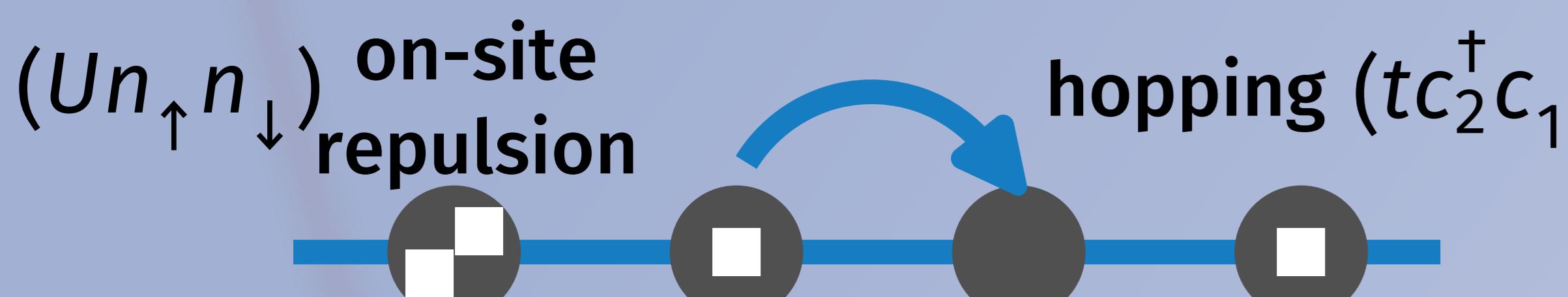


HUBBARD MODEL AND THE MOTT TRANSITION

Simplest lattice model for correlated electrons Combines effects of kinetic energy and local repulsion

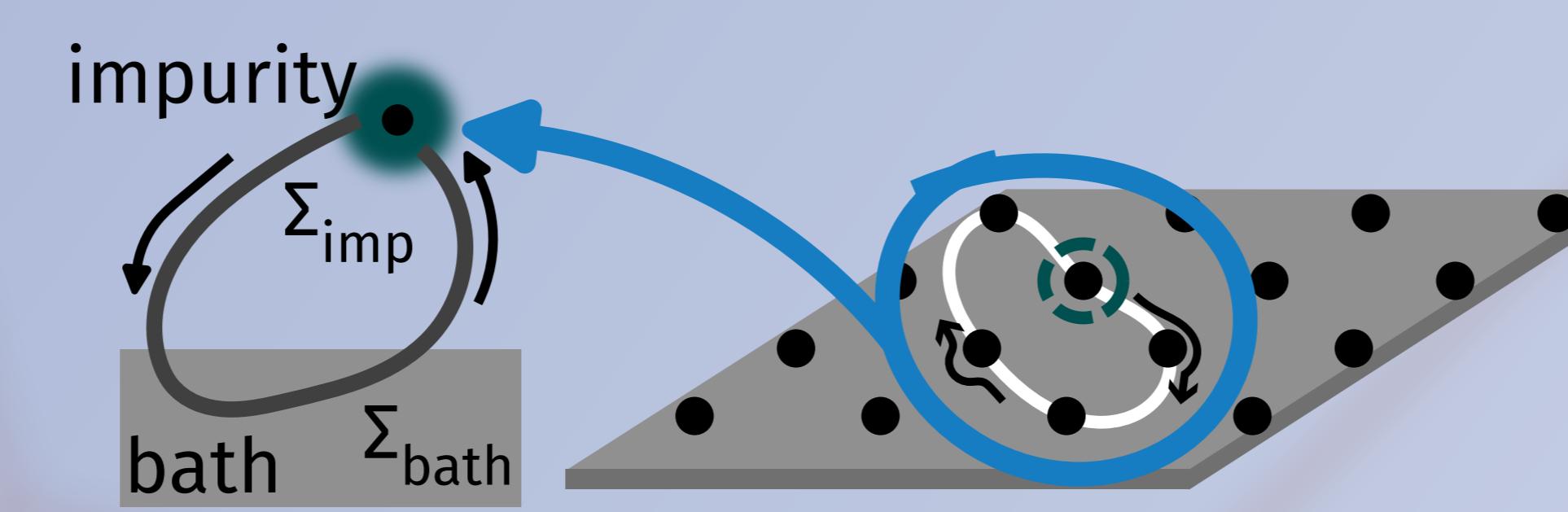
- **metallic** for $t \gg U$
- **Mott insulator** for $U \gg t$

Two phases separated by a **metal-insulator transition**



DYNAMICAL MEAN-FIELD THEORY: MAPPING THE HUBBARD MODEL TO IMPURITY MODELS

DMFT maps local Greens func. of the Hubbard to that of a **self-consistent impurity model**

