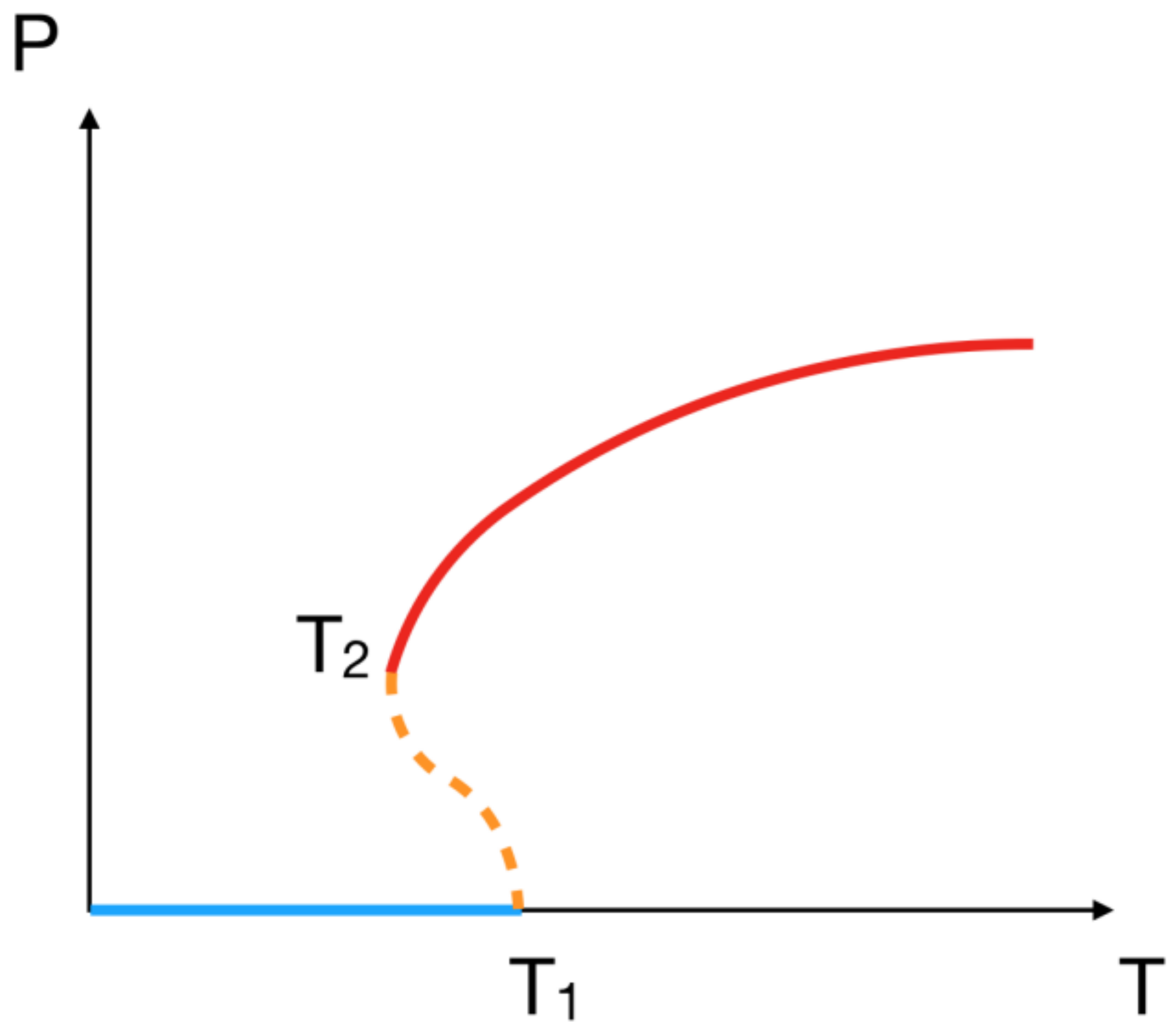
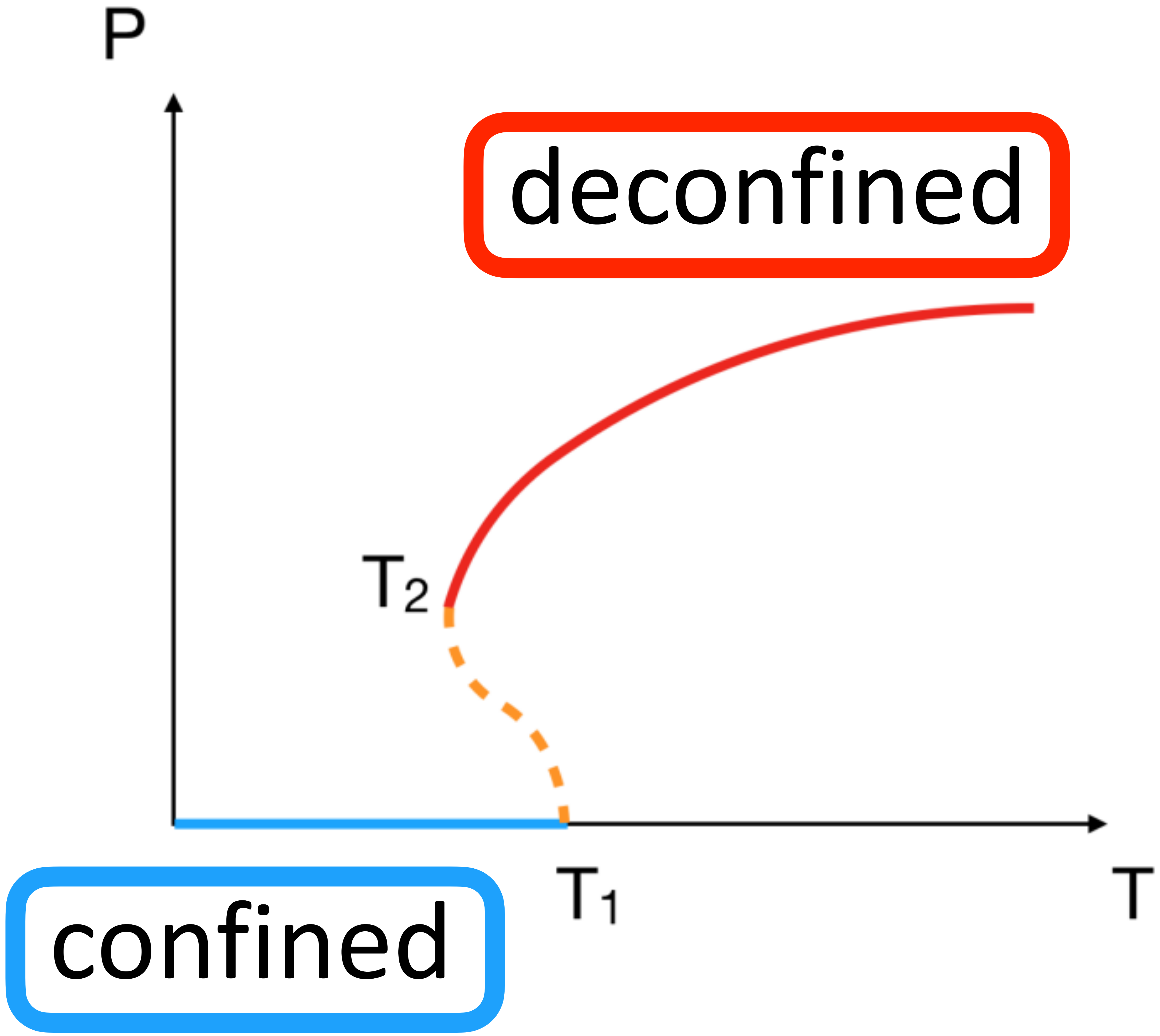
Global Symmetries as a Signature of Partial Confinement

Masanori Hanada, JH, Matthew Knaggs, Andy O'Bannon
[2112.11398]

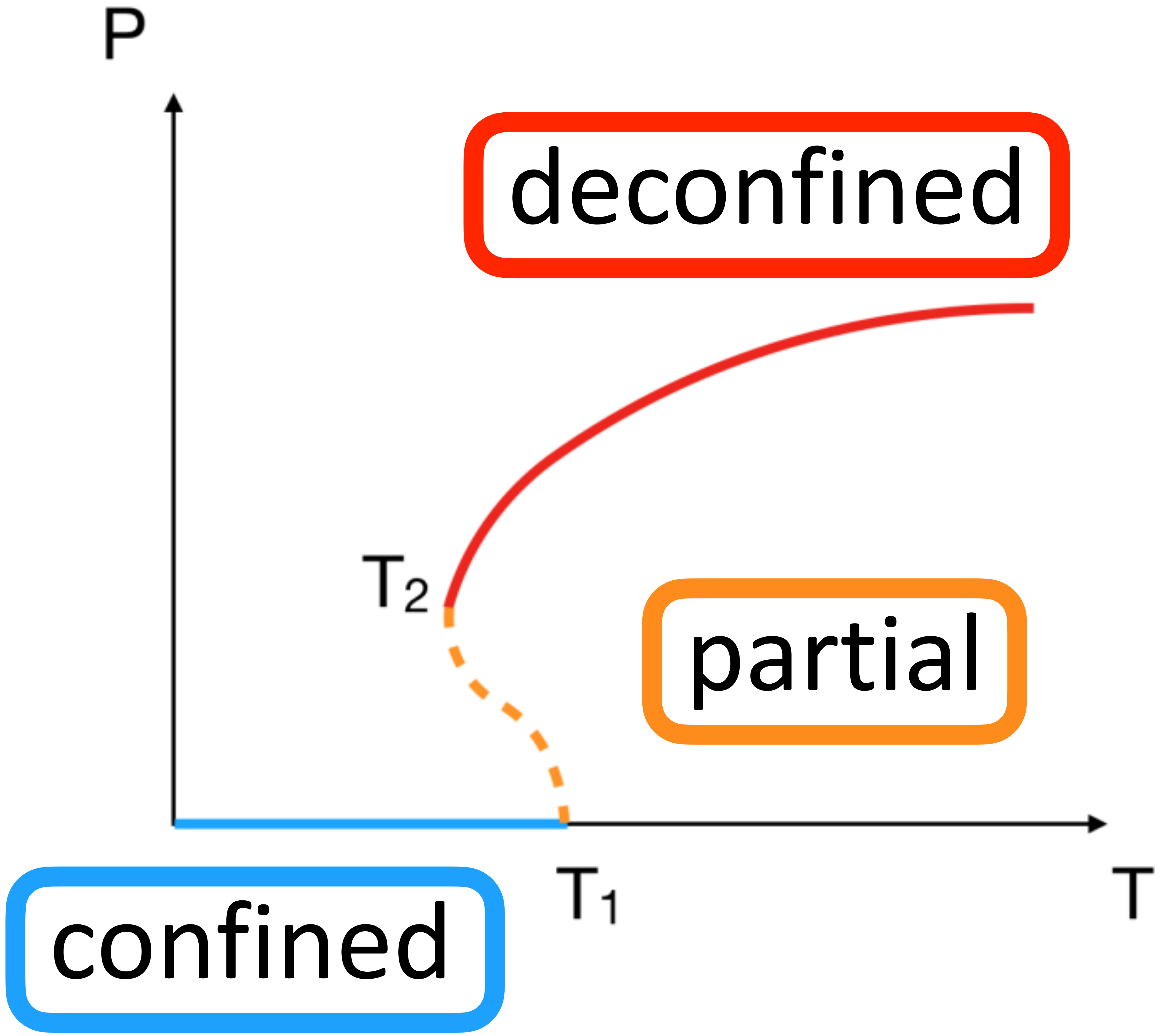
Vaibhav Gautam, Masanori Hanada, JH, Enrico Rinaldi
[22XX.XXXX]

