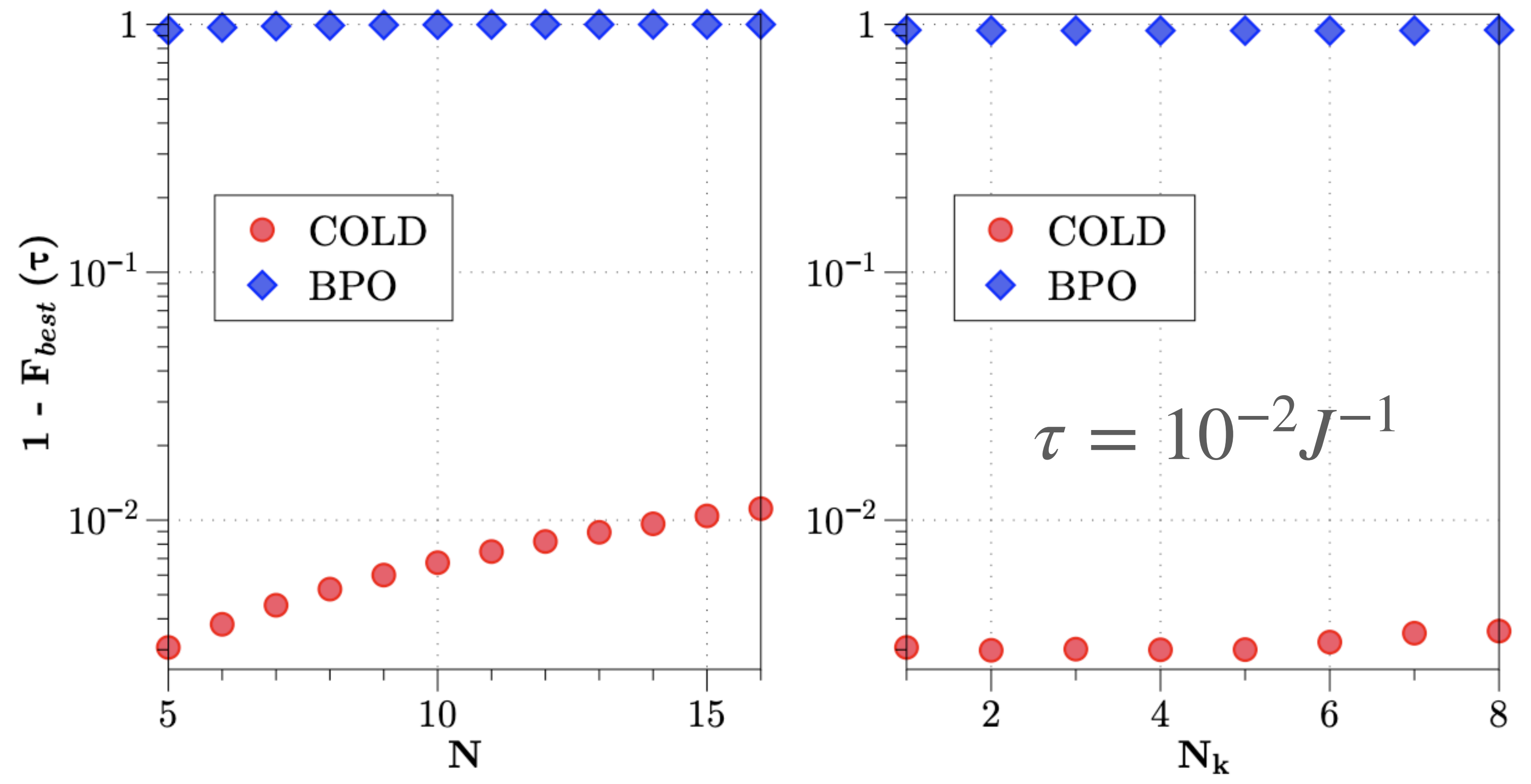
Result: Ising chain phase transition

Unconstrained

