# Tunable frustration as a discriminator of antiferromagnetic signatures in cold atoms

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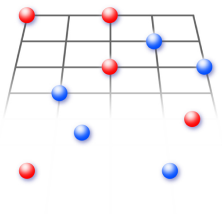
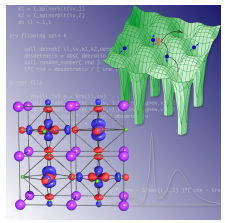


TR 49: *Condensed matter systems with variable many-body interactions*
Frankfurt / Kaiserslautern / Mainz

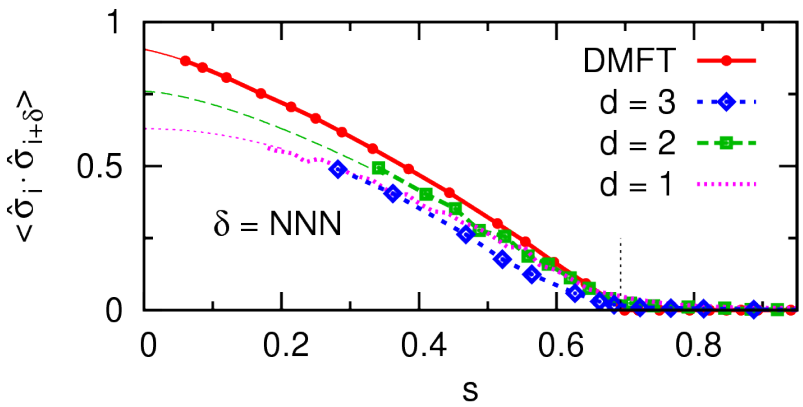
FOR 1346
LDA+DMFT
Augsburg *et al.*



# Motivation: tunable parameters in ultracold atomic systems

Strategies for detecting antiferromagnetism (LRO or finite-range AF)

1. vary $s$: best for "order parameter", e.g. NNN spin correlations



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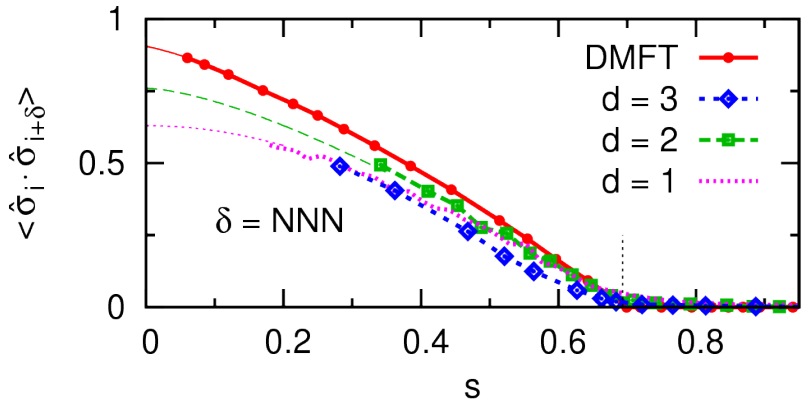