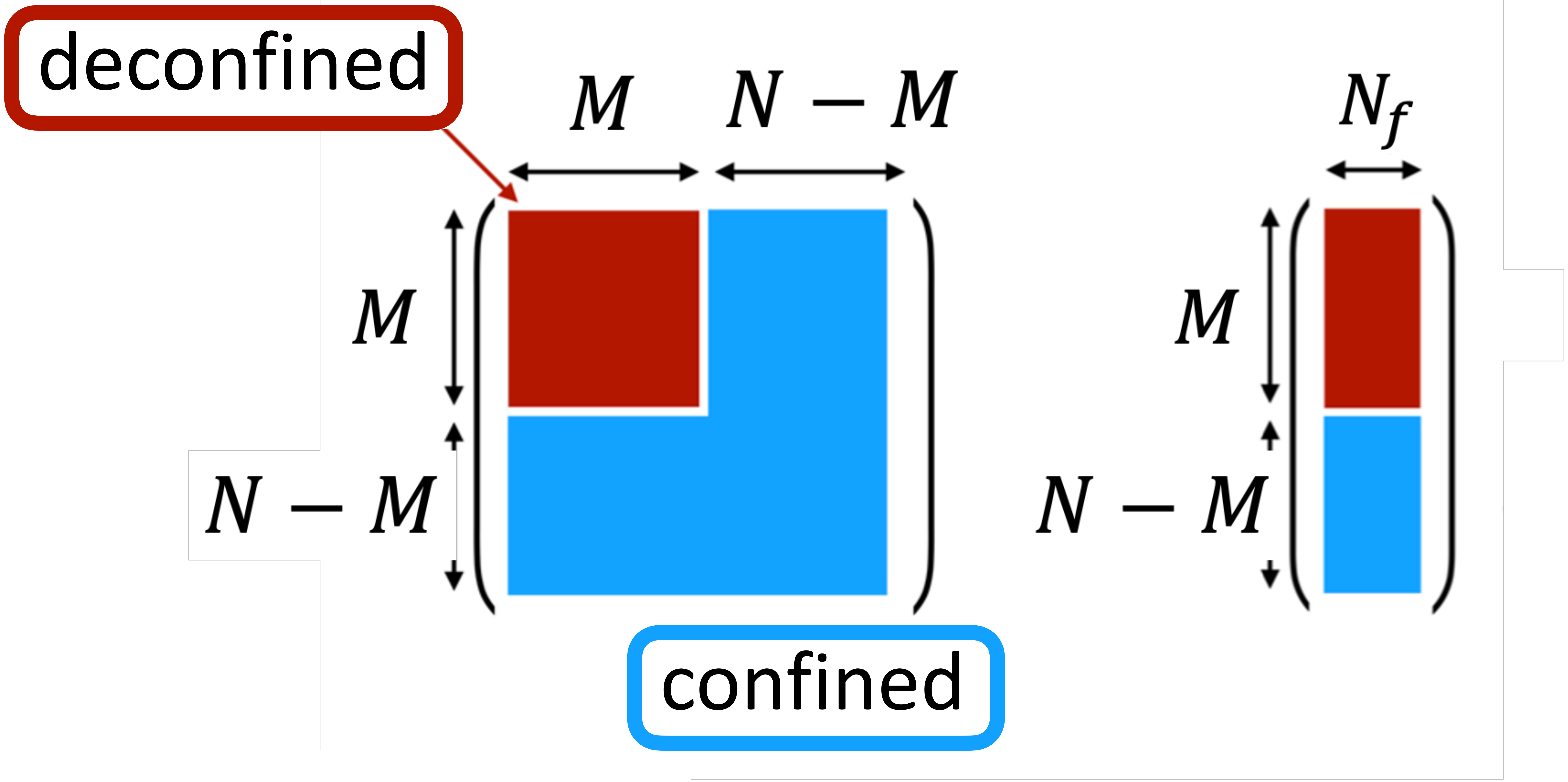
Jack Holden 5th August 2022


P
T₂
T₁
T

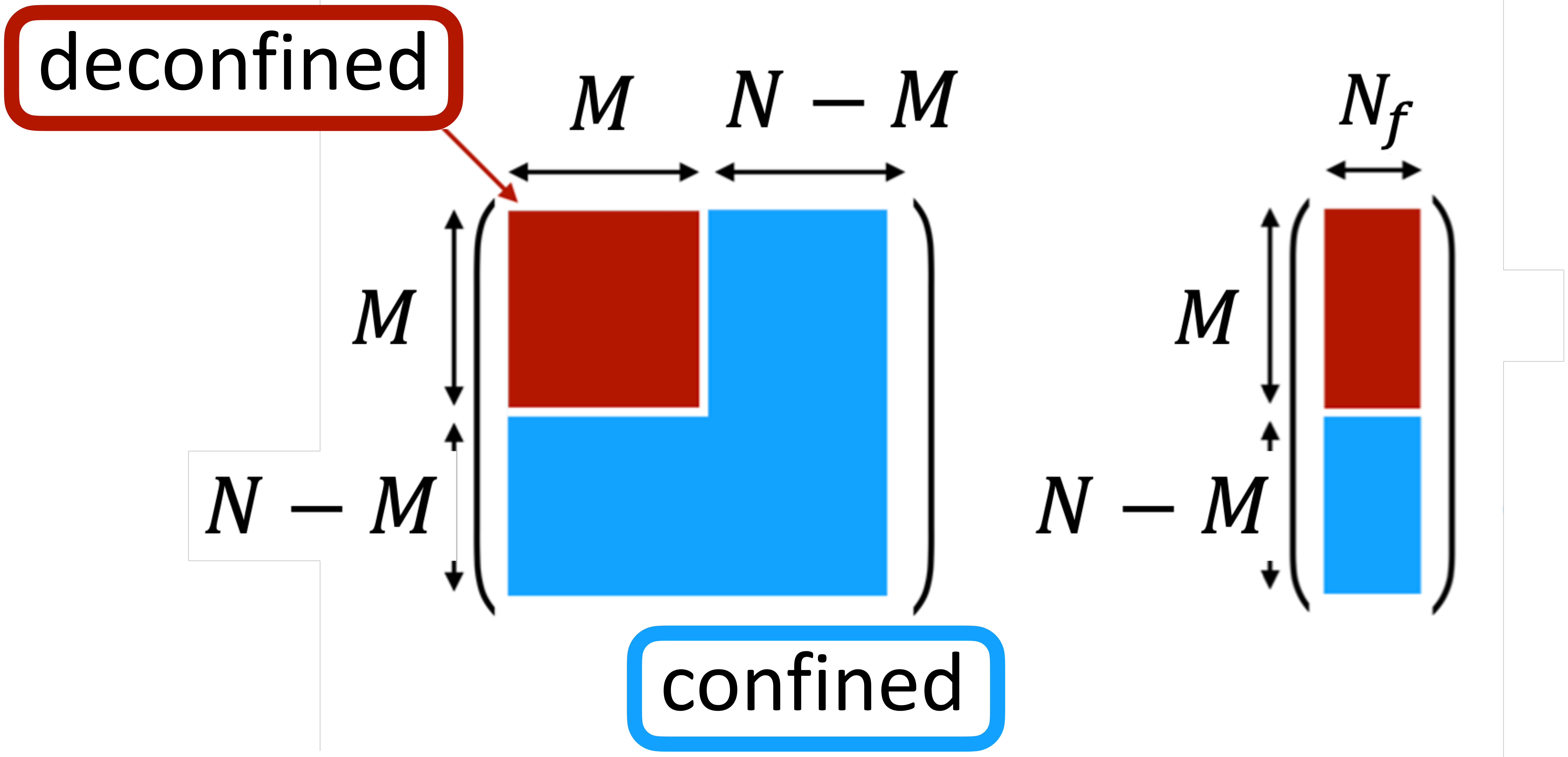


P
deconfined
T2
confined
T1
T


P
deconfined
T2
partial
T1
T
confined

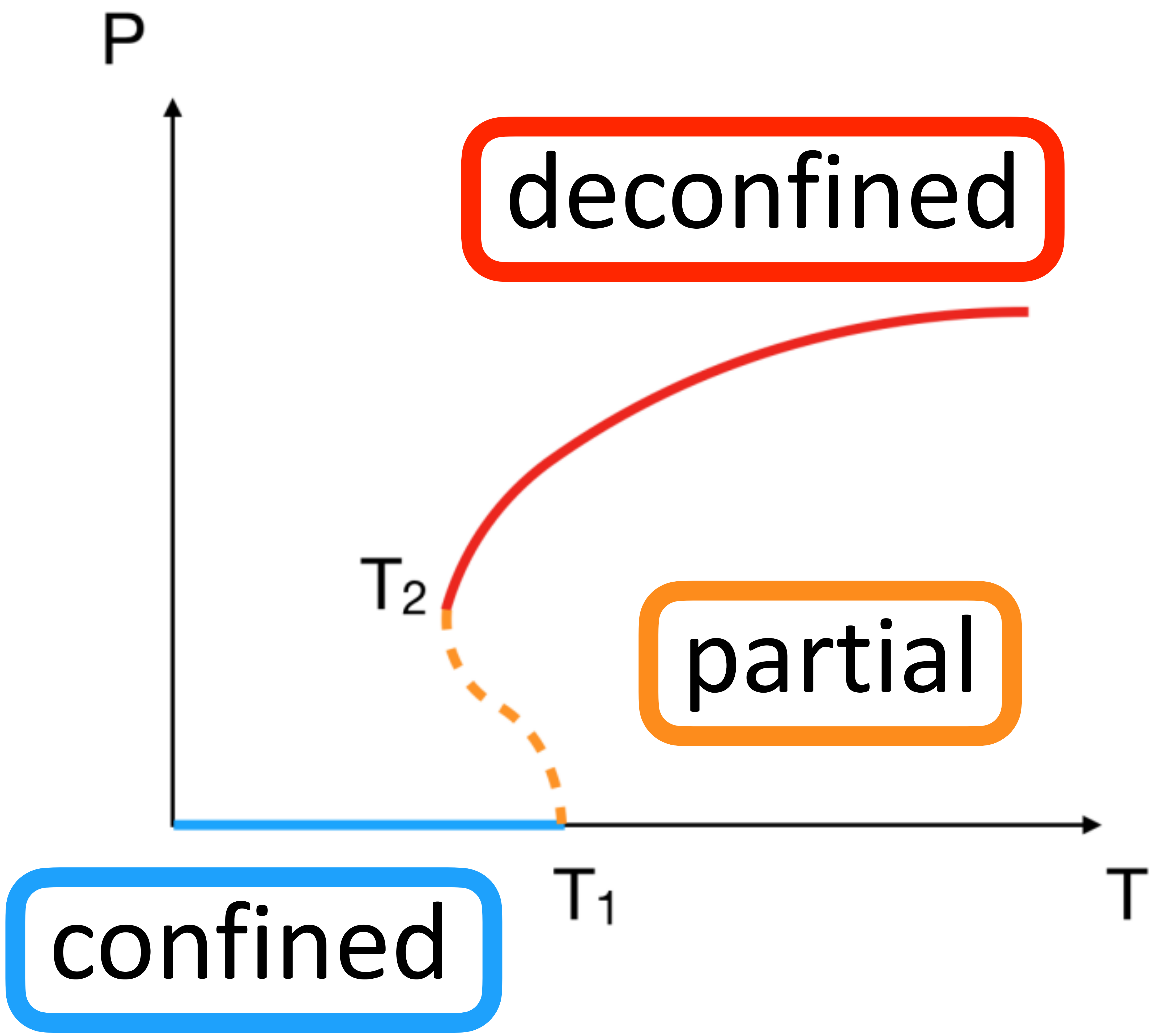


source: Hanada, Shimada, Wintergerst 2001.10459

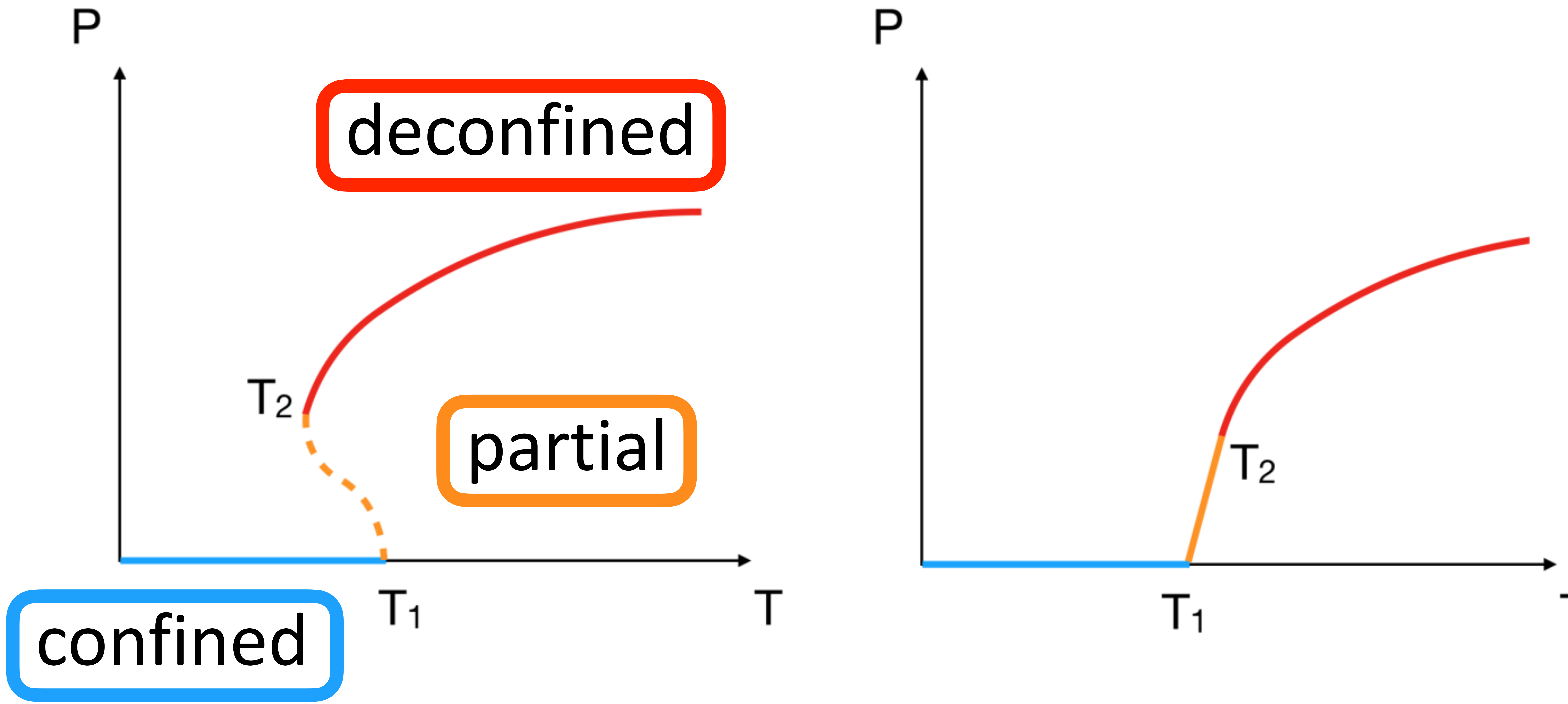


source: Hanada, Shimada, Wintergerst 2001.10459

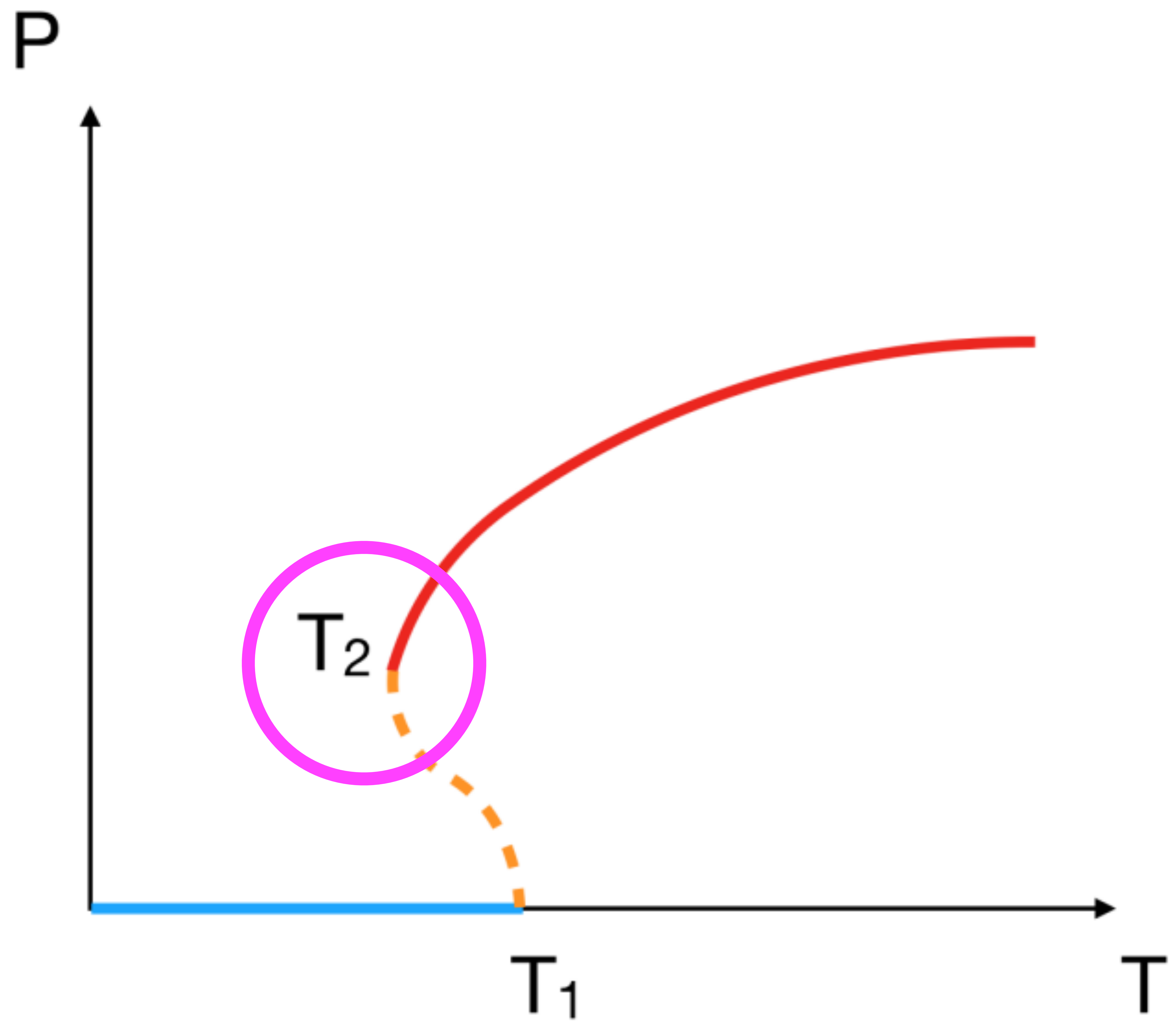
Hanada, Maltz 1608.03276
Berenstein 1806.05729



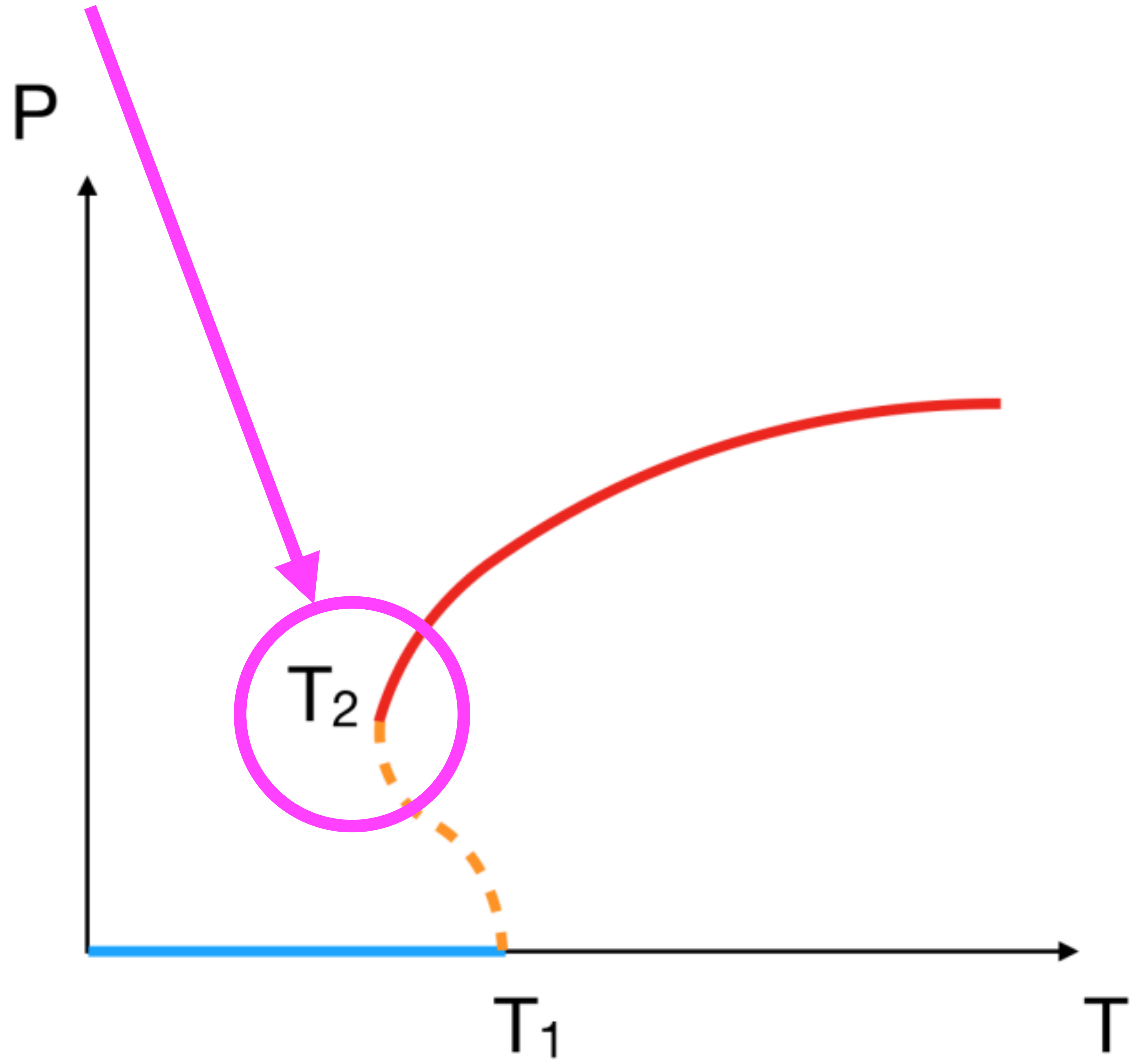
P
deconfined
T2
partial
confined
T1
T



P
deconfined
T2
partial
confined
T1
T
P
T2
T1
T

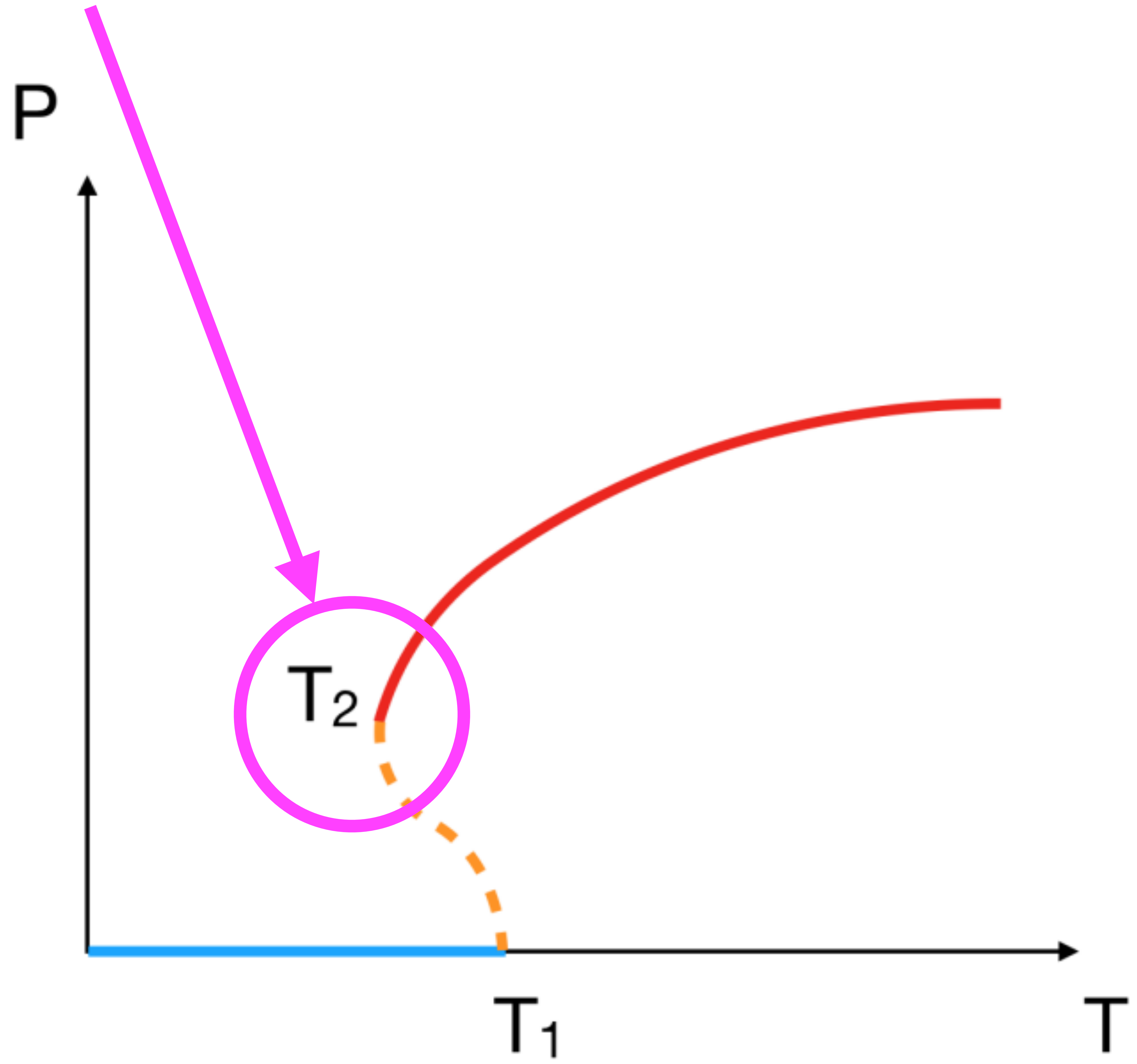

P
T
T1
T2

Global symmetry breaking?



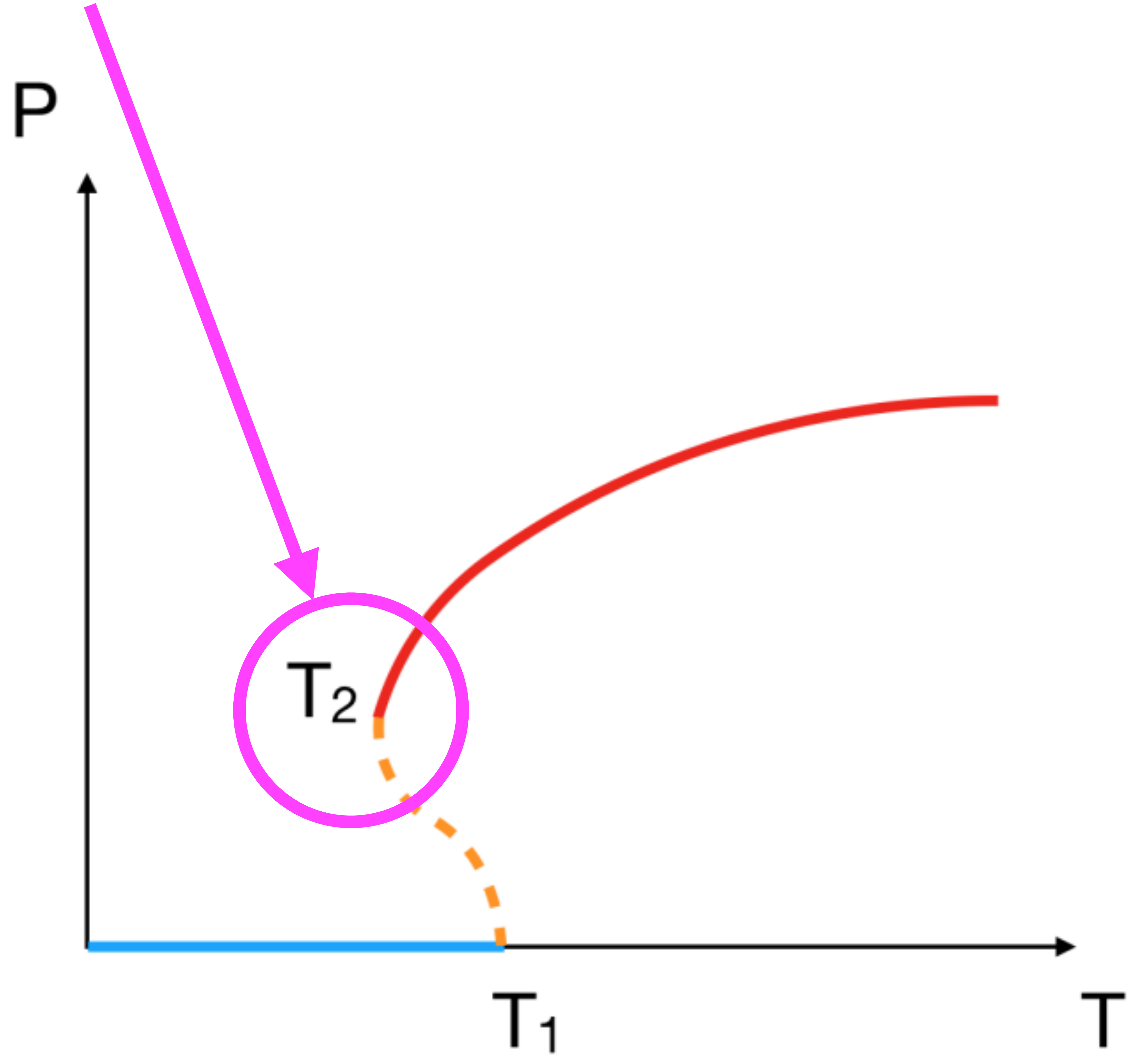
Global symmetry breaking?

