

# **Models And Analysis Of Evacuation Dynamics Of Asymmetrically Coupled Pedestrian Pairs**

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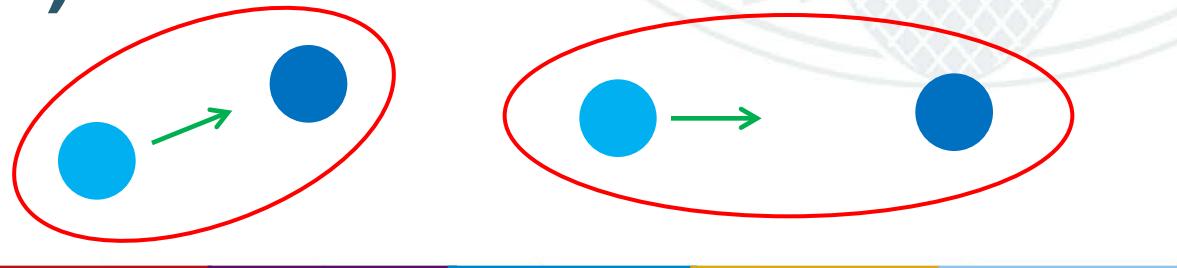
# Why are 2-person-groups of interest?

- Pedestrians rather move in groups - up to 70% (Moussaid et al., 2010)
- Most pedestrians walk in two-person-groups (Xi et al., 2014)
- Open question: How do these groups impact evacuation processes?



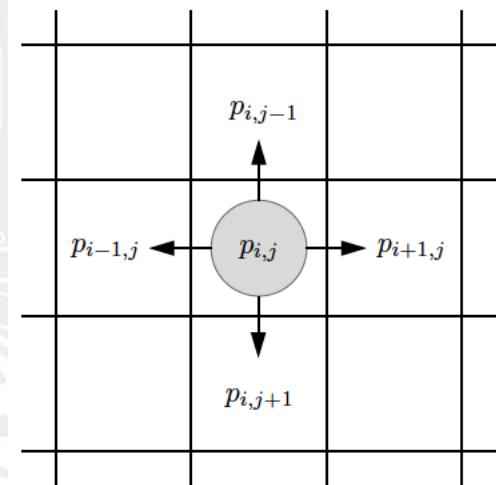
# Asymmetrically coupled pedestrian pairs

- Social group of two individuals with the tendency to maintain a spatial coherence
- Asymmetric interaction (leader and follower)



# Floor field cellular automata

- 2-dim lattice
- Stochastic
- Floor fields determine transition probabilities
- Parallel update



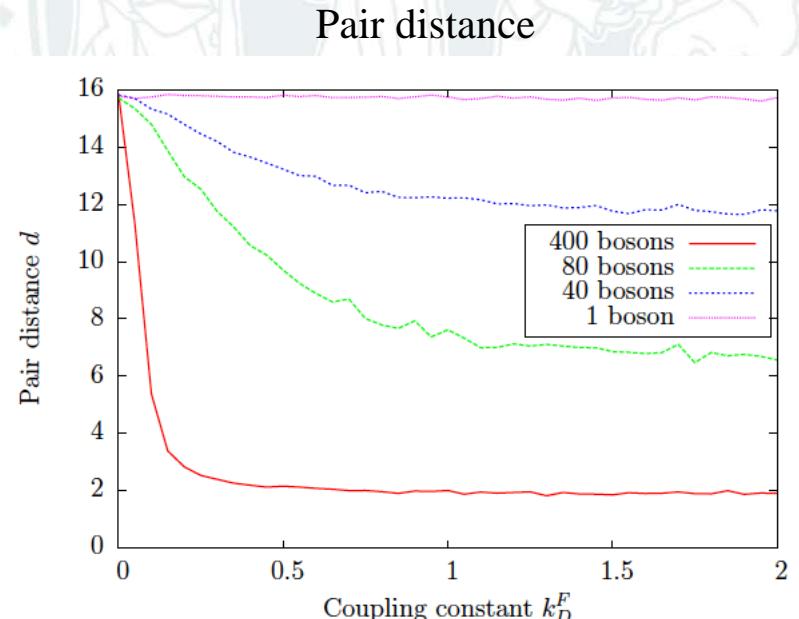
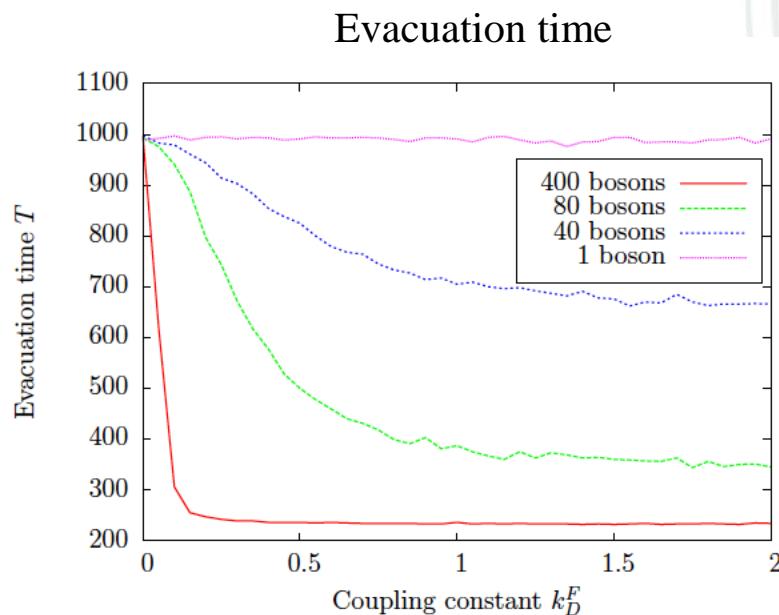
# Asymmetric pair coupling via DGFF