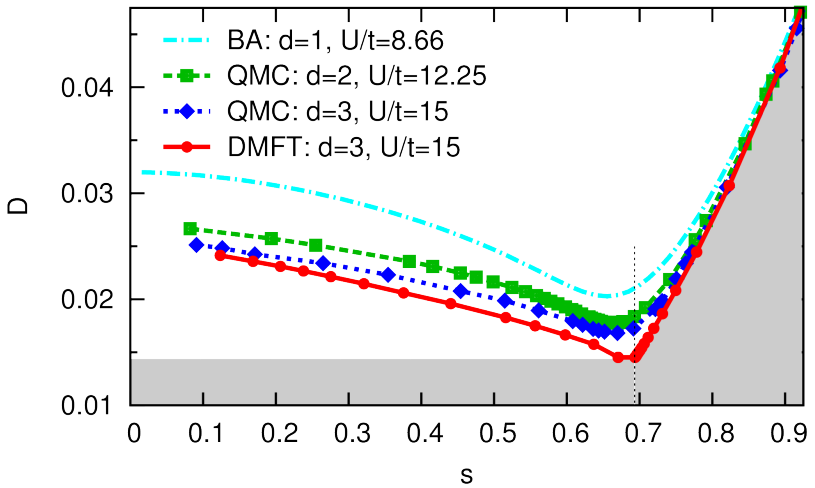

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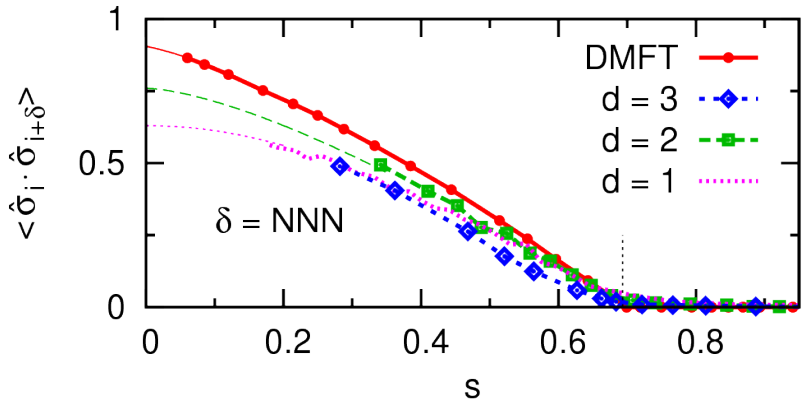
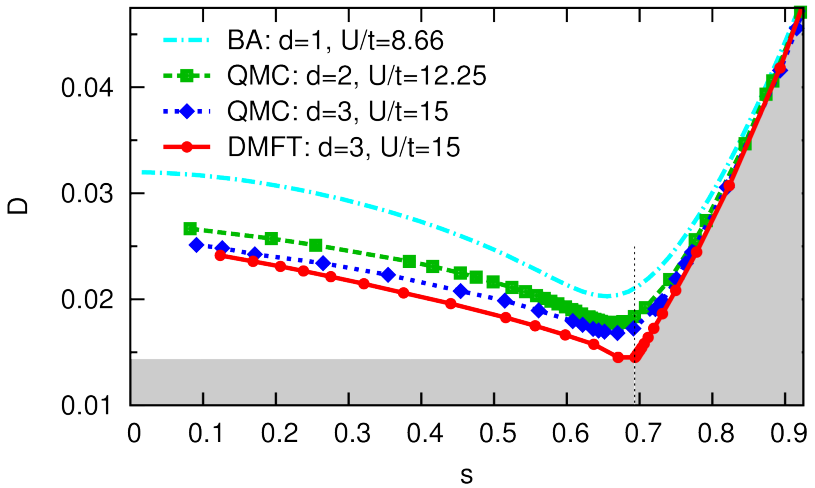
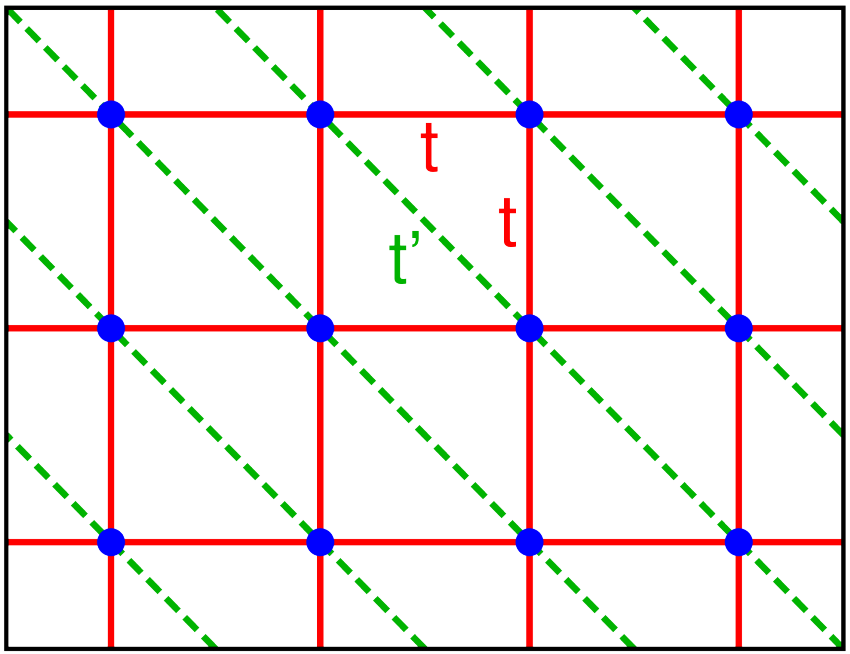
3. now: introduce + vary frustration



# Theorists' dream of tunable frustration: towards the triangular lattice

Introduce frustration in controlled way
by diagonal hopping in square lattice:

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$t' \to t$: topology of triangular lattice

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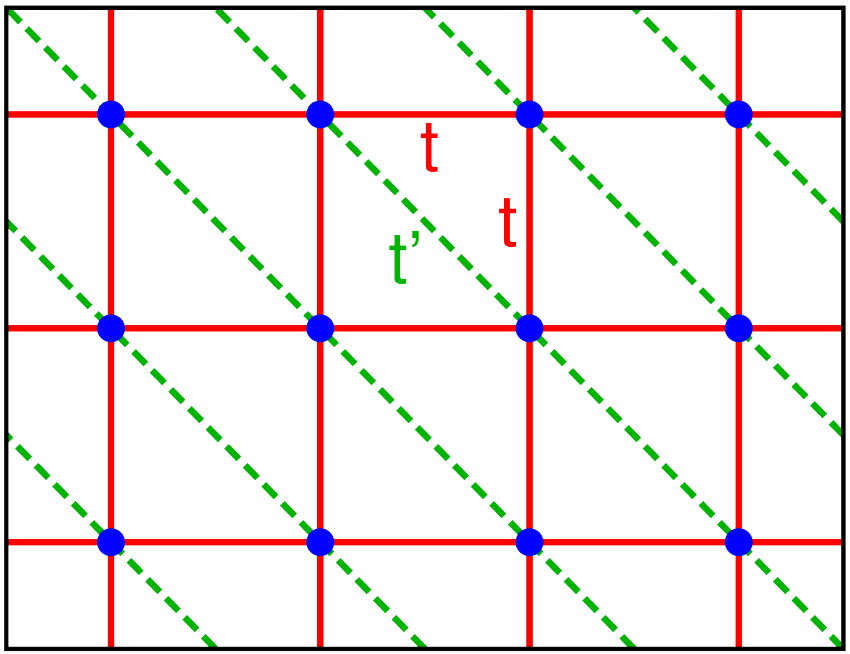


