Spin Drag in the Disordered Hubbard Model and Many-Body Localization

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Disordered Hubbard Model

\[ H = \sum_i U_i \hat{n}_i \uparrow \hat{n}_i \downarrow \\
- \sum_{ij} \langle ij \rangle, \sigma t_{ij} \left( \hat{c}_{j\sigma}^\dagger \hat{c}_{i\sigma} + h.c. \right) \\
+ \sum_i \left( \epsilon_i + m \omega^2 r_i^2 / 2 \right) \hat{n}_i \]

Pasienski, Nat. Phys (2010)
Kondov, arXiv:1305.6072
Transport in Dirty Metal

- Ultracold $^{40}$K
- 3D lattice + speckle
- Response to impulse
Transport in Dirty Metal
Transport in Dirty Metal

Interaction driven MIT!
Vary Temperature in Lattice

- Increase Temp for marginally localized gas
Vary Temperature in Lattice

- Increase Temp for marginally localized gas
Consistent with Many Body Localization

\( \sigma = 0 \) for \( T \neq 0 \)

Oganesyan and Huse (2007)
\( \sigma = 0 \) for \( T \rightarrow \infty \)

\( \sigma \) vs \( T \)

hopping conductivity
Consistent with Many Body Localization

MBL: Anderson localized states → interactions as perturbation

- Basko, Aleiner, Altshuler (2006) $\sigma = 0$ for $T \neq 0$

$\sigma$ vs $T$

hopping conductivity

MBL

$T_c$
Consistent with Many Body Localization

MBL: Anderson localized states → interactions as perturbation

- Basko, Aleiner, Altshuler (2006) \( \sigma = 0 \) for \( T \neq 0 \)

\[ V_{\text{COM}} \text{ (mm/sec)} \]

\[ T \text{ (nK)} \]

\[ \sigma \]

hopping conductivity

MBL

\[ T_c \text{, } T \]
Consistent with Many Body Localization

MBL: Anderson localized states $\rightarrow$ interactions as perturbation

- Basko, Aleiner, Altshuler (2006) $\sigma = 0$ for $T \neq 0$
- Oganesyan and Huse (2007) $\sigma = 0$ for $T \rightarrow \infty$
Quantitative behavior of metallic phase

$V_{\text{COM}}$ (mm/sec) vs. $\Delta (E_R)$

- Metal
- Insulator

$\Delta_c$
Spin Drag in Hubbard Gas

- Spin friction as analog of resistance
Spin Drag in Hubbard Gas

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Spin Drag in Hubbard Gas

- Spin friction as analog of resistance

Currently looking for non-Fermi liquid behavior...
Thanks!

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Brian DeMarco  Wenchao Xu