- Related to velocity density
- Decay and diffusion
- High field strength
- No self-interaction
- $p_{ij}^s = N \exp(k_S S_{ij}) \exp(k_D D_{ij}^s) (1 - \eta_{ij}) \xi_{ij}$

0	L	0	0
0	50	0	0
2	19	0	0
2	12	3	0
1	5	3	F
3	1	0	0



# Group cohesion with DGFF

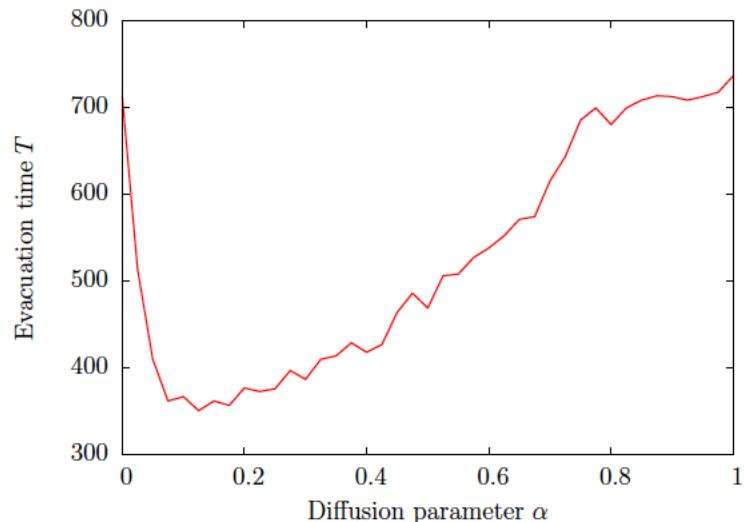


Low density situation ( $\rho = 0.02$ )

