How density of states singularities found in the Anderson model evolve with the addition of electron-electron interactions?

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Outline

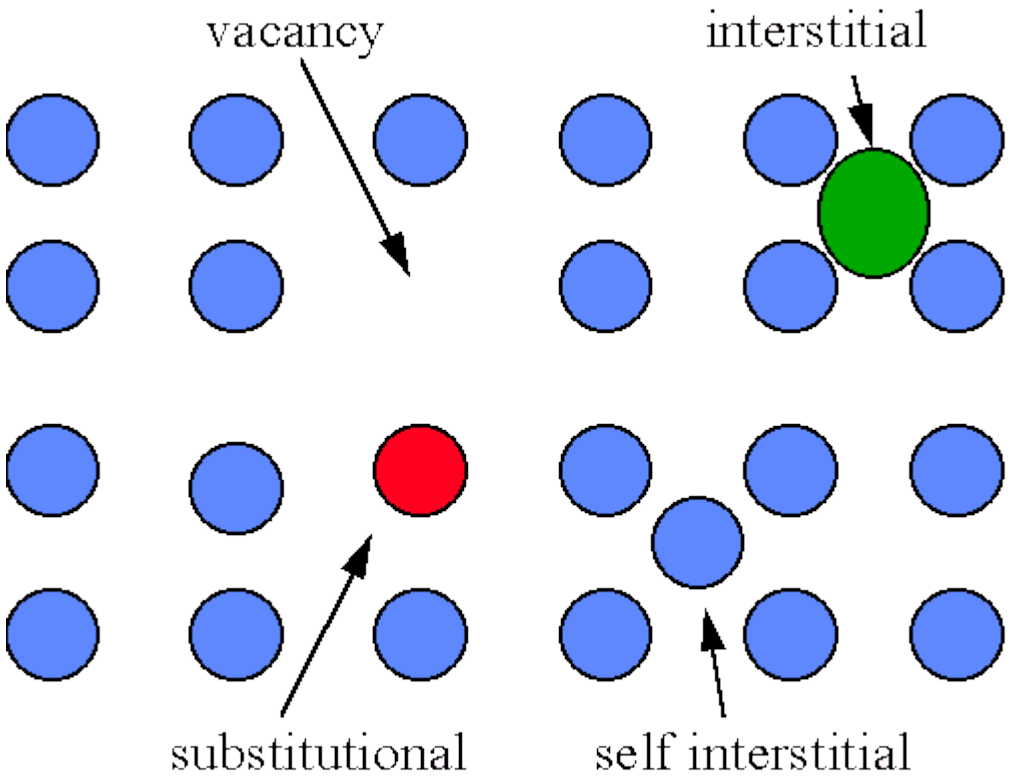
- Motivation
- Non-interacting case
- Interacting case

Motivation

- Interesting behaviors in transition metal oxides
- Recent progress in many-body localization
- Singular behaviors found in non-interacting Anderson model of localization

What do we mean by disorder?

- Intrinsic or can be introduced by doping



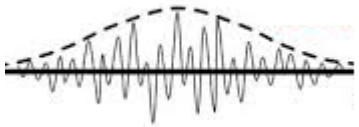
The non-interacting Anderson model

$$H = \sum_i \epsilon_i \, c_i^\dagger c_i + t \sum_{\langle i,j \rangle} c_i^\dagger c_j$$

Disordered site potentials

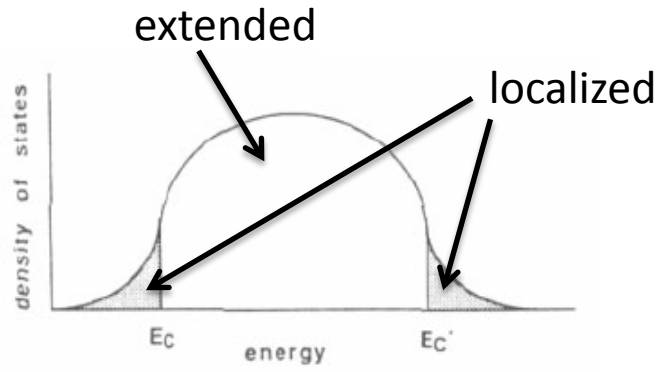
Hopping

Anderson 1958: single particle wave functions are localized in disordered medium.



