The Abdus Salam
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2254-15

Workshop on Sphere Packing and Amorphous Materials

25 - 29 July 2011

Glass and Jamming Transition from the Mean-Field Perspectives

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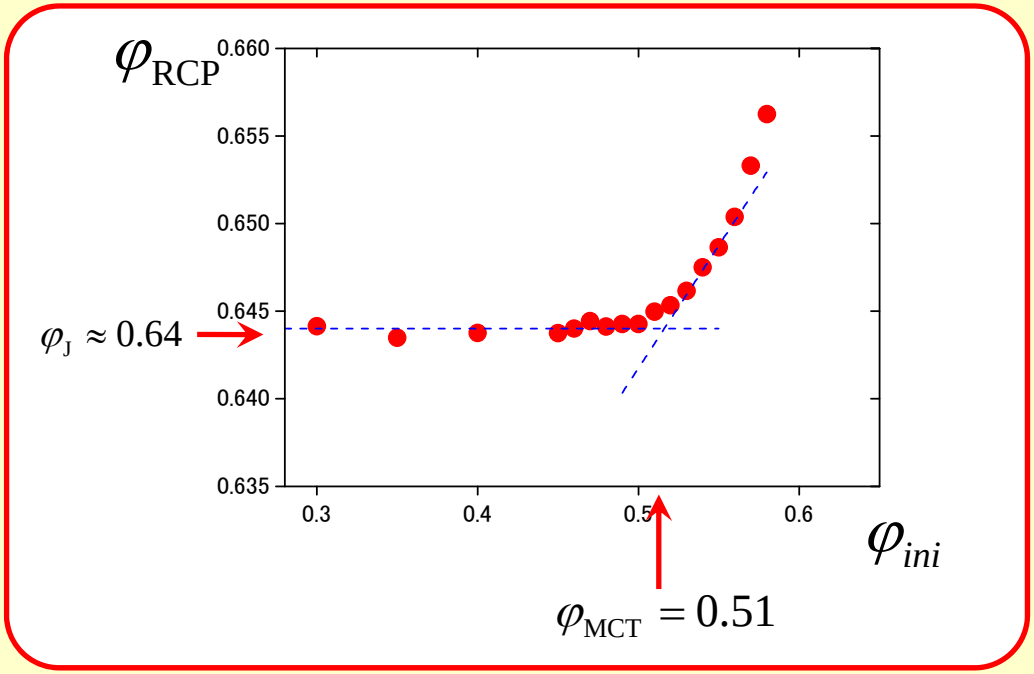
Glass and Jamming Transition from the Mean-Field Perspectives

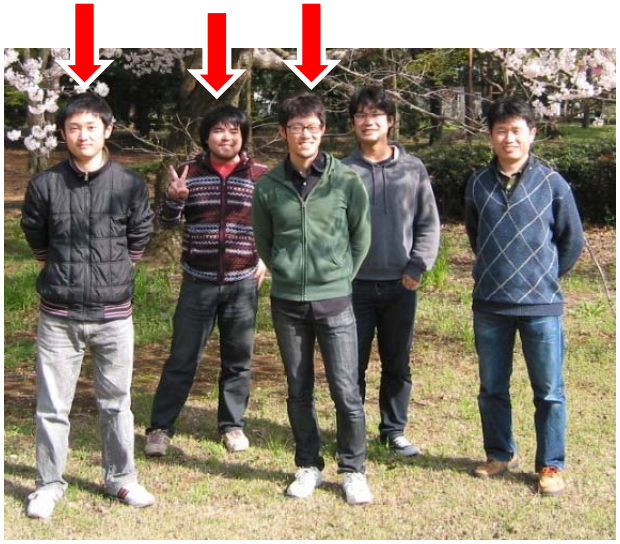


Kunimasa Miyazaki

- *Phys. Rev.* E **81**, 040501(R) (2010)
- *Phys. Rev. Lett.* **104**, 255704 (2010)
- *Phys. Rev. Lett.* **106**, 015701 (2011)

(Talk at Trieste 07/28/2011)

ACKNOWLEDGEMENTS



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Misaki Ozawa
Takeshi Kuroiwa