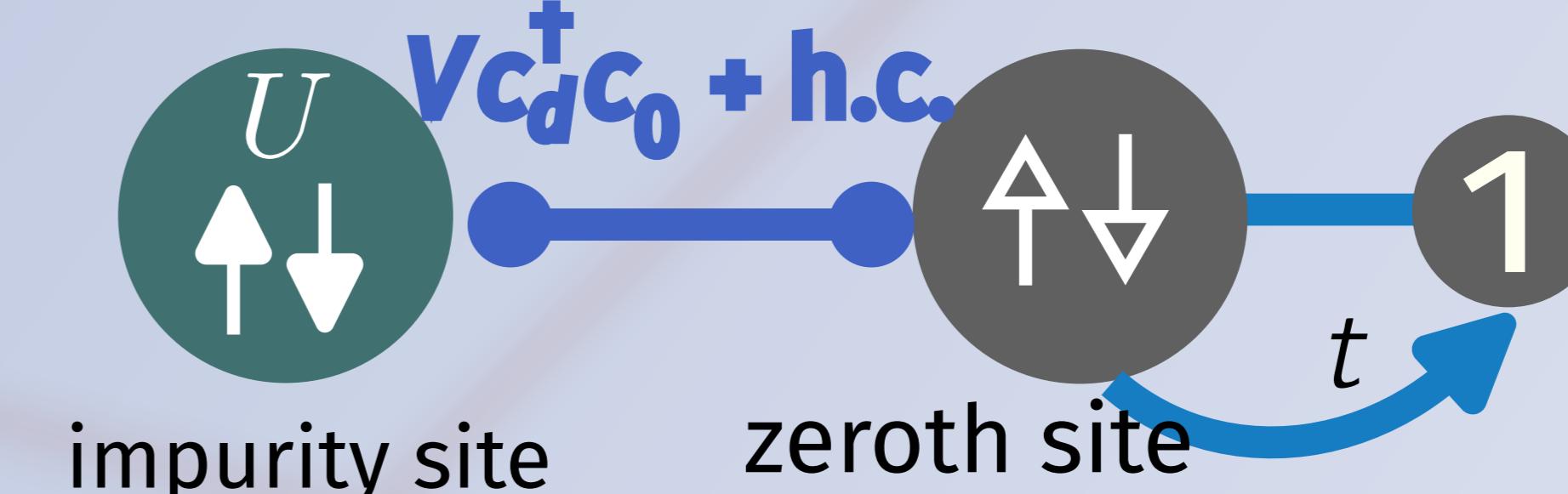


Ignores **non-local** contributions; exact in **infinite dimensions**

Shows metal-insulator transition at finite U

QUESTION: CAN WE EXTRACT THE SELF-CONSISTENT IMPURITY MODEL THAT SHOWS A TRANSITION?

Anderson impurity model: correlated impurity hopping into and out of a bath



no transition, impurity always screened

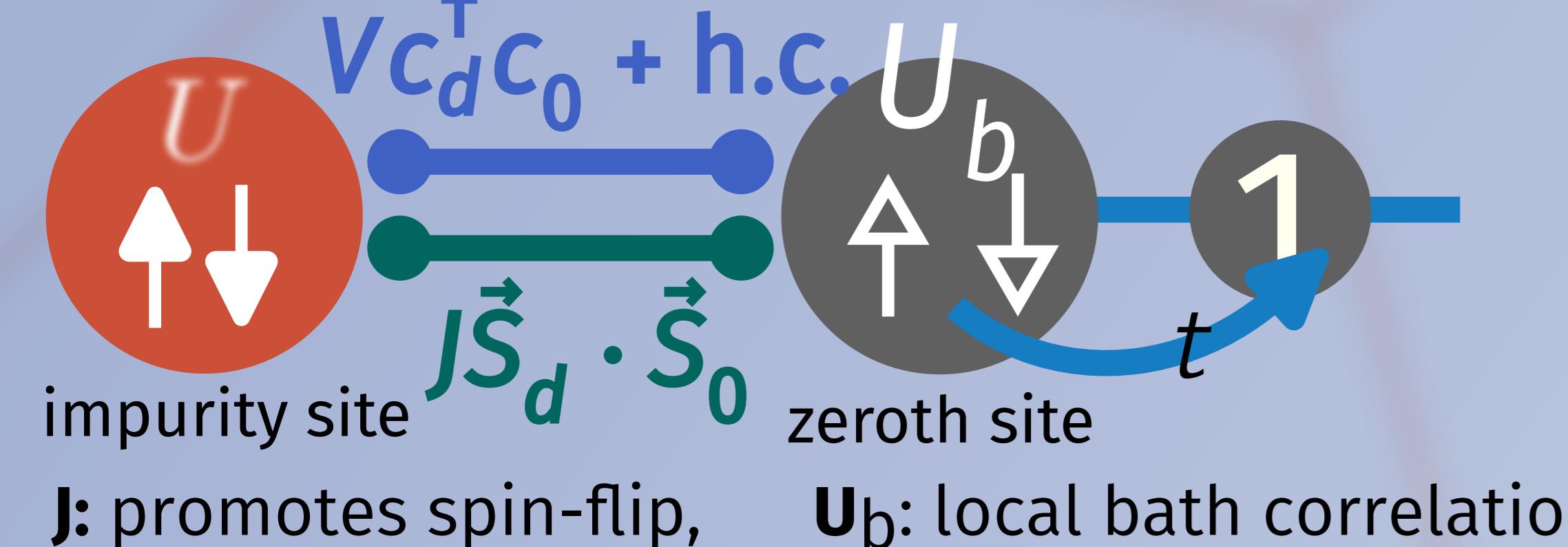
Self-consistency must lead to **drastic modification** of the bath;

What is this modified impurity model? What insight can it offer on the Mott MIT?