The density of states

Density of states ρ(ϵ) is the number of state into which you can add one electron or from which you can remove one electron between energies ϵ and ϵ + dϵ



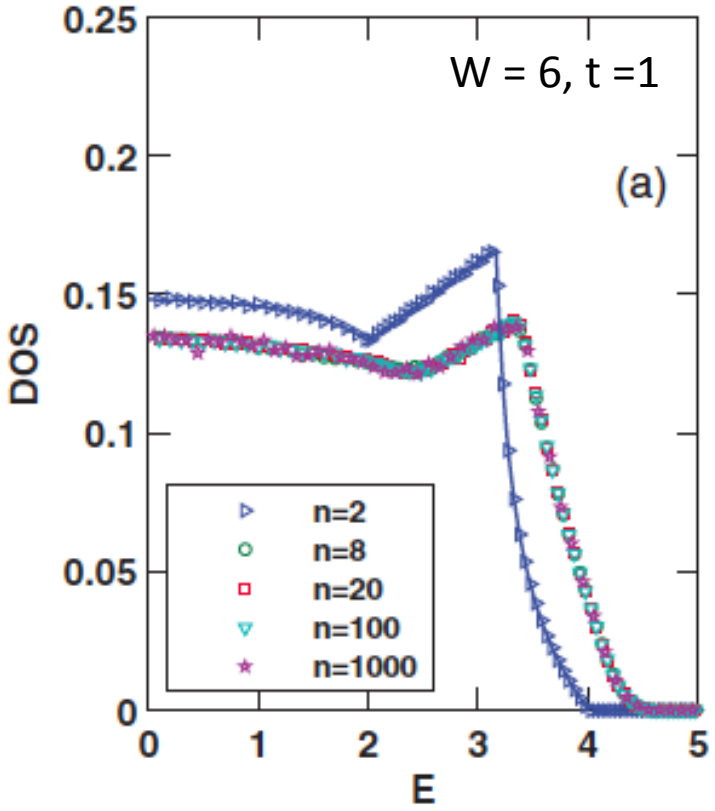
Is there a singularity?

- Edward & Thouless 1971: no singularity in band center when site potentials are chosen from a uniform bounded distribution

- Wegner 1981: no singularity anywhere in the band from a Gaussian disorder

Singularities found in non-interacting disordered system

$$H = \sum_i \epsilon_i \, c_i^\dagger c_i + t \sum_{\langle i,j \rangle} c_i^\dagger c_j$$



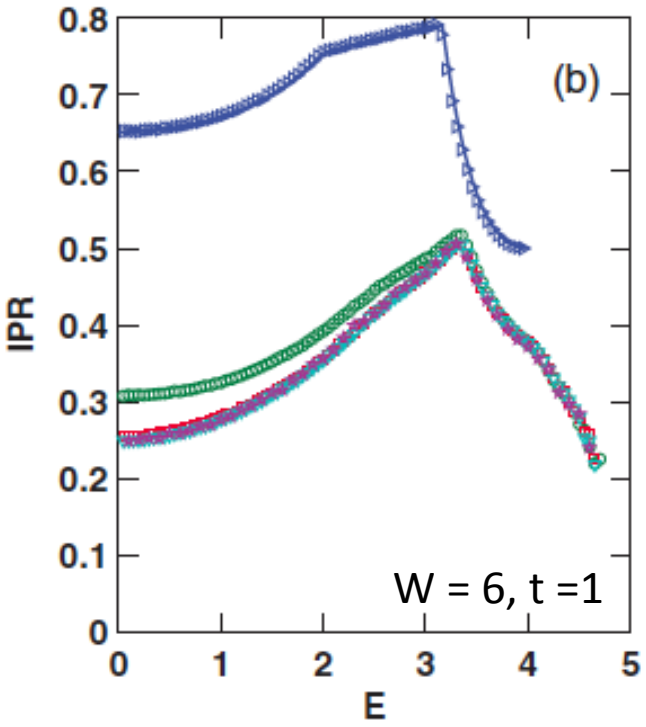
Johri S. & BhattR.N. PRL 109 076402 (2012) and PRB 86 125140 (2012)