Patrick Charbonnau
Duke University

Funded by

2006 - 2010 NEQ SOFT Non-equilibrium soft matter physics

筑波大学 University of Tsukuba

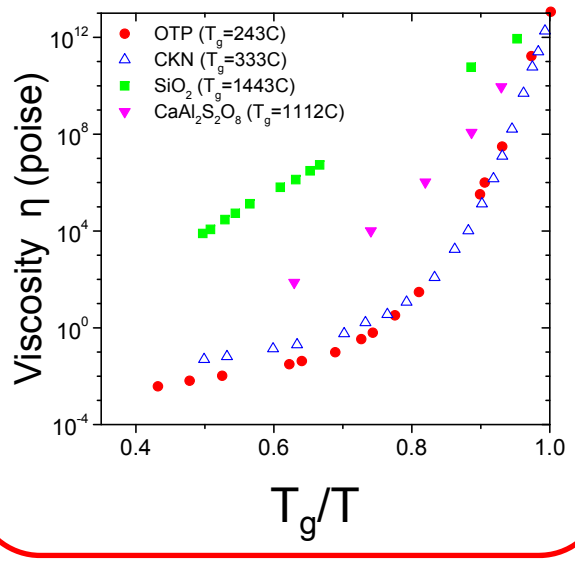
OVERVIEW

- Introduction
- Numerical Test of Mean Field Scenario
  - *Glass transition in Higher dimensions*
  - *Glass transition for Ultra-Soft Fluids*
  - *Jamming transition vs. MCT transition*
  - *Replica Theory vs Mode-Coupling Theory*
- Conclusions

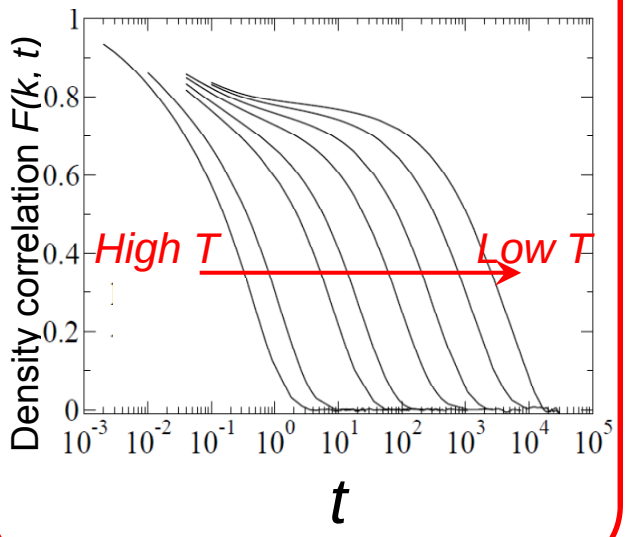
INTRODUCTION

- What is the Glass Transition?

