Holographic doped Mott insulator

Alexander Krikun
(Instituut Lorentz, Leiden)

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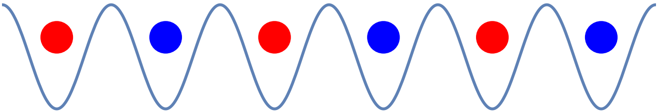
References

arXiv:1512.02465	Tomas Andrade, **A.K.**
arXiv:1701.04625	Tomas Andrade, **A.K.**
arXiv:1708.08306	T.Andrade, M. Baggioli **A.K** and N. Poovuttikul
arXiv:1710.XXXXX	T.Andrade, **A.K.**, K.Schalm and J.Zaanen
arXiv:1710.XXXXX	**A.K.**

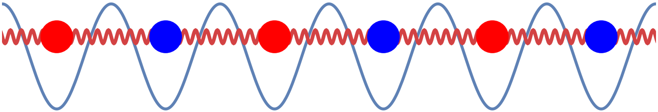
Mott insulator

Take the periodic lattice, half-filled with electrons



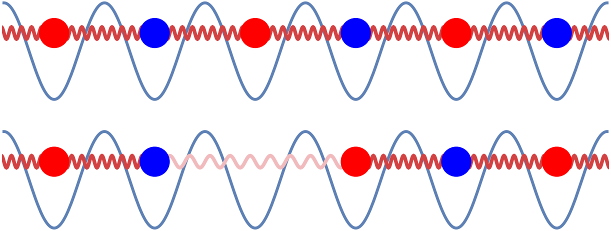
Mott insulator

Include interaction between electrons



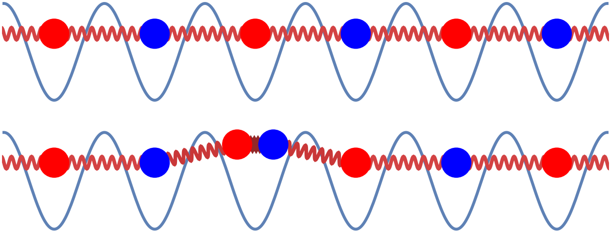
Doped Mott insulator

Doping either removes an electron



Doped Mott insulator

Or adds an electron

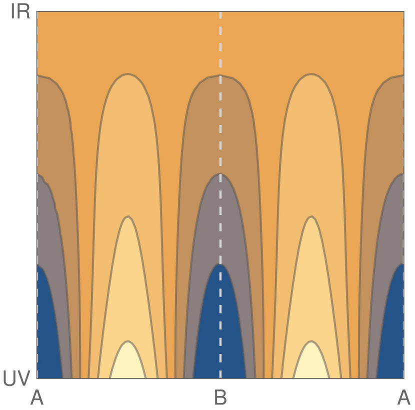


Holographic Mott insulator

Holographic Mott insulator

Take the ionic lattice

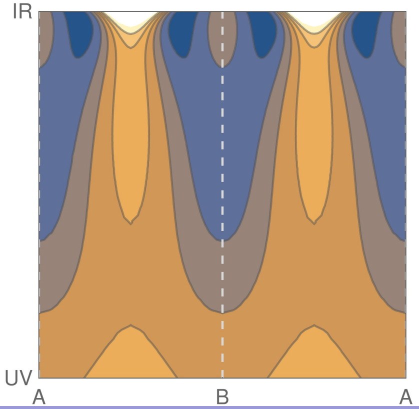
$$\mu(x) = \mu_0 \left(1 + A\cos(kx)\right)$$



Holographic Mott insulator

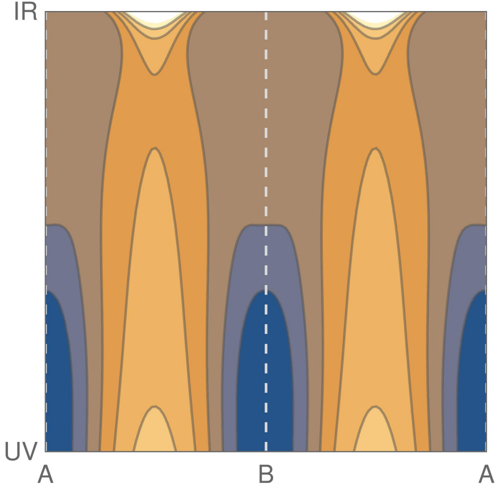
Take the spontaneous inhomogeneous structure

$$S = \int d^4x\sqrt{-g}\left(R - \frac{1}{2}(\partial\psi)^2 - \frac{\tau(\psi)}{4}F^2 - V(\psi)\right) - \frac{1}{2}\int \vartheta(\psi) F\wedge F$$