- Precise definition

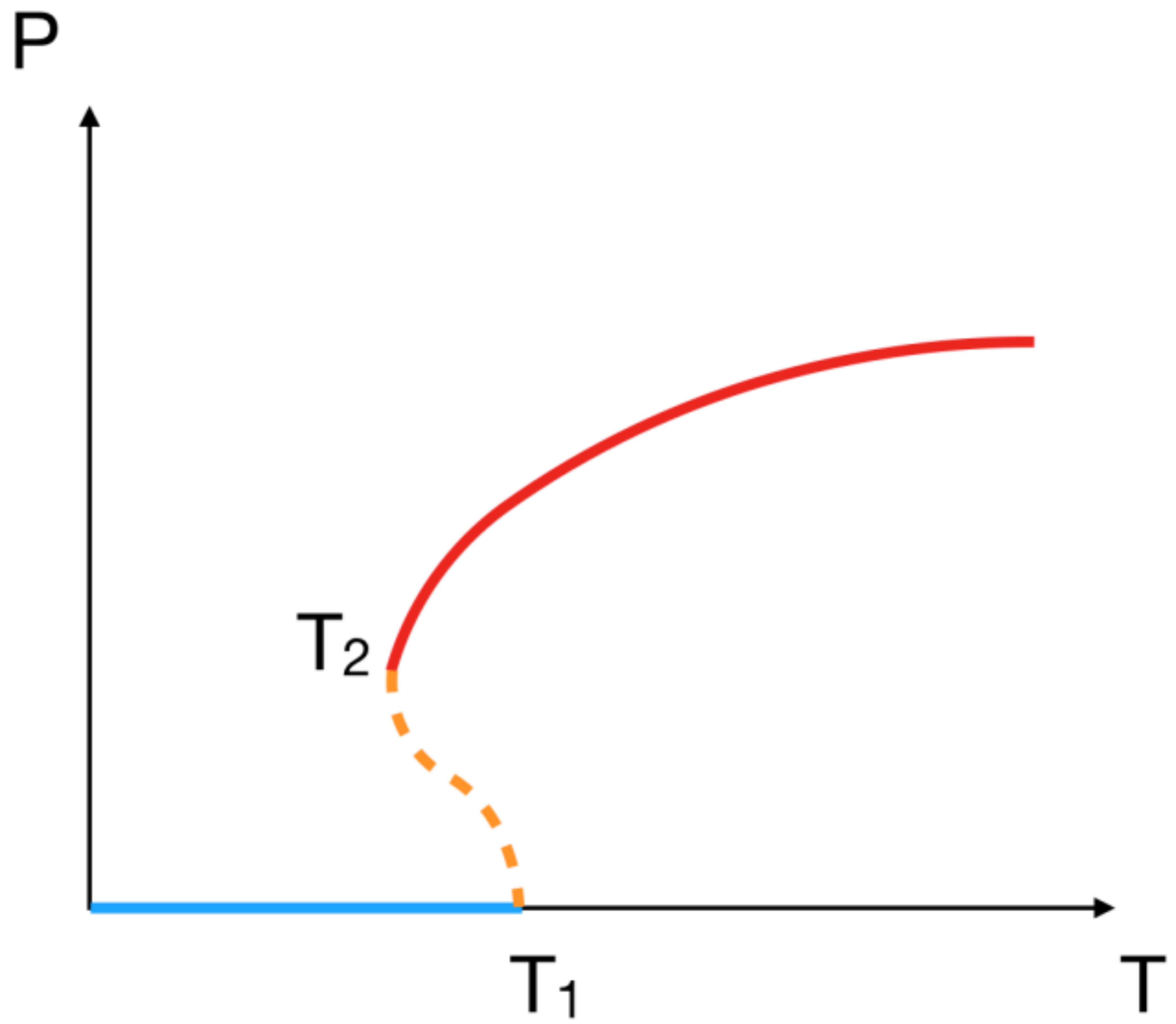


Global symmetry breaking?

- Precise definition
- Physical consequences

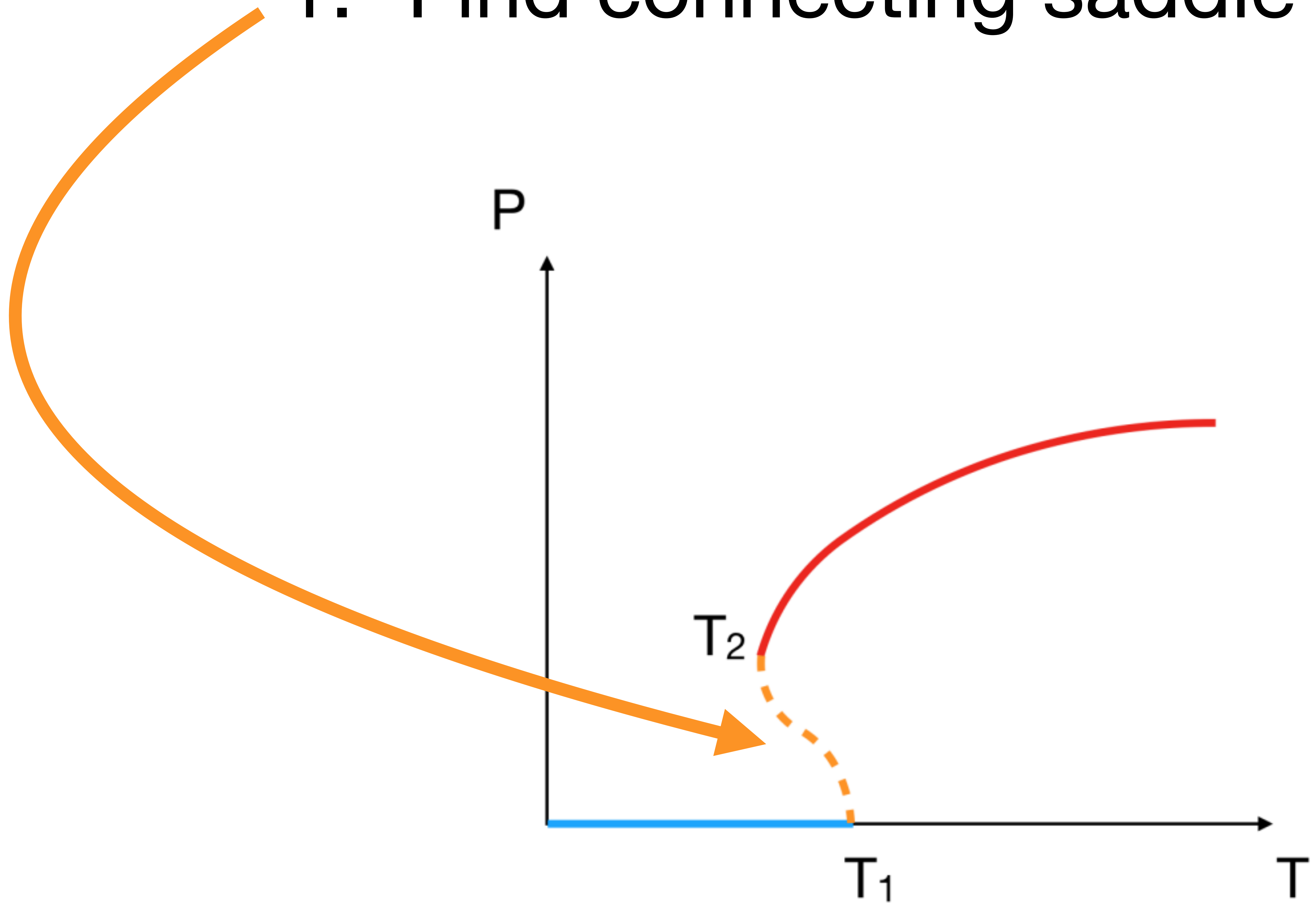


Testing the conjecture



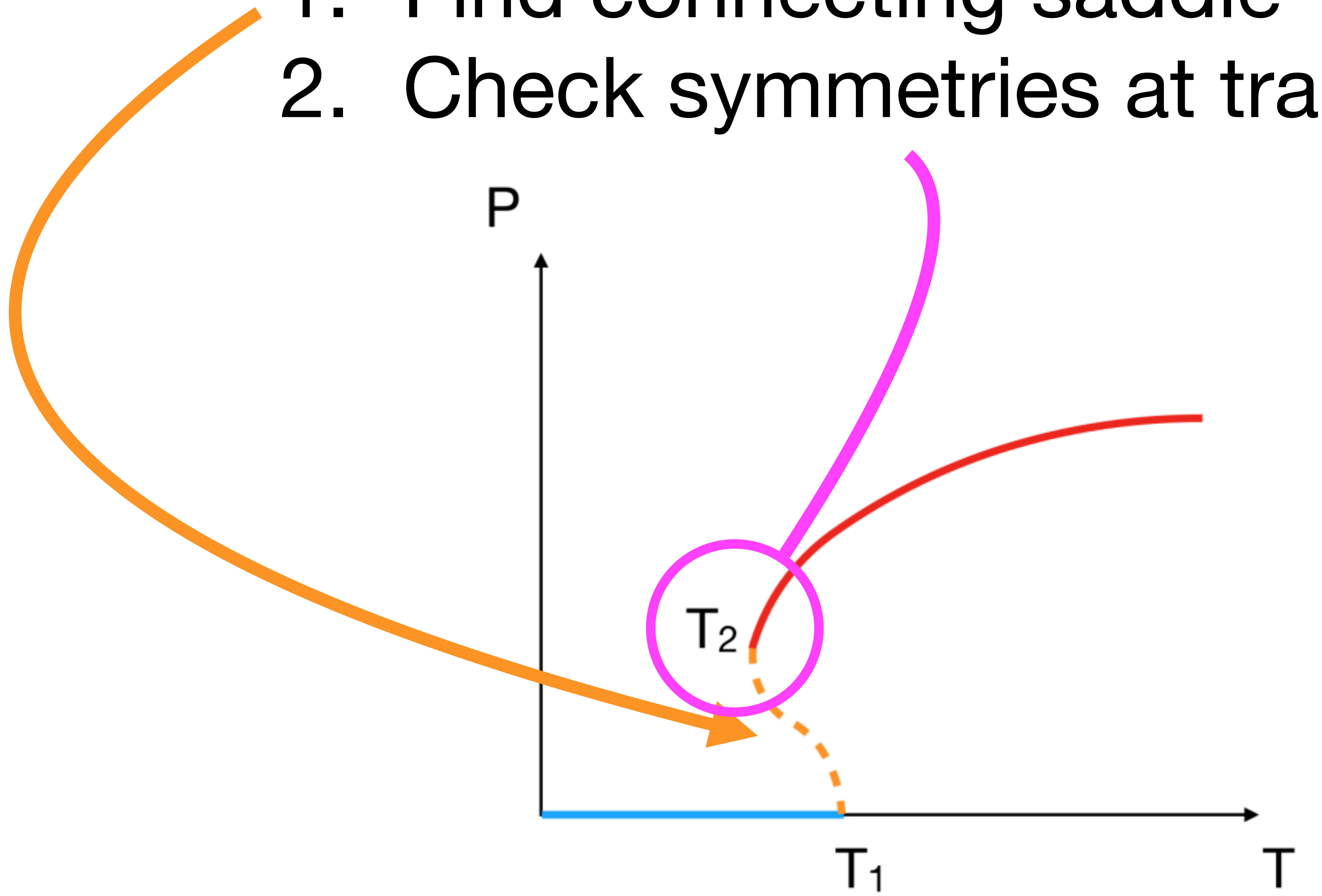
Testing the conjecture

1. Find connecting saddle



Testing the conjecture

1. Find connecting saddle
2. Check symmetries at transition



Test 1:

U(N) pure YM

large N, strong coupling

U(N) YM

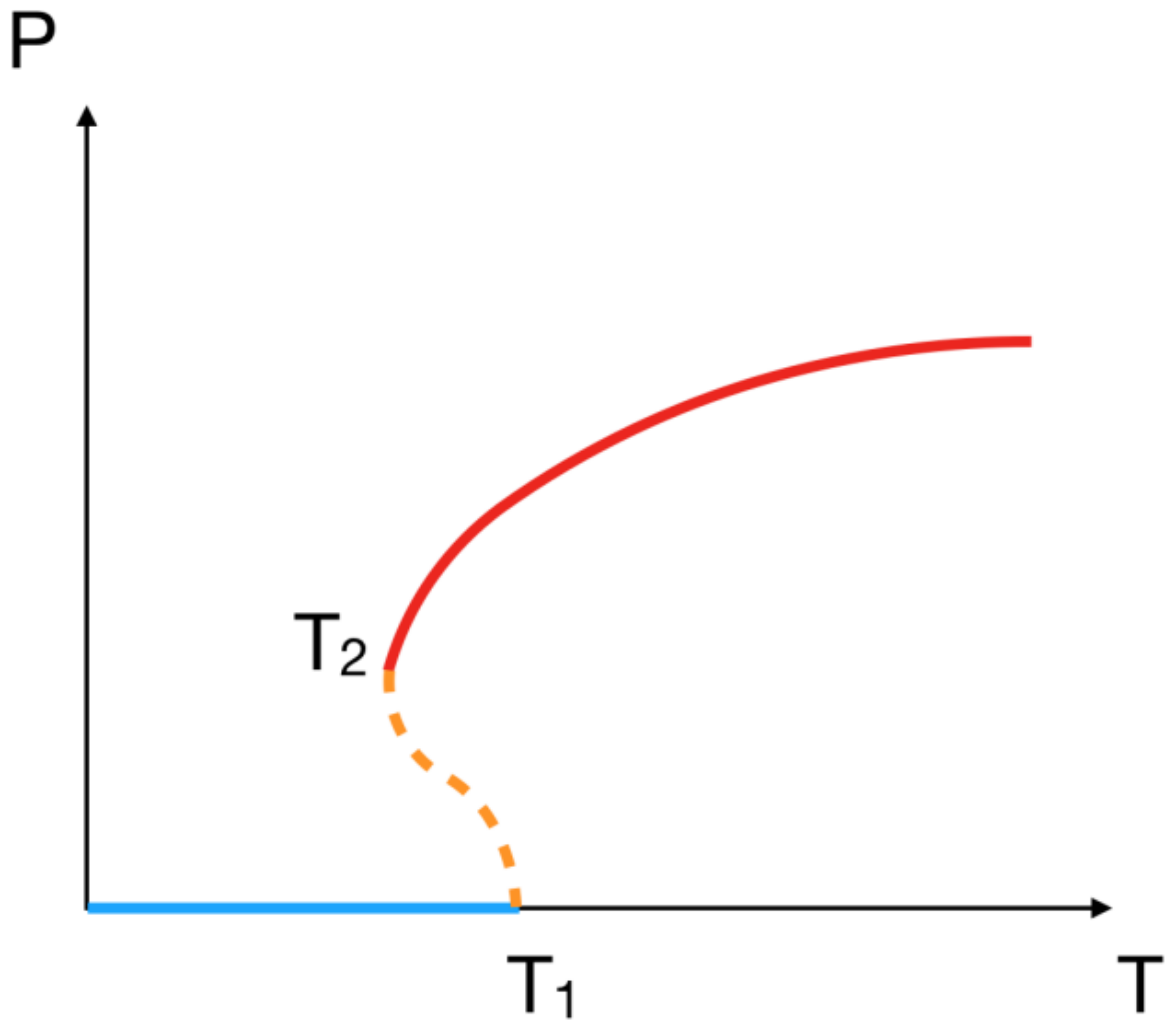
Centre	Chiral	
✓	✗	Confined
✗	✓	Deconfined