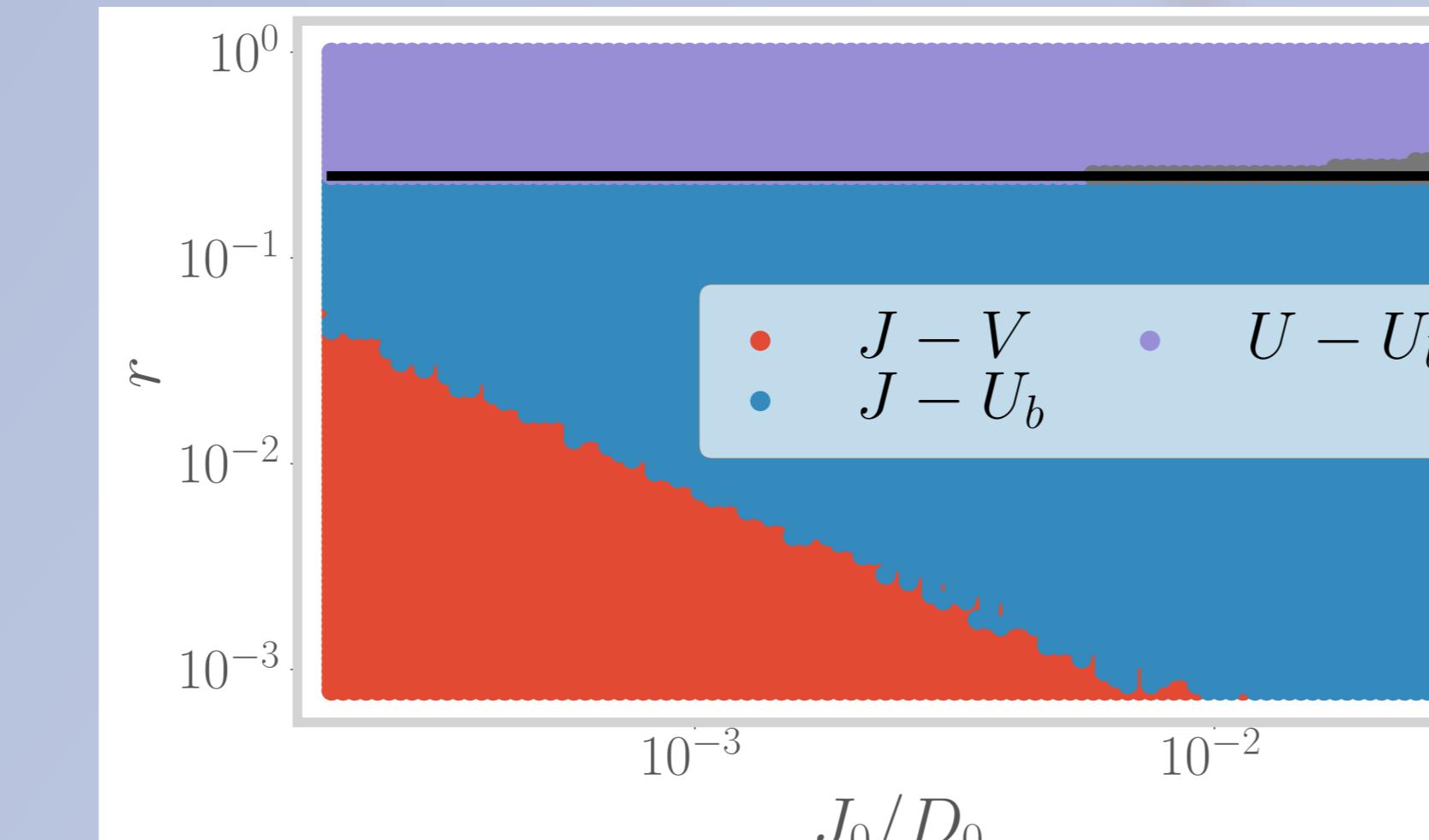
ADDING LOCAL INTERACTION IN THE BATH

Kondo screening : entanglement of impurity & bath e⁻s
Mott MIT: frustration of Kondo screening