resonant states

Singularities found in non-interacting disordered system

Inverse participation ratio

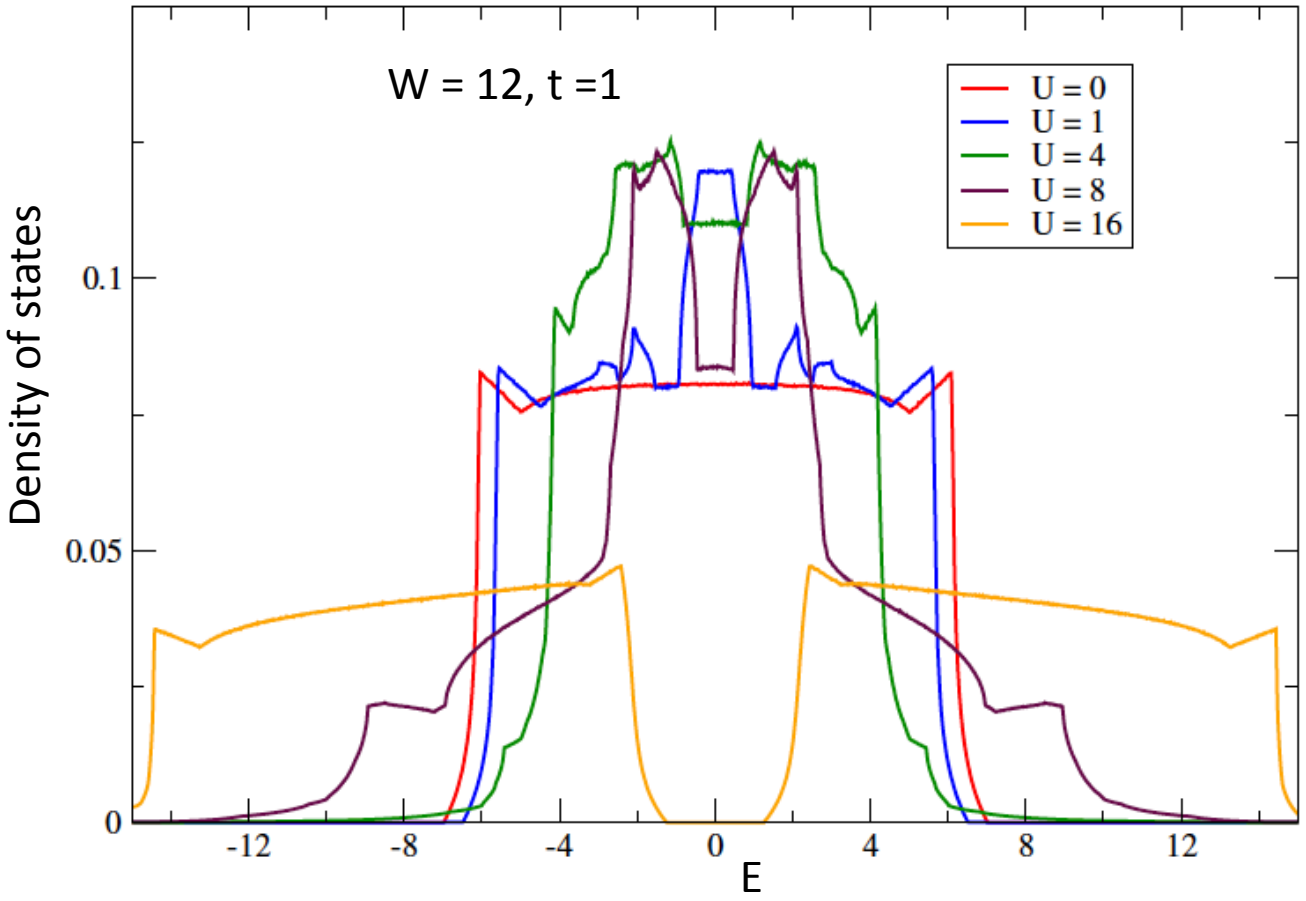
$$I_\alpha = \frac{\sum_i |\psi_\alpha(r_i)|^4}{\left(\sum_i |\psi_\alpha(r_i)|^2\right)^2}$$