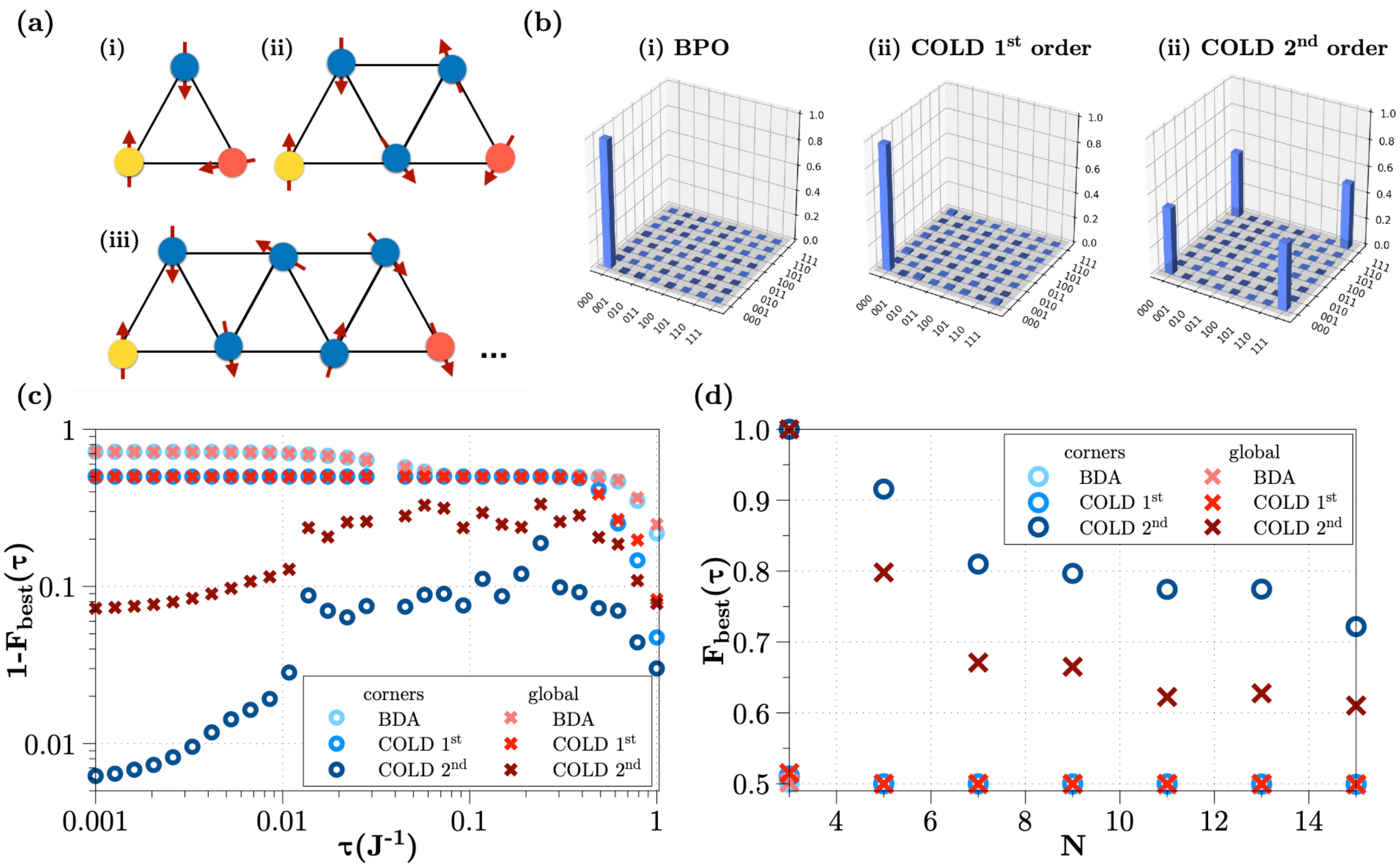


Constrained

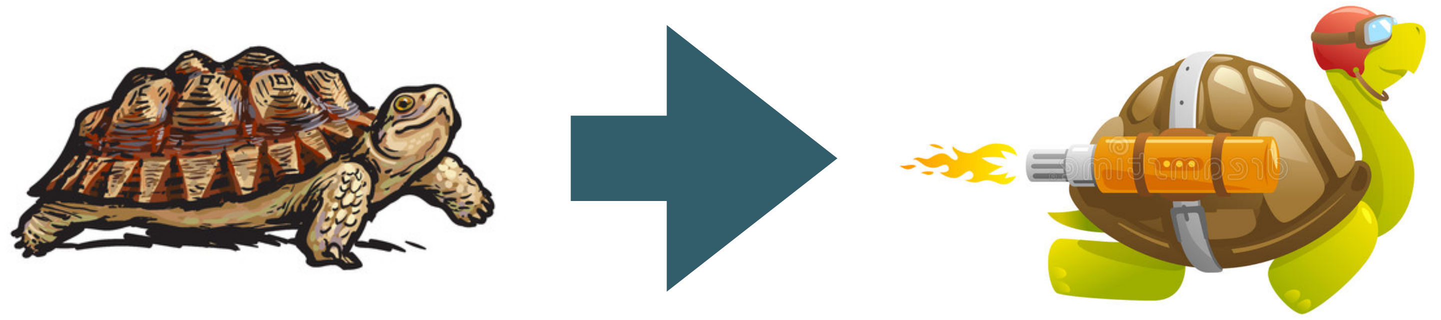