U(N) YM

Centre	Chiral	
✓	×	Confined
×	✓	Deconfined
?×?	?×?	Partial

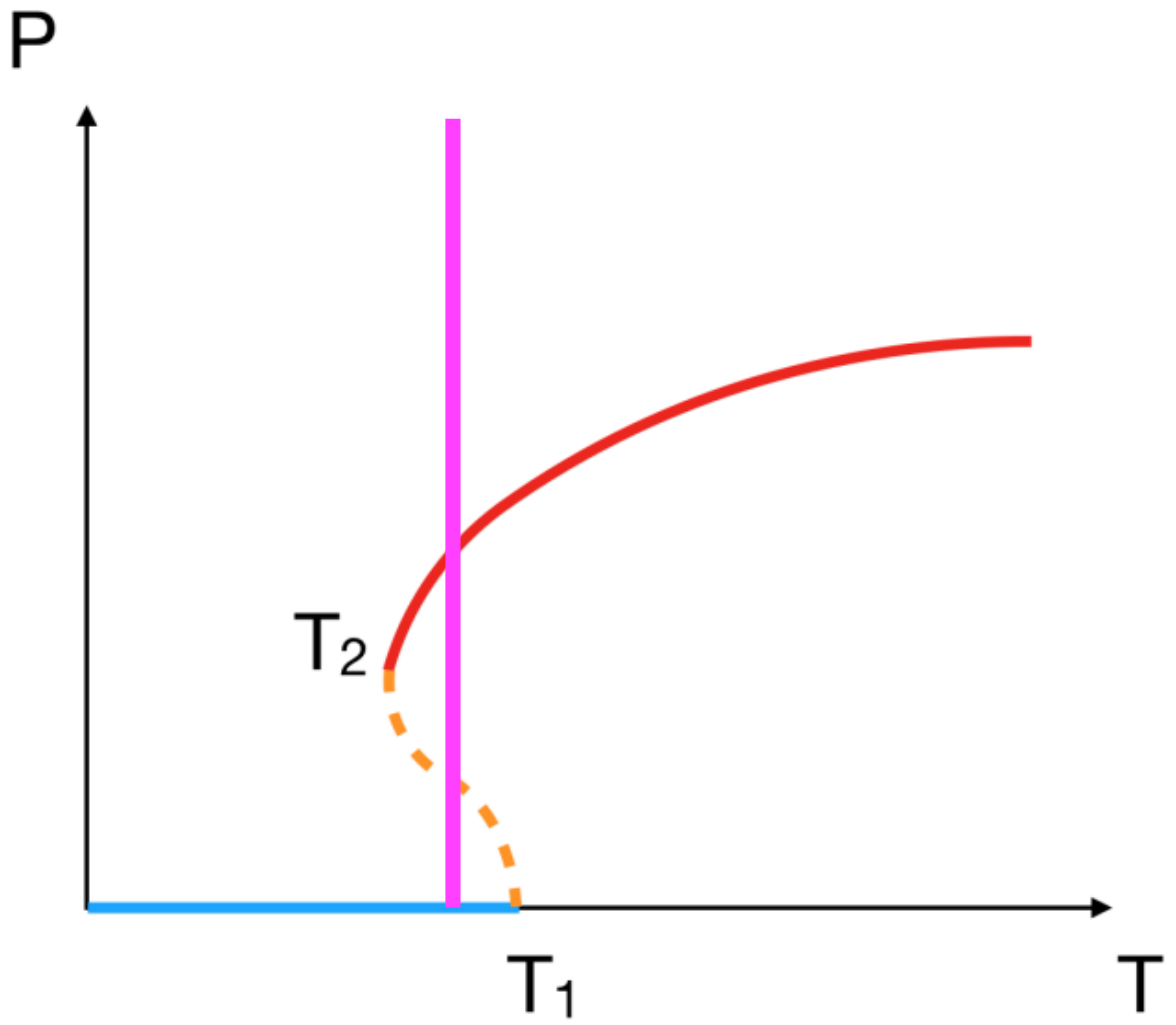
U(N) YM

1. Find connecting saddle



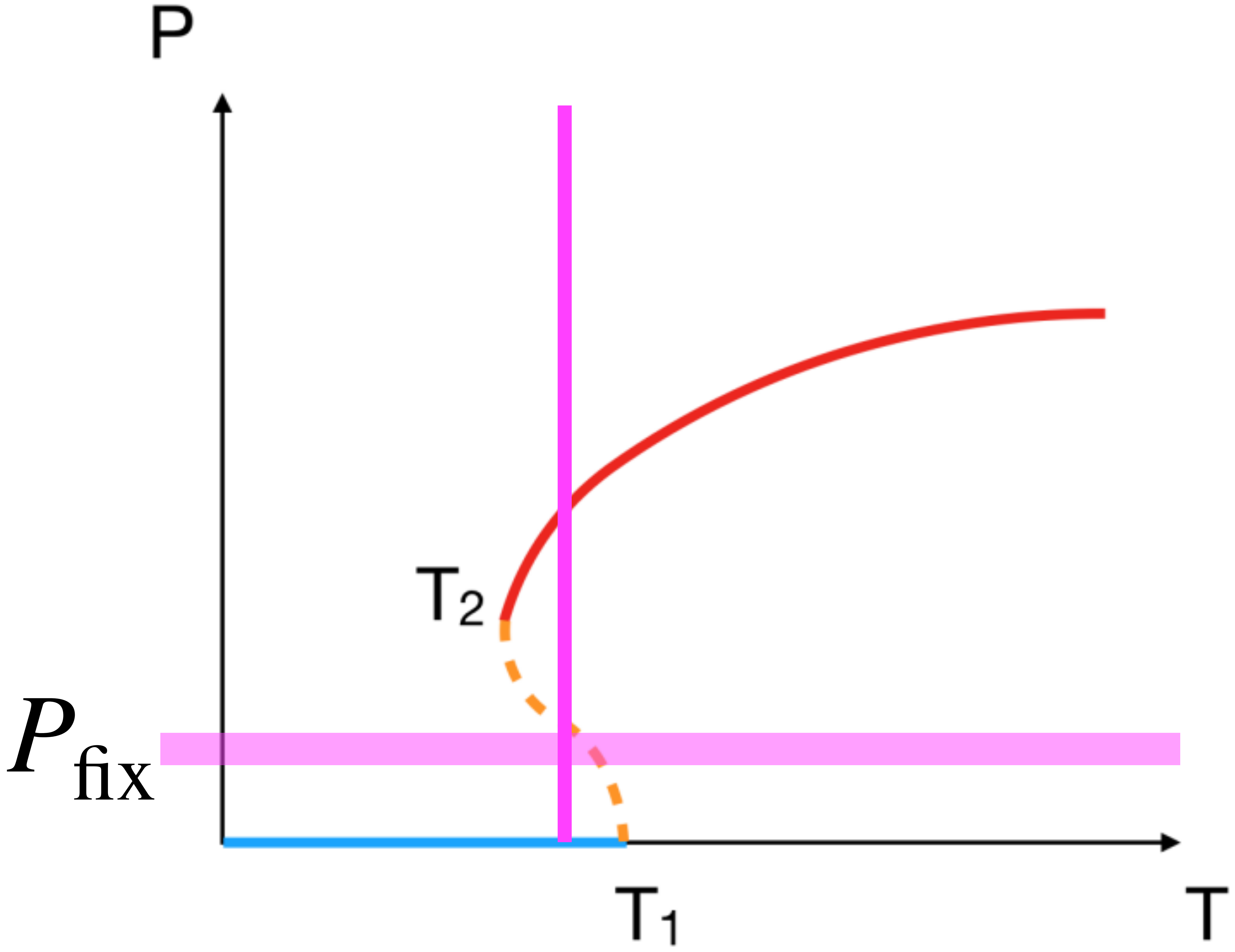
U(N) YM

1. Find connecting saddle



U(N) YM

1. Find connecting saddle



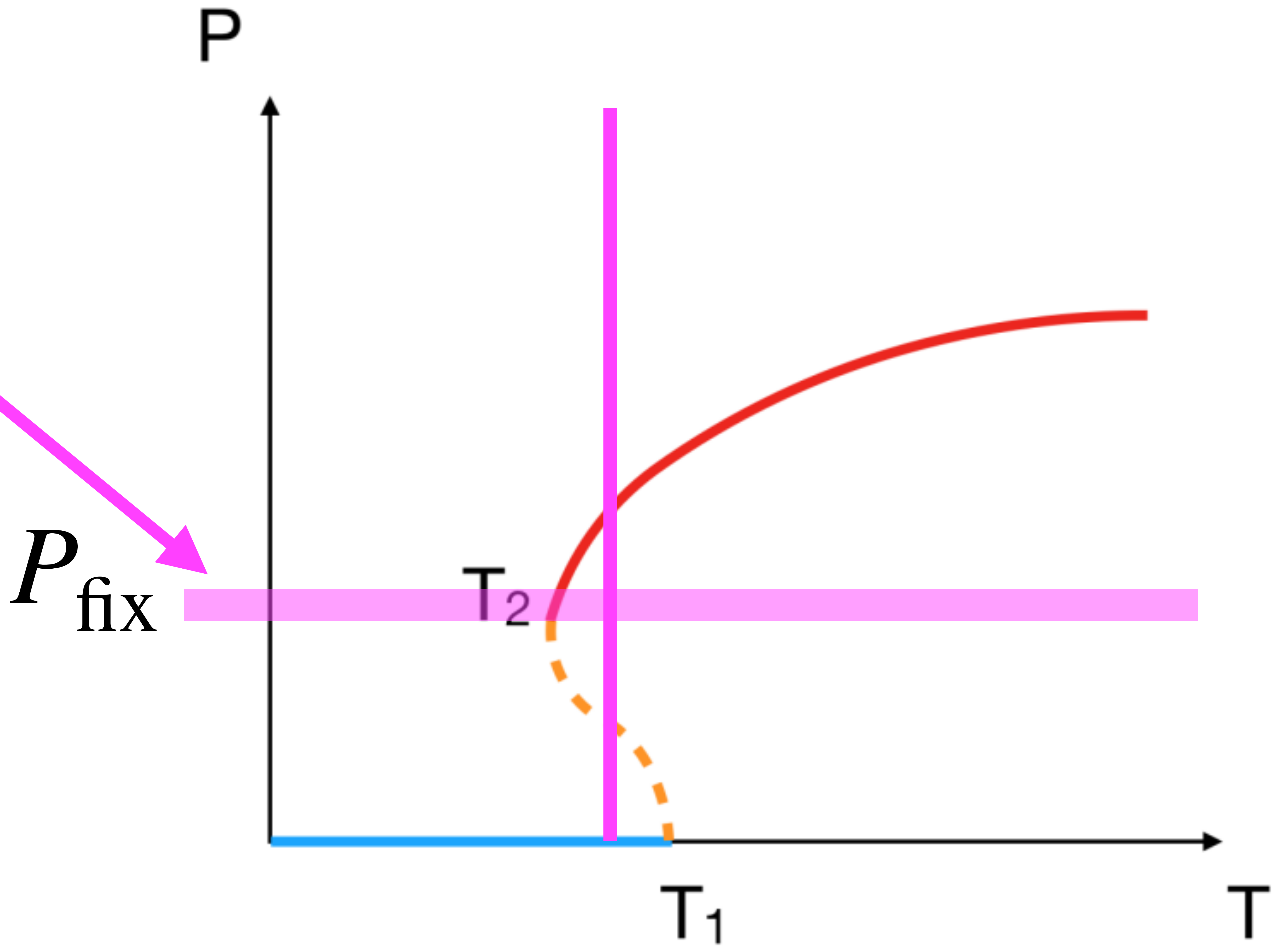
U(N) YM

2. Check symmetries at transition

U(N) YM

2. Check symmetries at transition

Transition $P \sim 0.35$



U(N) YM

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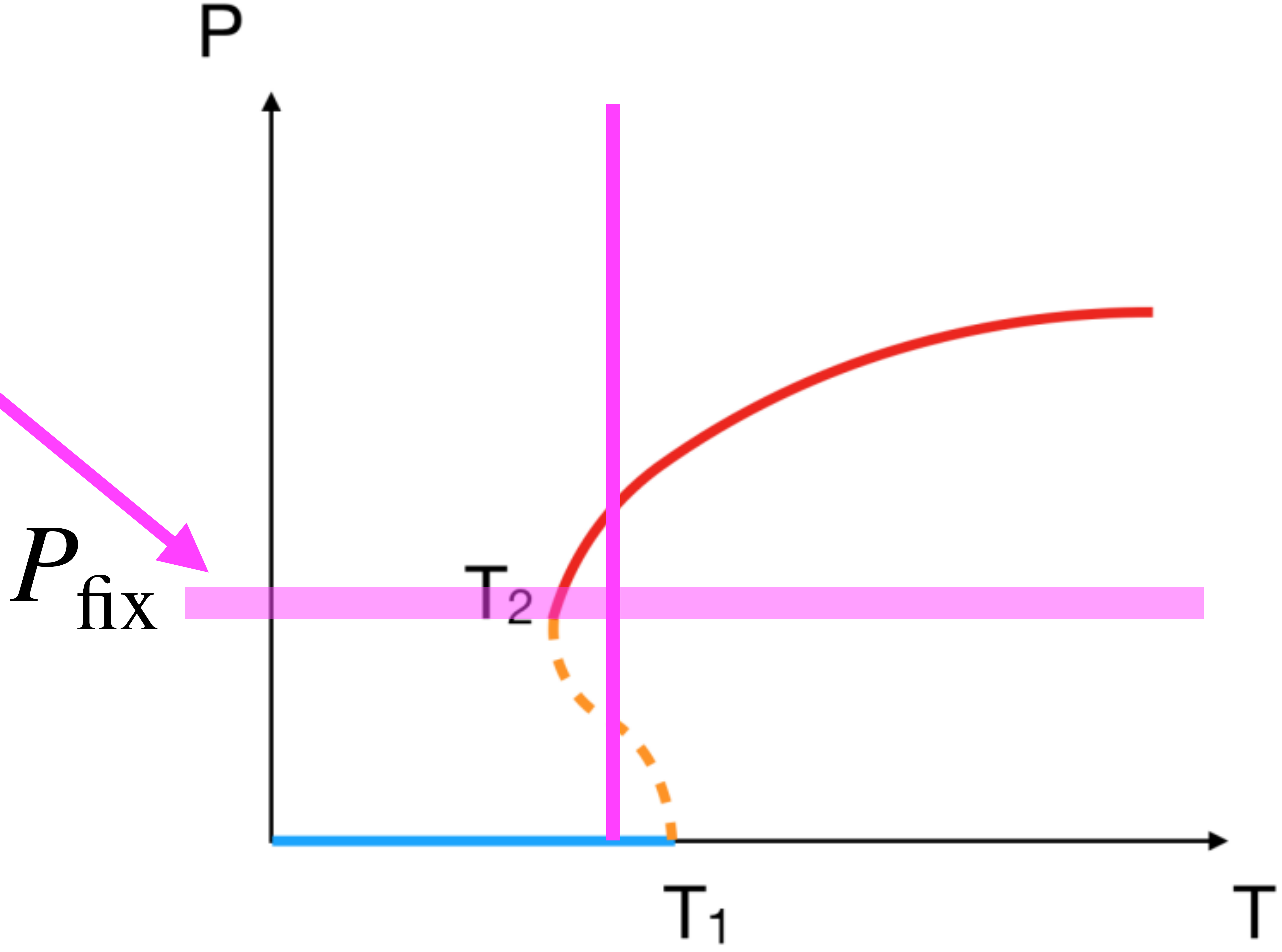
Transition $P \sim 0.35$



χSB $P \sim ???$

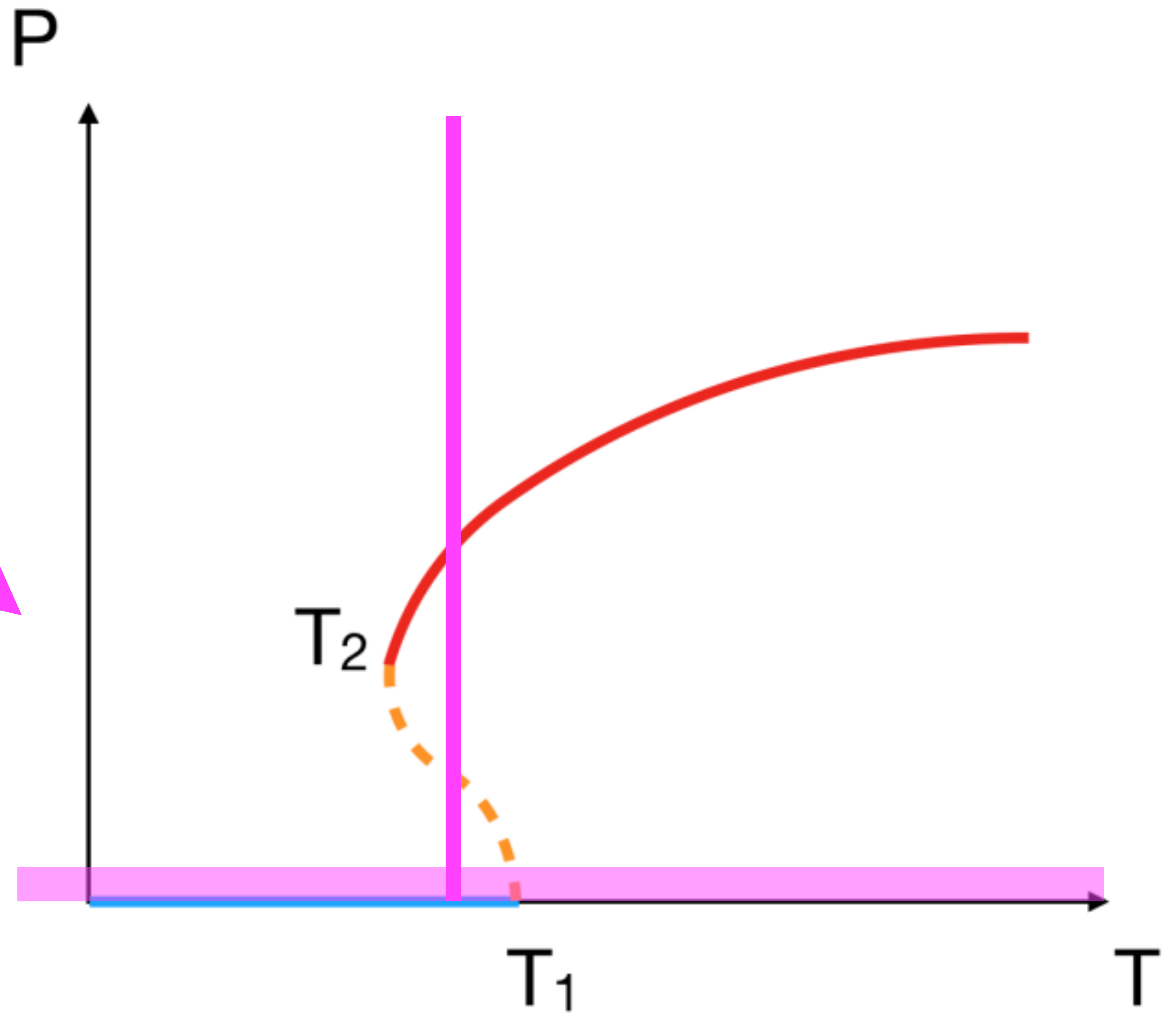
U(N) YM

2. Check symmetries at transition

Transition $P \sim 0.35$

χSB $P \sim ???$

P_{fix}



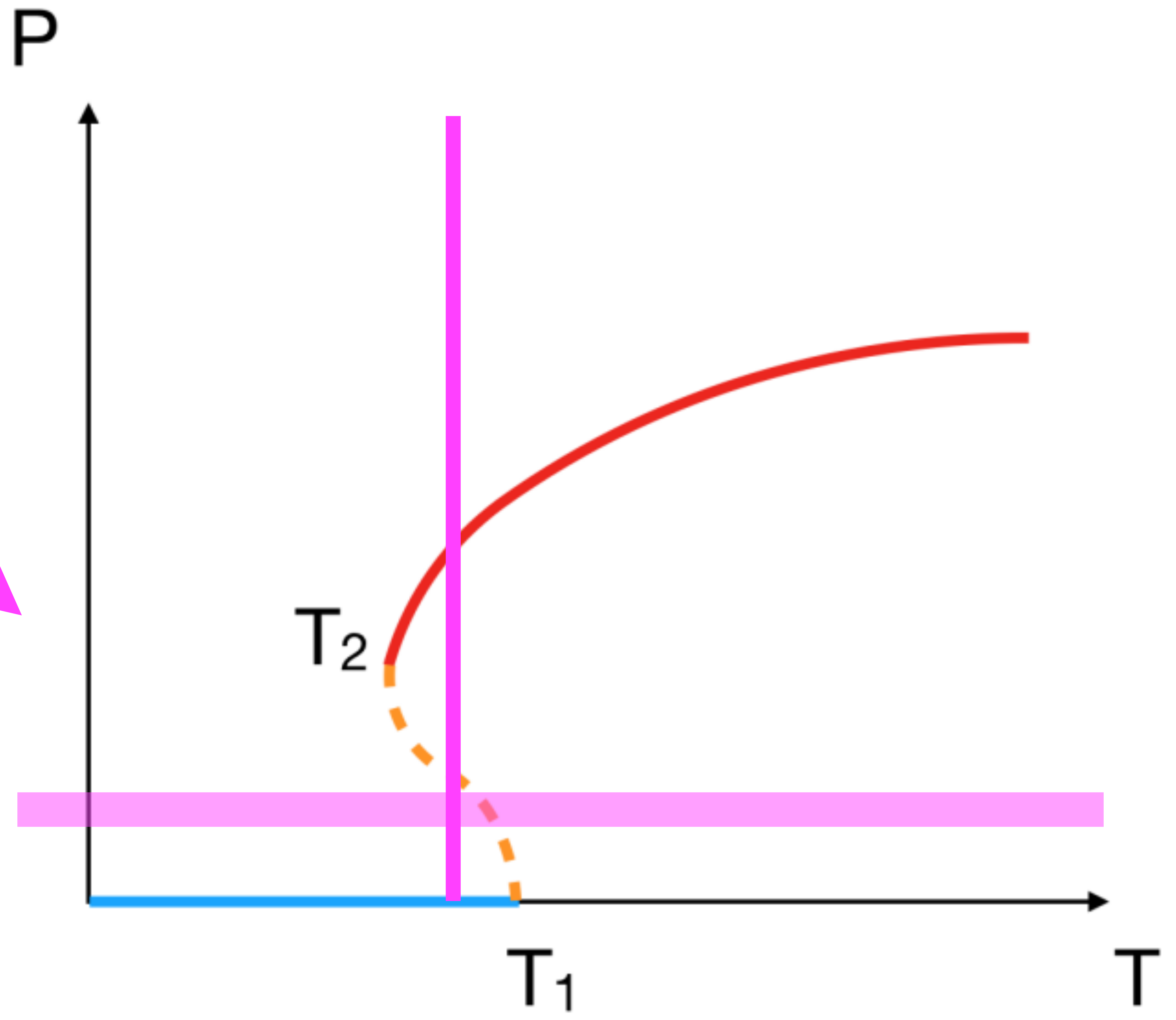
U(N) YM

2. Check symmetries at transition

Transition $P \sim 0.35$

χSB $P \sim ???$

P_{fix}



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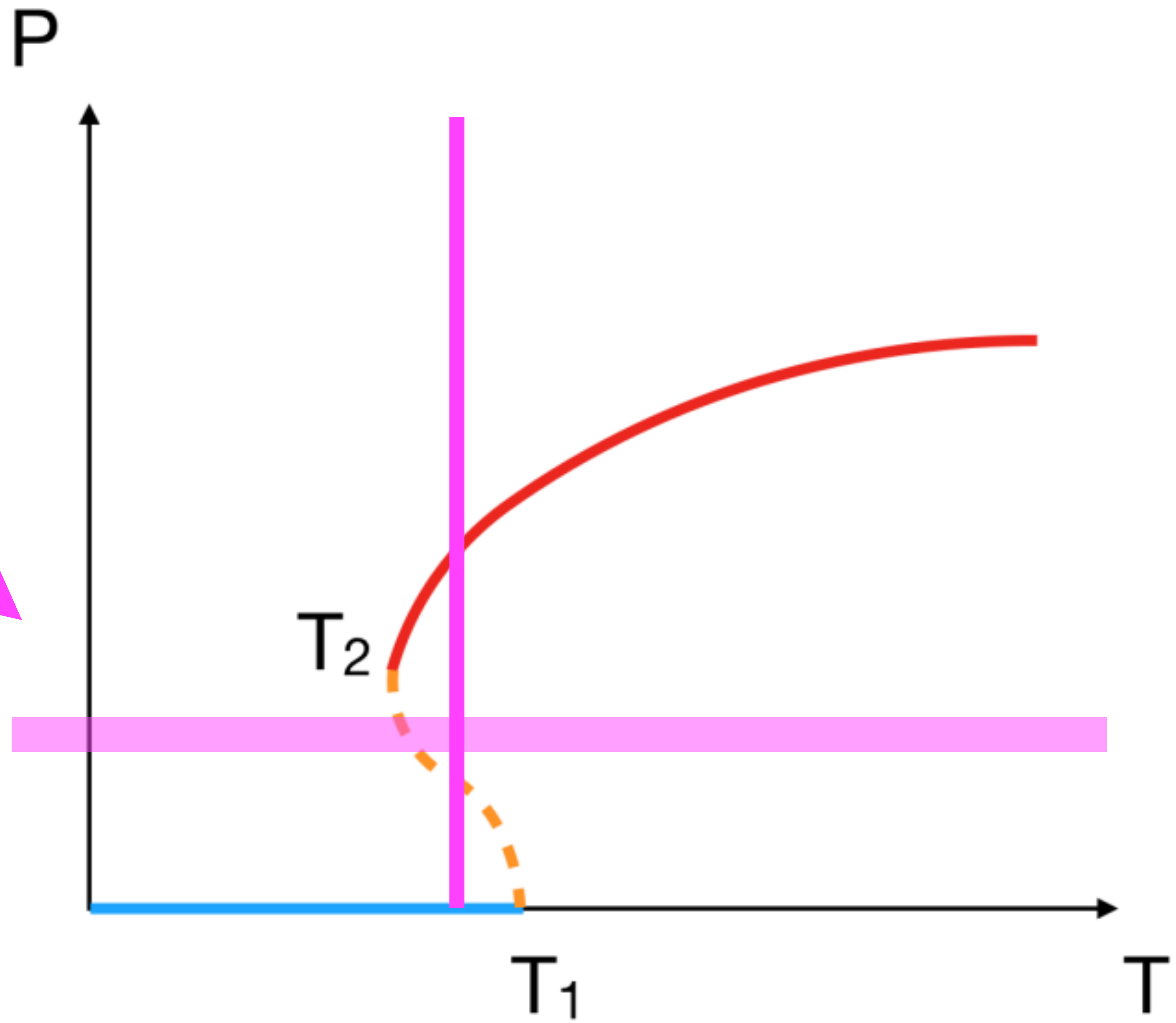