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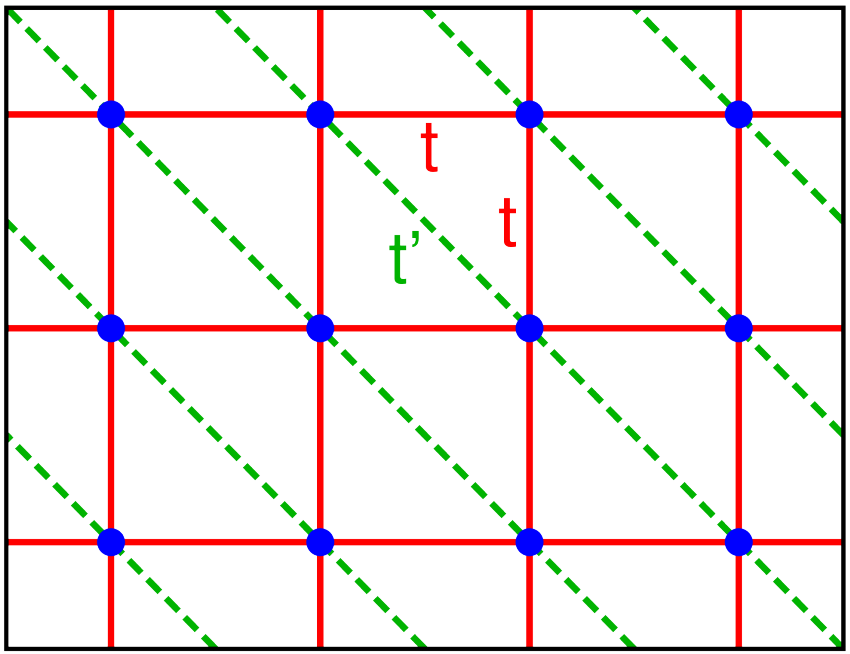


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(general $t'$: "anisotropic triangular lattice", relevant e.g. for copper chlorides)

# New experiments: interference between orthogonal lattice beams

Usual experimental setup:

incoherent superposition of standing waves

in $x$, $y$, and $z$ direction (frequency offset)

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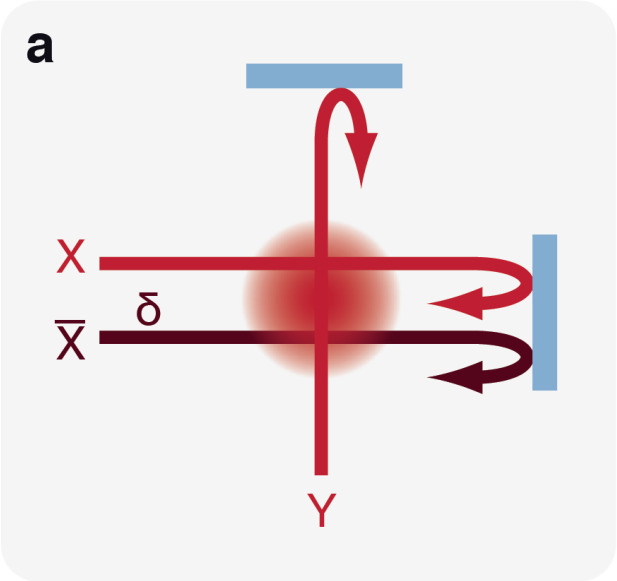