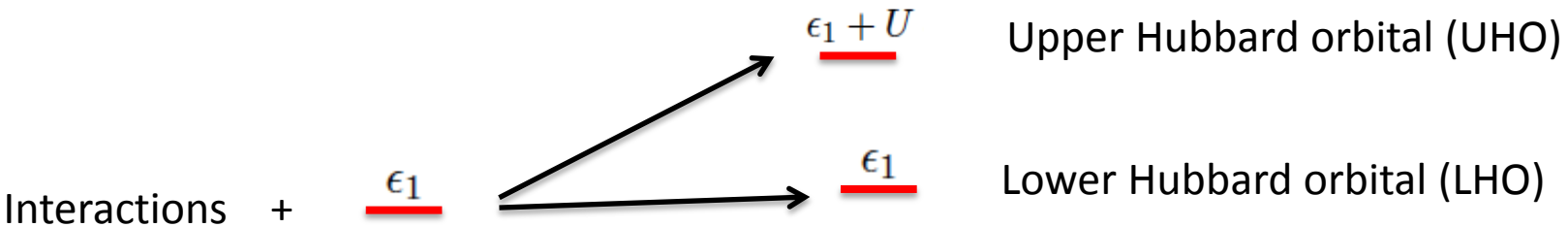
Johri S. & BhattR.N. PRL 109 076402 (2012) and PRB 86 125140 (2012)

What happen to the DOS singularity when interactions are added?

$$H = \sum_{i=1,2} \sum_{\sigma=\uparrow,\downarrow} \epsilon_i \, c^{\dagger}_{i\sigma} c_{i\sigma} - t \sum_{\sigma=\uparrow,\downarrow} (c^{\dagger}_{1\sigma} c_{2\sigma} + c^{\dagger}_{2\sigma} c_{1\sigma}) + U \sum_{i=1,2} n_{i\uparrow} n_{i\downarrow}$$

