# When sociophysics produces new physical results

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A. O. Sousa from Liège and K. Malarz from Cracov

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# Sociophysics : from physics to social sciences

Physicists are still divided, some are convinced it will produce new understanding of social phenomena, some are dubitative

But who would have expected sociophysics could contribute to pure physics ?

What is the story?

It begins from an informal controversy between me and almost all my colleagues working in the field

What was the subject of the controversy?

The nature of my model of opinion dynamics which uses a reshuffling of agents between two consecutive local updates

The model in short:

A simple illustration to implement the dynamics and show how the model works → next

Some references:

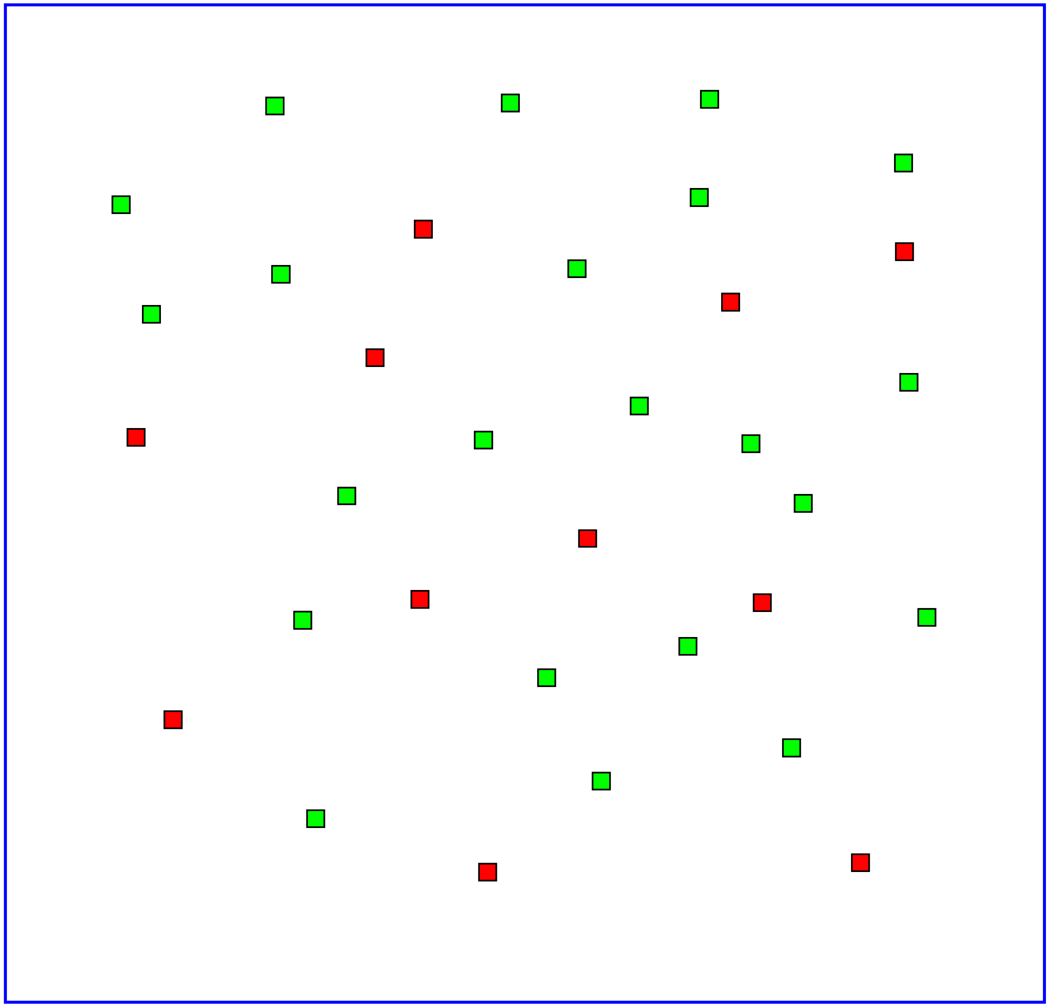
* Eur. Phys. J. B 25 Rapid Note (2002) 403

* Physica A  320 (2003) 571

* Phys. Rev. E **71**, 046123 (2005)