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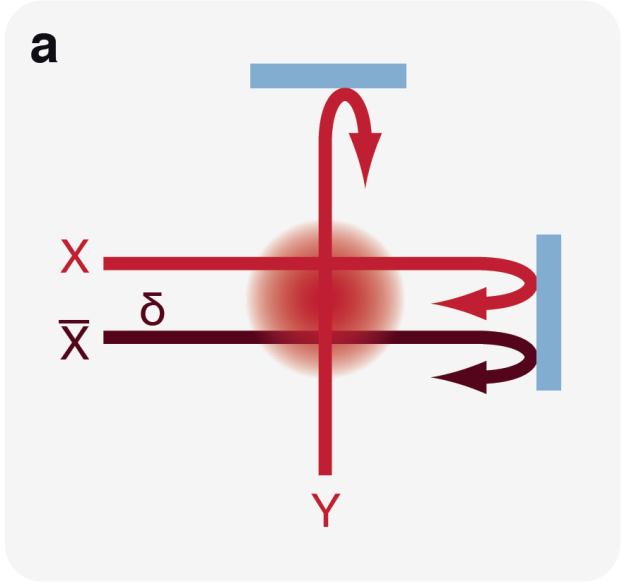
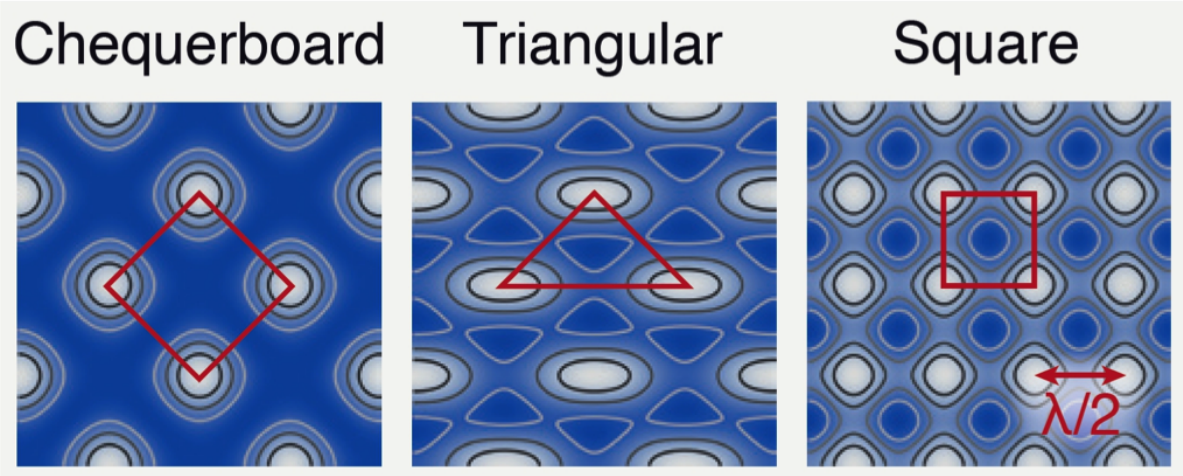
$\rightsquigarrow$ square, triangular, honeycomb, ...



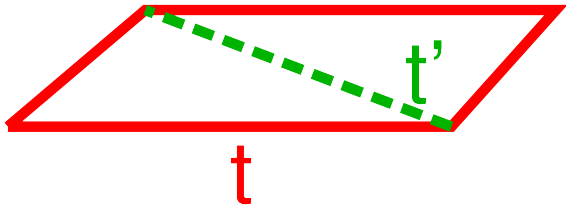

A theorists' dream come true !?

[L. Tarruell, D. Greif, T. Uehlinger, G. Jotzu, and T. Esslinger, arXiv:1111.5020]

# Effects of diagonal hopping: frustration + larger coordination

Note: $t'$ changes coordination number $(4 \to 6)$ and

bandwidth $\langle \epsilon^2 \rangle \equiv \int_{-\infty}^{\infty} d\epsilon\, \epsilon^2 \rho_0(\epsilon) = 4t^2 + 2t'^2$



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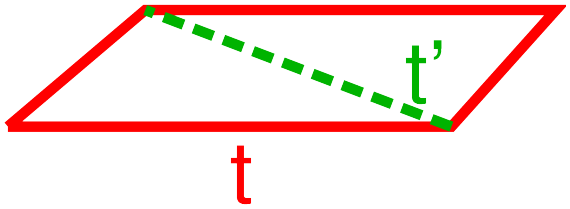


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but also changes energy scale for interaction $U$ and temperature $T$

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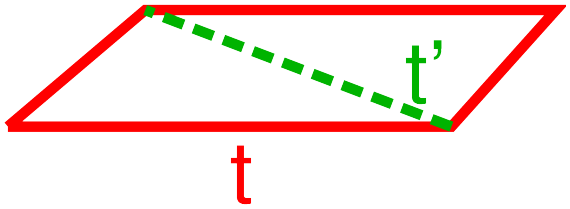