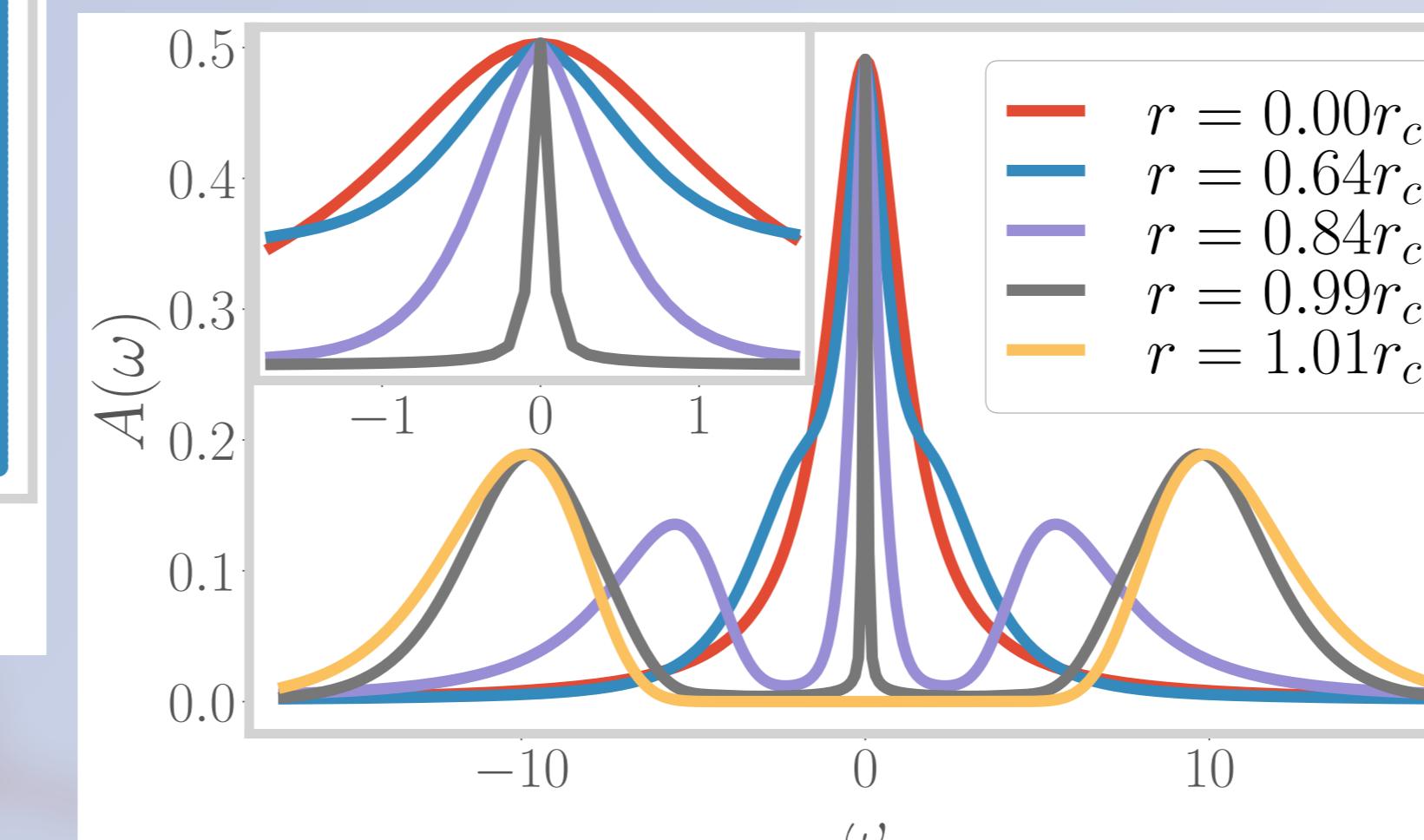
To see this, we **enhance** the Anderson impurity model