U(N) YM

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χSB $P \sim 0.35$

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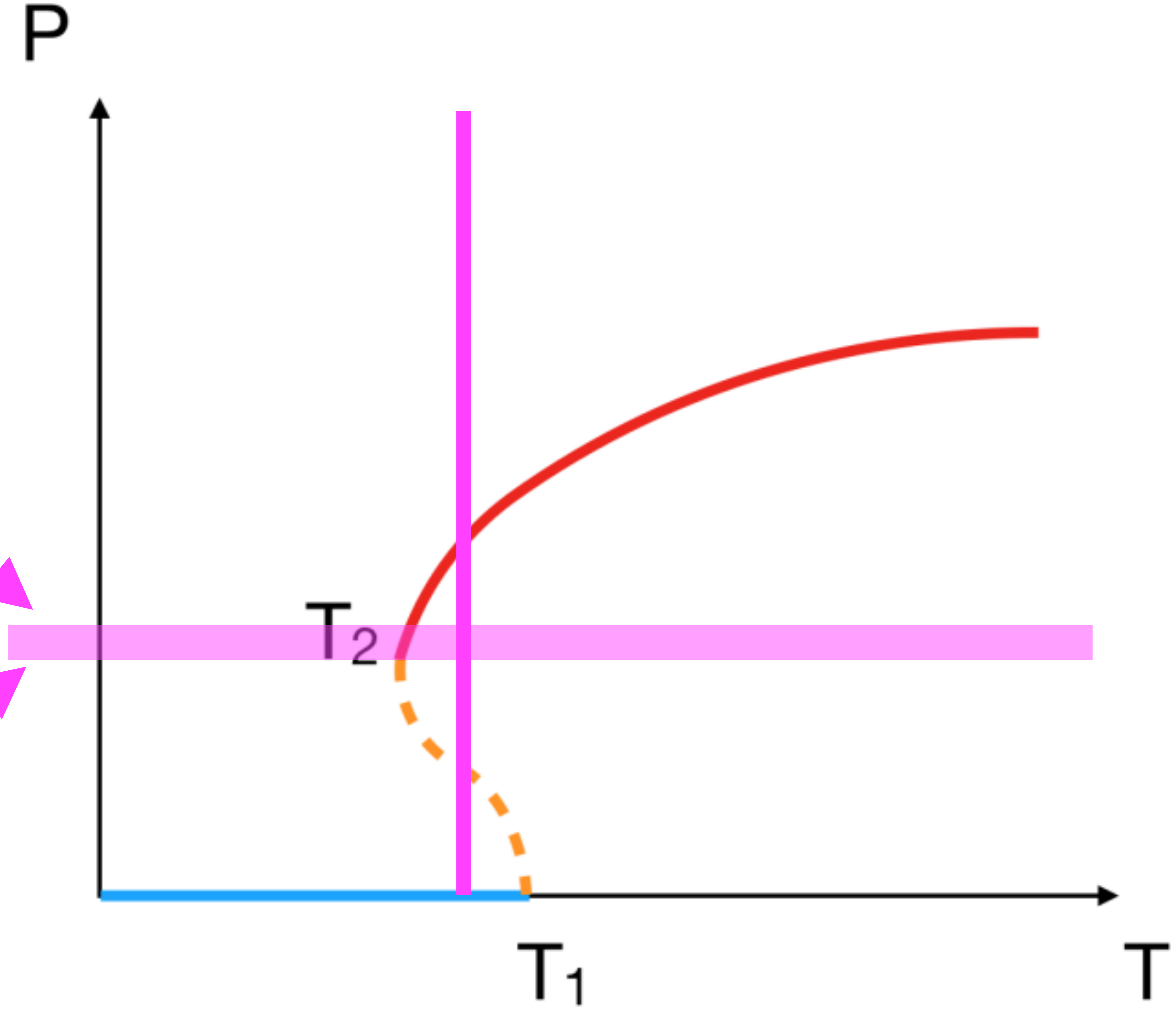


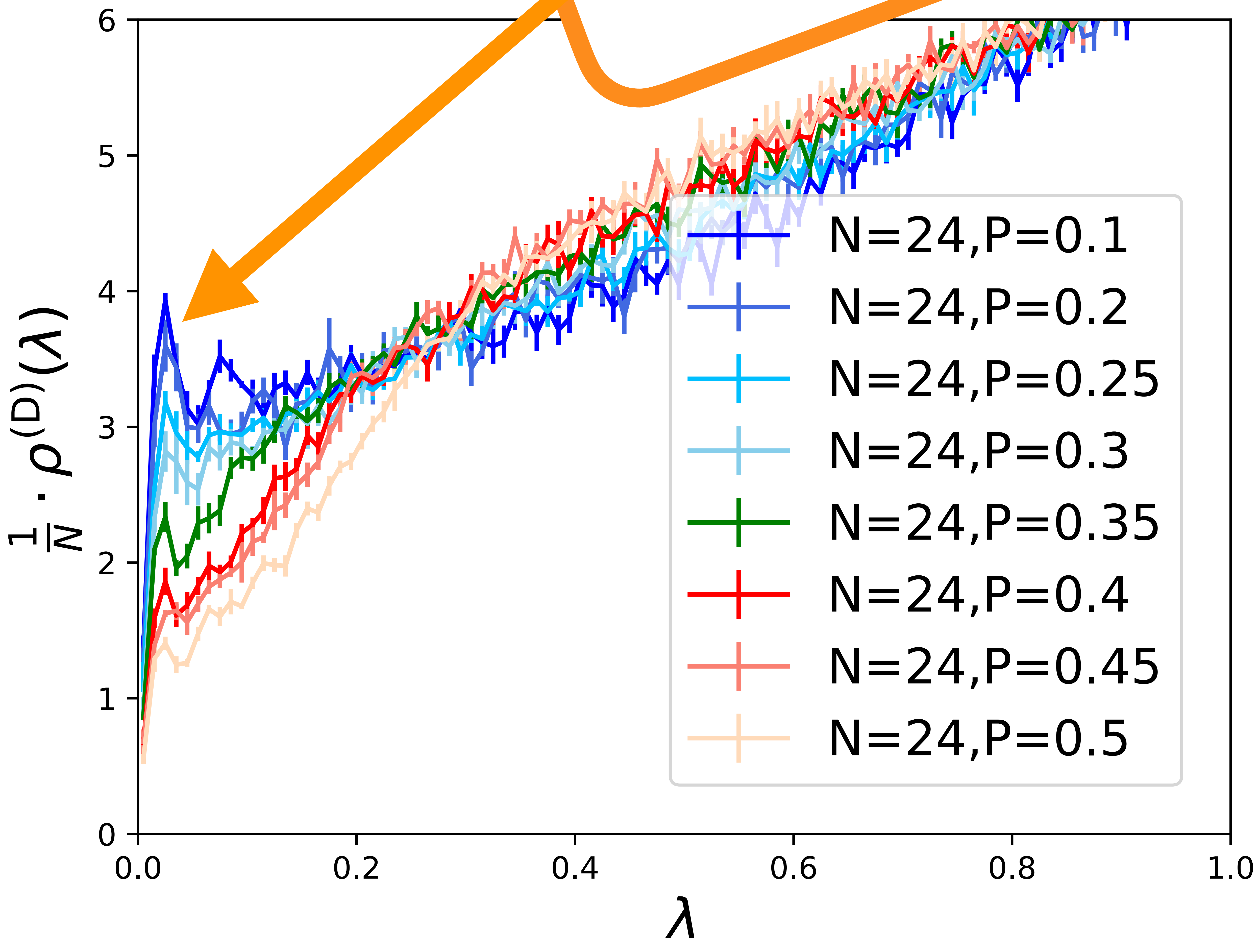
U(N) YM

2. Check symmetries at transition

Transition $P \sim 0.35$

χSB $P \sim 0.35$

χSB order param at $\lambda = 0$



U(N) YM

Centre	Chiral	
✓	✗	Confined
✗	✓	Deconfined
✗	✗	Partial

Test 2:

SU(N)

$\mathcal{N} = 1$ deformed-SYM

on $\mathbb{R}^3 \times S^1$

$\theta = \pi$

$N = 1$ SU(N) dSYM on $\mathbb{R}^3 \times S^1$, $\theta = \pi$

$N=1$ SU(N) dSYM on $\mathbb{R}^3\times S^1, \theta=\pi$

dSYM : small fermion mass breaks SUSY

$N=1$ SU(N) dSYM on $\mathbb{R}^3 \times S^1, \theta = \pi$

dSYM : small fermion mass breaks SUSY

Poppitz, Schäfer, Ünsal:
1205.0290, 1212.1238

Ünsal, Yaffe (dSYM):
0803.0344

Poppitz (review):
2111.10423

$N=1$ SU(N) dSYM on $\mathbb{R}^3 \times S^1, \theta = \pi$

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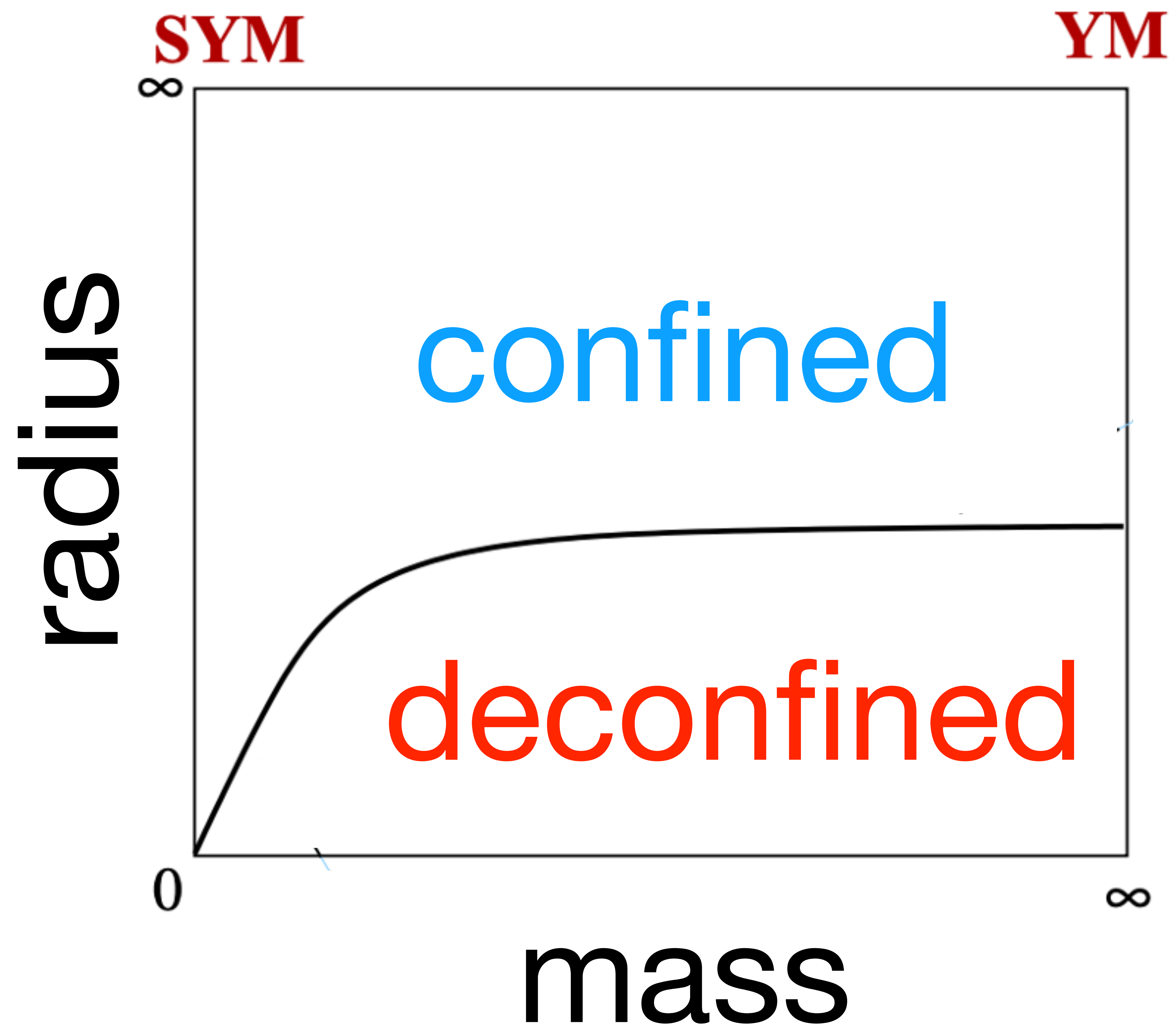

source: Poppitz, Schäfer, Ünsal 1205.0290 (modified)

$N=1$ SU(N) dSYM on $\mathbb{R}^3 \times S^1, \theta = \pi$

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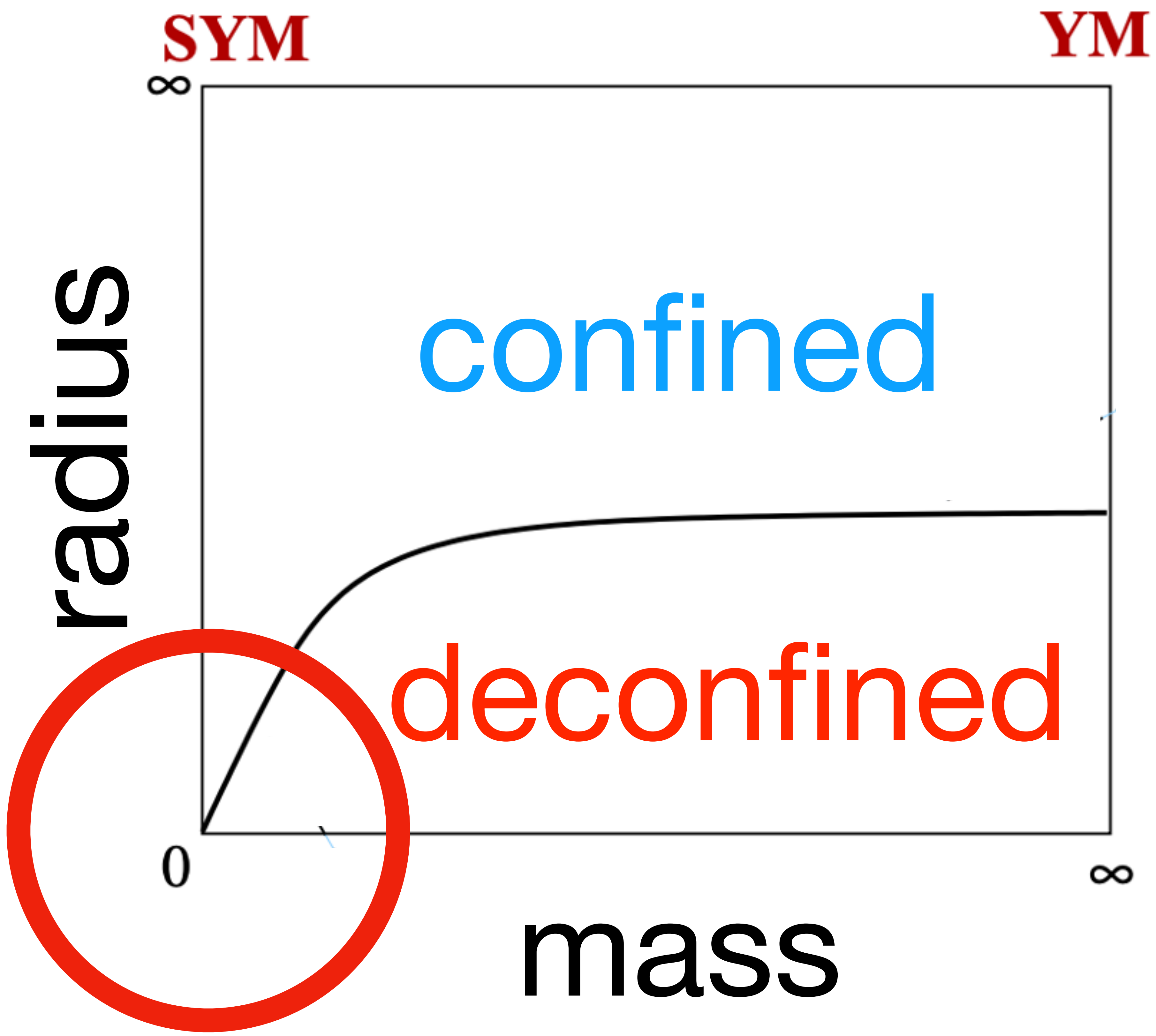


Small radius
$\Longrightarrow$ weak coupling

source: Poppitz, Schäfer, Ünsal 1205.0290 (modified)

$\mathcal{N} = 1$ SU(N) dSYM on $\mathbb{R}^3 \times S^1, \theta = \pi$

Centre	CP	
✓	✗	Confined
✗	✓	Deconfined

$N = 1$ SU(N) dSYM on $\mathbb{R}^3 \times S^1, \theta = \pi$

Centre	CP	
✓	✗	Confined
✗	✓	Deconfined

Gaiotto et al. 1703.00501: At least centre or CP must be broken

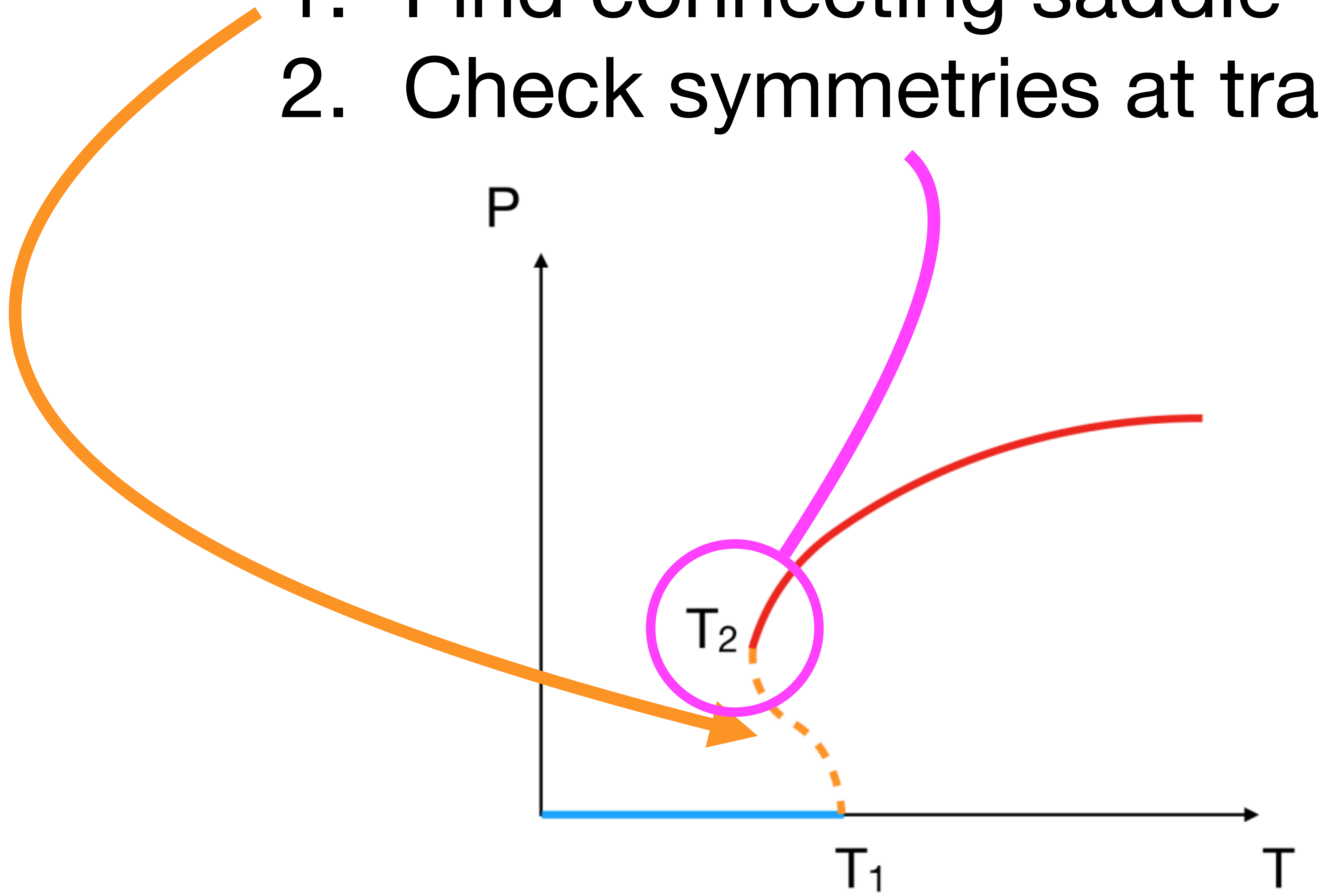
$\mathcal{N}=1$ SU(N) dSYM on $\mathbb{R}^3 \times S^1$, $\theta = \pi$