A population of 33 persons with 22 in favor of a reform and 11 against it

**People on their own**

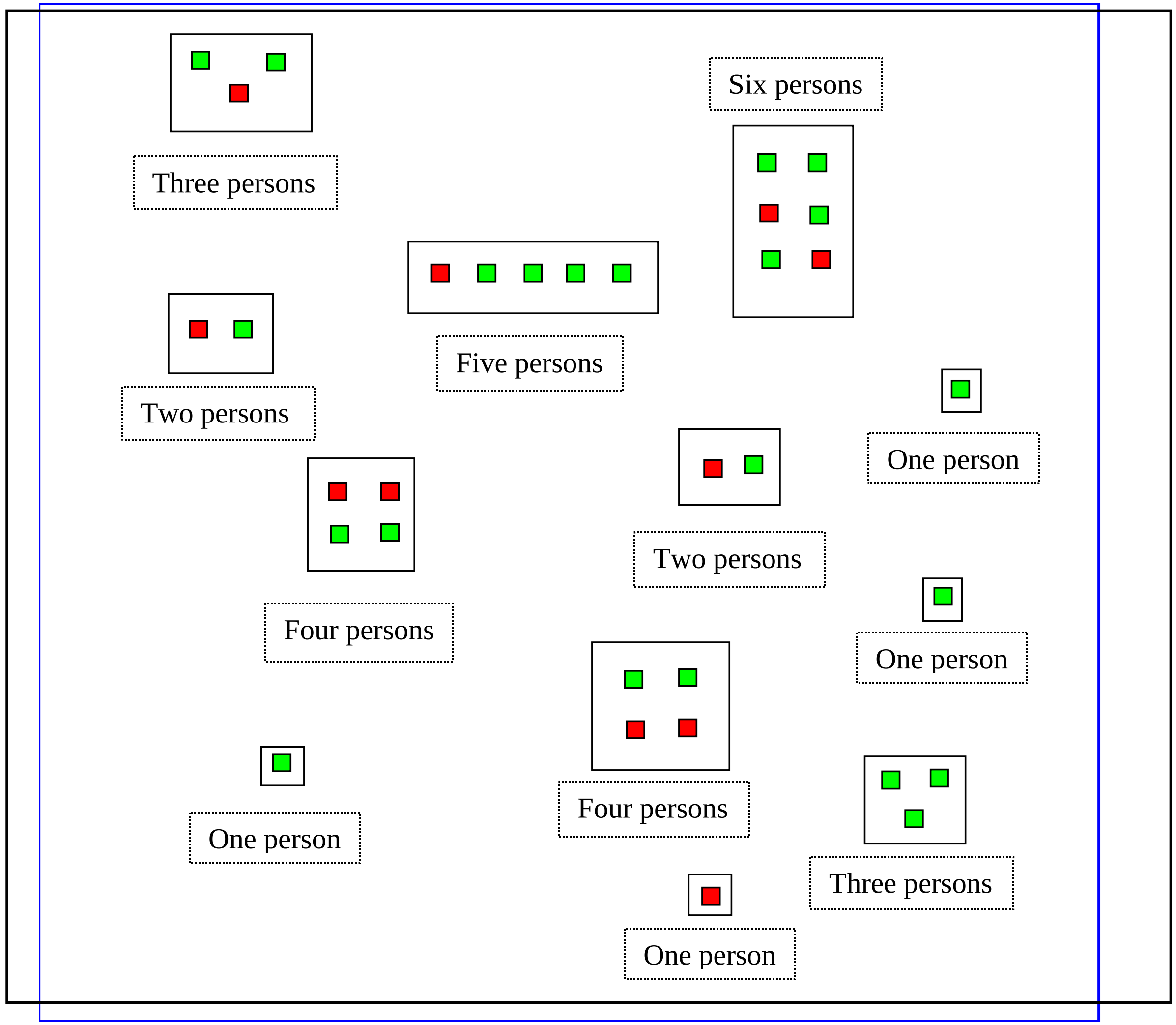


The same people at lunch

22 in favor and 11 against

Beginning of the first series of local updates