PHASE TRANSITION IN OUR EXTENDED IMPURITY MODEL



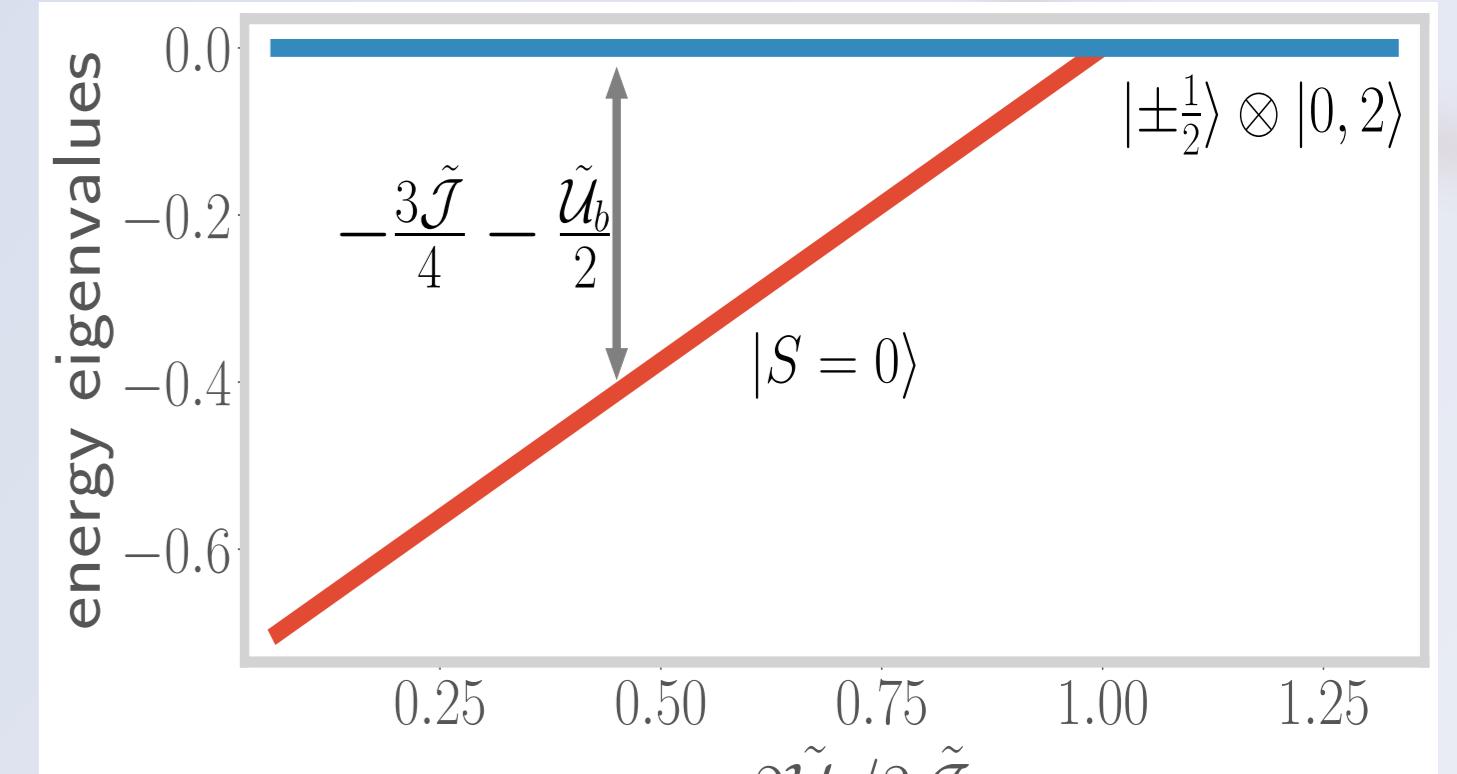
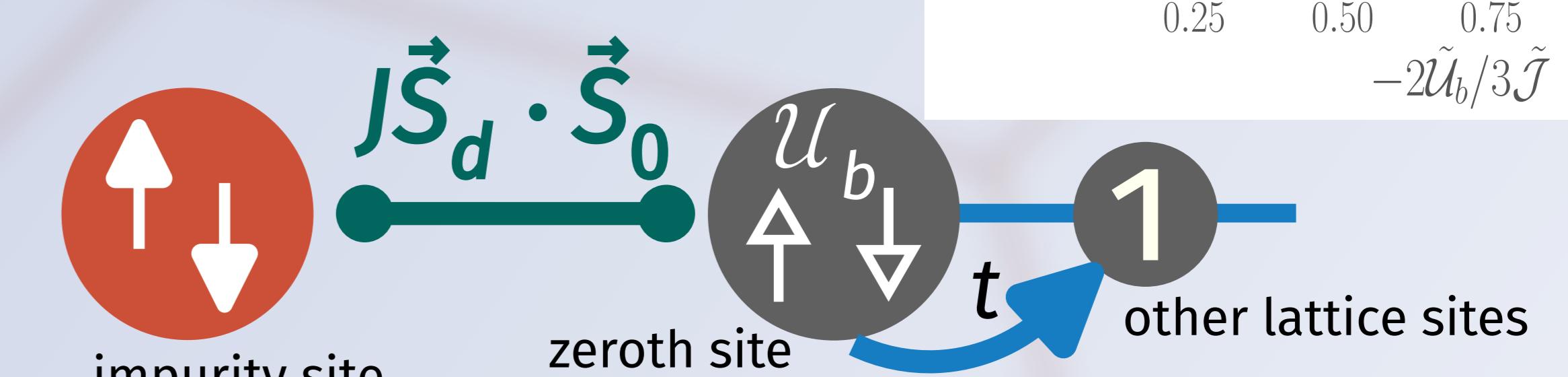
Unitary RG study shows presence of a **gapped phase** for $r=U_b/J < 0$



UNIVERSAL DESCRIPTION FOR THE MOTT MIT

Mott MIT involves two **competing tendencies**:

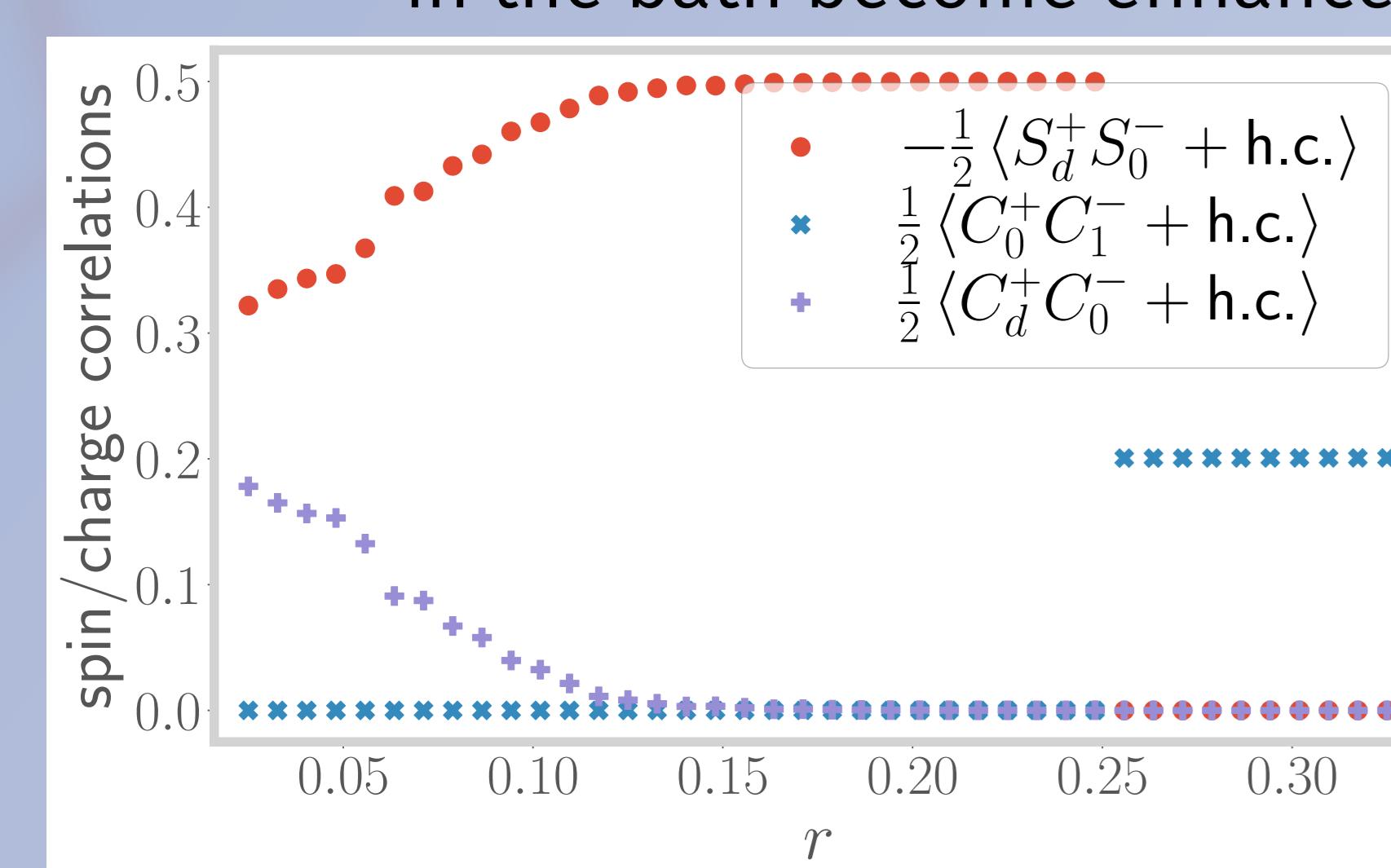
- correlated hopping $J\vec{S}_d \cdot \vec{S}_0$
- pairing tendency $-U_b\hat{n}_{0\uparrow}\hat{n}_{0\downarrow}$