Macroscopic dynamics



Microscopic dynamics



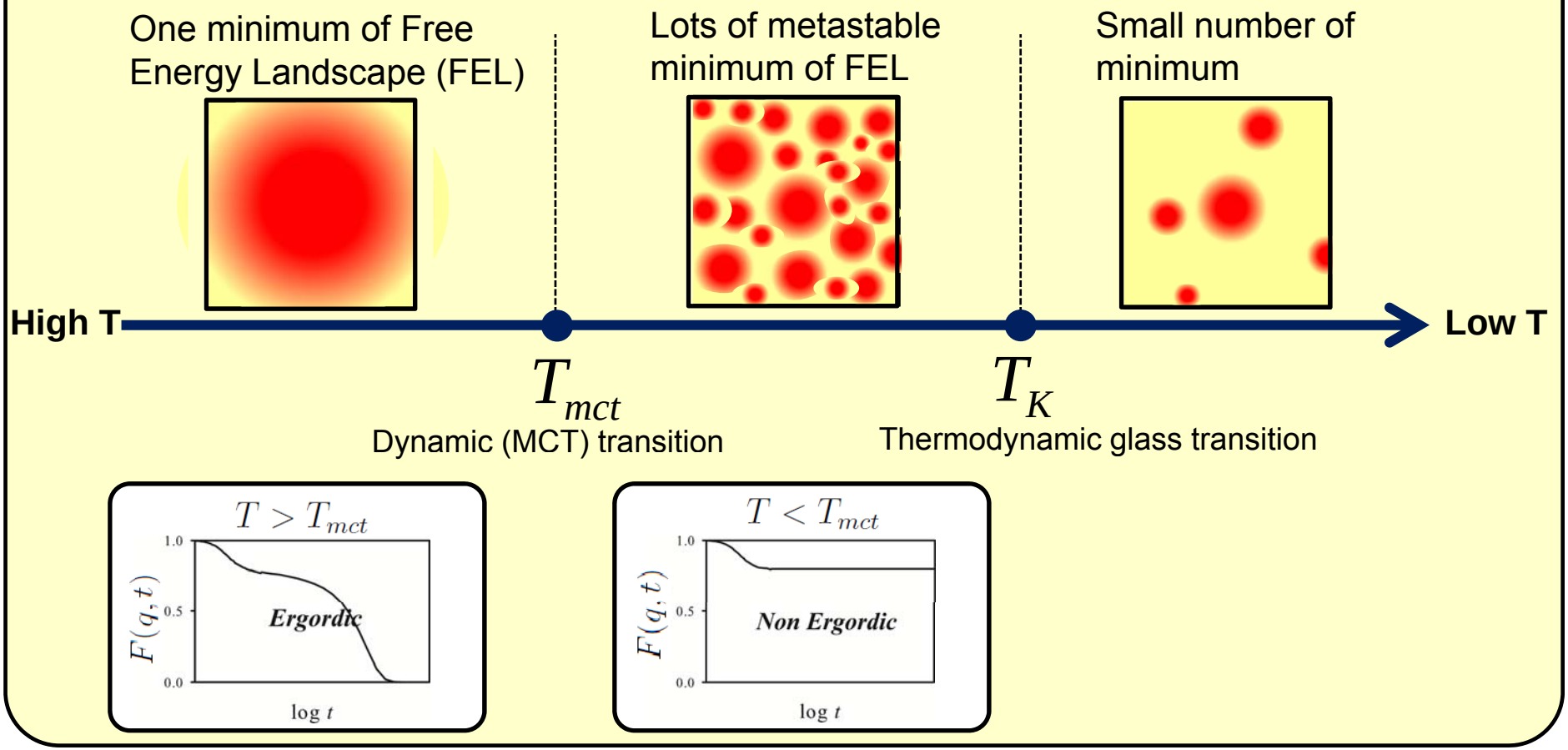
Drastic slow down of dynamics of supercooled liquids at low temperature

INTRODUCTION

- A Mean Field Scenario of the Glass Transition

A possible scenario inspired by a spin-glasses

- Mode-Coupling Theory and Replica Theory (Mezard and Parisi, 1996)



GRADING MCT

If this mean field scenario is correct,

- *MCT should work better in Higher Dimensions*
- *MCT should work better for Long-Ranged Systems*
- *Dynamic(MCT) transition point should mark the crossover of the inherent structure (Jamming transition point!)*
- *MCT and Replica theory should be consistent*