**They are discussing**

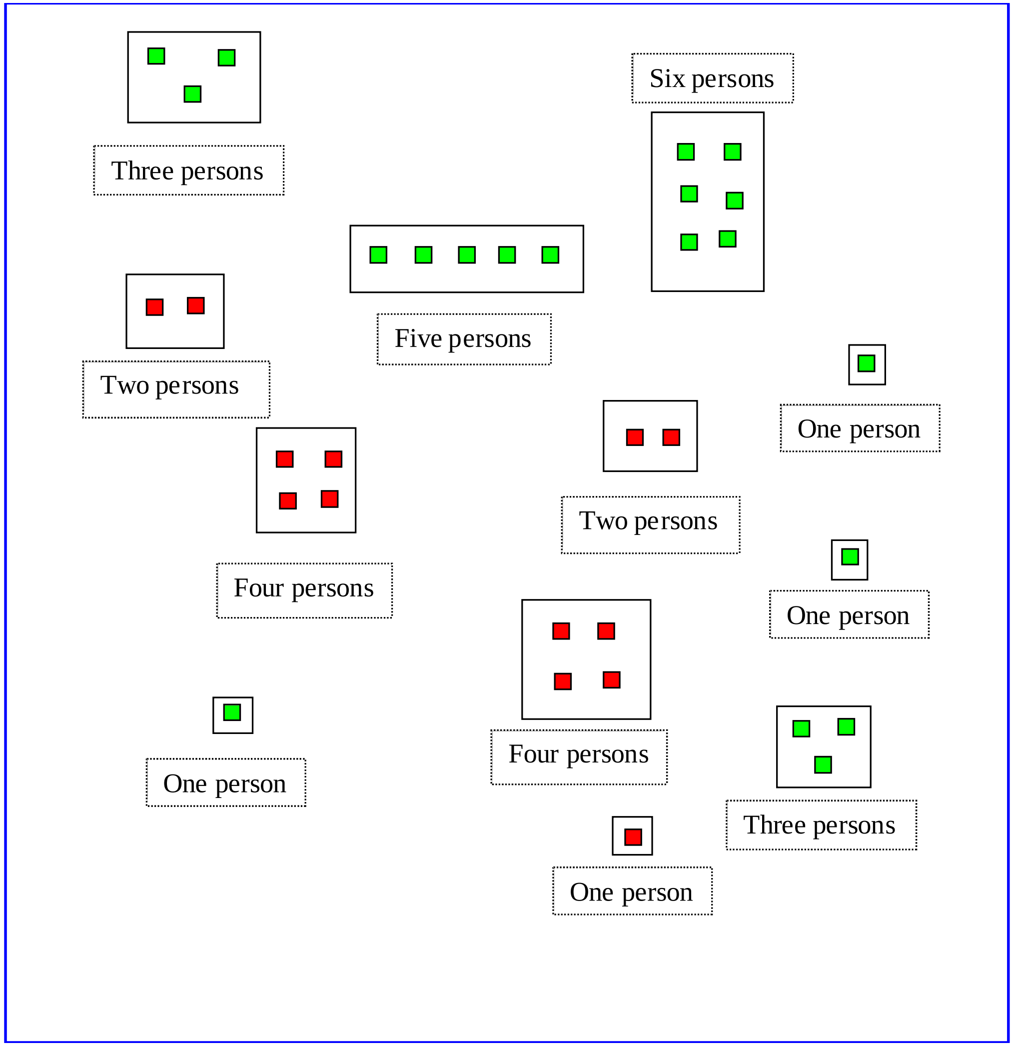


# Lunch is over

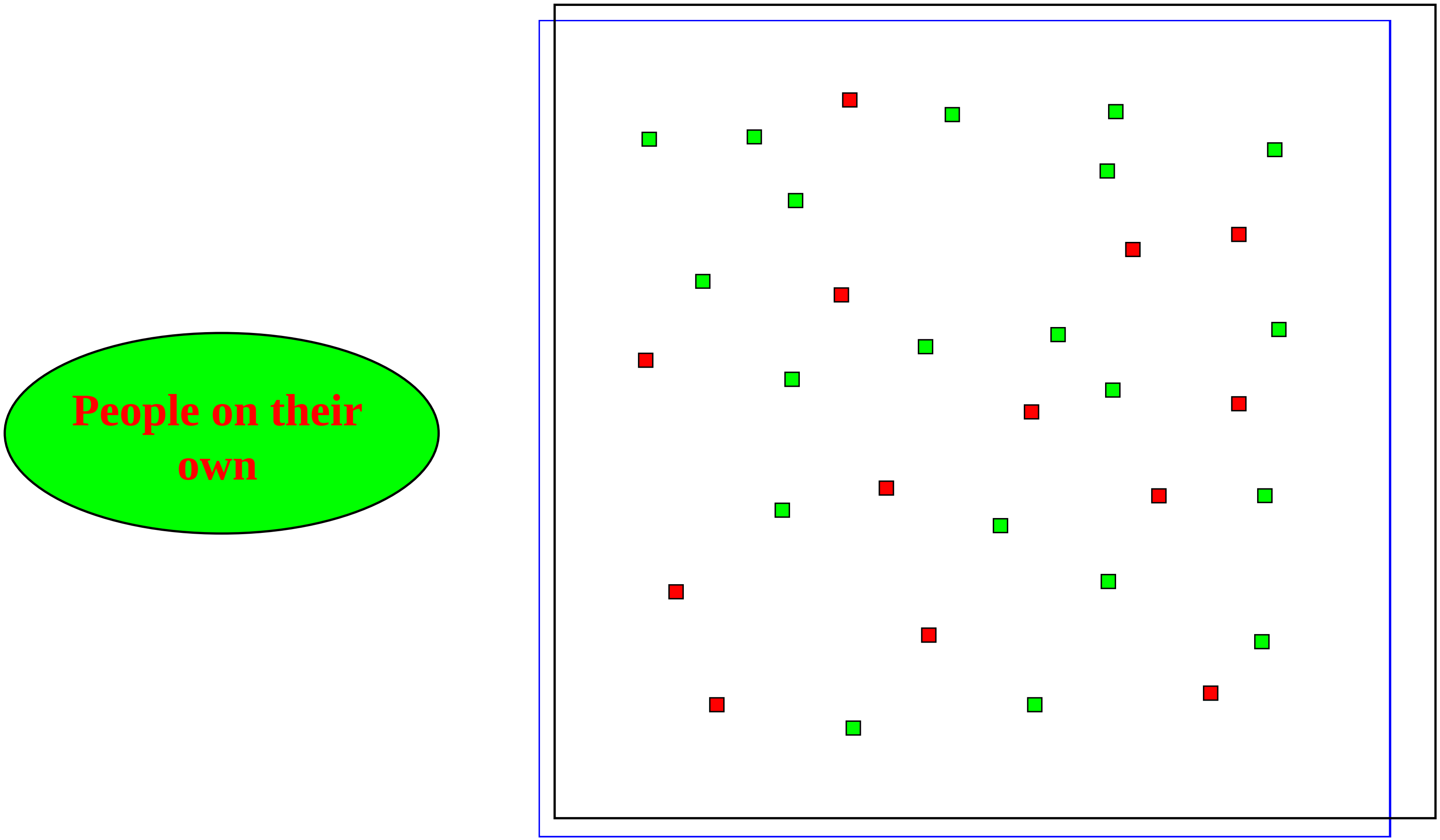
## 20 in favor and 13 against

End of the first series of local updates

Local polarization