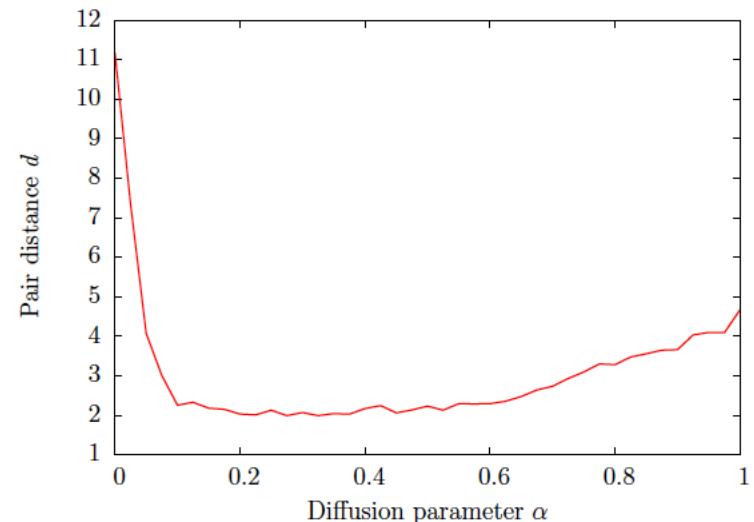


# Relevance of diffusion for group cohesion

Evacuation time

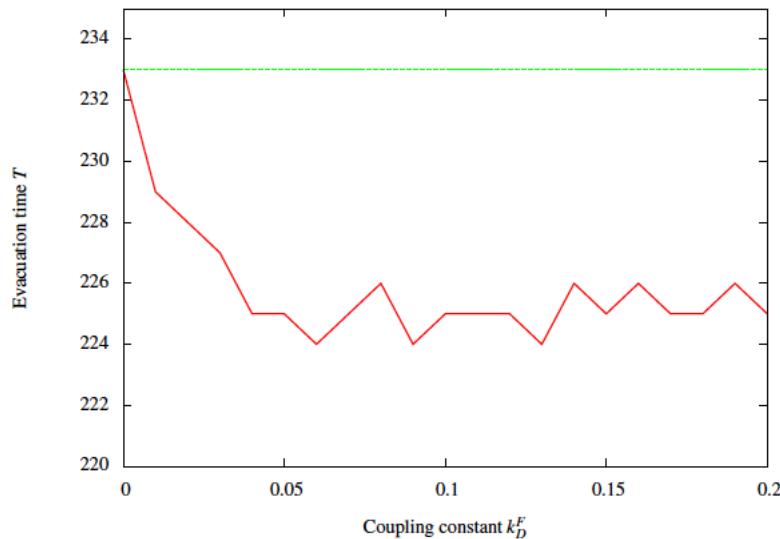


Pair distance

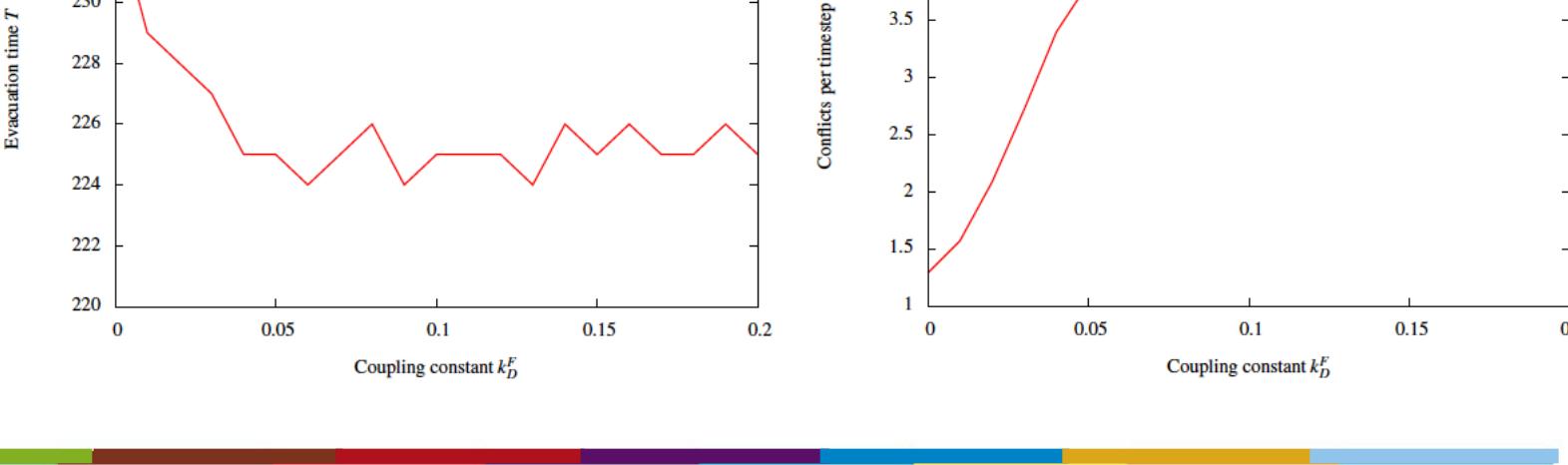
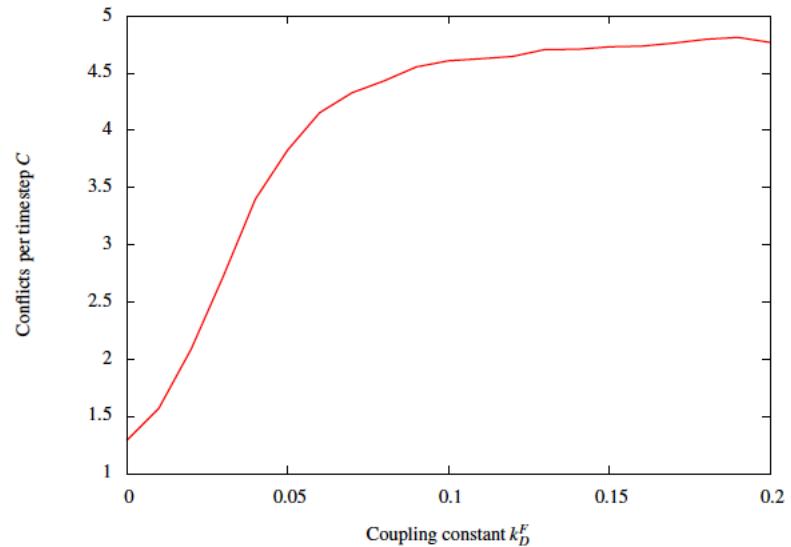