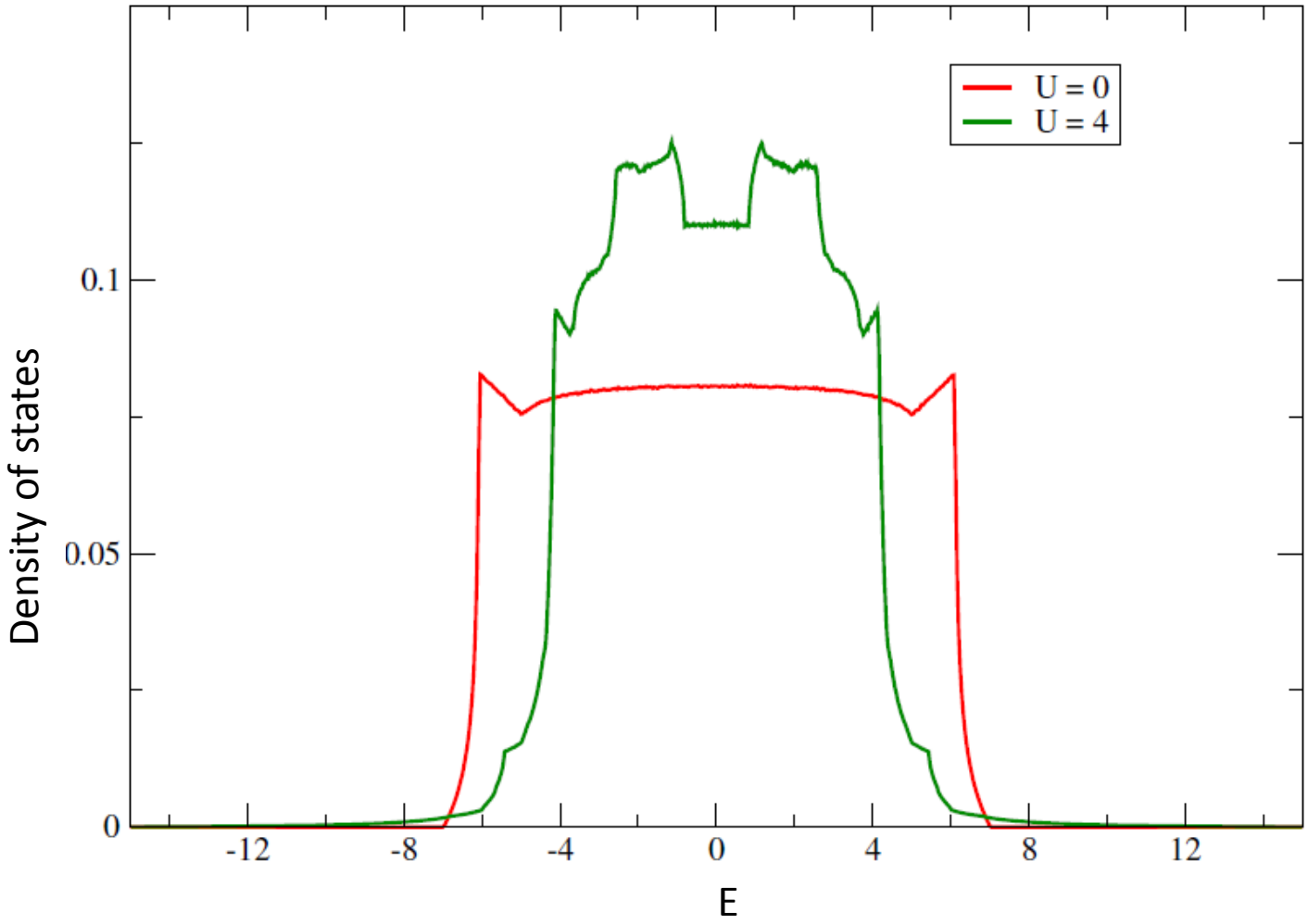


Resonances



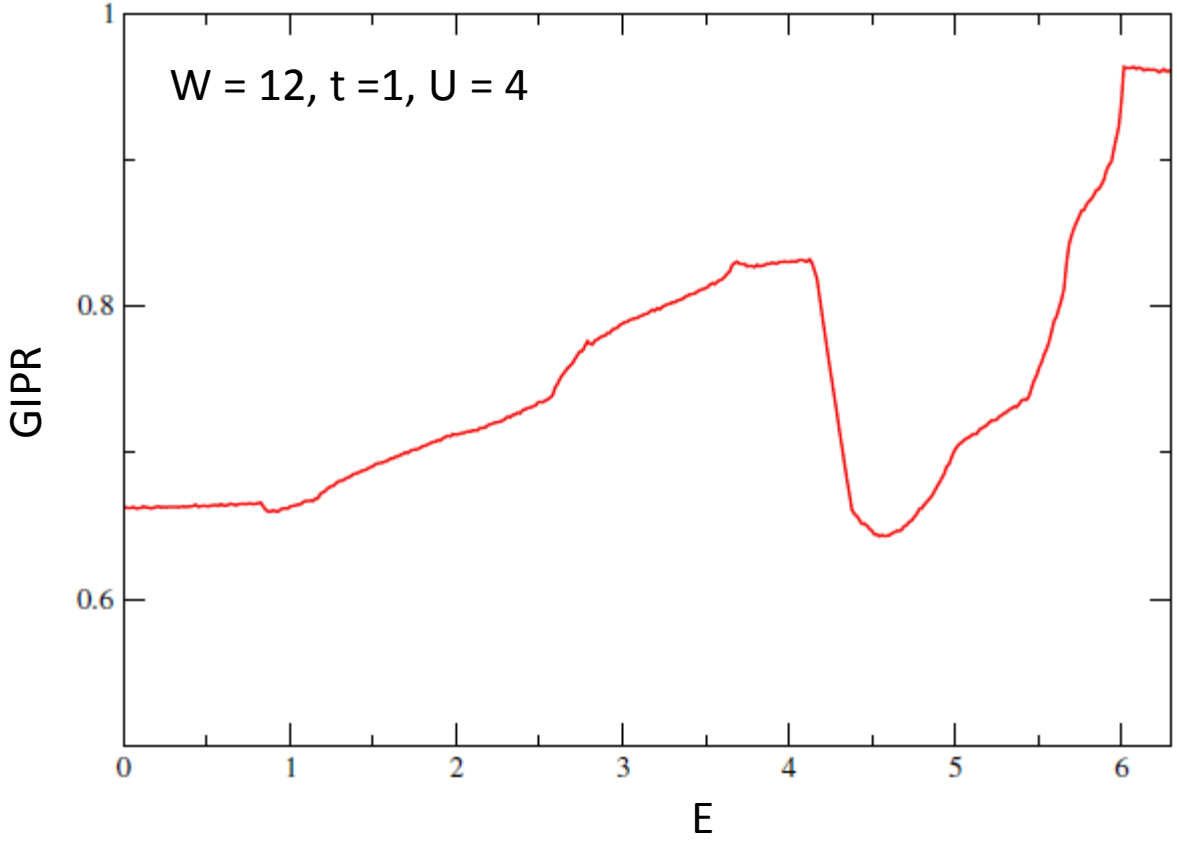
There are two types of resonances in two-site interacting system.

Peaks associated with resonances in two-site interacting disordered system



What happen to the IPR singularity when interactions are added?

Generalized IPR $$GI(\omega^*) = \frac{\rho(r_1,\omega^*)^2 + \rho(r_2,\omega^*)^2}{\left(\rho(r_1,\omega^*) + \rho(r_1,\omega^*)\right)^2}$$