Numerical Test of Mean Field Scenario

MCT should work better in Higher Dimensions

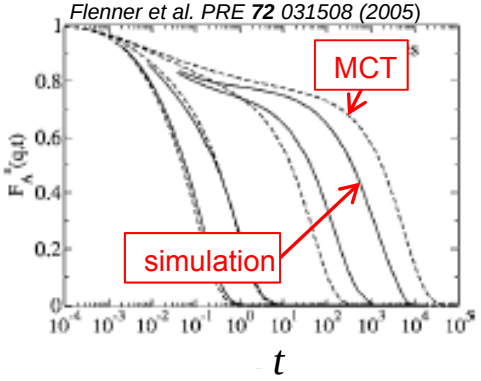
MD for a Hard Sphere Fluid

d=3

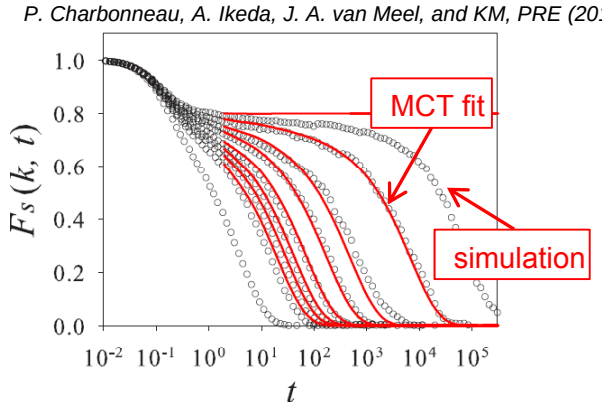
d=4

Density correlation

*Flenner et al. PRE **72** 031508 (2005)*



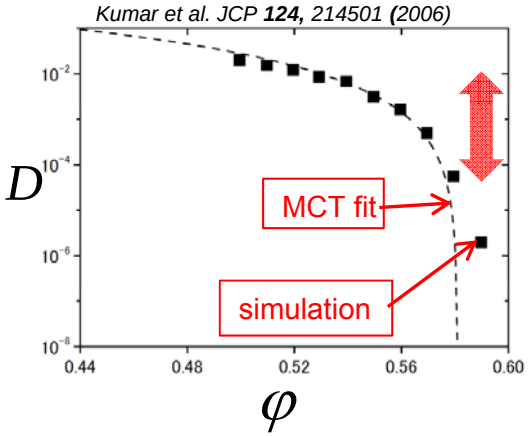
P. Charbonneau, A. Ikeda, J. A. van Meel, and KM, PRE (2010)

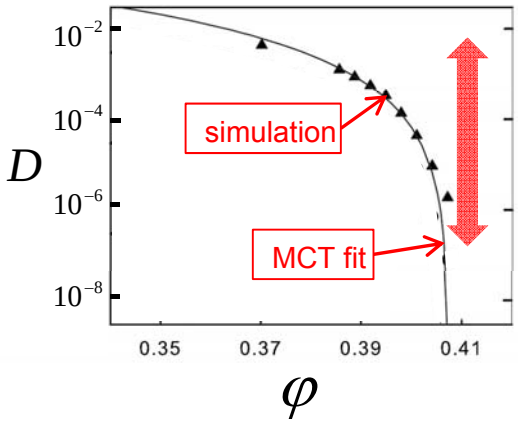


Diffusion constant

$$D \propto |\varphi - \varphi_{mct}|^{\gamma}$$

*Kumar et al. JCP **124,** 214501 (2006)*





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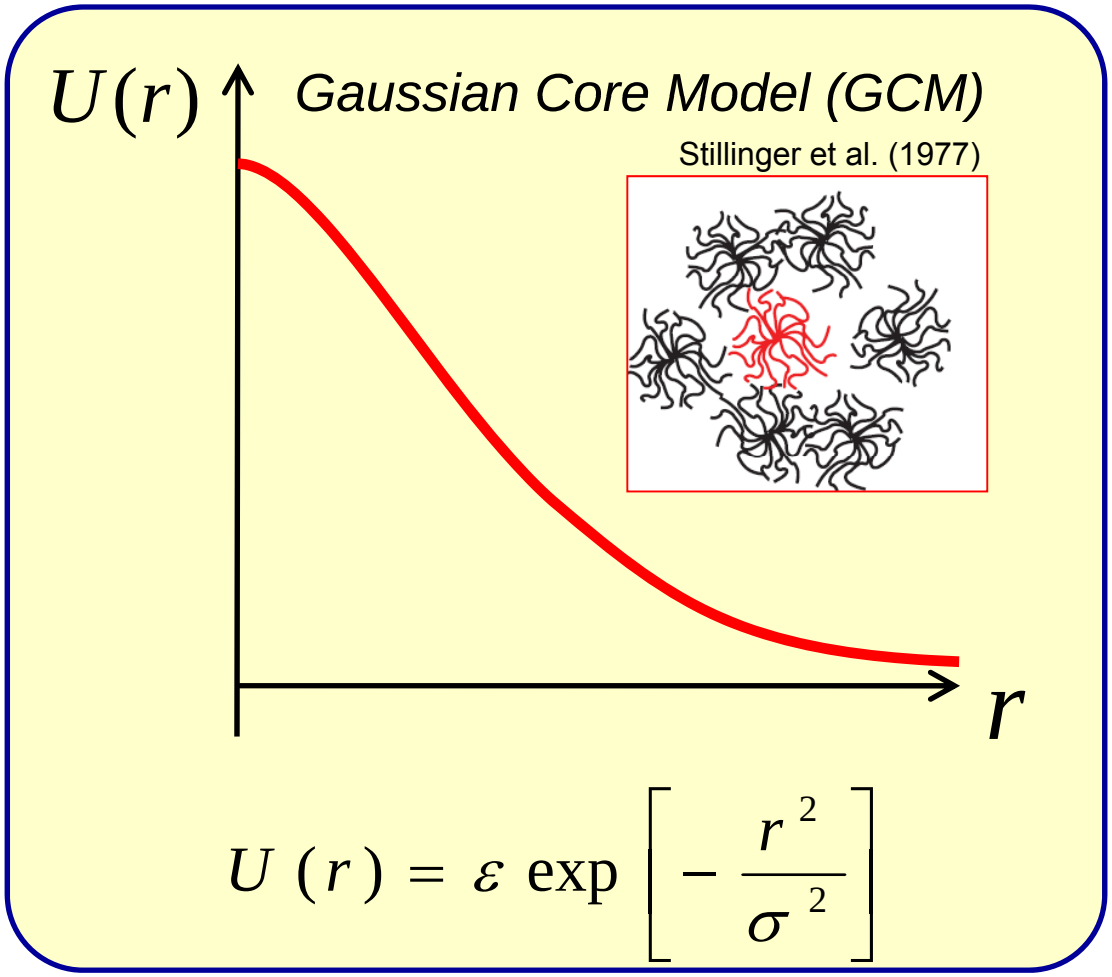
Numerical Test of Mean Field Scenario