# Influence of DGFF coupling on evacuation time

Evacuation time

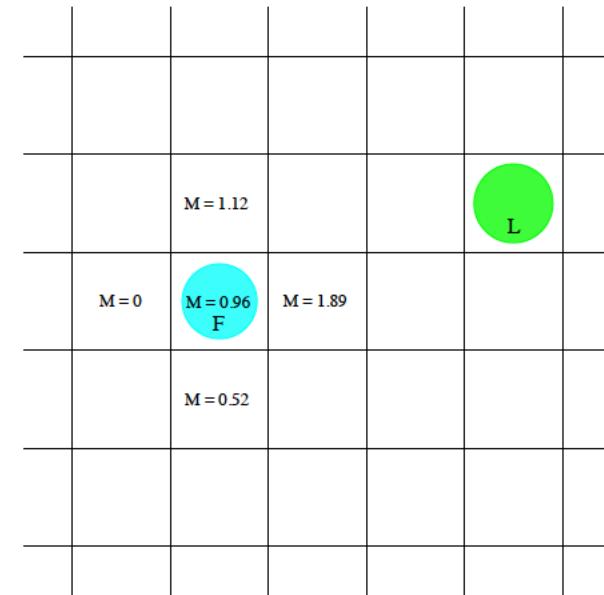


Conflicts per timestep



# Asymmetric pair coupling via Moving Target Floor field

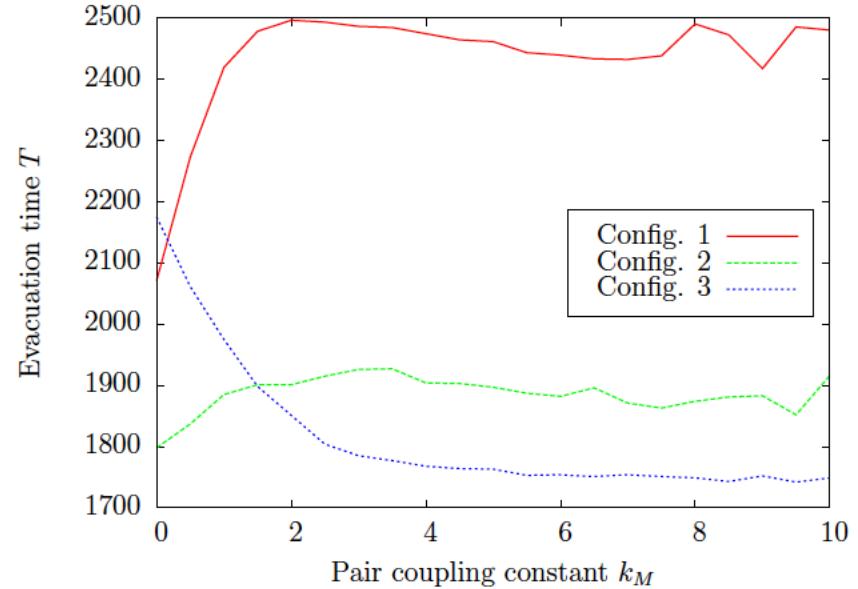
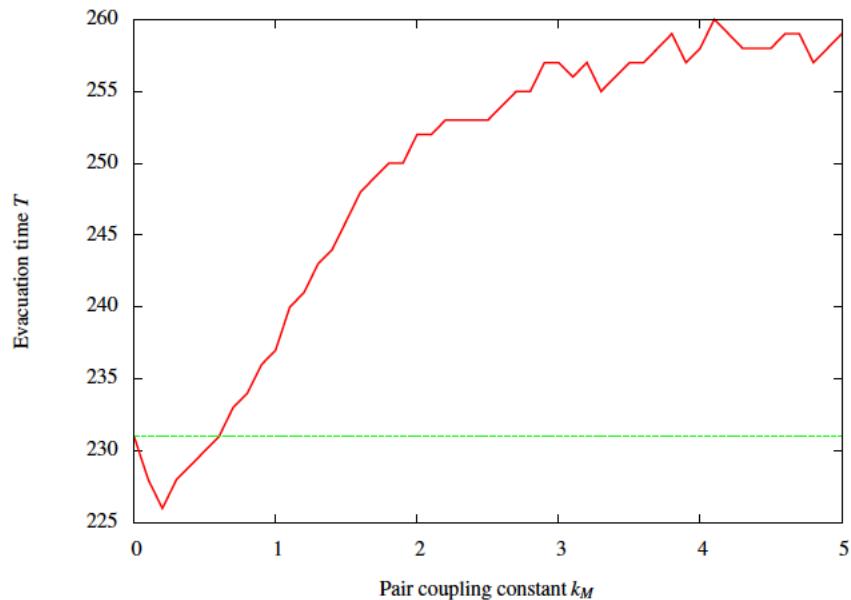
- Euclidean distance metric
- Related to position
- Permanent, asym., unlimited reach



$$M_{ij}^{(s)}(T) = \max_{(\tilde{i}, \tilde{j})} \left\{ \sqrt{(i_L(T) - \tilde{i})^2 + (j_L(T) - \tilde{j})^2} \right\} - \sqrt{(i_L(T) - i)^2 + (j_L(T) - j)^2}$$