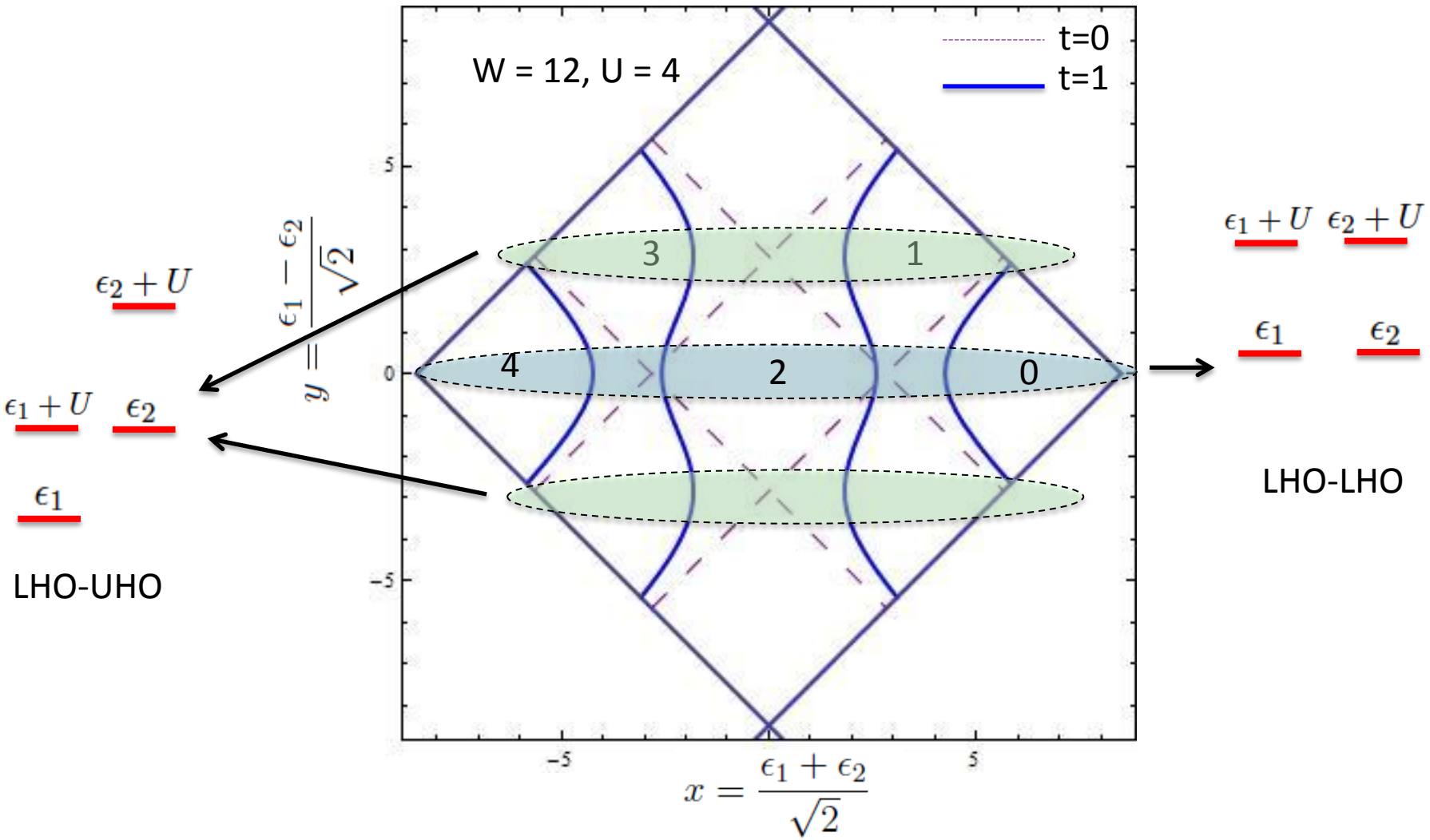
Summary

How the singularities found in non-interacting Anderson model evolve with the addition of electron-electron interactions?

- There are many peaks in the DOS and IPR in two-site interacting systems.
- Some DOS peaks are from the same resonances as in non-interacting systems.
- Some DOS peaks come from a new type of resonance unique to strongly correlated systems.

Thank you !

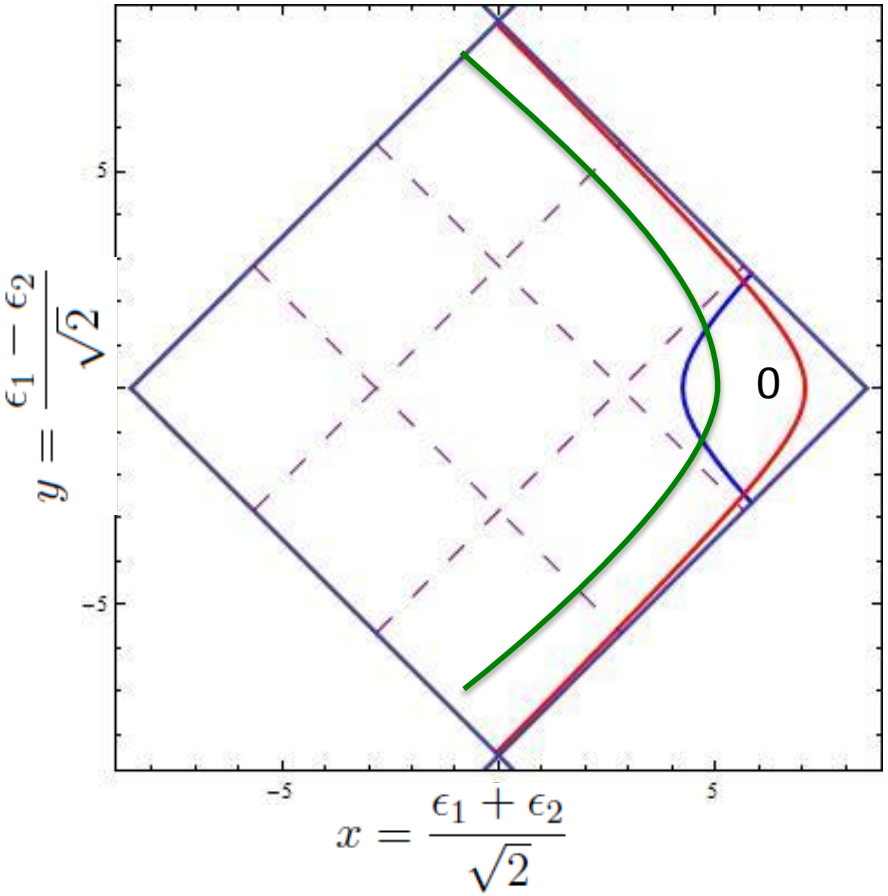
Understanding the DOS singularities in a two-site interacting disordered system