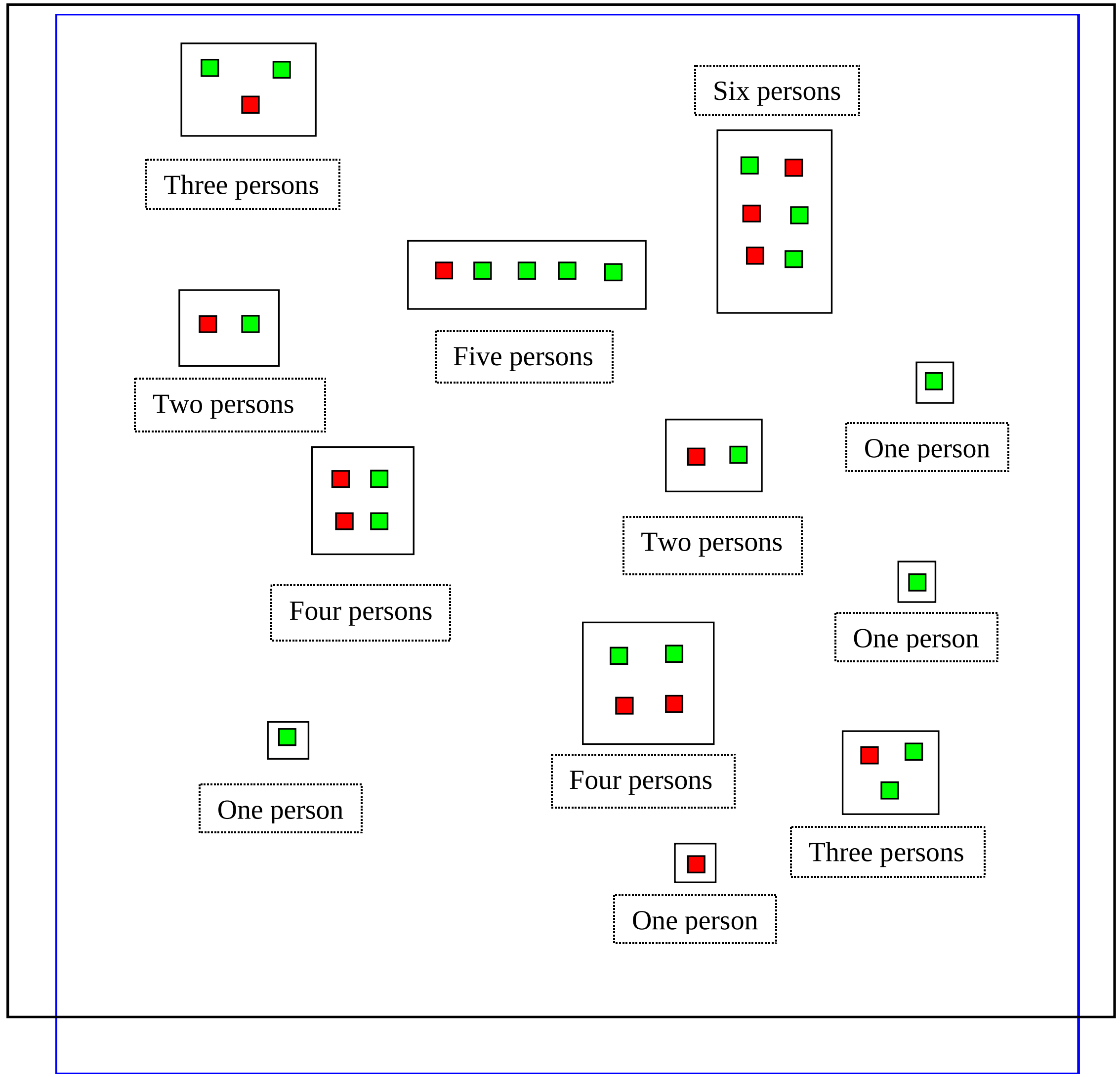
# Total reshuffling of agents



# Dinner time

20 ▪ in favor and 13 ▪ against

Beginning of the second series of local updates



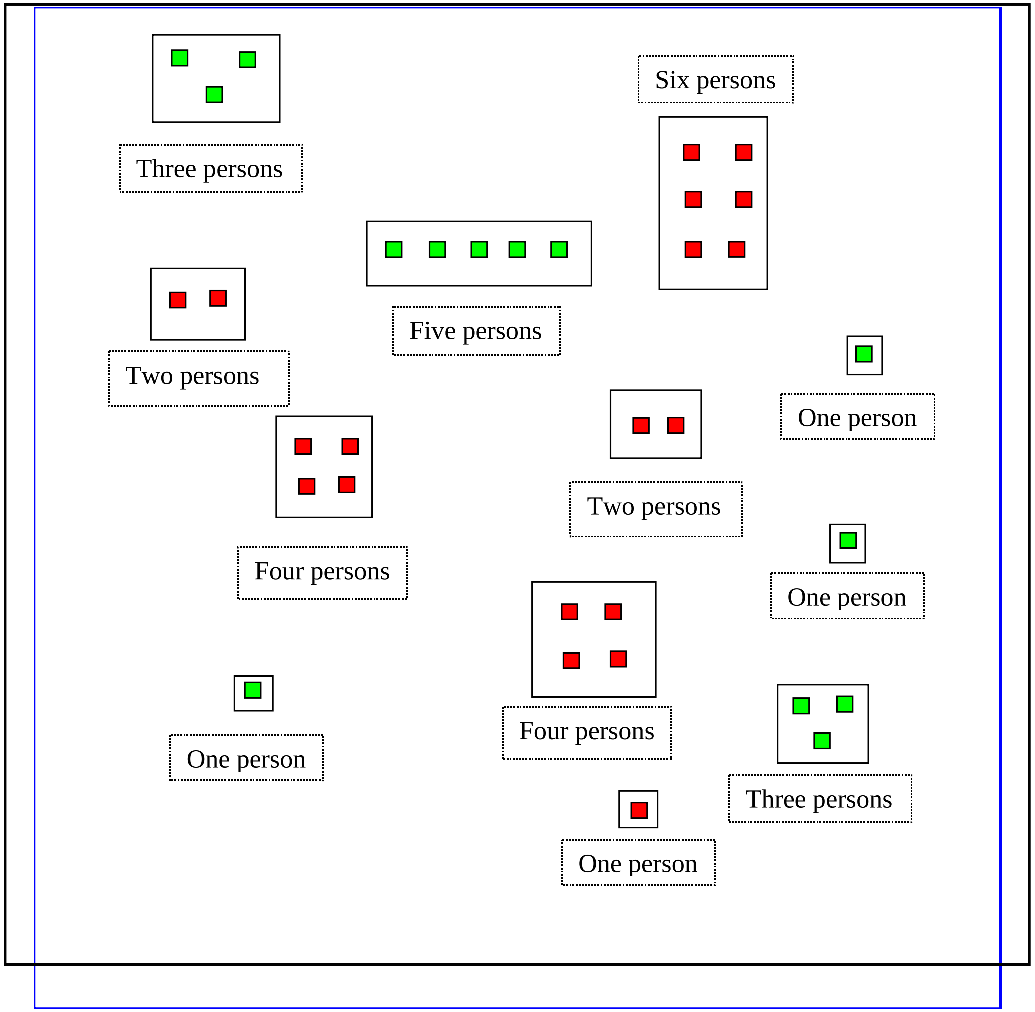