- *MCT should work better for Long-Ranged Systems*

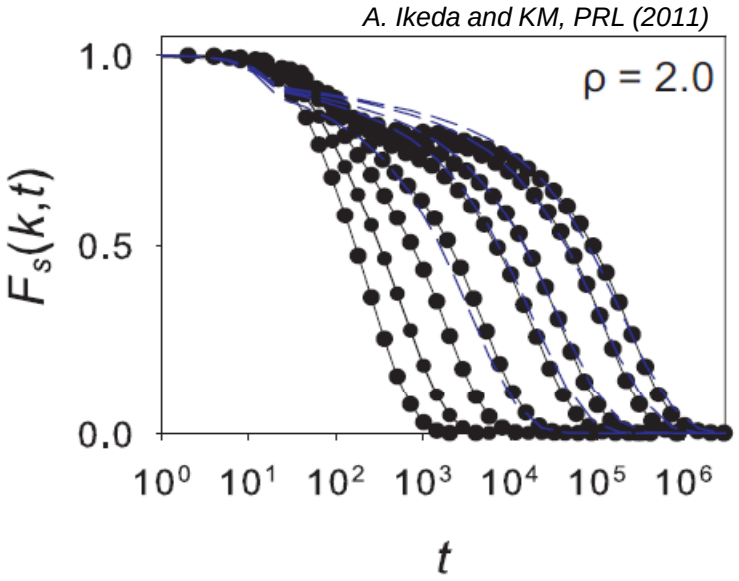
Long-ranged Potential = Dense Ultra-Soft Potential



Numerical Test of Mean Field Scenario

- *MCT should work better for Long-Ranged Systems*

MCT works unprecedentedly well !



	KA LJ	GCM (ρ = 1.5)	GCM (ρ = 2.0)
T_{mct} (simulation+fitting)	0.435	0.202×10^{-5}	0.266×10^{-6}
T_{mct} (theory)	0.922	0.266×10^{-5}	0.340×10^{-6}
Deviations	112 %	33 %	28 %

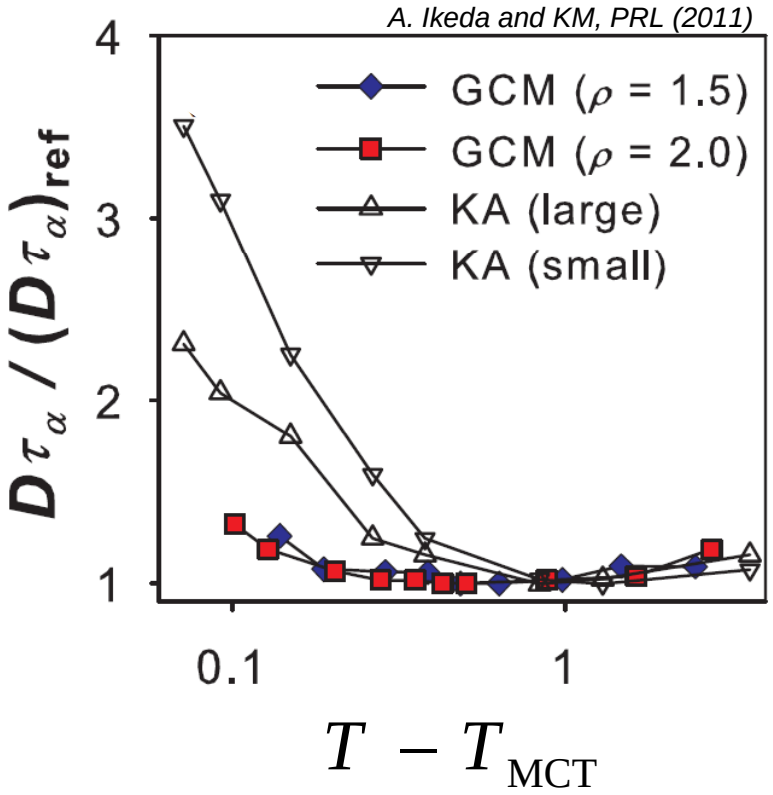
Numerical Test of Mean Field Scenario

- *MCT should work better for Long-Ranged Systems*

MCT works unprecedentedly well !