# Impact of MTFF on evacuation time

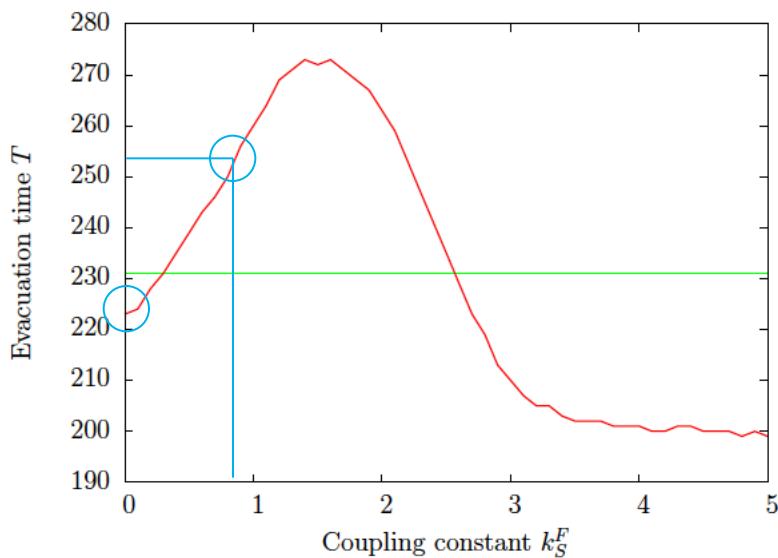


$$p_{ij} = N \exp(k_{SF} S_{ij} + k_M M_{ij}^{(s)}) (1 - \eta_{ij}) \xi_{ij}$$

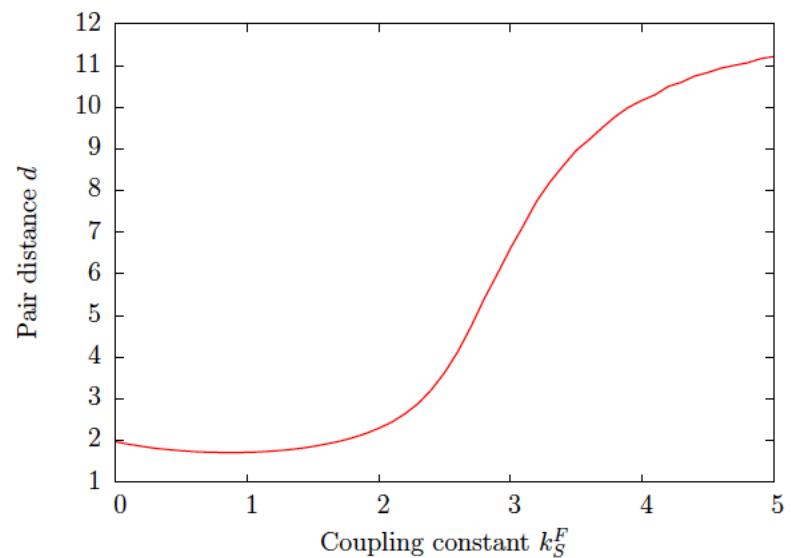


# Influence of follower orientation

Evacuation time



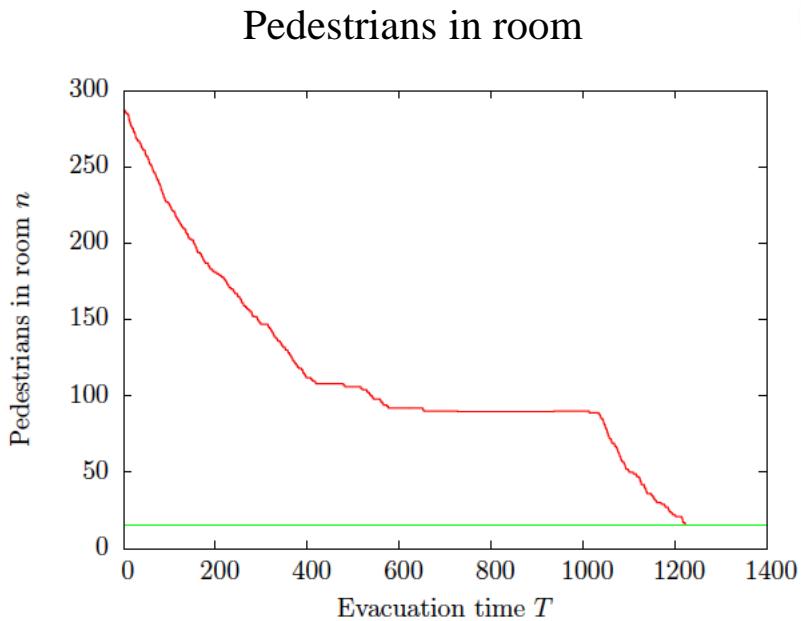