PAIRING CORRELATIONS DRIVE THE TRANSITION

Vanishing spin correlations between impurity and bath

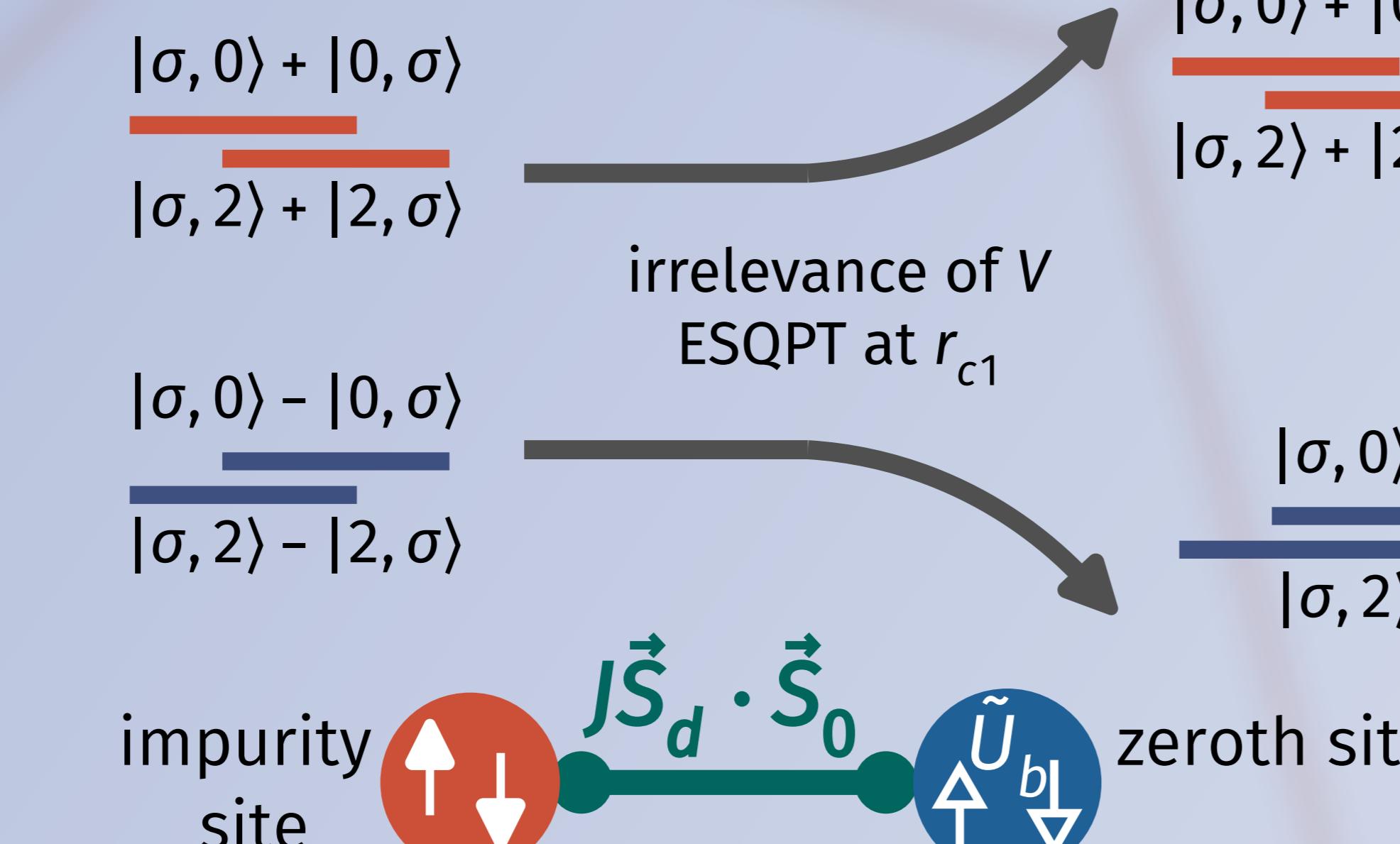
Pairing correlations in the bath become enhanced



PRECURSOR: EXCITED STATE QPT

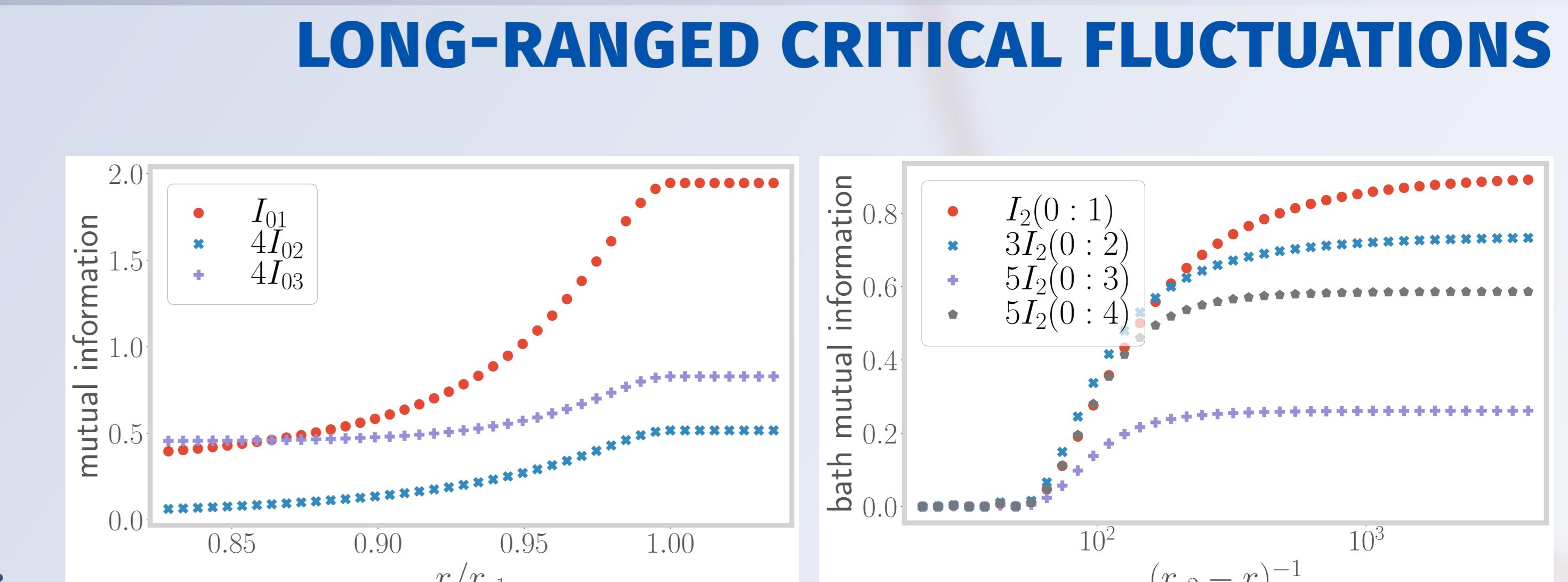
MIT found to occur in 2 steps:

1. **excited state transition:** loc. moment states emerge
2. **level crossing** of singlet and local moment states.