**They are discussing**

Usually group compositions are different

Dinner is over

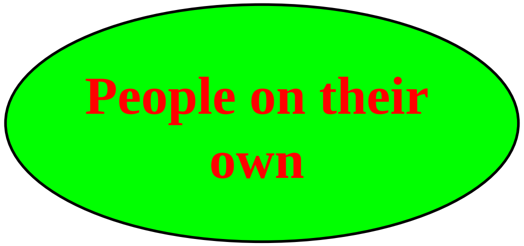
14 ■ in favor and 19 ■ against

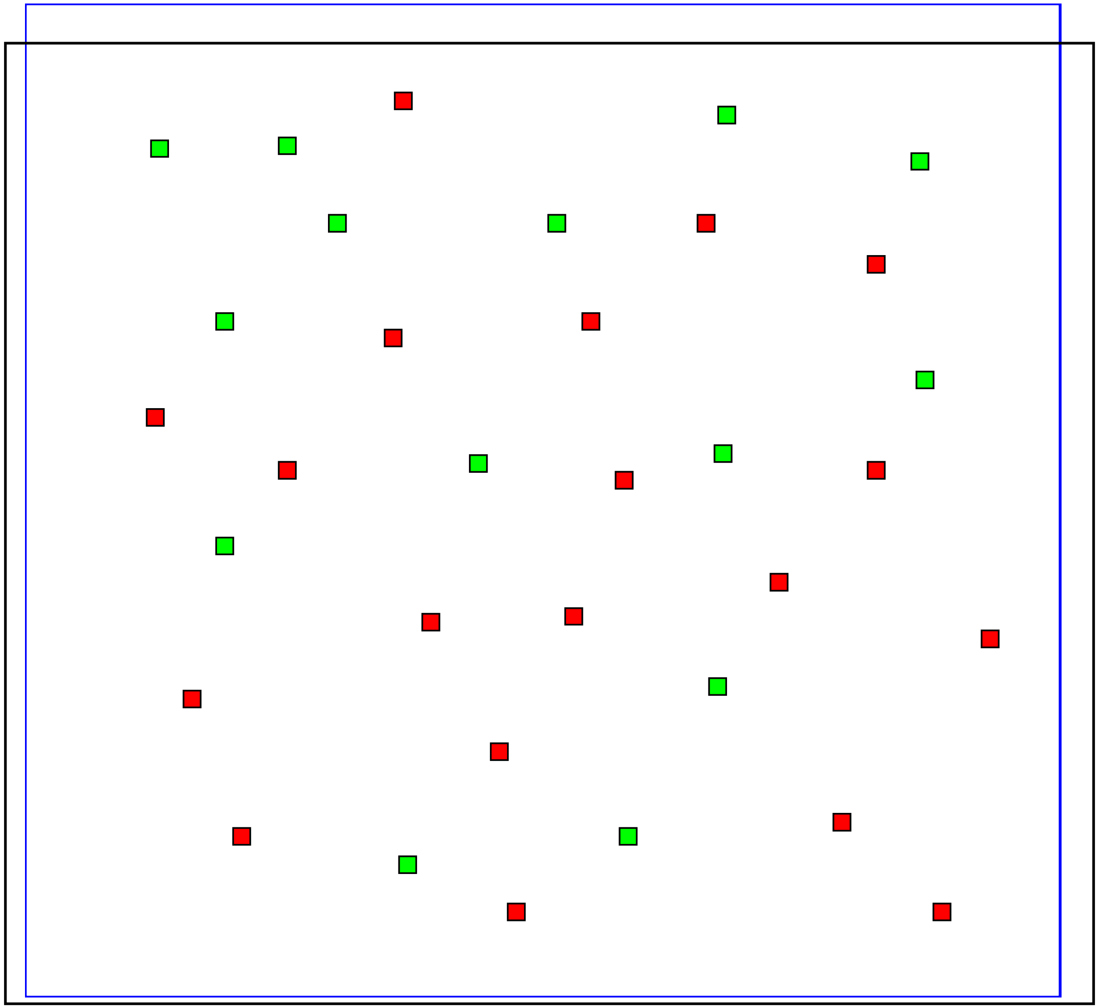
End of the second series of local updates