Centre	CP	
✓	×	Confined
×	✓	Deconfined
?×?	?×?	Partial

Gaiotto et al. 1703.00501: At least centre or CP must be broken

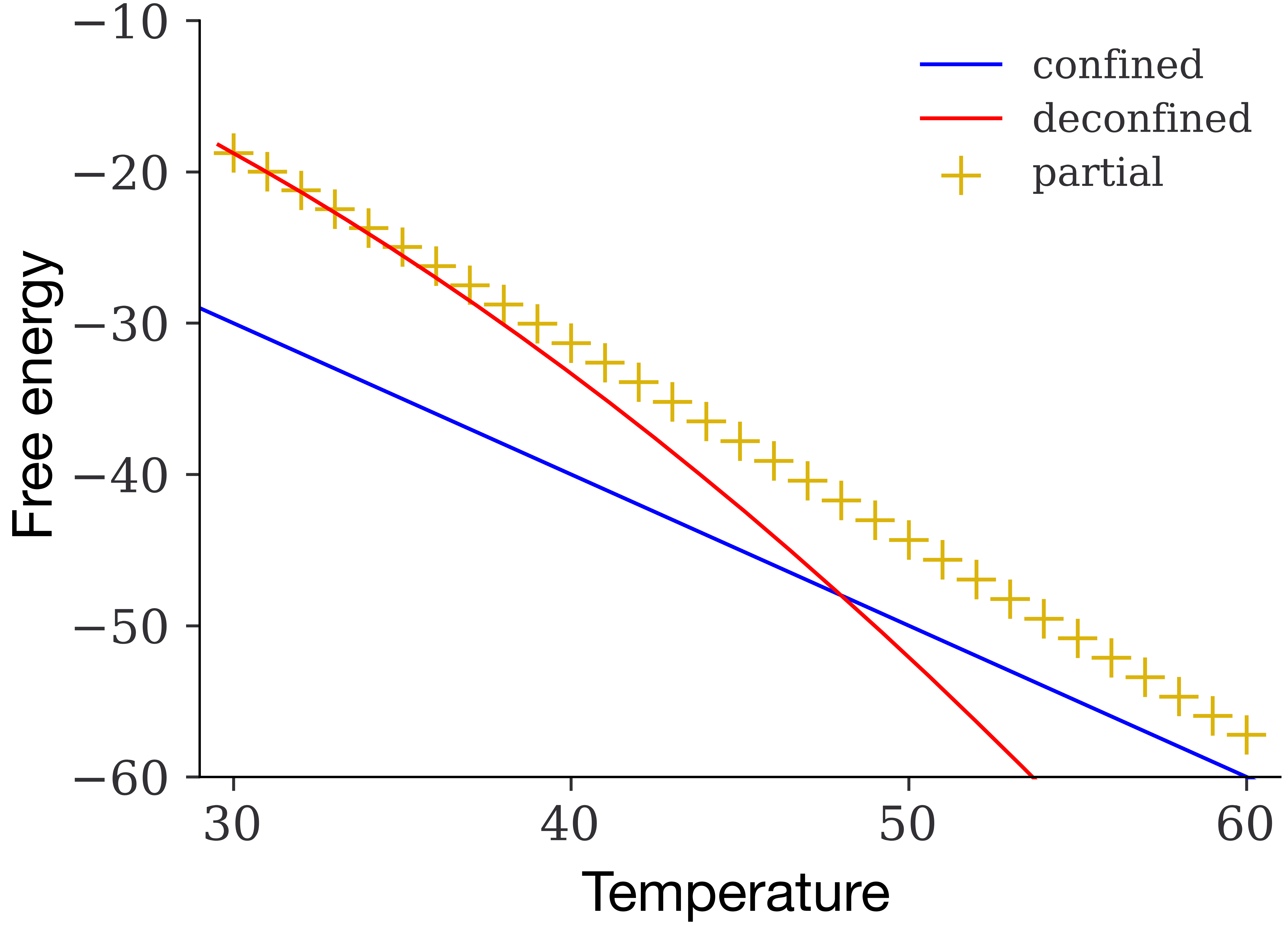
Test

1. Find connecting saddle
2. Check symmetries at transition



$N = 1$ SU(N) dSYM on $\mathbb{R}^3 \times S^1$, $\theta = \pi$

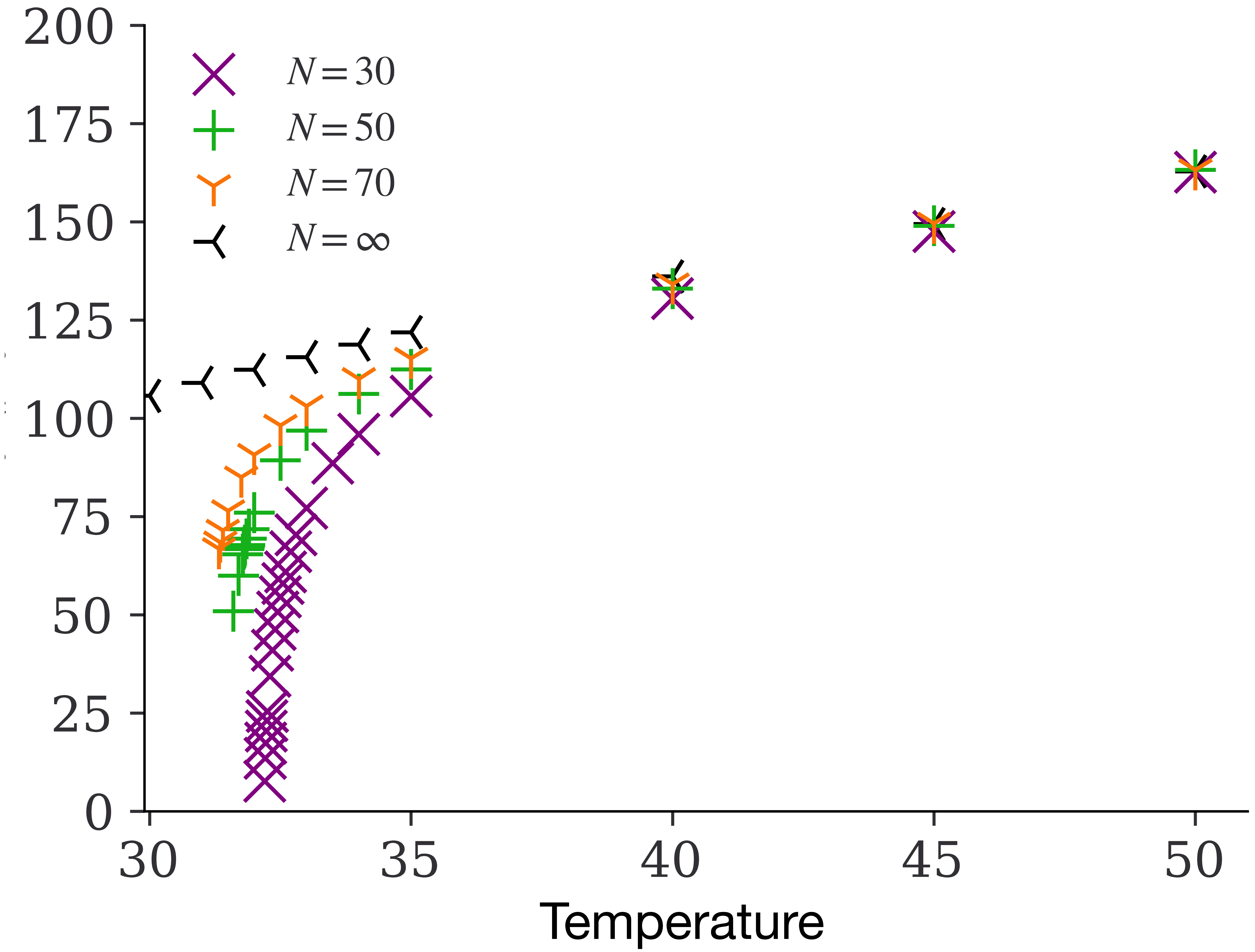
1. Find connecting saddle



$\mathcal{N}=1$ SU(N) dSYM on $\mathbb{R}^3 \times S^1, \theta = \pi$

2. Check symmetries at transition

$\left\langle F\tilde{F} \right\rangle$



Order parameter for CP breaking

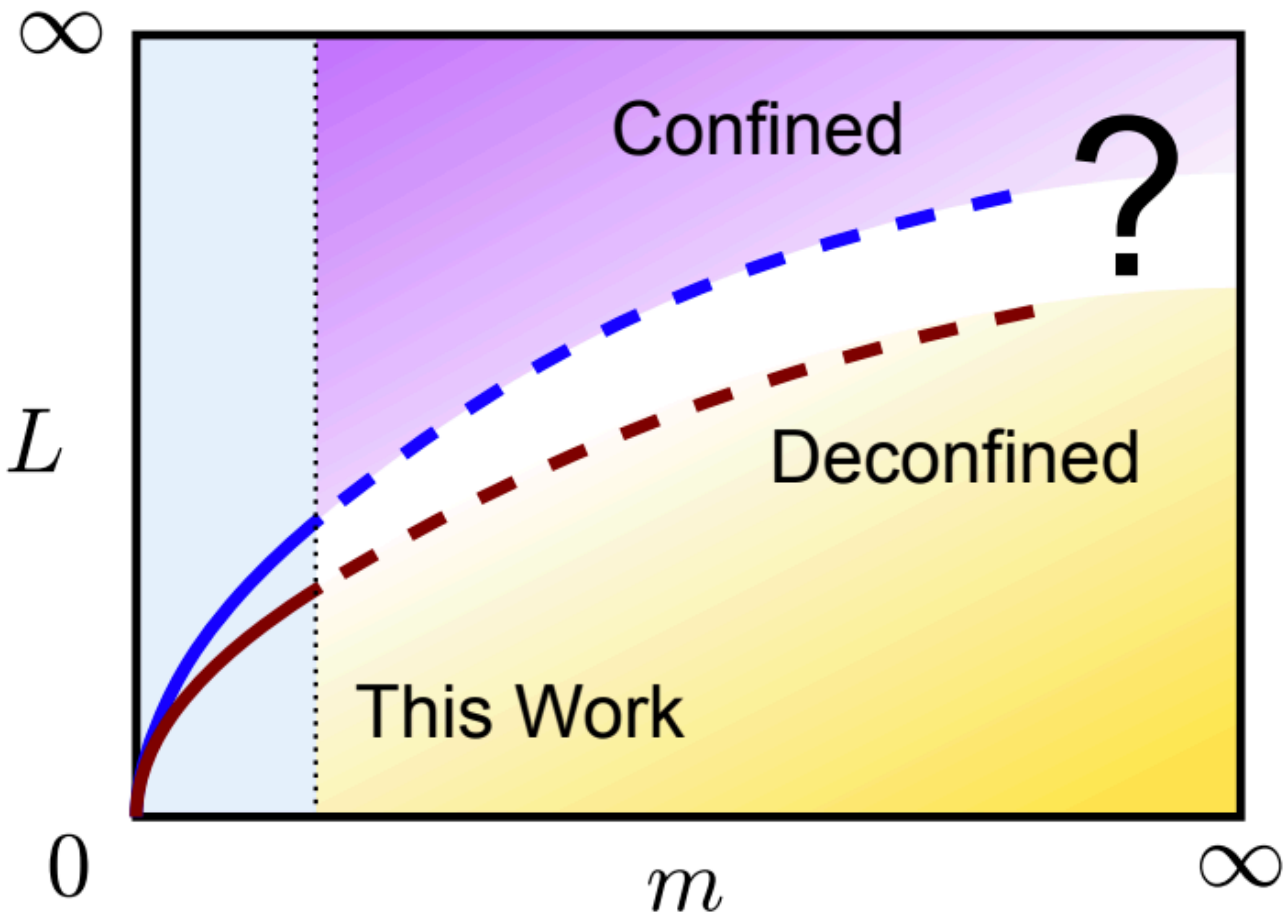
$N = 1$ SU(N) dSYM on $\mathbb{R}^3 \times S^1$, $\theta = \pi$

Centre	CP	
✓	✗	Confined
✗	✓	Deconfined
✗	✗	Partial

$N=1$ **SU(2)** dSYM on $\mathbb{R}^3 \times S^1, \theta = \pi$

$\mathcal{N} = 1$ SU(2) dSYM on $\mathbb{R}^3 \times S^1, \theta = \pi$

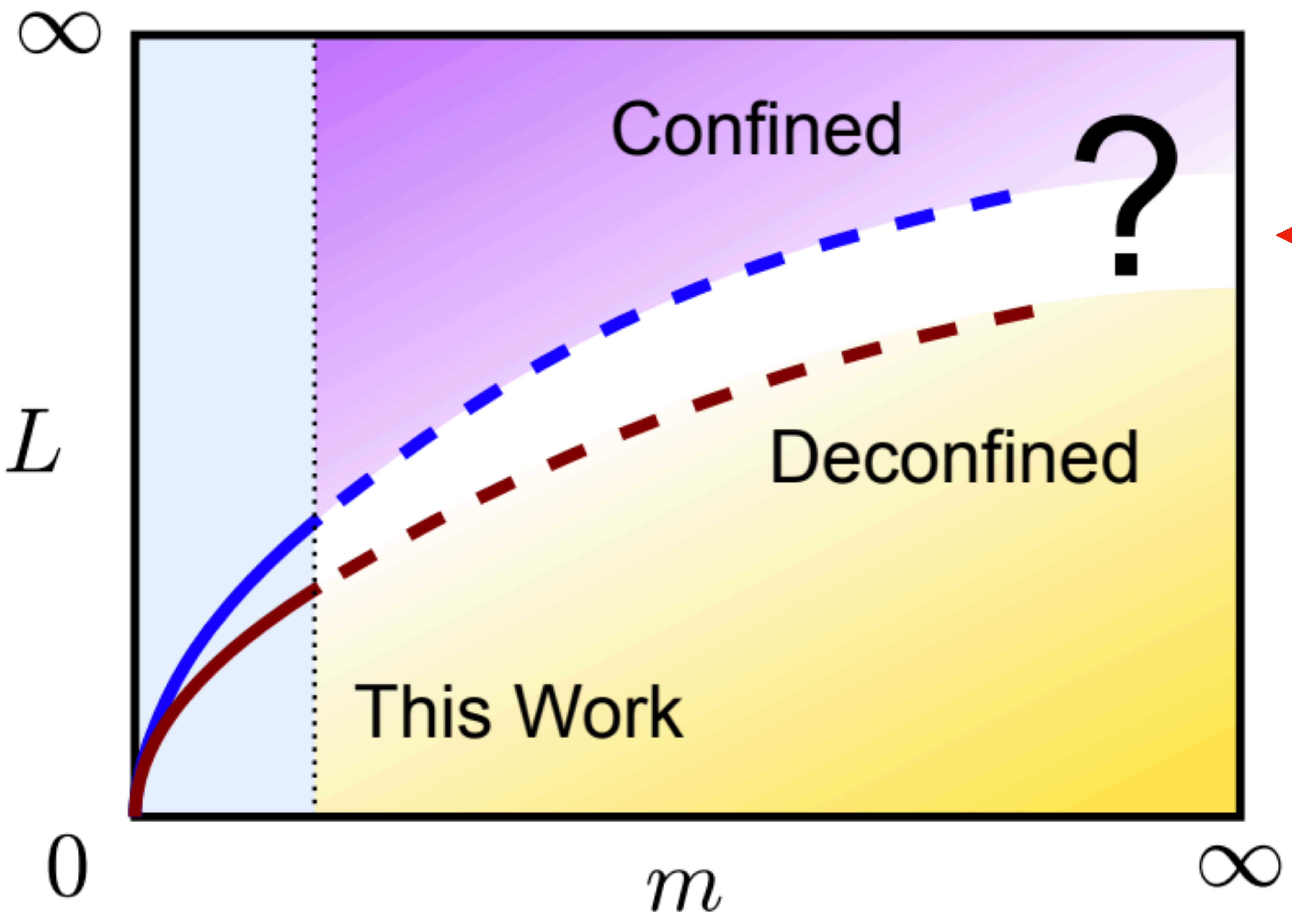
Chen, Fukishima, Nishimura, Tanizaki: 2006.01487



source: Chen et al. 2006.01487

$\mathcal{N}=1$ SU(2) dSYM on $\mathbb{R}^3 \times S^1$, $\theta = \pi$

Chen, Fukishima, Nishimura, Tanizaki: 2006.01487



Partial phase?

source: Chen et al. 2006.01487

$N = 1$ SU(N) dSYM on $\mathbb{R}^3 \times S^1, \theta = \pi$

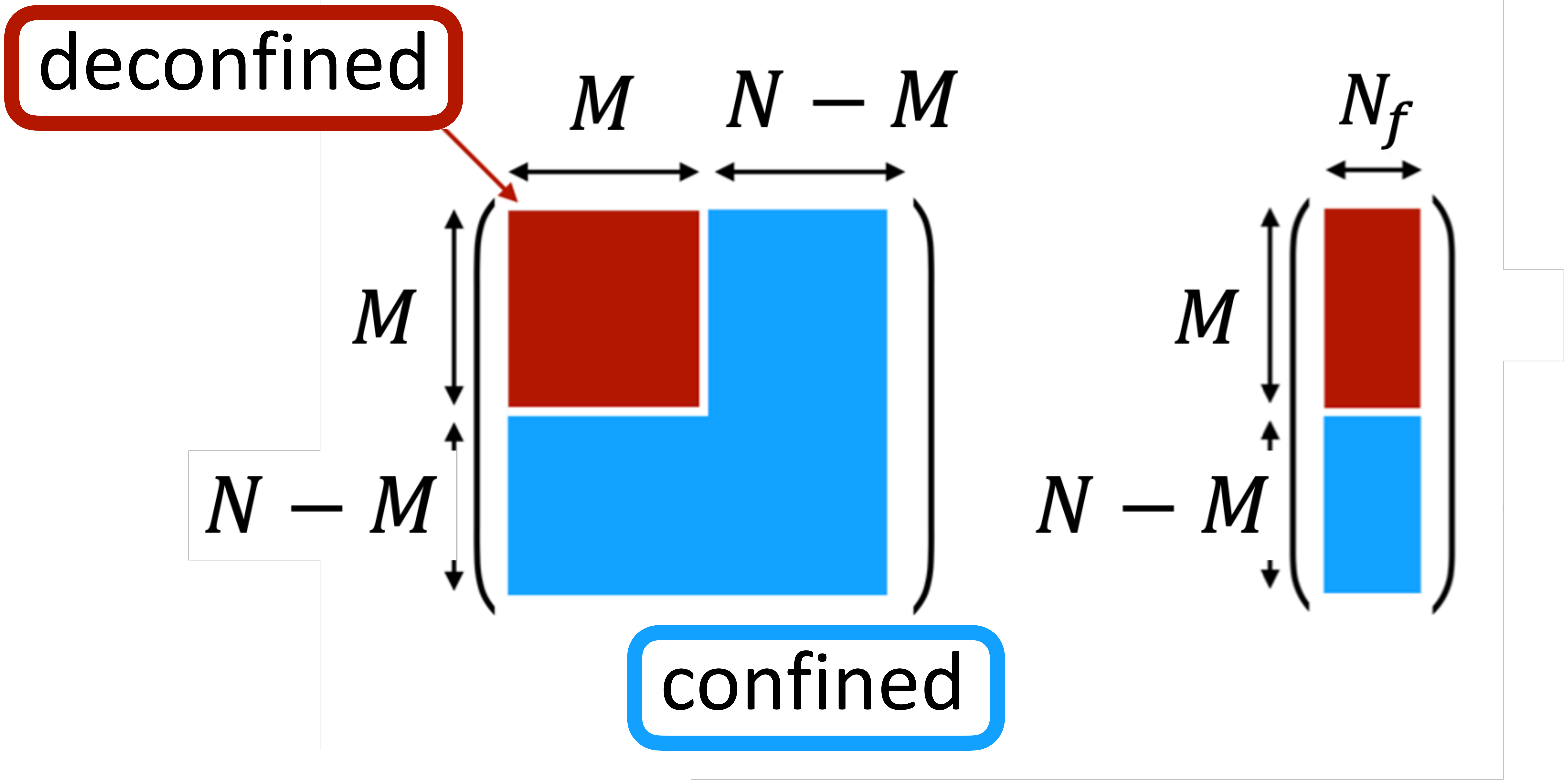
Centre	CP	
✓	✗	Confined
✗	✓	Deconfined
✗	✗	Partial

Partial confinement **can** be characterised by global symmetry breaking

(in these systems)

Partial confinement:

What about flux tubes?