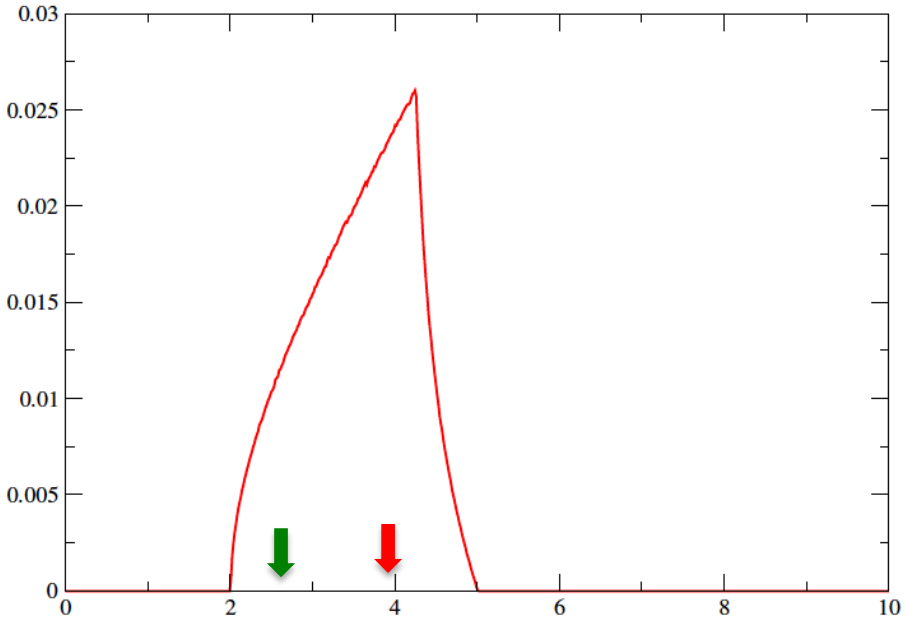


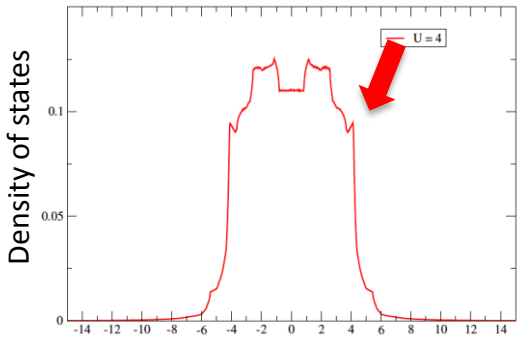
The DOS peak associated with resonance of LHO-LHO

Transition: 0 particle ground state to 1-particle anti-bonding state

W = 12, U = 4, t = 1







The DOS peak associated with resonance of LHO-UHO

Transition: 2 particle ground state to 1-particle bonding state

W = 12, U = 4, t = 1