Total reshuffling of agents

And repeat the local updates again



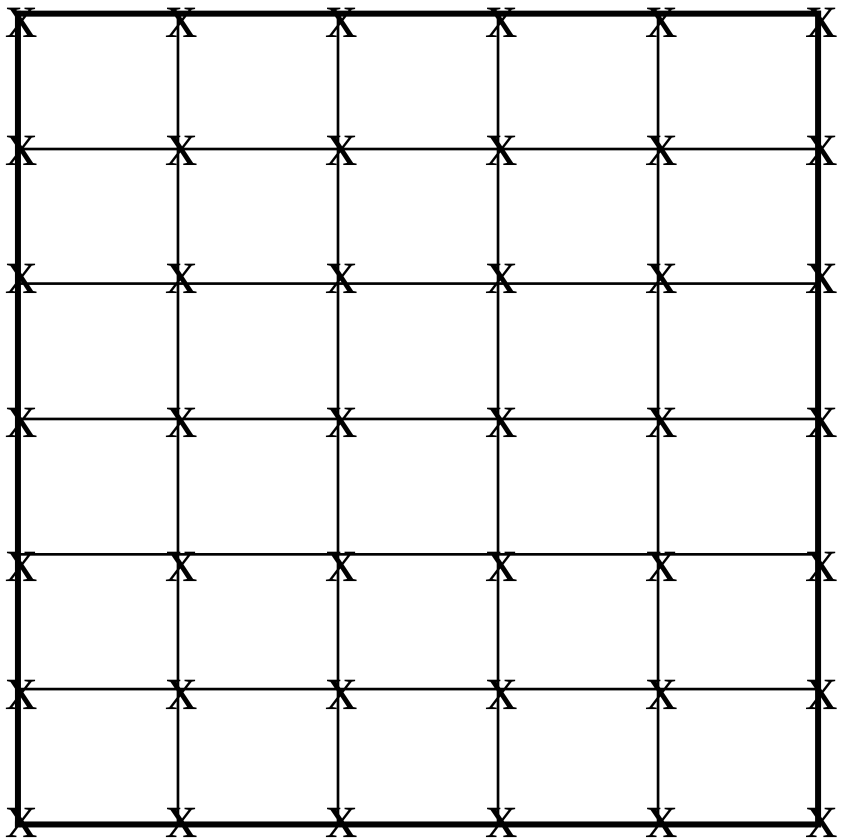



**The very formulation of the model has been perceived as the signature of an intrinsic mean field nature, in particular since its dynamics is monitored by a total reshuffling of agents between repeated local updates: in principle everybody can interact to everybody. This fact has been understood as everybody does interact with everybody simultaneously… as in a mean field treatment**

**However that is not the case due to the local range of interactions which are restricted to separate small groups of agents after each reshuffling. At least, for years, I was adamant in claiming it but at odd with everyone else claiming the contrary.**

Then I come to the conclusion that to solve the controversy on a neutral ground, the best would be to go back to pure physics and to study the effect on reshuffling on the well studied classical two-dimensional nearest neighbor Ising model

And we did it with Sousa and Malarz thorough a numerical Monte Carlo  investigation



$$\mathcal{H} = -\frac{1}{2}\sum_{i,j} J_{ij} S_i S_j,$$

Reshuffling is introduced gradually according to the variable $0 \leq p \leq 1$ where p is the probability of reshuffling all the spins of the lattice at each Monte Carlo step

We call it the Gradually Reshuffled Ising Model and denote it by GRIM

It is worth to stress that after each spin reshuffling, interactions stay local among NN

During reshuffling each spin keeps its current orientation

Gradual reshuffling was studied earlier for the opinion dynamics model in:

S. Galam, B. Chopard, A. Masselot and M. Droz, Eur. Phys. J. B 4(1998) 529

The critical temperature $T_c$ is calculated for a series of values of p from p = 0 (square lattice Ising model --- SLIM) up to p = 1 (totally reshuffled Ising model --- TRIM) from the magnetization data