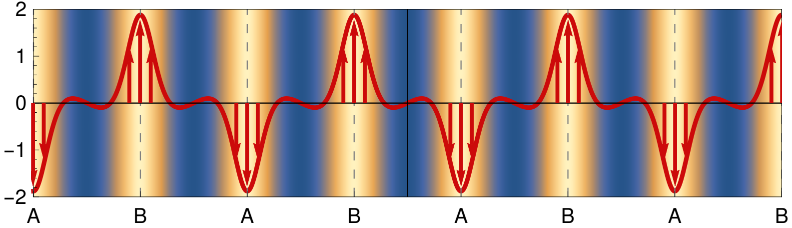
Holographic Mott insulator

They form commensurately locked state



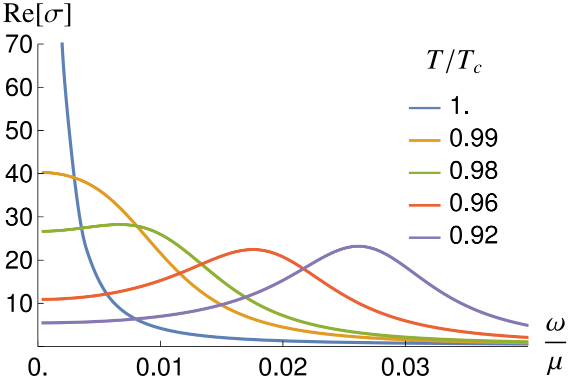
Holographic Mott insulator

The locked state features the staggered current pattern



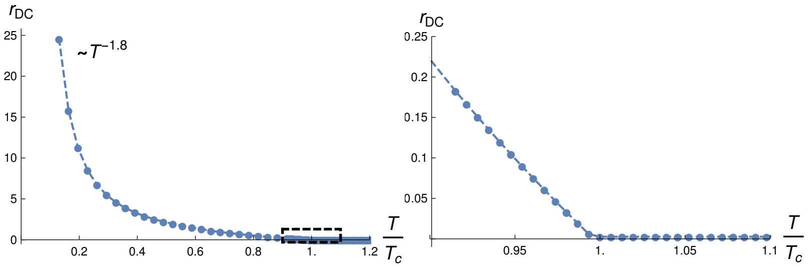
Metal - insulator crossover

Drude peak is pinned at T_c



Metal - insulator crossover

At low temperature this is an algebraic insulator



Discommensurations

Commensurate fractions

Suppose lattice has momentum k and period λ_k
And spontaneous wave has momentum p and period λ_p

The state with commensurate fraction:

$$\frac{N_p}{N_k} = \frac{p}{k}$$

Has a unit cell of the size

$$\lambda_\Sigma = N_p \lambda_p = N_k \lambda_k$$

Discommensuration

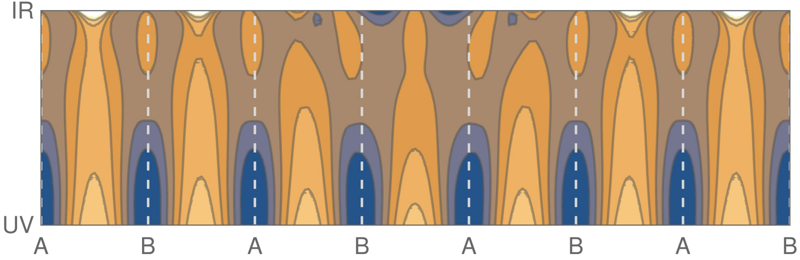
Almost commensurate state has $N_p = N_k + 1$

$$\frac{N_p}{N_k} = 1 + \frac{1}{N_k}$$

One *discommensuration* per N_k lattice units

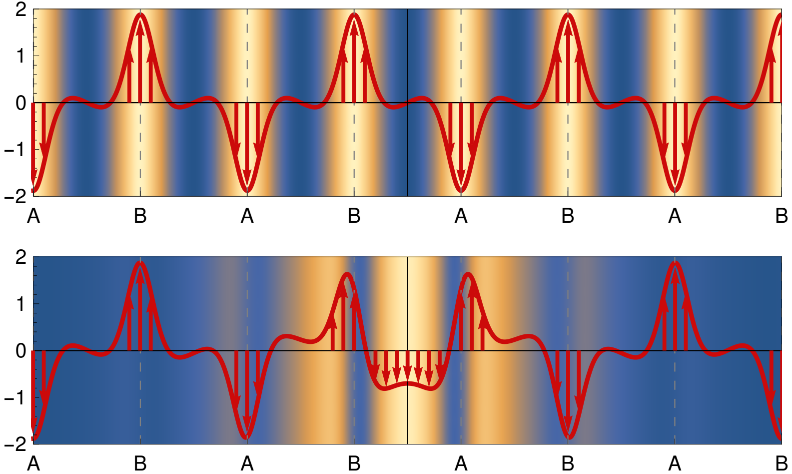
Discommensuration

The mismatch of the periods is accounted for in the core.