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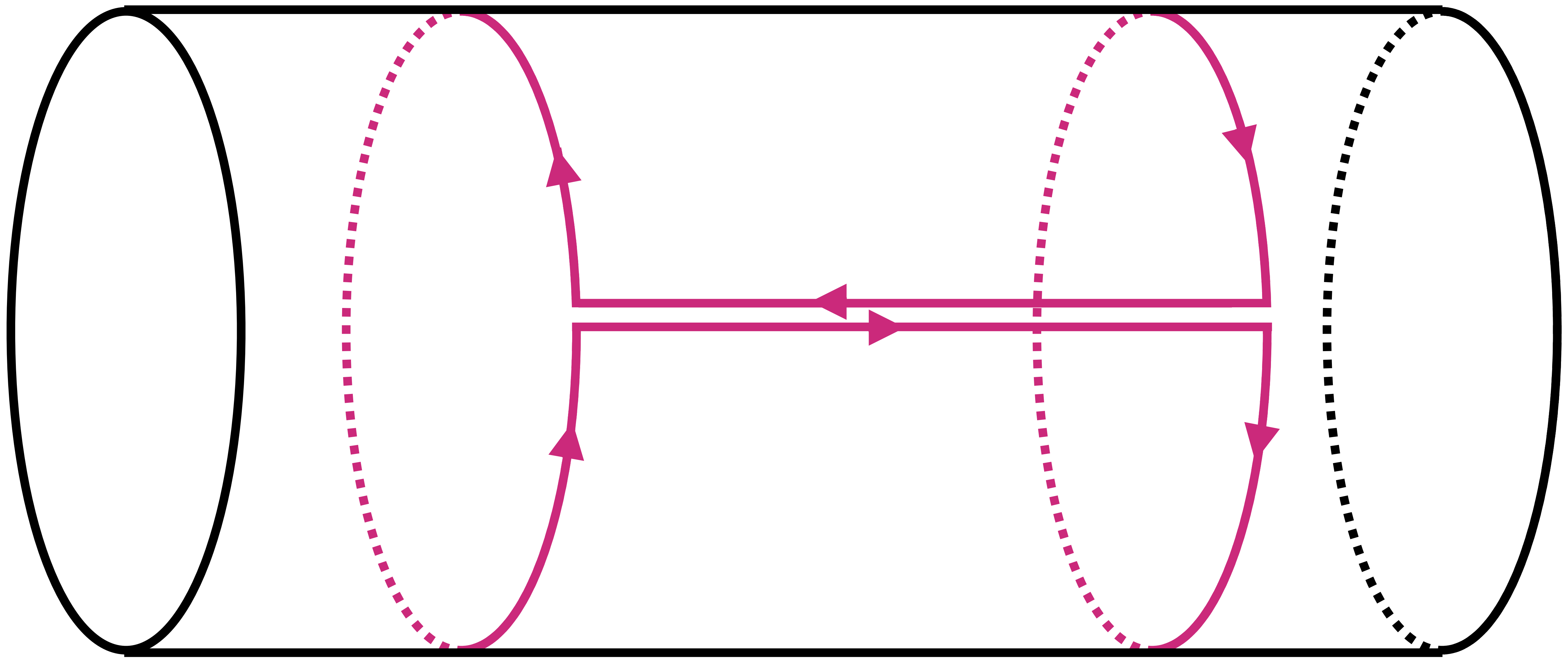
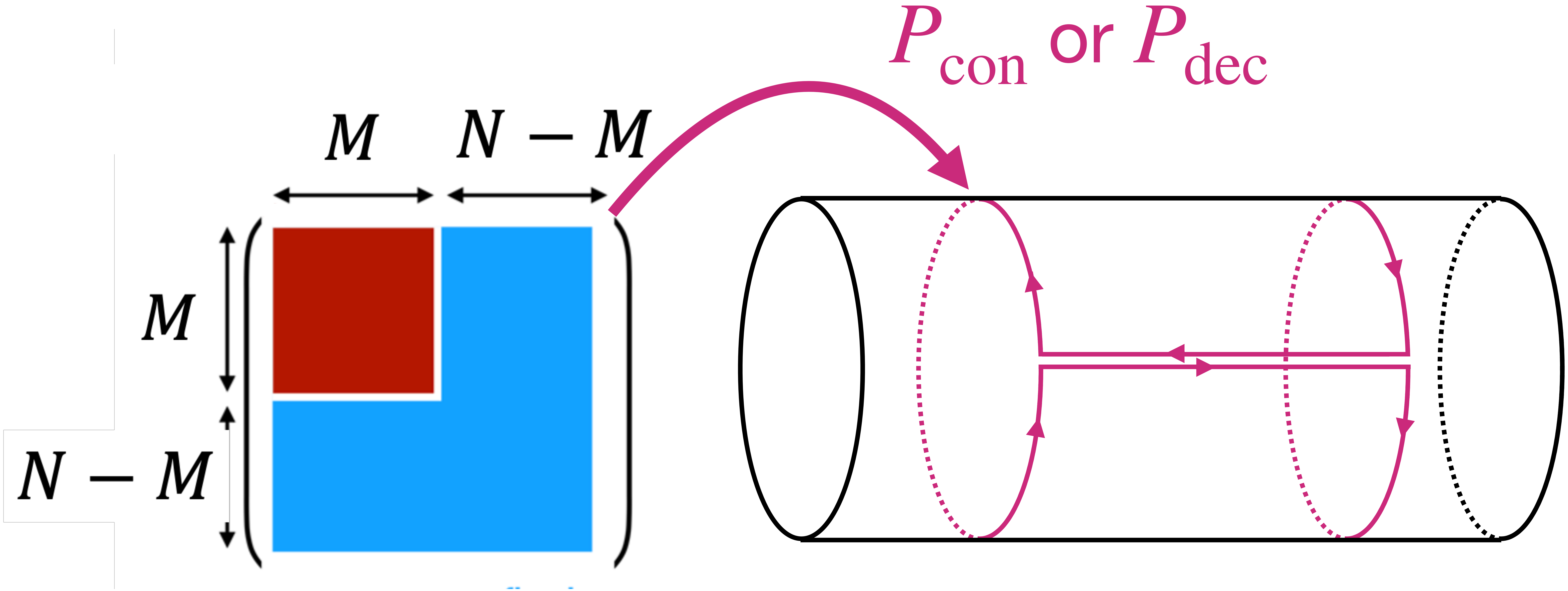
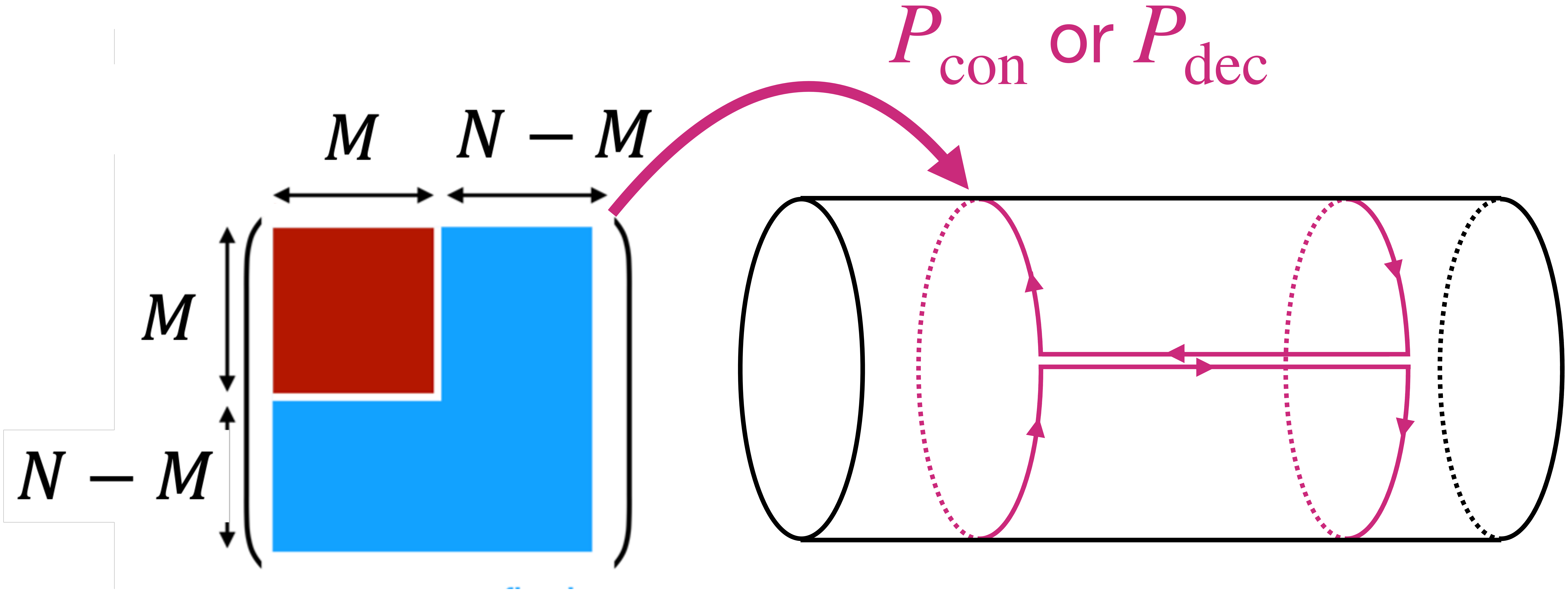




M
$N - M$
M
$N - M$
P_{con} or P_{dec}



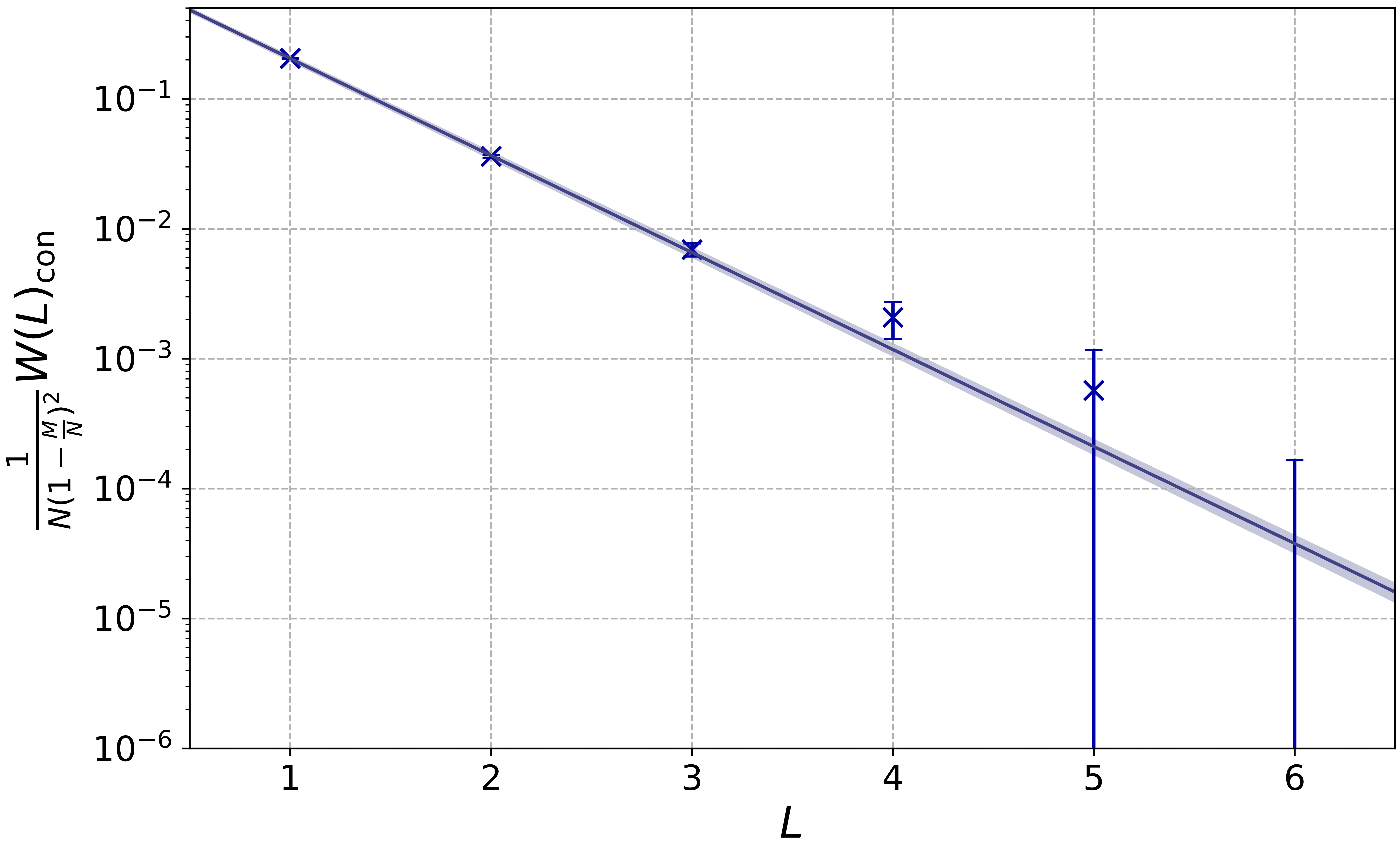
two-point function of
con/dec subsectors

Test:

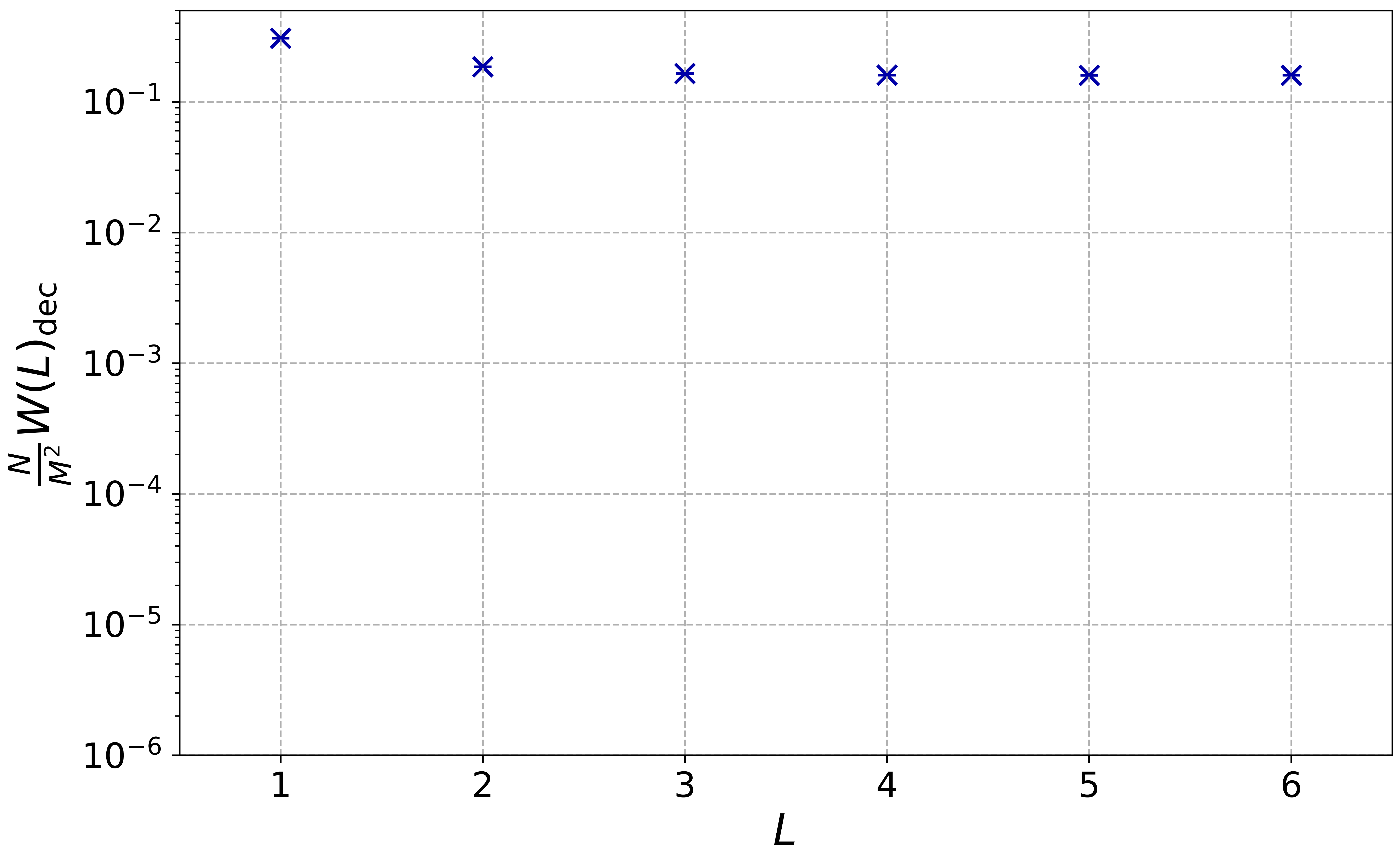
U(N) pure YM

large N, strong coupling

Confined subsector



Deonfined subsector



The partial phase has a linear potential in the confined subsector

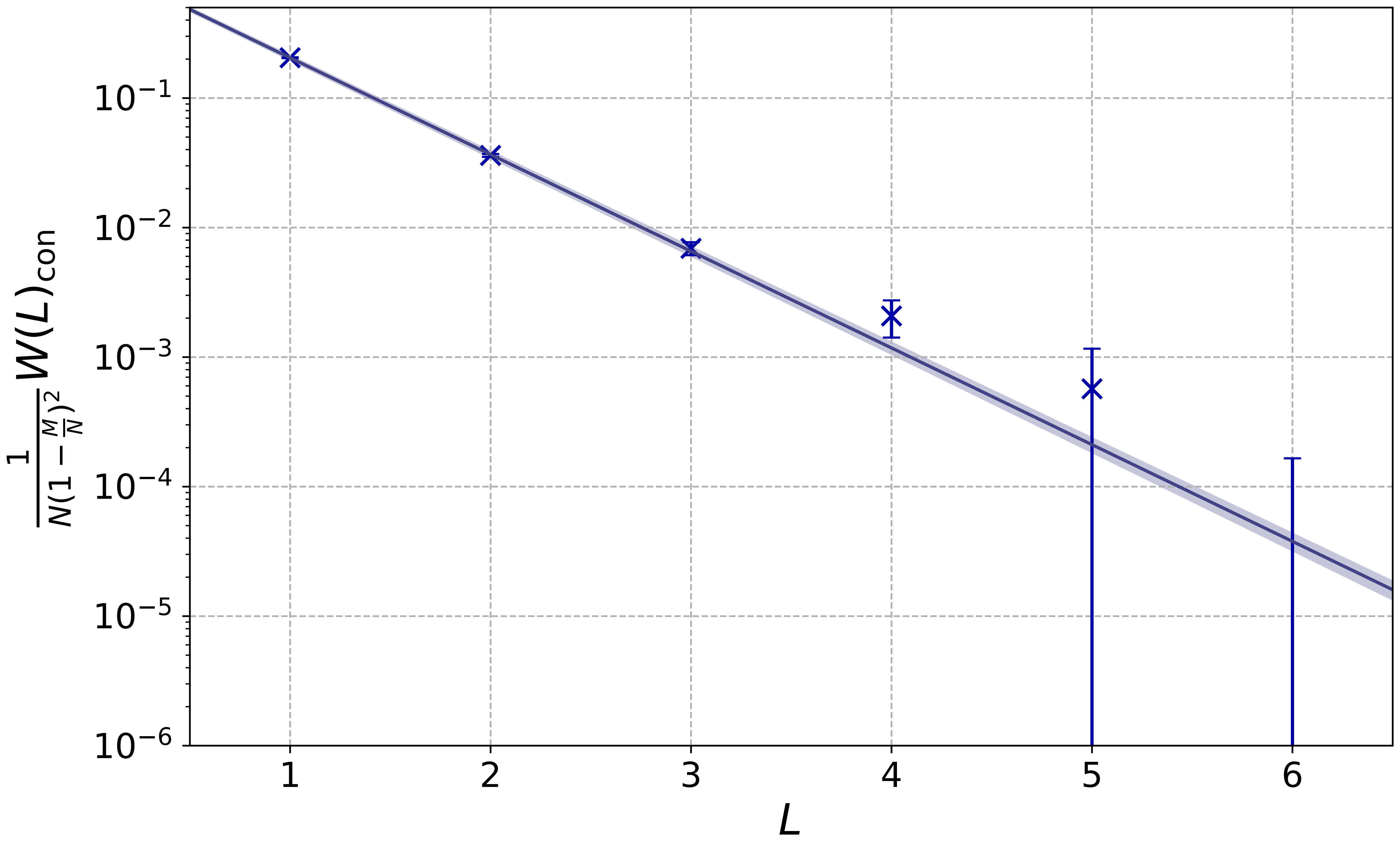
Global symmetry breaking signature

Centre	CP	
✓	✗	Confined
✗	✓	Deconfined
✗	✗	Partial

Global symmetry breaking signature

Centre	CP	
✓	✗	Confined
✗	✓	Deconfined
✗	✗	Partial

Linear potential subsector



Questions:

- More systems / general theory

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  - Bound quarks?