And dynamic heterogeneities are weak !!

Weaker violation of Stokes-Einstein relation



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Numerical Test of Mean Field Scenario

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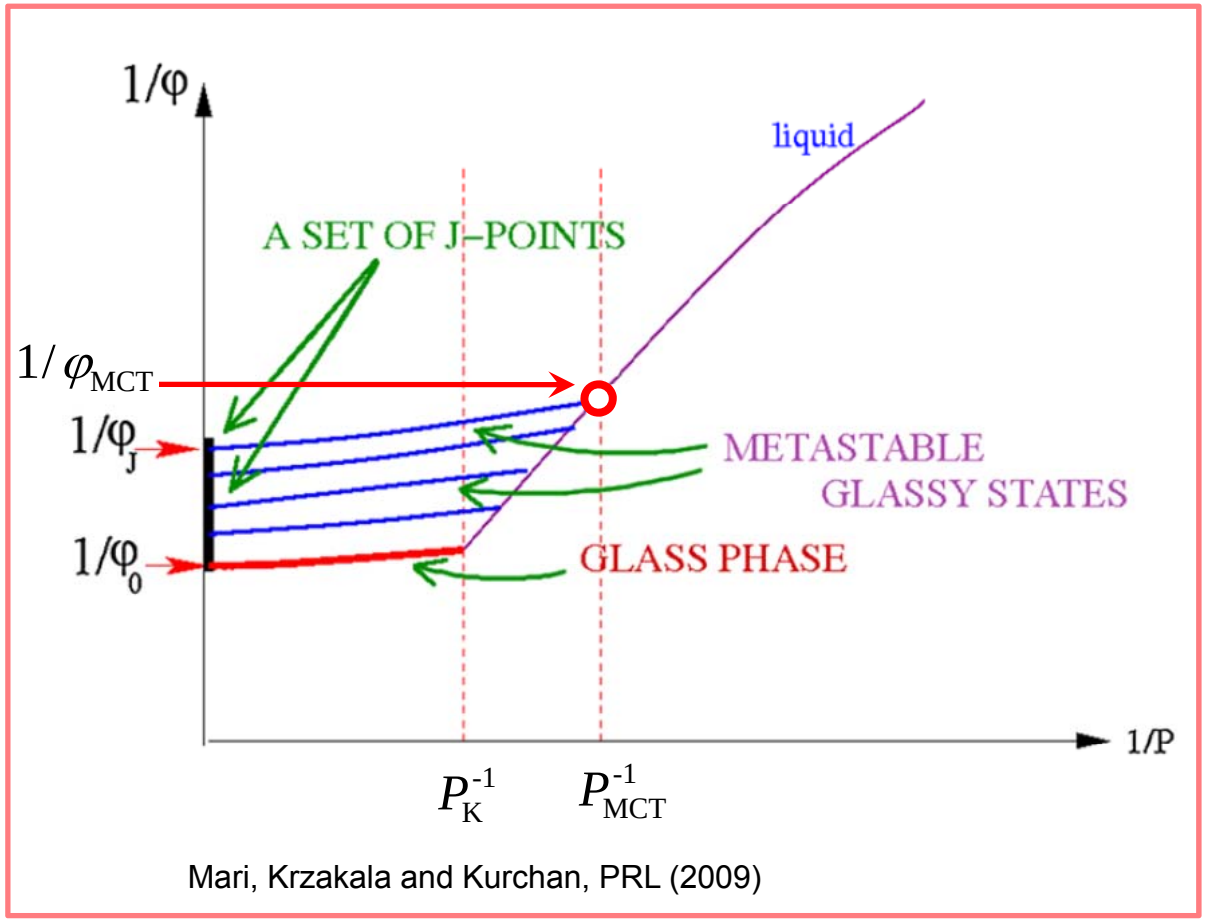