Pair distance



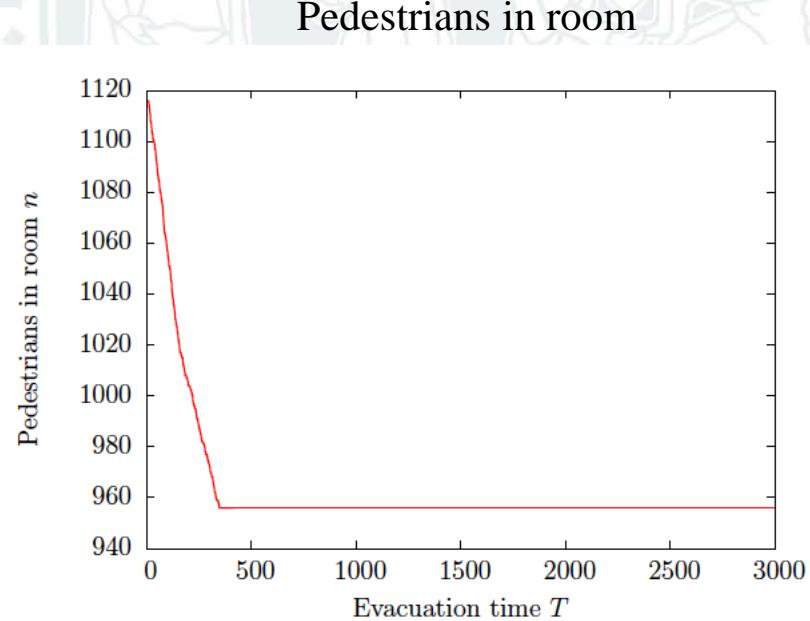
$$\rho = 0.02, k_S^L = 0.8, k_M = 2 \quad (k_S = 0.8)$$



# Temporary clogging and permanent gridlocks



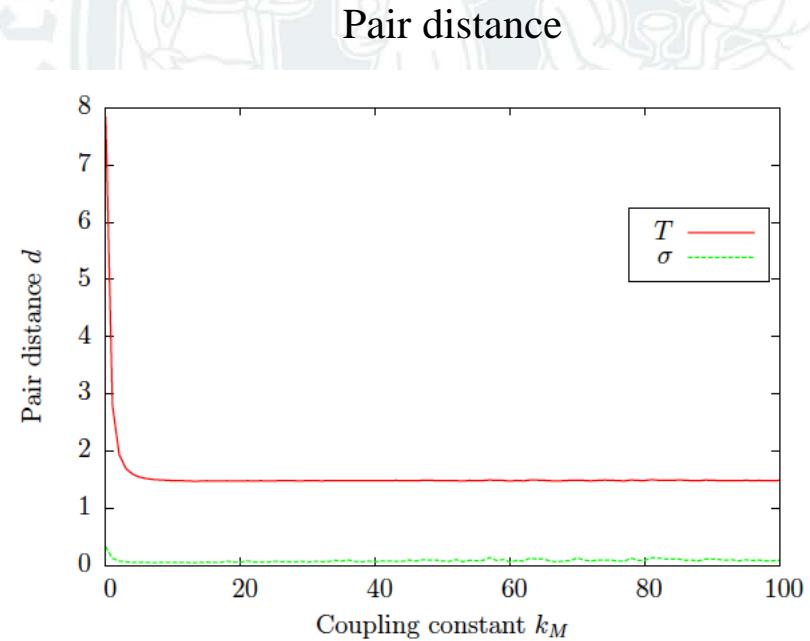
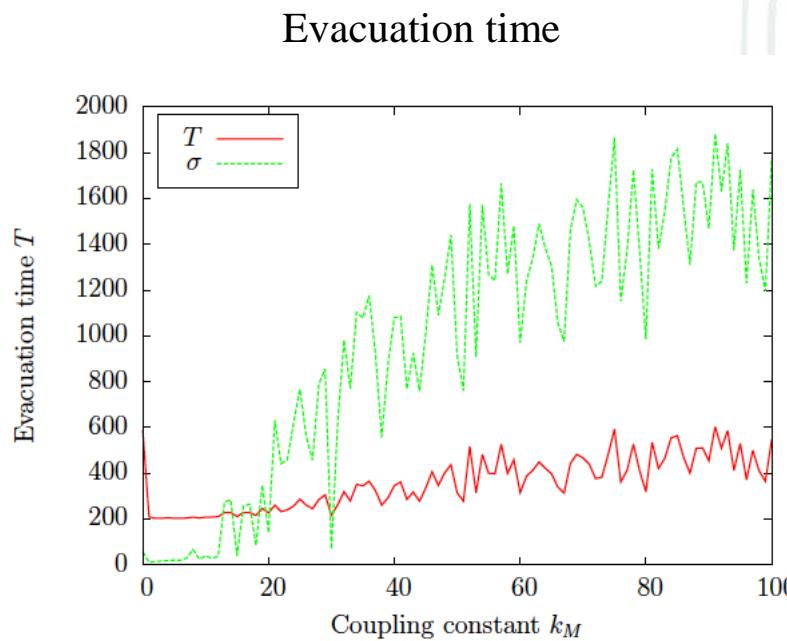
$$k_M = 30$$