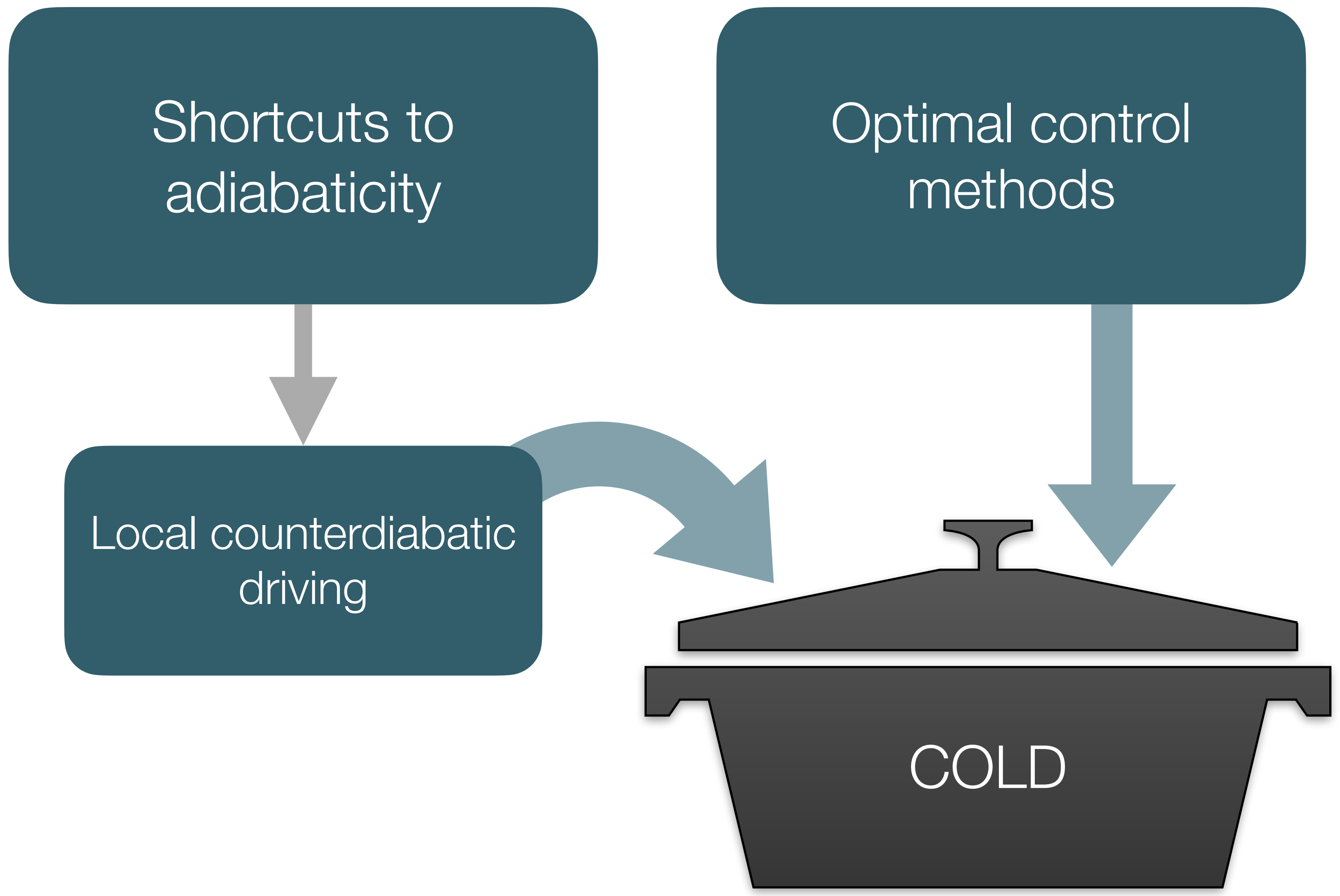
Result: GHZ state preparation in a system of frustrated spins