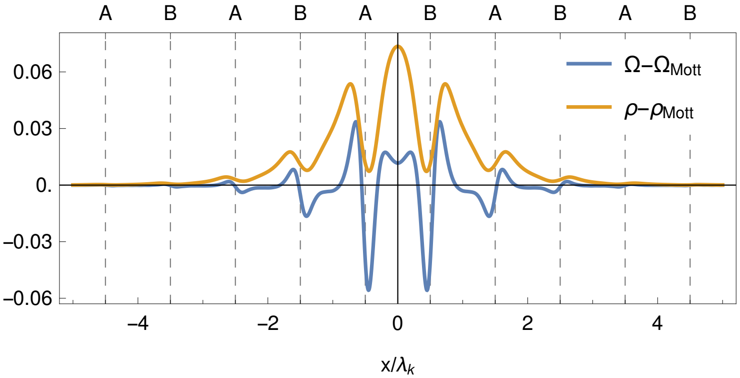
Discommensuration

Discommensuration is a domain wall in the staggered current



Discommensuration

Discommensuration is a soliton with finite size and positive **charge**



Doping the holographic Mott insulator

Doping

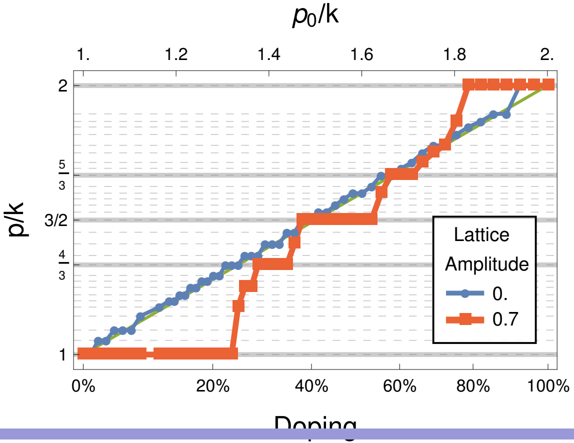
By **doping** one changes the charge density. The excess charge can be stored in discommensurations.

State with finite **density of discommensurations** (n_d) is a *higher commensurate state*

$$\frac{N_p}{N_k} = 1 + \frac{N_d}{N_k} \equiv 1 + n_d$$

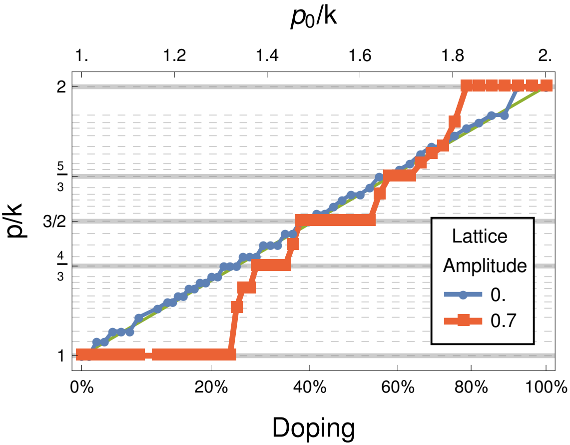
Higher commensurate points

Higher commensurate states are assumed due to commensurate lock in when the periods of pure spontaneous wave and the lattice are significantly different.



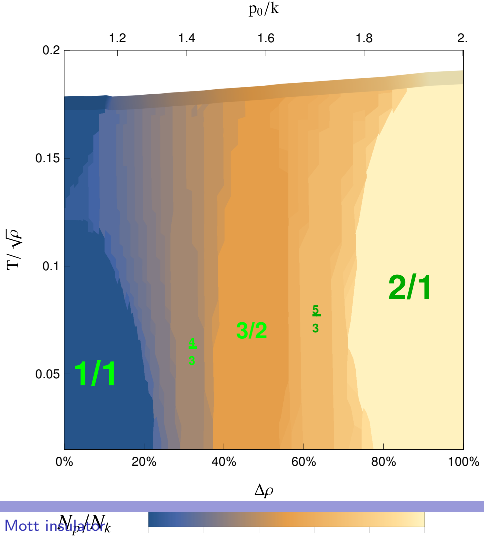
Higher commensurate points

Keeping the lattice constant fixed one can change the period of spontaneous structure by tuning μ_0 or charge density (doping)



Phase diagram of commensurate states

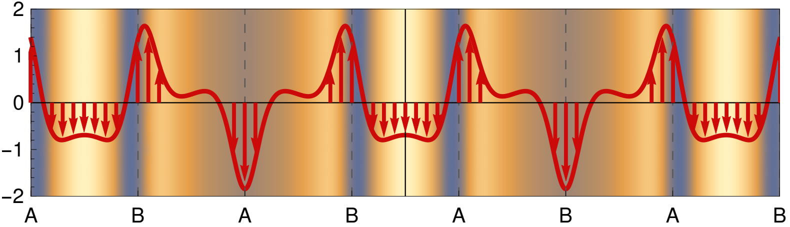
Commensurate lock in is stronger at lower temperature



Discommensuration lattices

Doped Mott insulator has finite density of discommensurations which arrange themselves as periodic lattices.

$$\text{3a} - \text{lattice}: \qquad \frac{N_p}{N_k} = 1 + \frac{1}{3} = \frac{4}{3}$$



Conclusion

- Holographic Mott insulator is the lowest order commensurate state of the spontaneous wave.
- Doping promotes higher commensurate states and discommensurations
- Discommensurations are similar to spin stripes observed in reality
- Higher commensurate lock in makes discommensuration lattices robust against doping.