Binder's cumulant for $T_c$ evaluation is used to avoid finite size effect

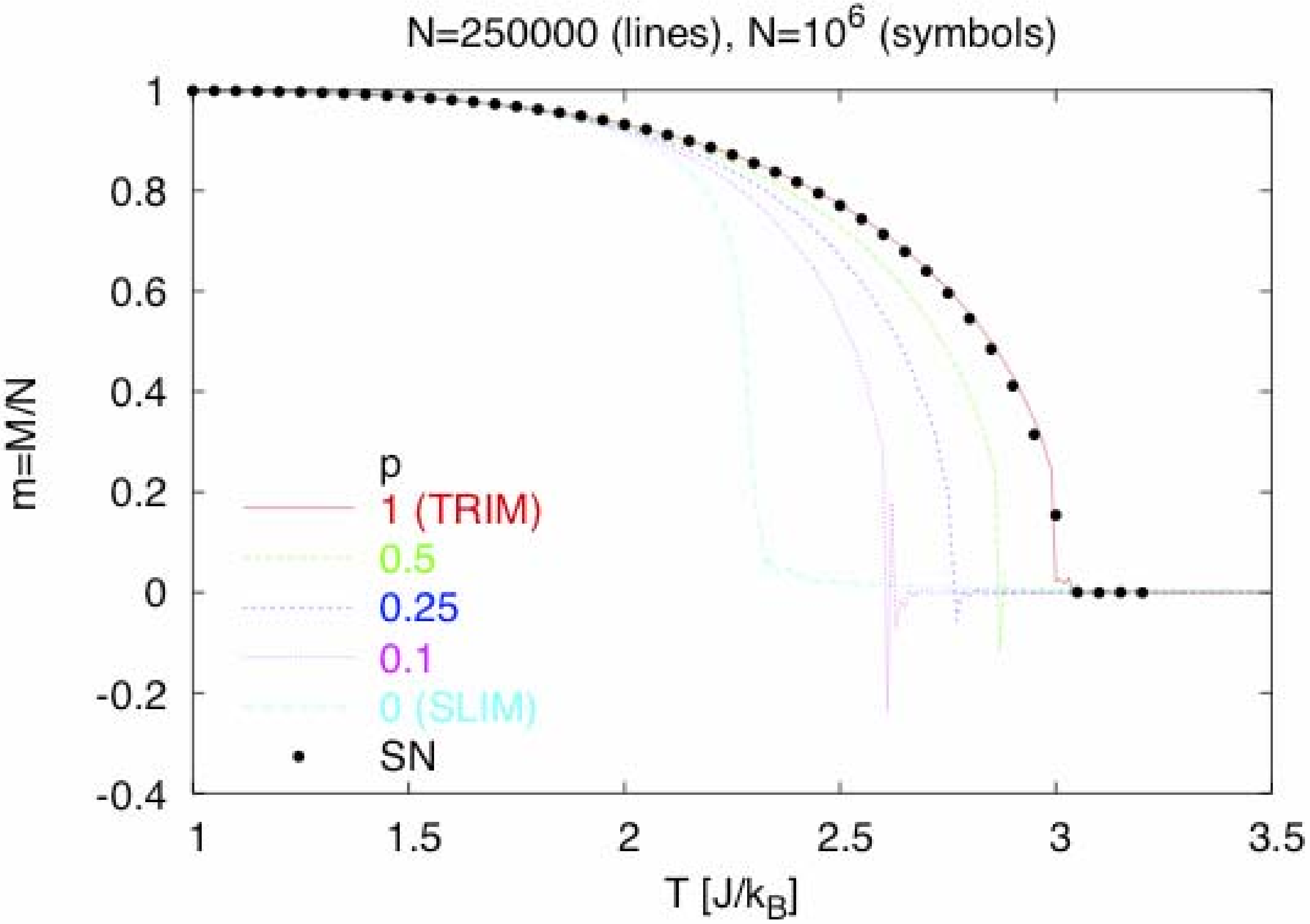



Figure 1: Magnetization $m(T)$ dependence for $L = 500$ obtained with Glauber dynamics. For the SN $N = 10^6$ spins were simulated.

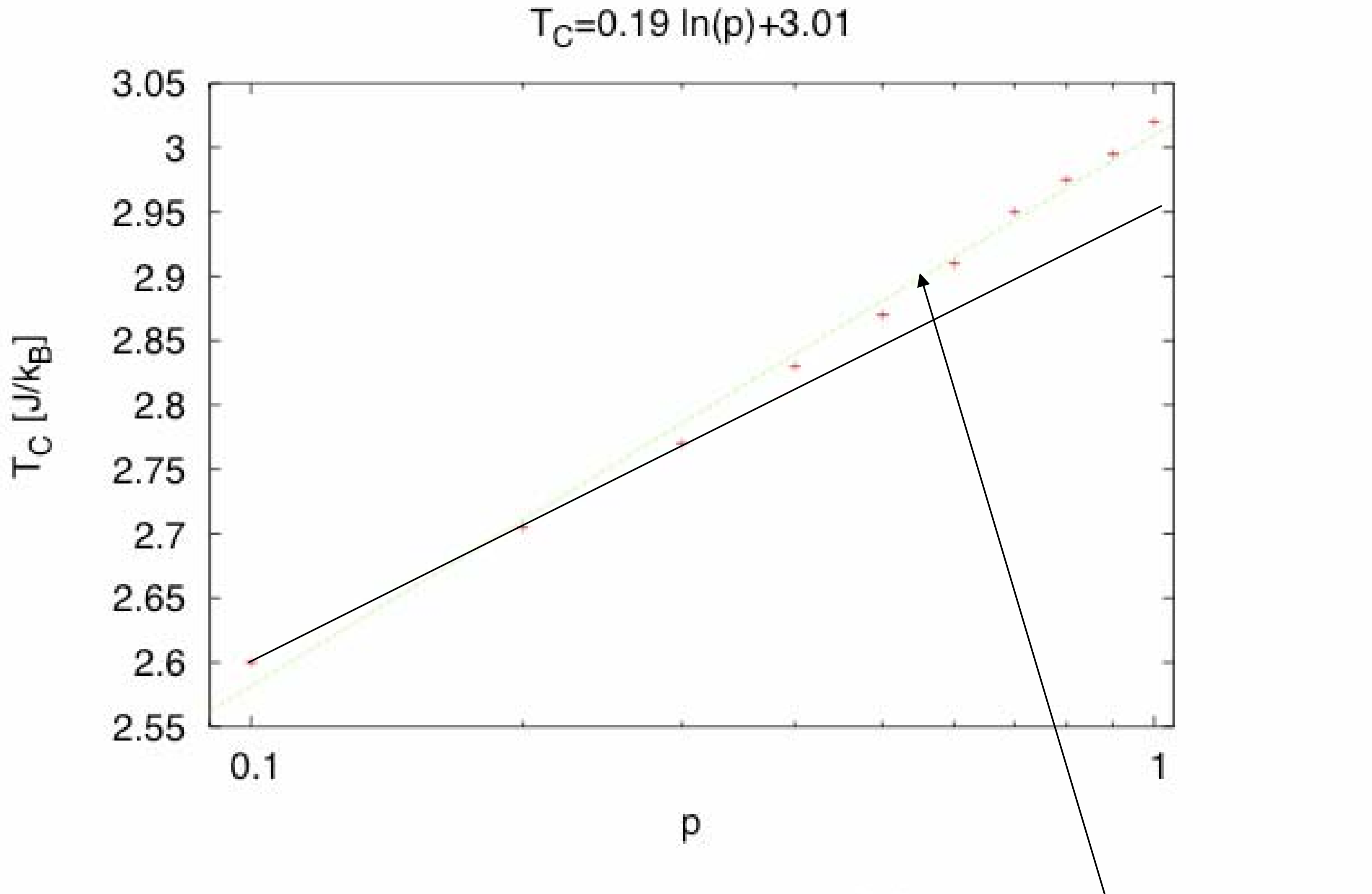



Figure 2: Dependence of Curie temperature $T_C(p) = 0.19 \ln p + 3.01$ on the reshuffling probability $p$ given via cross-point of $U(T)$ curves for different system sizes $50 \leq L \leq 300$.