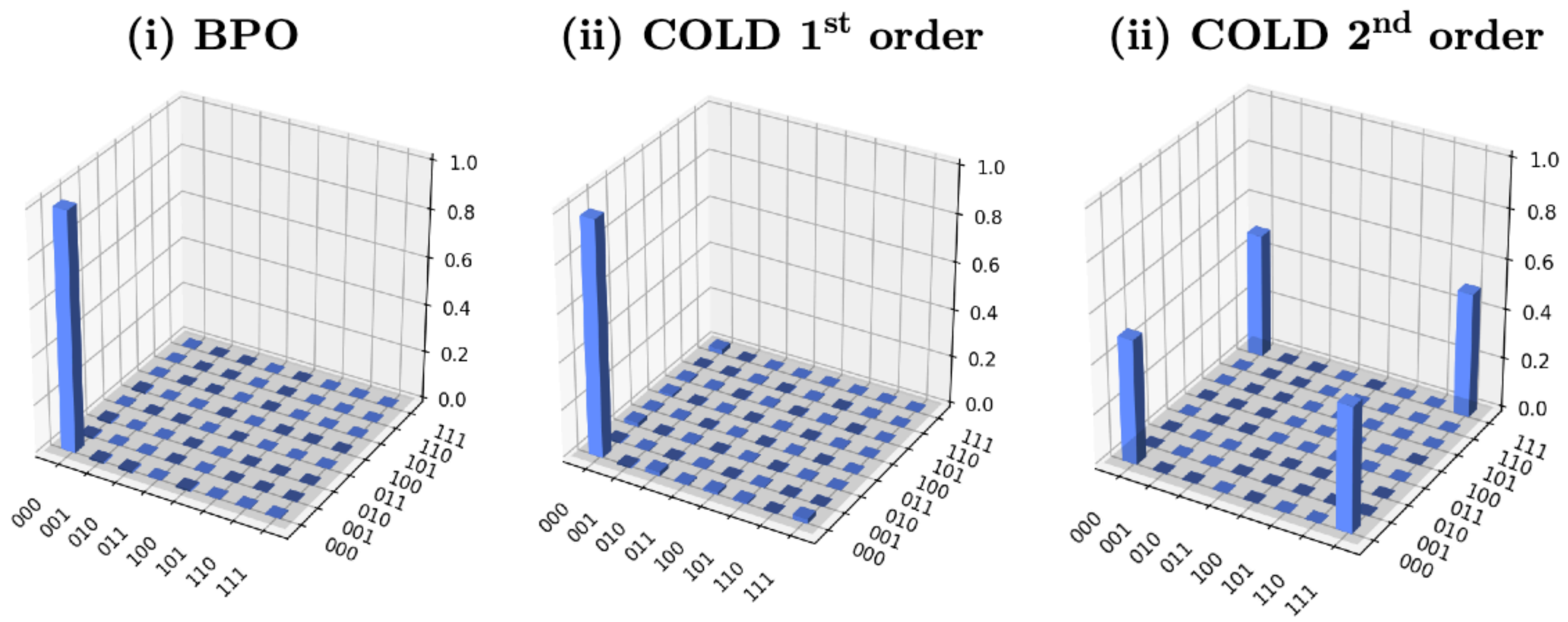


Summary

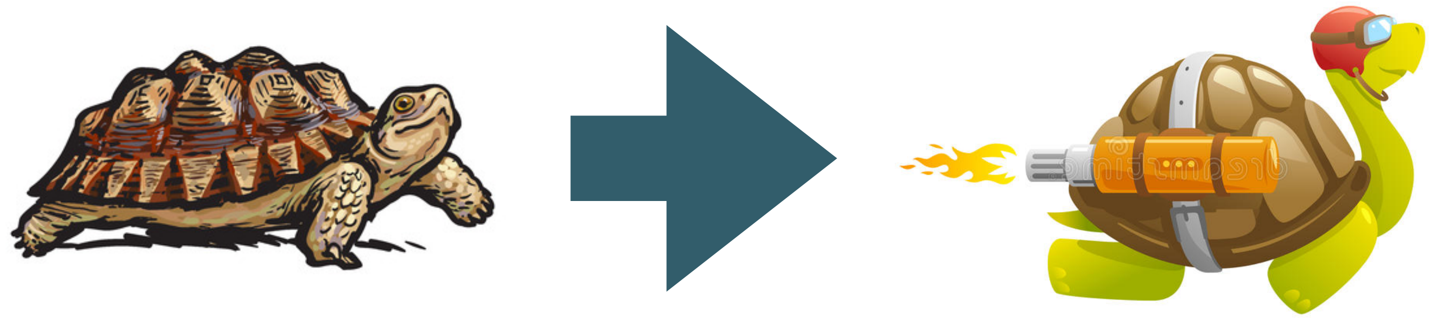


- **COLD**: new method for speeding up adiabatic processes
- Improves upon LCD and optimal control methods
- Outlook
    - Better understanding of AGP to inform/improve optimisation
    - Upcoming paper on new numerical/analytic methods for AGP on random Ising graphs!
      (See myself/**Ewen Lawrence: Y02:11 & N00:230**)





Links



Blogpost

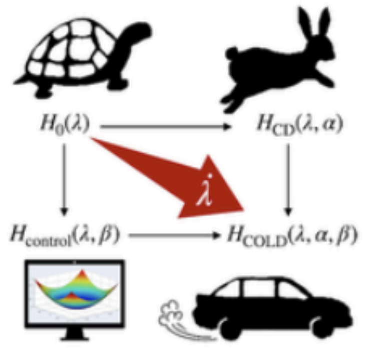
COLD: Counterdiabatic Optimised Local Driving

ievutec · January 31, 2023 · Own work
counterdiabatic driving, Own work, quantum computing · Edit

Paper

Counterdiabatic Optimized Local Driving

Ieva Čepaitė, Anatoli Polkovnikov, Andrew J. Daley, and Callum W. Duncan
PRX Quantum **4**, 010312 (2023) – Published 30 January 2023



A hybrid approach to achieving coherent control, dubbed COLD, promises substantial improvement when applied to annealing protocols, state preparation schemes, entanglement generation, and population transfer on a lattice.

Show Abstract +

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