Mari, Krzakala and Kurchan, PRL (2009)

$$\varphi_{RCP} = \lim_{P\to\infty} \varphi(P)$$

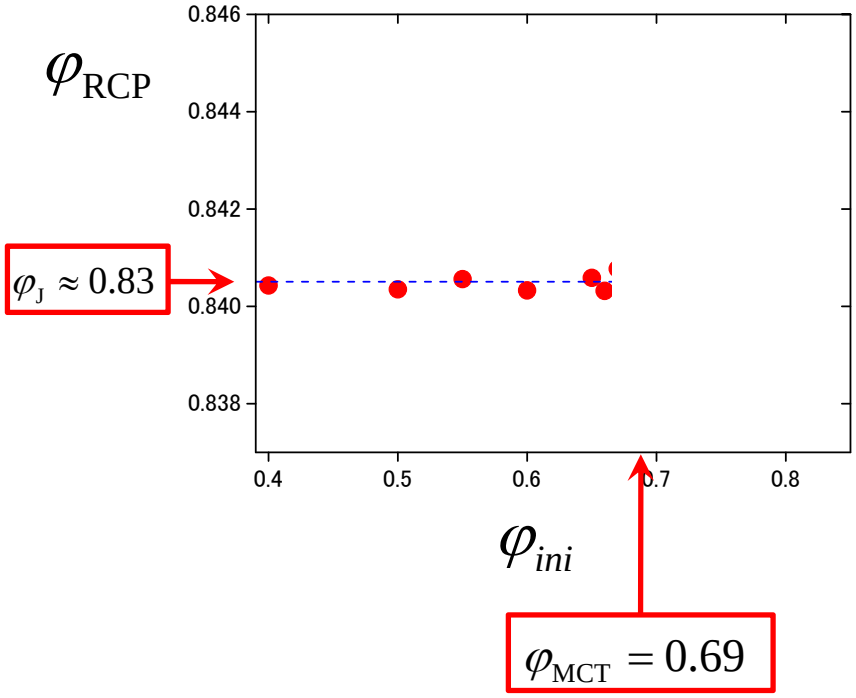
$$= \varphi_J \quad \text{for} \quad \varphi_{ini} < \varphi_{\text{mct}}$$

$$> \varphi_J \quad \text{for} \quad \varphi_{ini} > \varphi_{\text{mct}}$$

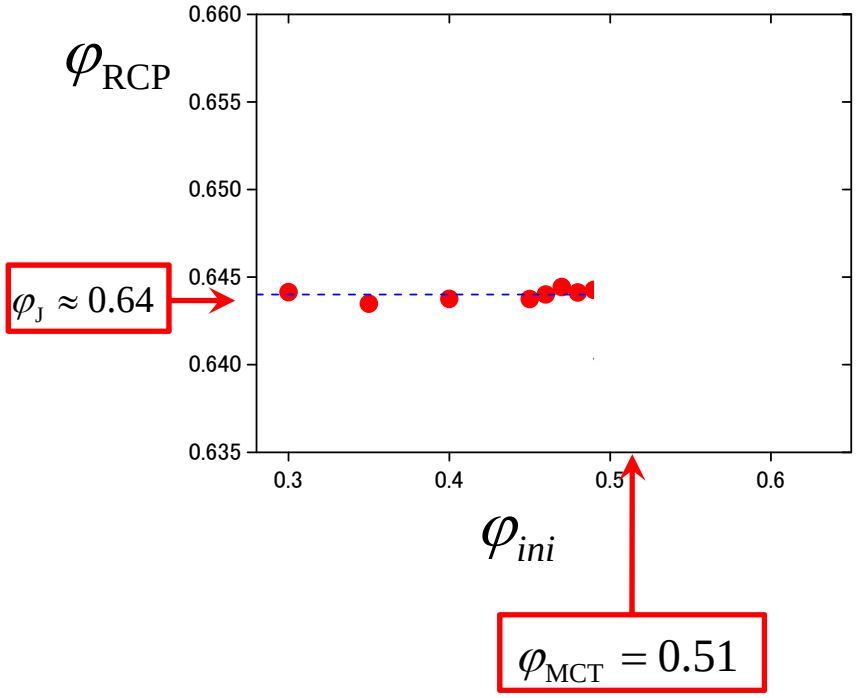
Numerical Test of Mean Field Scenario

- *Dynamic(MCT) transition point should mark the crossover of the inherent structure (Jamming transition point!)*

d=2



d=3



Ozawa, Kuroiwa, Ikeda, and KM (in preparation)