$$k_M = 200$$



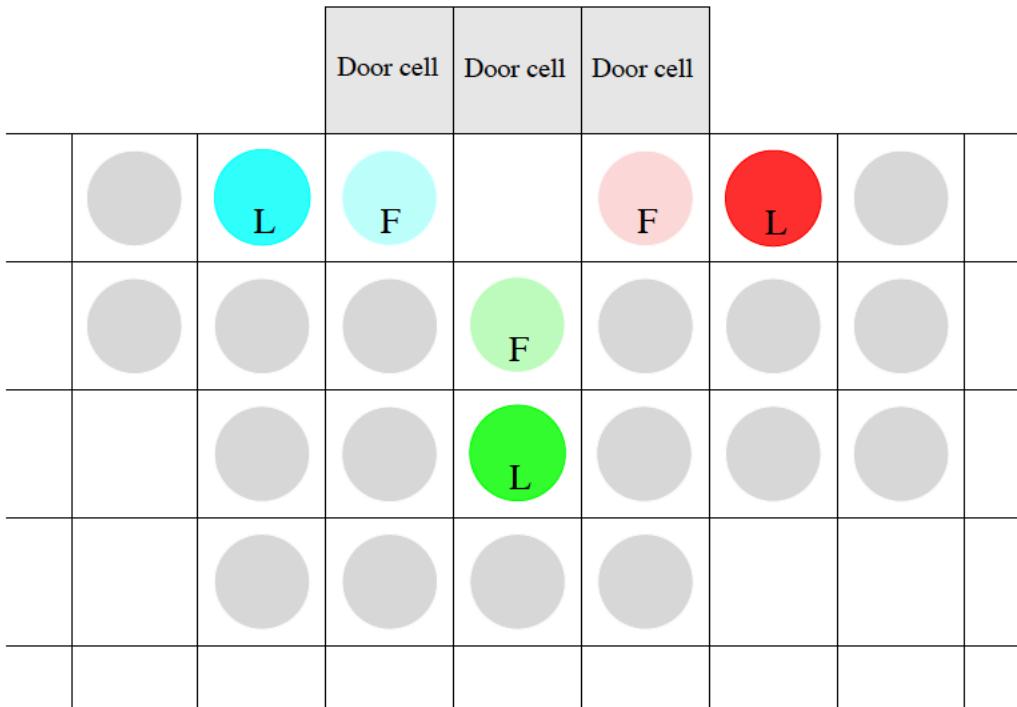
# Clogging and evacuation time



$\rho = 0.3$ , cut off when  $T = 10000$  is reached.