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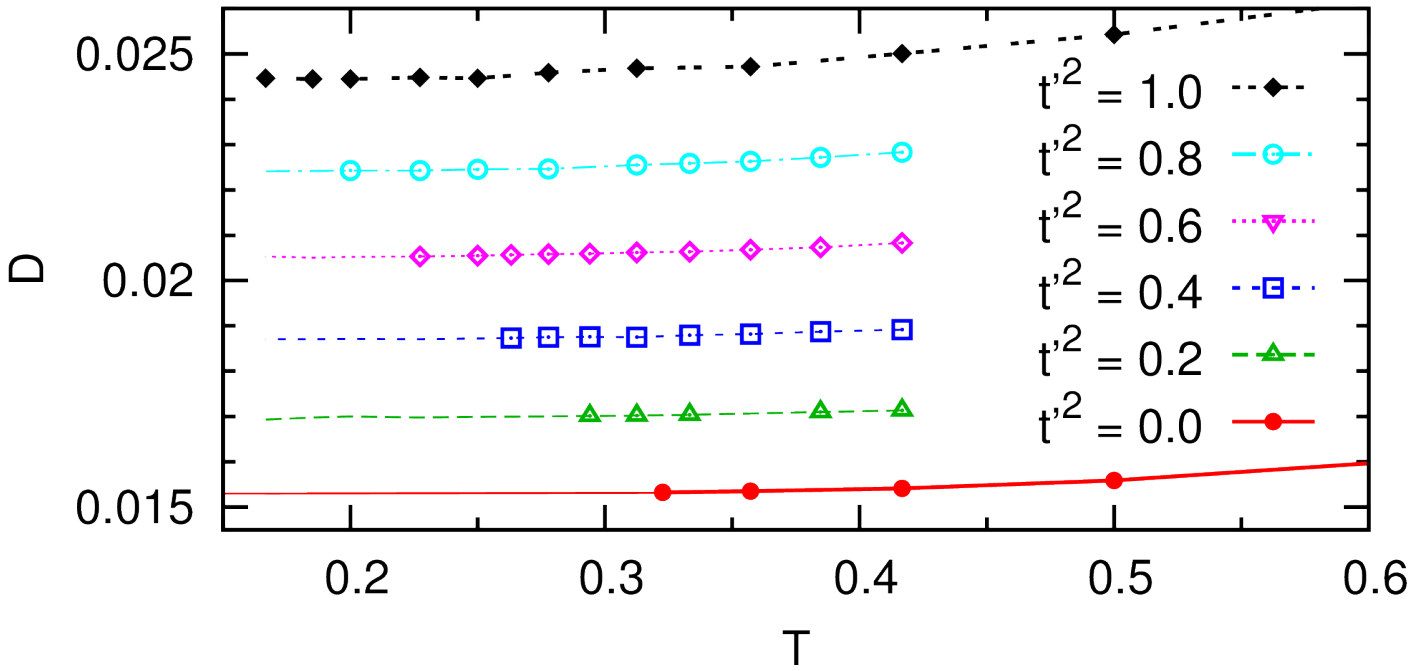


impact already within nonmagnetic DMFT (fixed $U$, $T$)

$U/t = 12$

# Clean tuning of frustration: cubic $\longleftrightarrow$ triangular lattice

New concept: add third dimension

and hopping $t_z$ between planes

with $t_z^2 = t^2 - t'^2$

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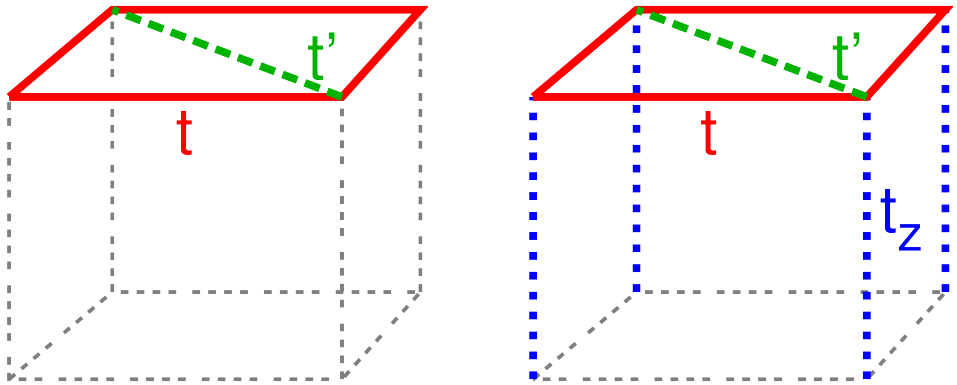
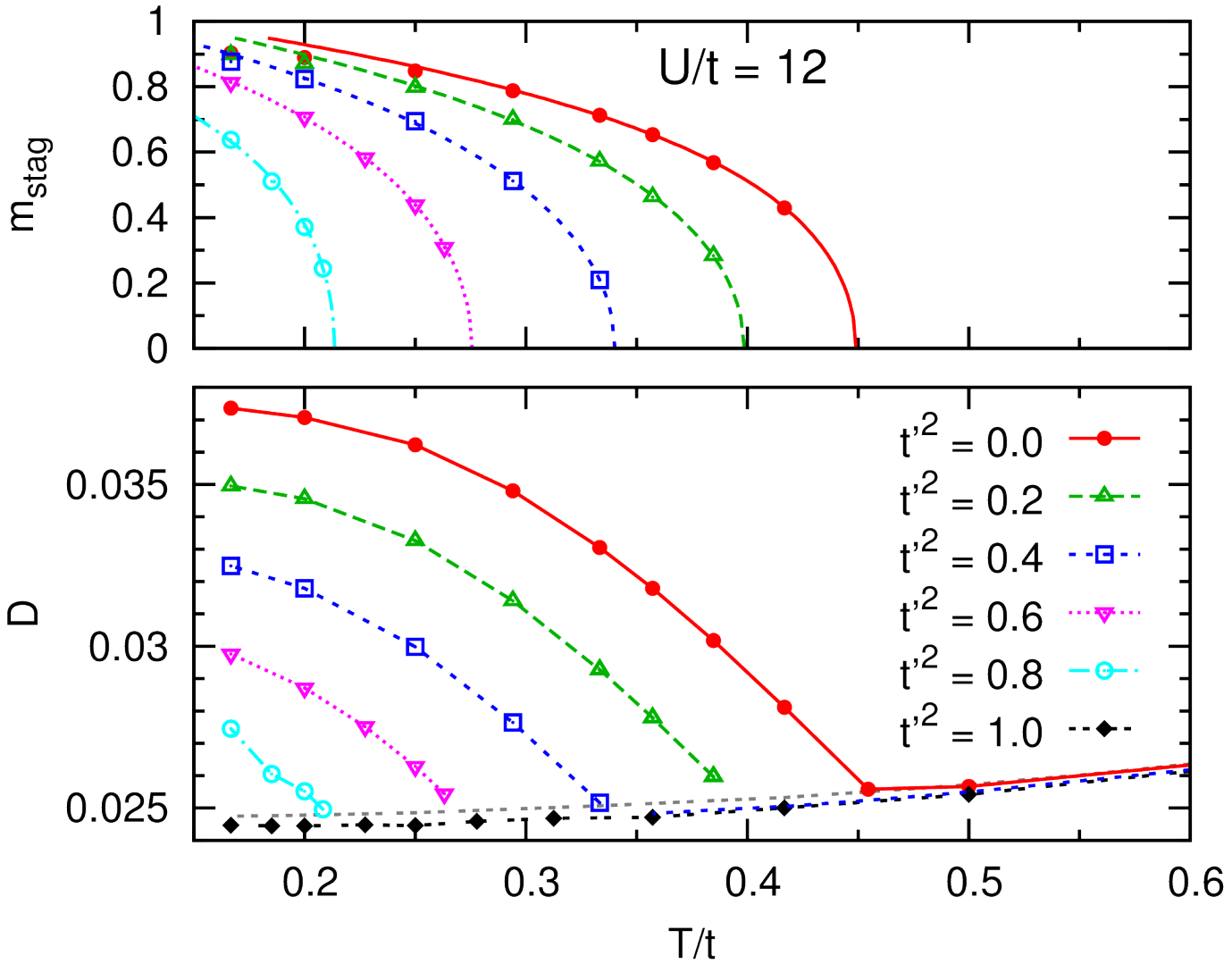
$\rightsquigarrow$ effective coordination $Z = 6 \,\forall\, t'$