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  - t’Hooft-Higgs duality?

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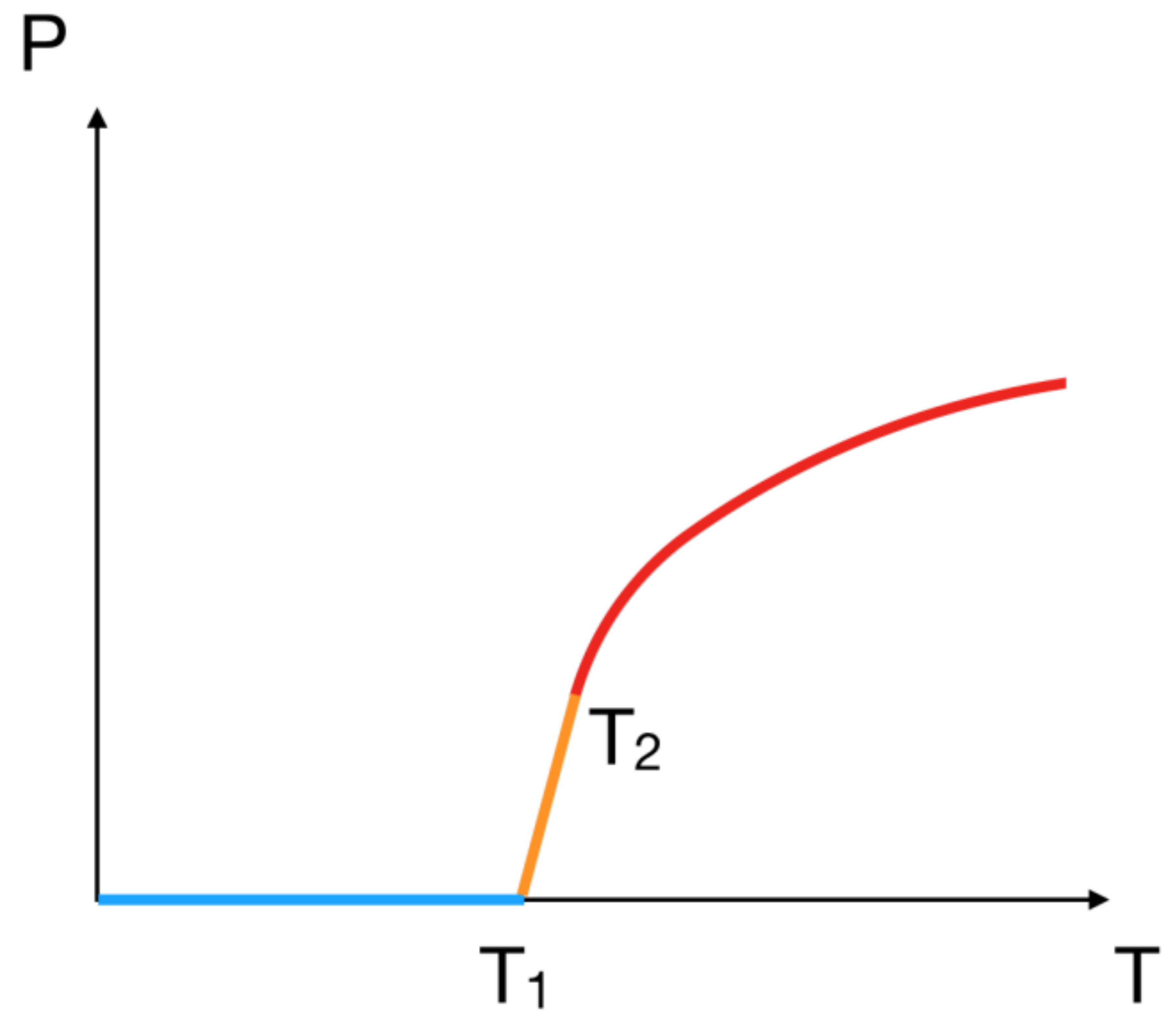
- More systems / general theory
  - Bound quarks?
  - t'Hooft-Higgs duality?

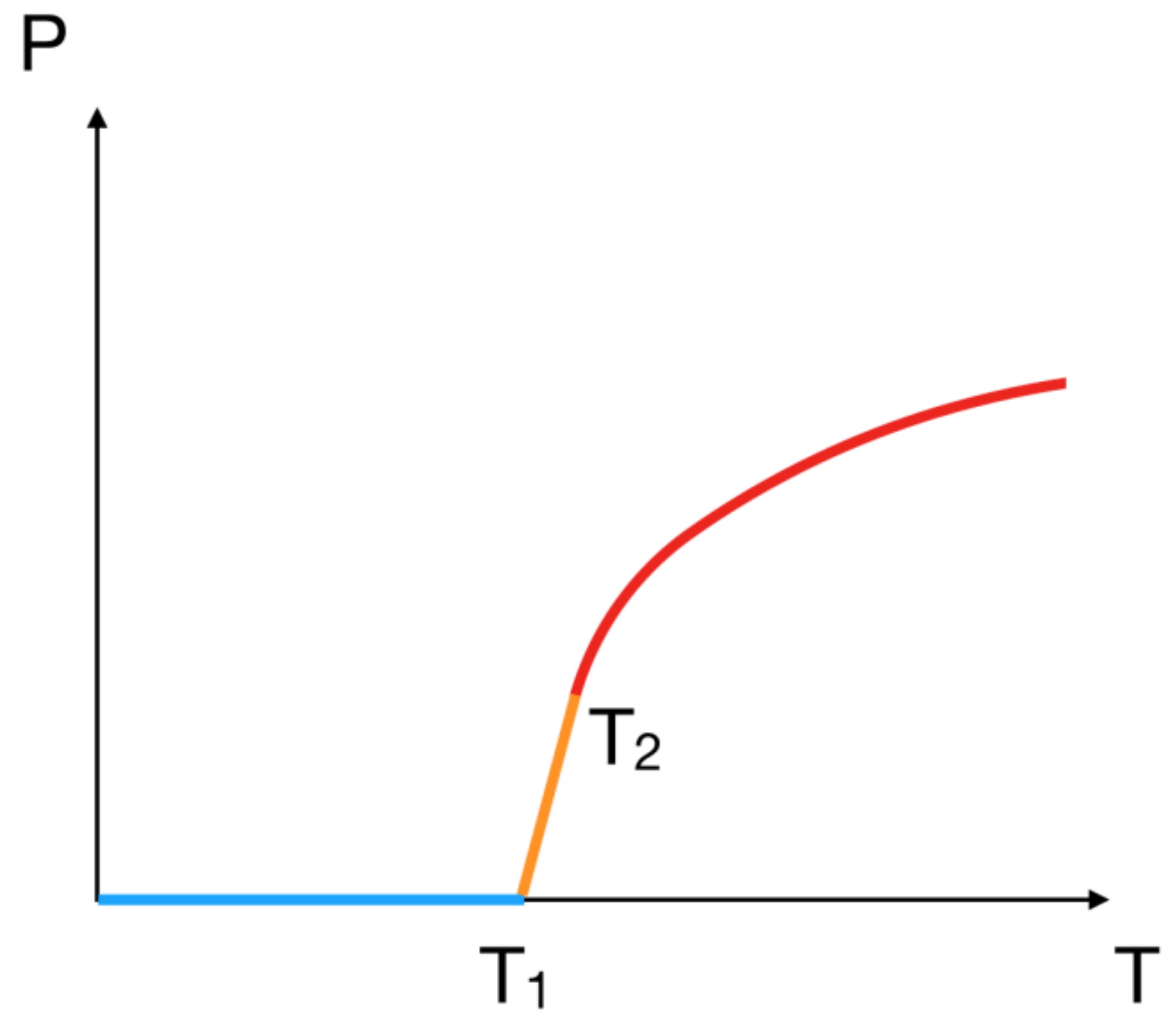
- QCD
  - stable phase?



Questions:

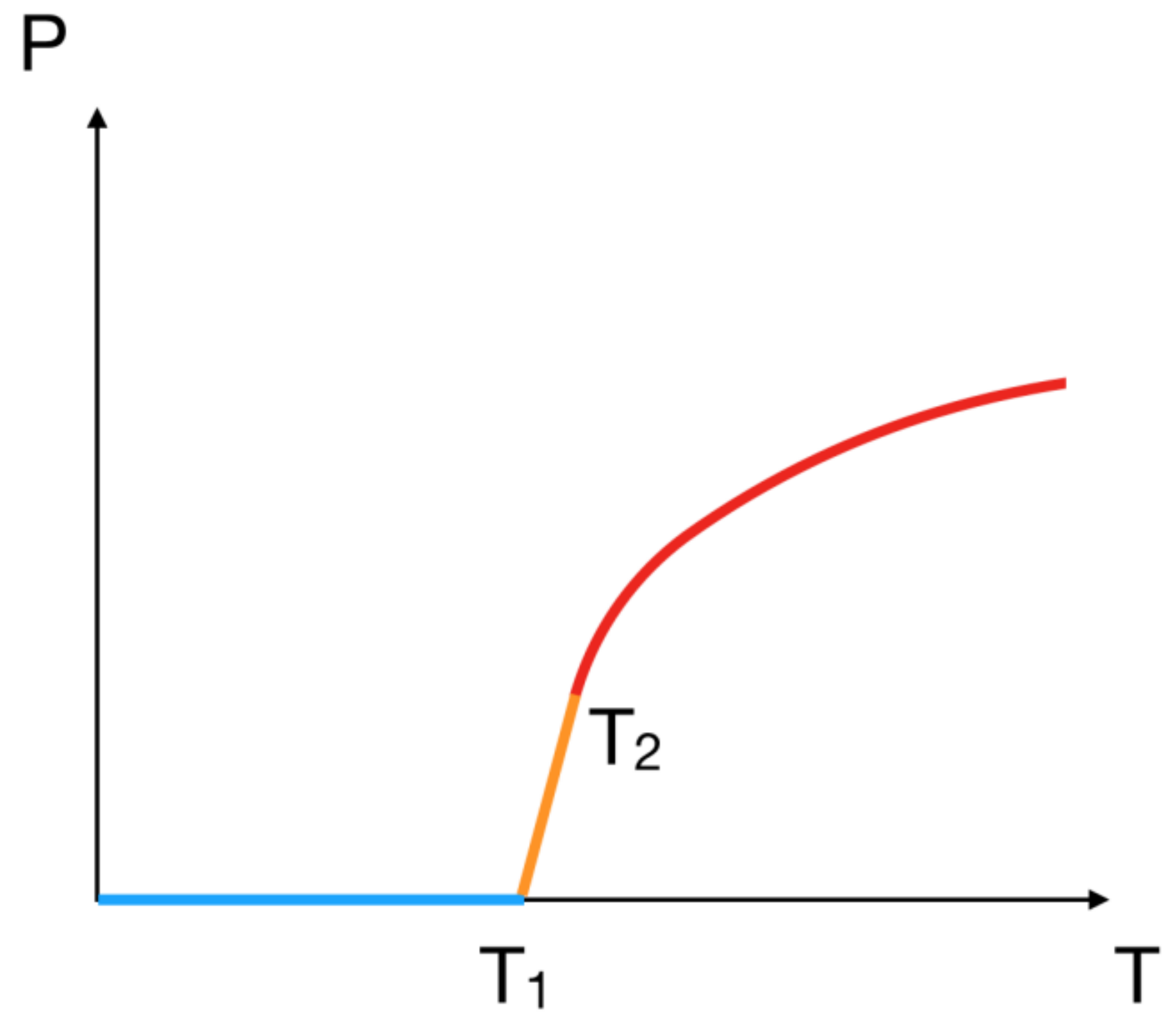
- More systems / general theory
  - Bound quarks?
  - t'Hooft-Higgs duality?

- QCD
  - stable phase?
  - χSB vs. confinement



Questions:

- More systems / general theory
  - Bound quarks?
  - t'Hooft-Higgs duality?
- QCD
  - stable phase?
  - χSB vs. confinement
- Holography



Global symmetry breaking signature

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✗	✓	Deconfined
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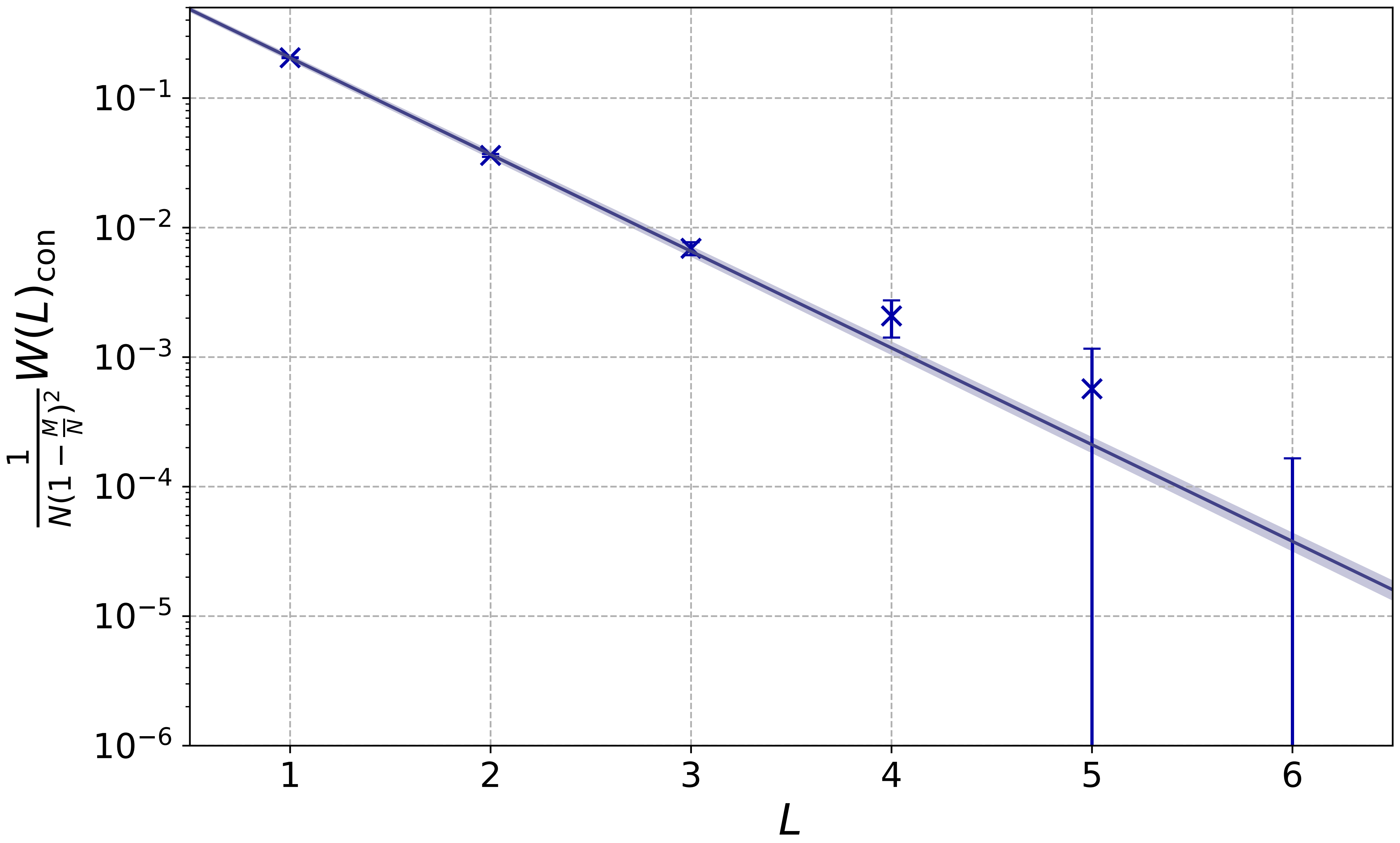
Linear potential subsector



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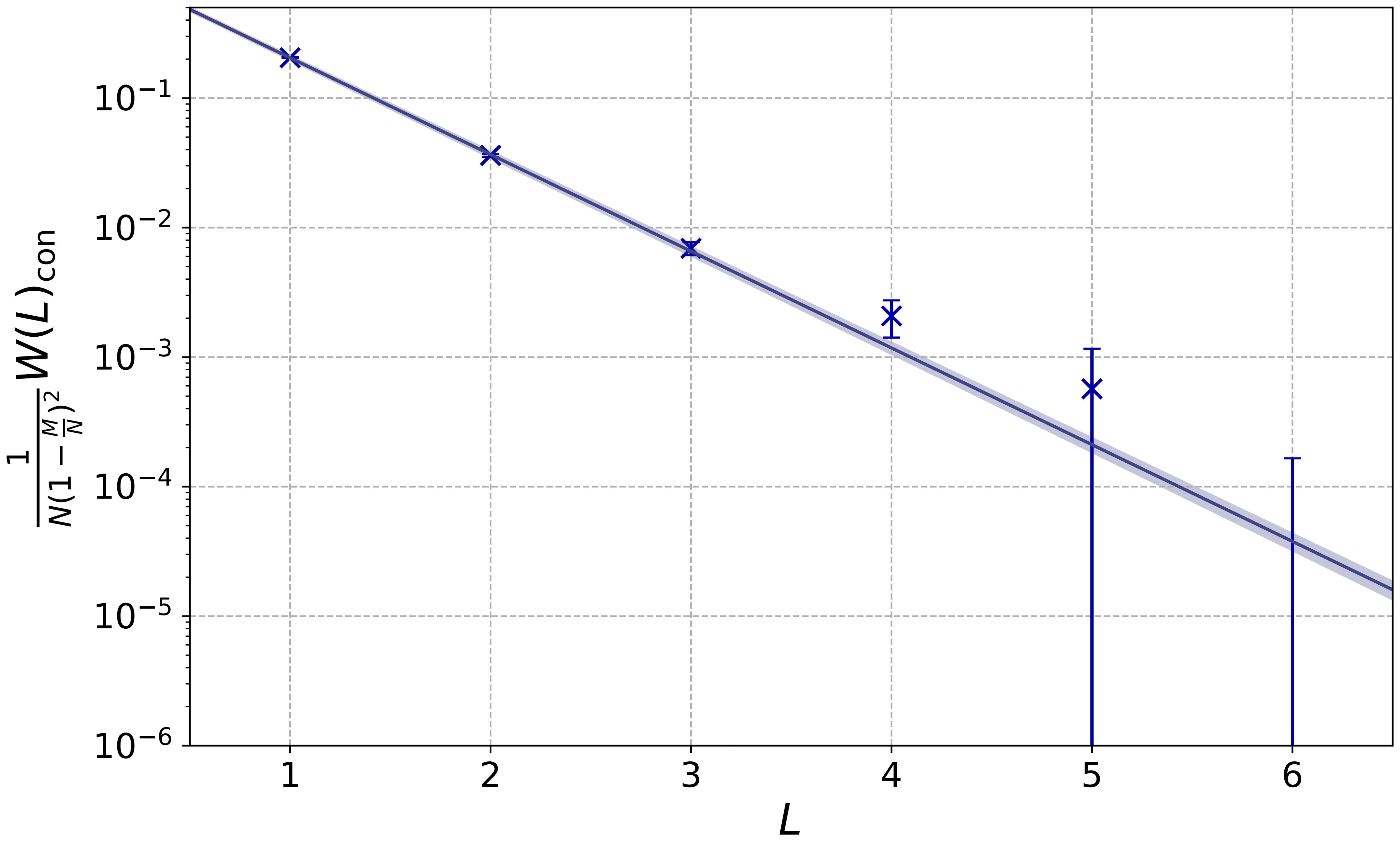

Thank you for listening!