GRADING MCT

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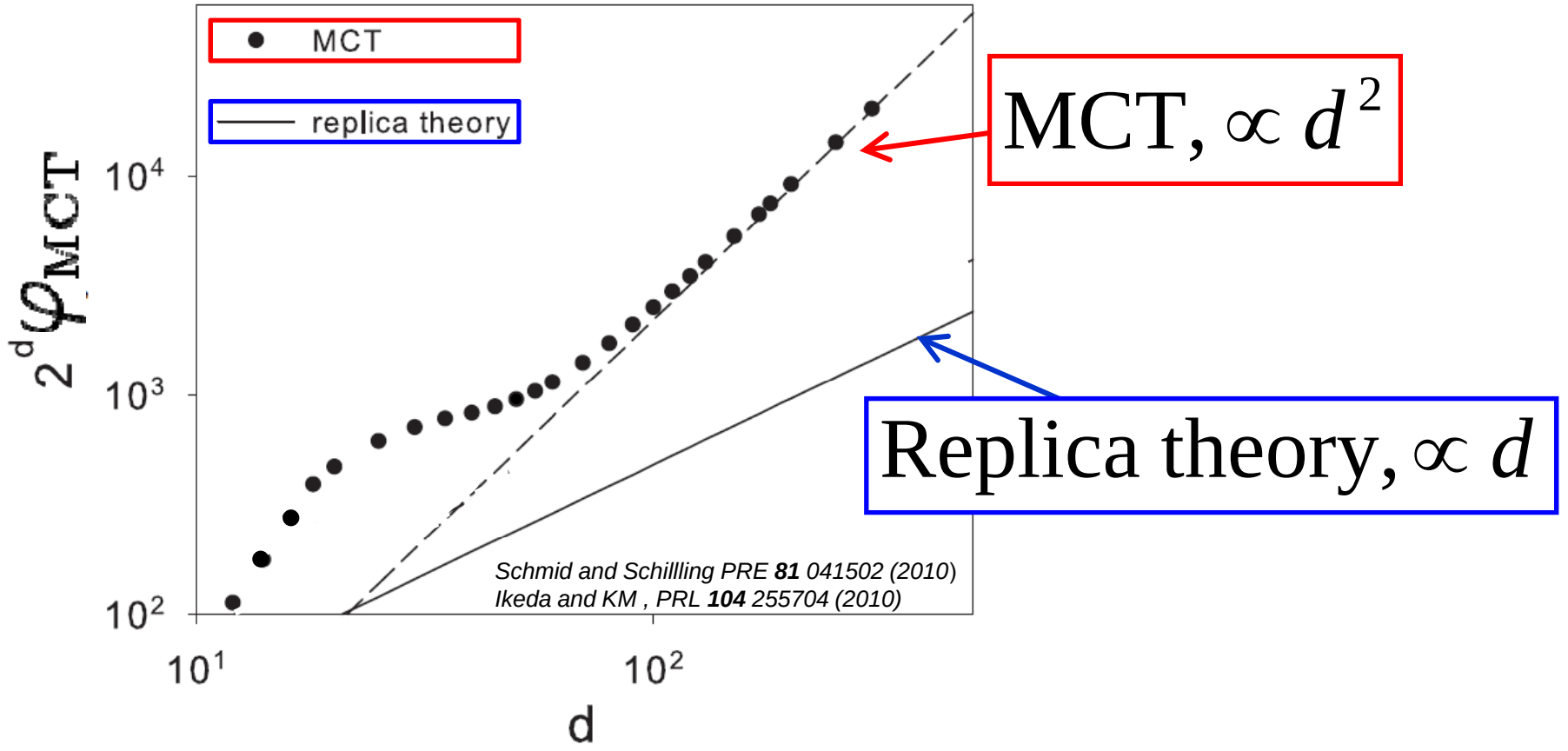
Numerical Test of Mean Field Scenario

- *MCT and Replica theory should be consistent*



CONCLUSIONS

GRADE of MCT

- ☑ *MCT should work better in Higher Dimensions* ***???***
- ☑ *MCT should work better for Long-Ranged Systems*
- ☑ *Dynamic(MCT) transition point should mark the crossover of the inherent structure (Jamming transition point!)*
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