# Typical clogging and gridlock configuration



For

$$k_S^F = 1 \text{ and } k_M = 100$$

$$p_{door} \approx 1 \cdot 10^{-43}$$



# Comparison with Experiment



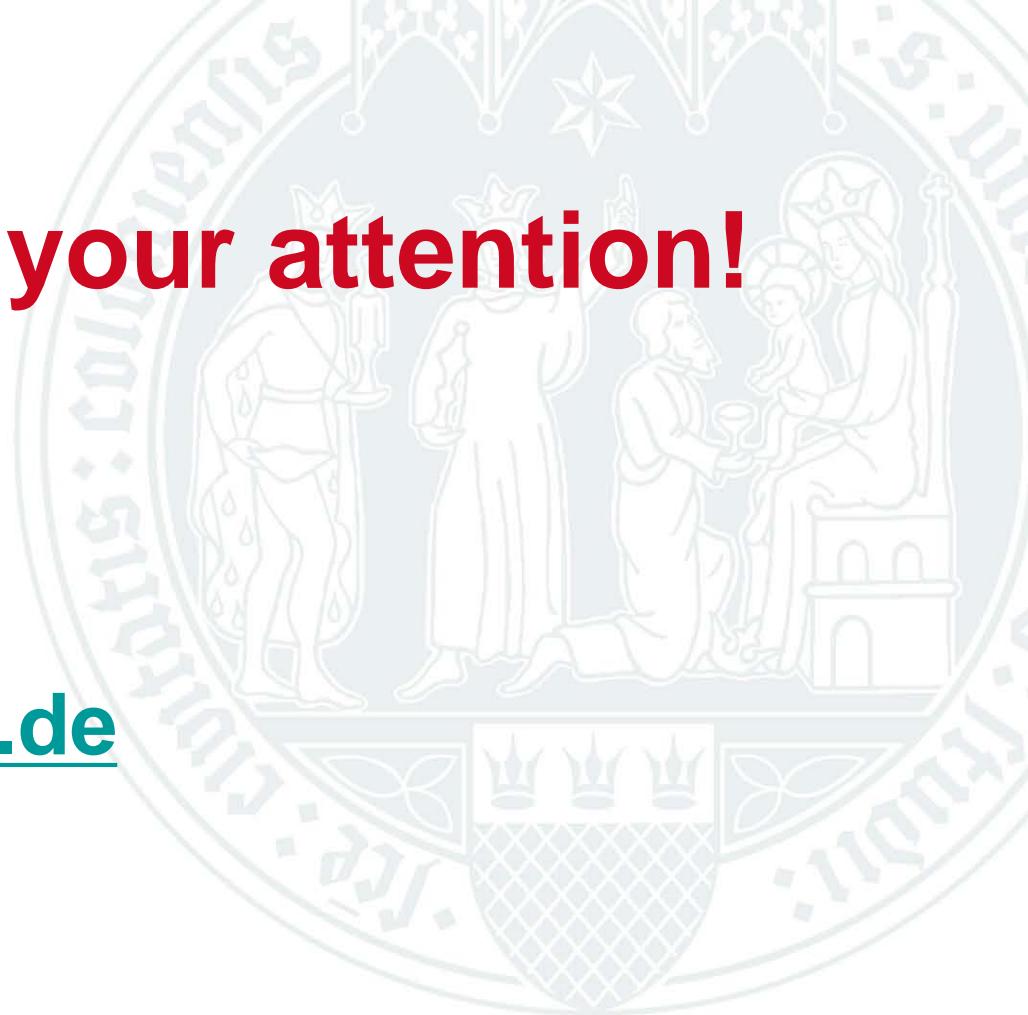
# Thank you for your attention!

Contact:

Frank Müller

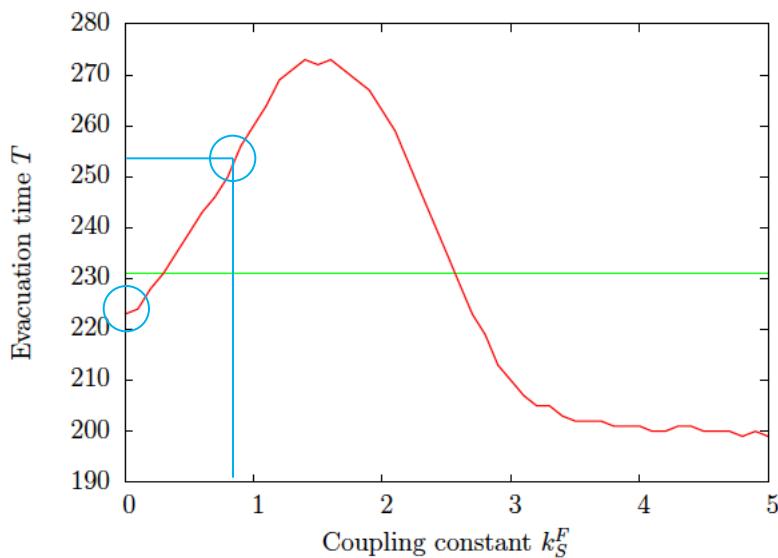
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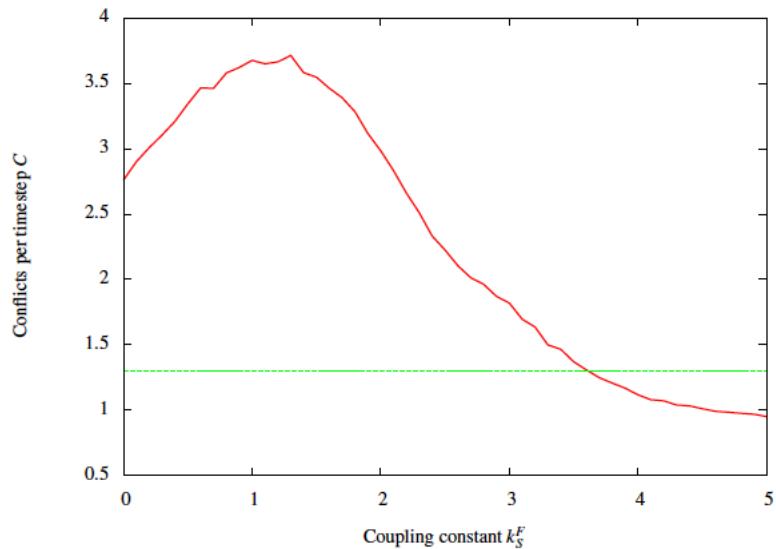


# Influence of follower orientation

Evacuation time



Conflicts per timestep



$$\rho = 0.02, k_S^L = 0.8, k_M = 2 \quad (k_S = 0.8)$$