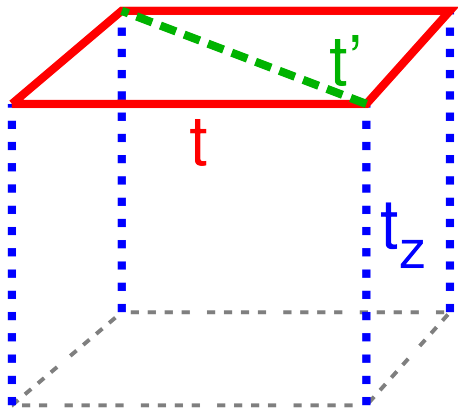



Hope: $t'$ should act as pure frustration parameter, affecting only magnetic phases

# DMFT results: cubic $\longleftrightarrow$ triangular lattice

Dynamical mean-field theory (DMFT) using Hirsch-Fye QMC (at $\Delta\tau \to 0$)

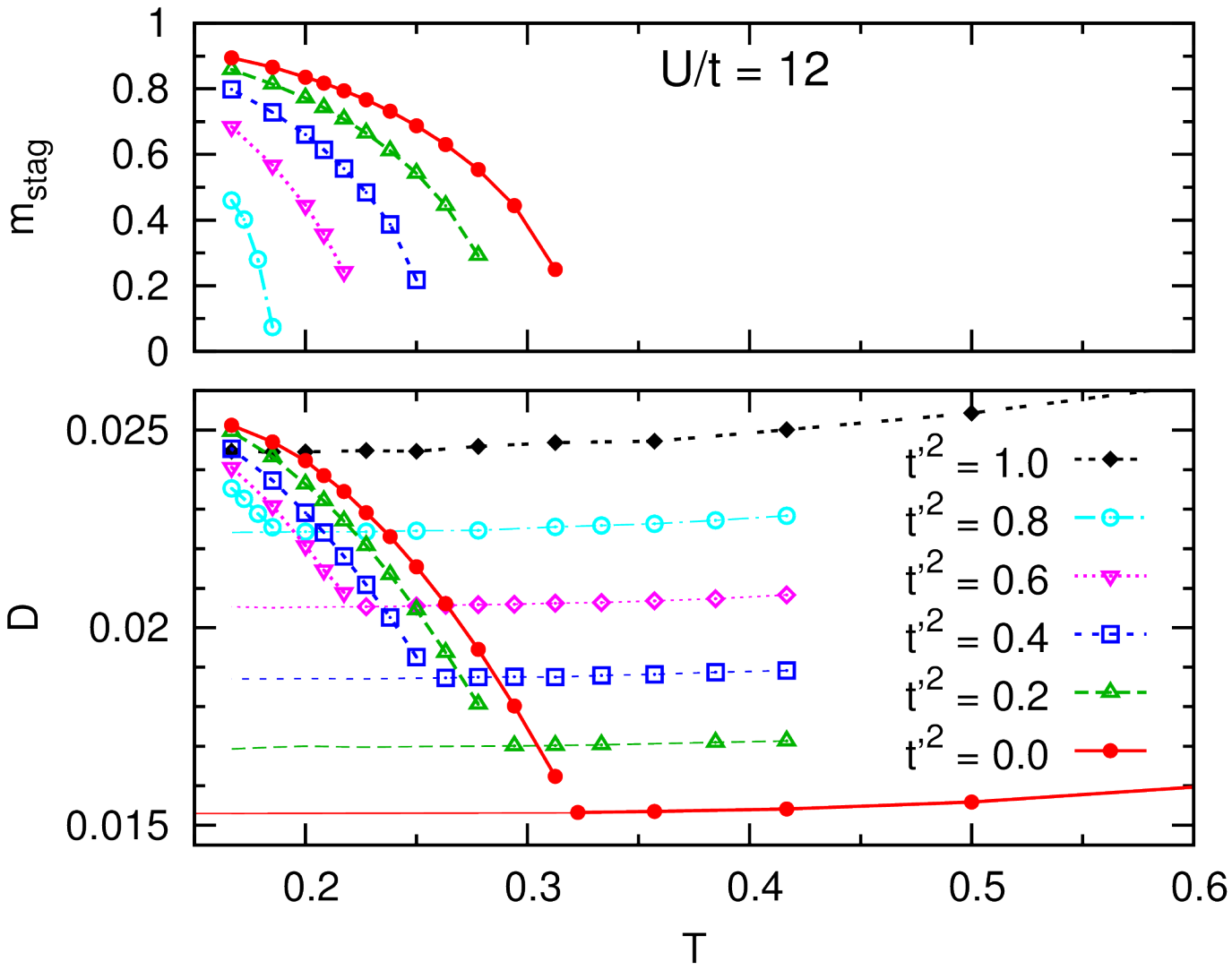


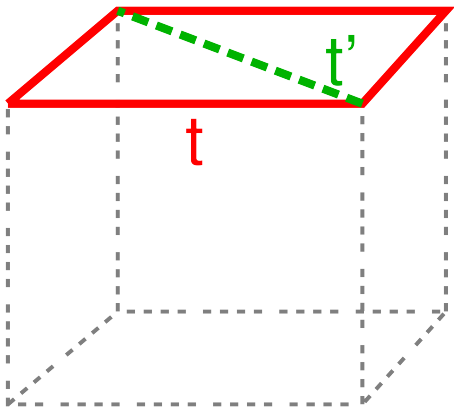




*D* suppressed before AF breaks down

paramagnetic phase hardly affected by $t'$

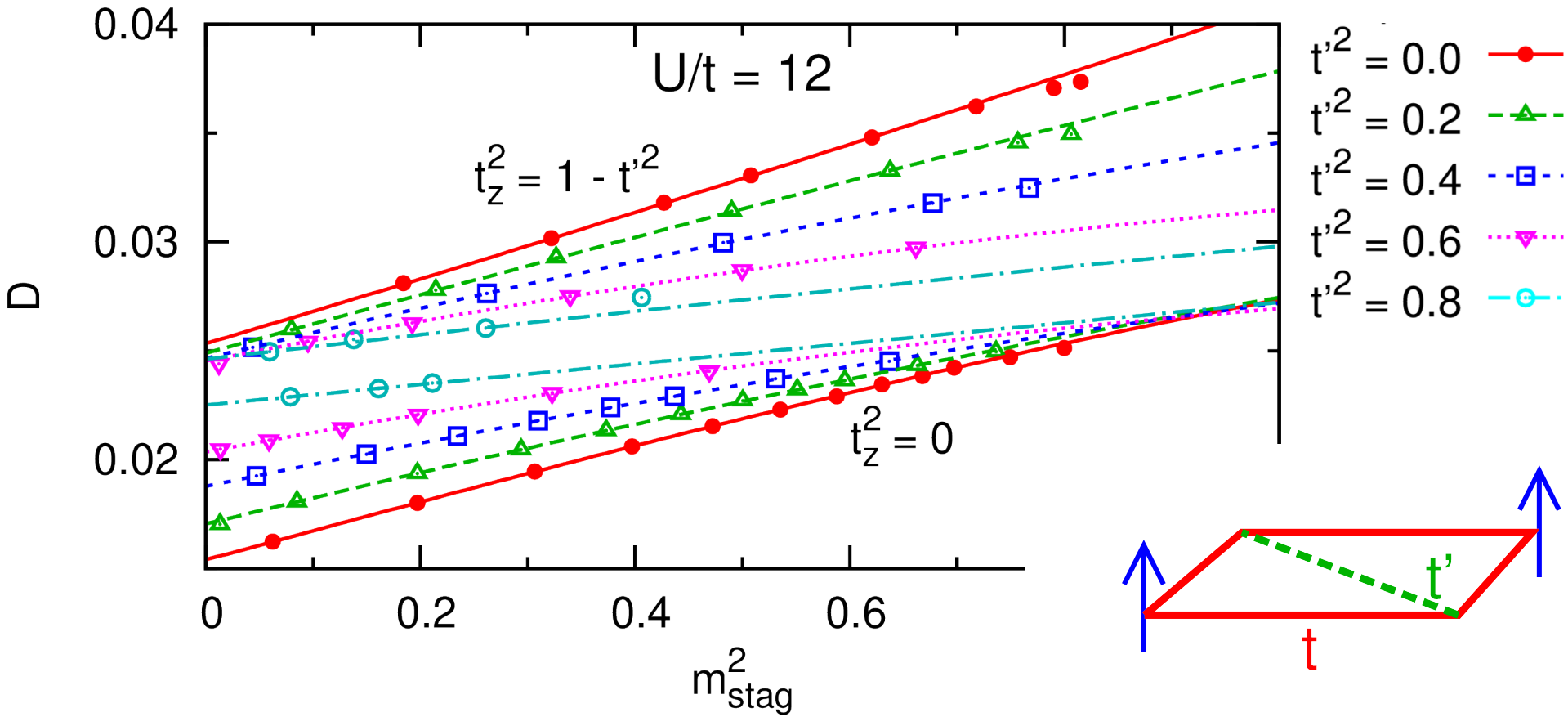
# DMFT results: square $\longleftrightarrow$ triangular lattice