As expected, at p = 0 the SLIM exact value $T_c = 2 / \text{arcsinh}(1) \approx 2.27$ [J/kB] is recovered

The variation of the GRIM Tc as function of p is found to exhibit a non-linear behavior

$T_c = 3.01$ at $p = 1$ (TRIM)

$T_c = 4$ for mean field

A non trivial result but a different Tc does not imply necessary a non field nature

We must check some exponent

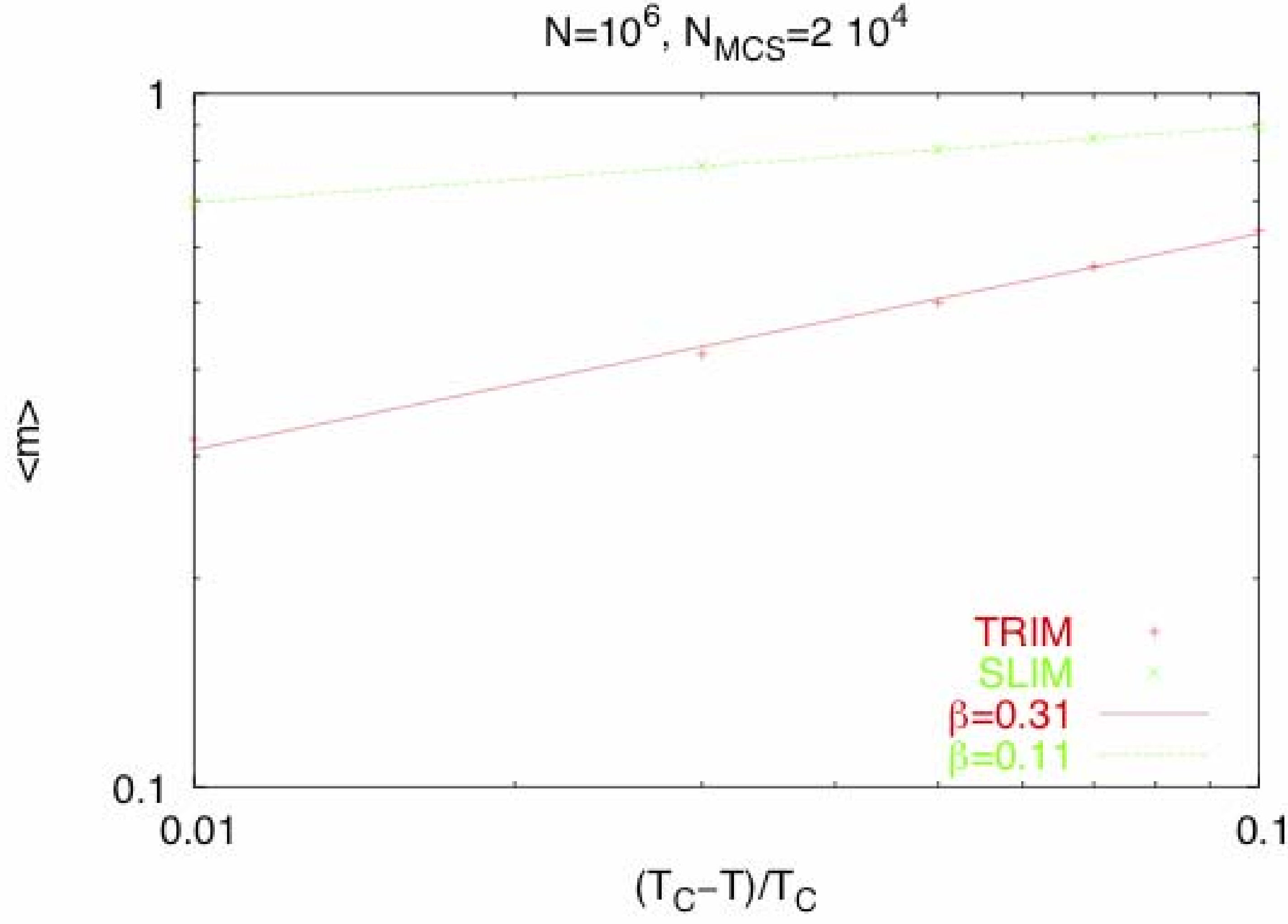



Figure 5: Critical exponents $\beta$ — which describes magnetization behavior in the vicinity of $T_C$ — for $p = 0$ and $p = 1$ are $\beta_{\rm SLIM} = 0.11$ and $\beta_{\rm TRIM} = 0.31$, respectively. $N = 10^6$ spins were simulated. $N_{\rm MCS} = 2 \cdot 10^4$ and $\langle m \rangle$ is averaged over last $10^4$ [MCS]. $\beta_{MF} = \frac{1}{2} = 0.5$

We have demonstrate that reshuffling is not a mean field scheme

In addition we have discovered a new value for the critical exponent $\beta = 0.31$ for total reshuffling

It hints to a possible new universality class for the 2-d Ising model

The exact value for beta at p = 0 is 1/8. To get numerically a better precision would requires much larger simulations which is out the scope of the present work

# A lot of work ahead:

More simulations to determine an other exponent

More simulations to calculate the exponents for different value of p

Determine at which value of p does the crossover occur

And to understand the nature of this possible new universality class for the Ising model