FIRST-ORDER PHYSICS & SPINODALS

Between ESQPT and QPT, metal and insulator **coexist**.
Explains presence of **spinodals** and **coexistence region** in DMFT results



Near ESQPT and QPT, **long-ranged correlations and entanglement** build up in the system.

Indicates the **critical nature** of the system.
Likely **source of critical fluctuations** observed in DMFT.

REFERENCES

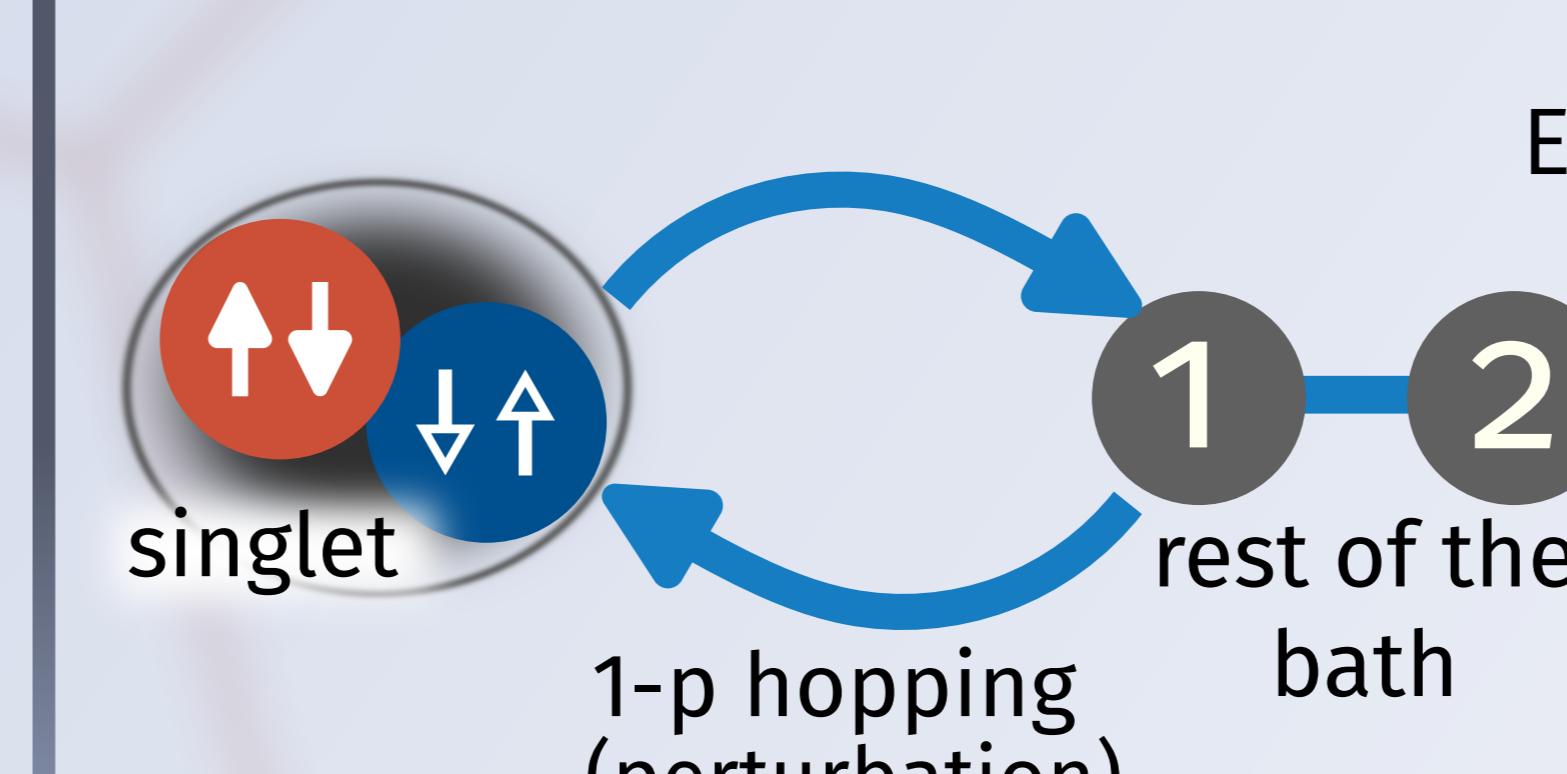
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[1] Theoretical Sciences Unit, JNCASR [2] Department of Physics, IIT KGP.

CONCLUSIONS & OUTLOOK

1. **Pairing correlations** in the bath drive the Mott MIT.
2. Entire MIT occurs in 2 steps: an **ESQPT** and a **QPT**.
3. **Critical fluctuations** proliferate in both the steps.
4. Can be tested on mesoscopic quantum dots
5. Extensions include studying the role of **hole doping**.

Exactly at MIT, the excitations are of **non-Fermi liquid** kind:



- scatter between orthogonal states of the bath
- have vanishing 1-site quasiparticle residue
- power-law behaviour in self-energy and correlations
- fractional magnetisation and entanglement entropy