Now situation reversed: strong $t'^2$ dependence only in paramagnetic phase

# Connection between double occupancy and spin correlations?



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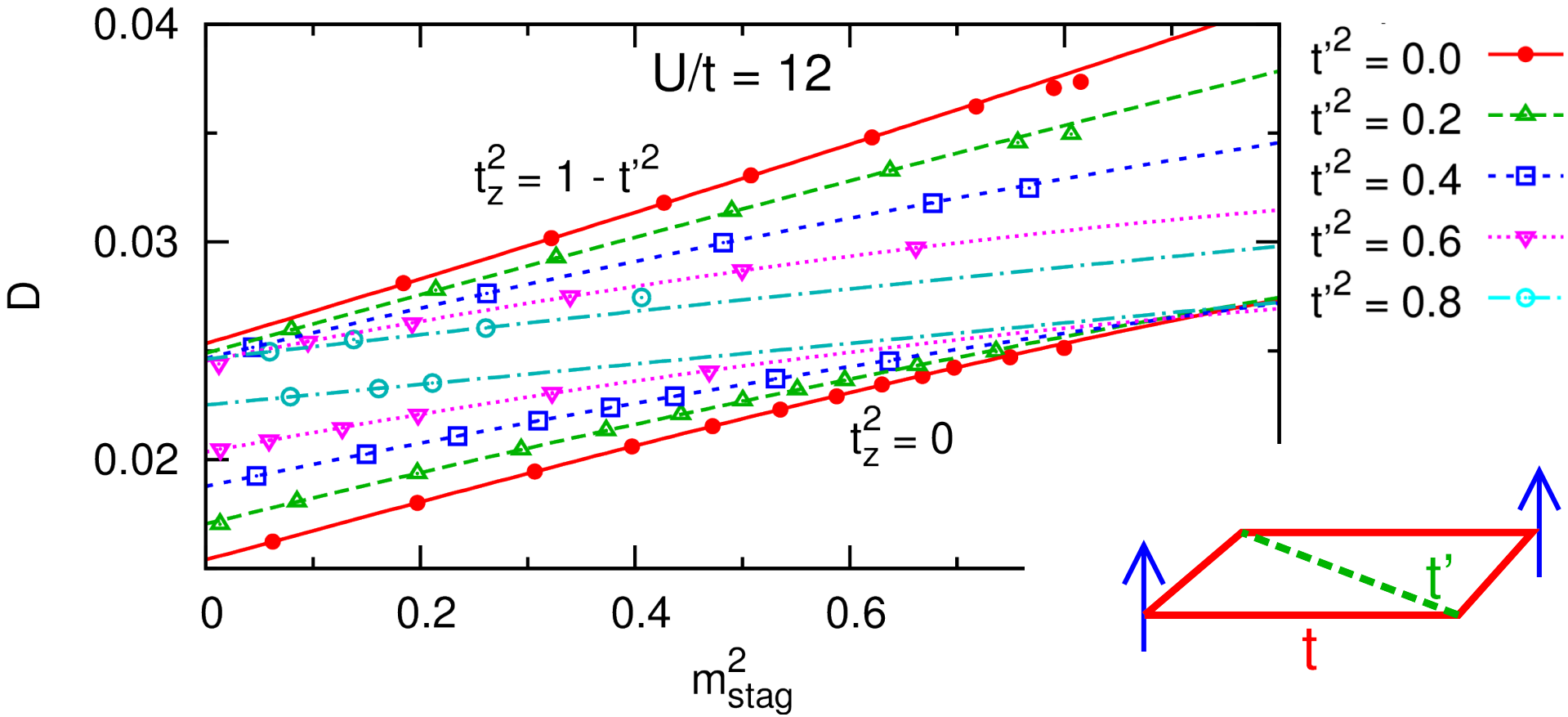


Results collaps in
- paramagnetic limit for $t_z^2 = 1 - t'^2$
- AF limit for $t_z^2 = 0$

Constant $m^2_{\text{stag}} \sim$ constant entropy?

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- spectra (so far "only" square lattice)

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Elena Gorelik

Daniel Rost

Preview to DPG Frühjahrstagung FKM Berlin (TT 10.9, 2012/3/26):

Momentum-dependent pseudogaps in the half-filled 2d Hubbard model

Access to high-$T_c$ like physics in ultracold fermions at $s \approx 0.5$?