

Heider balance, asymmetric ties, and gender segregation

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28th Marian Smoluchowski Symposium
on Statistical Physics

Thermodynamics in a Nanoscale

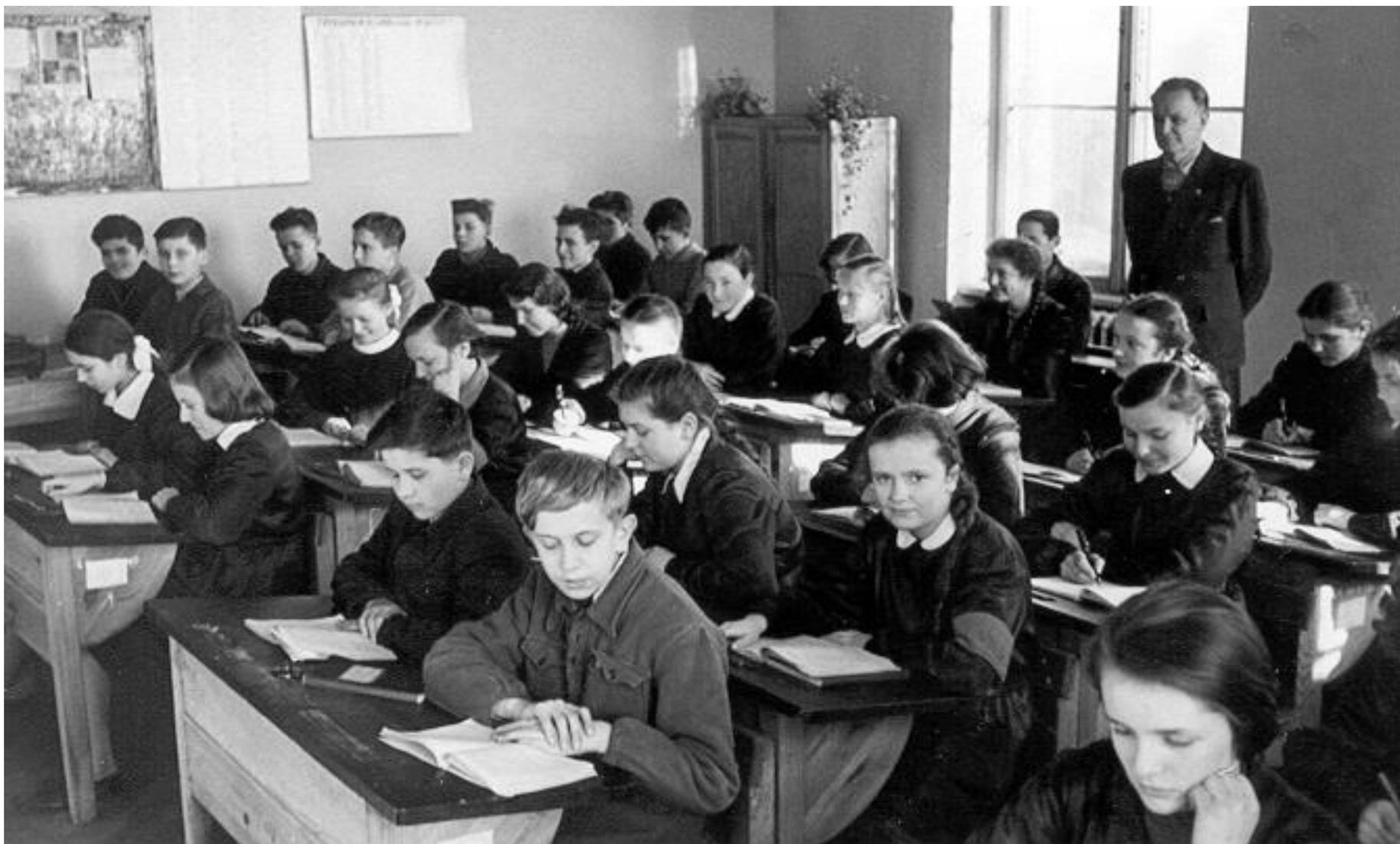
September 14-17, 2015, Kraków, Poland

outline

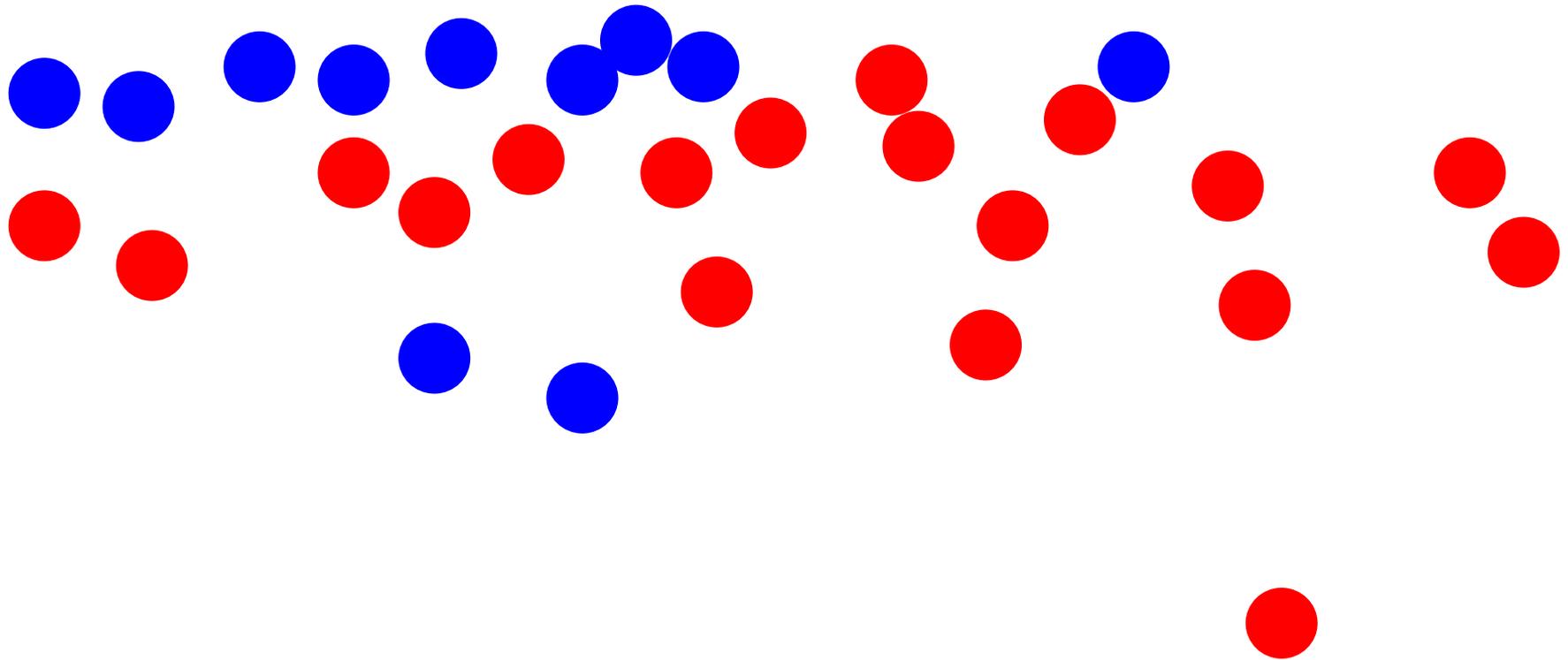
- Motivation and context
- Segregation and identity formation
- The Mexican data – school children
- Cognitive dissonance and Heider equilibrium
- Theory for asymmetric ties
- The obtained partitions and what came out
- A word about adults



Hylas and the Nymphs, John William Waterhouse, 1896



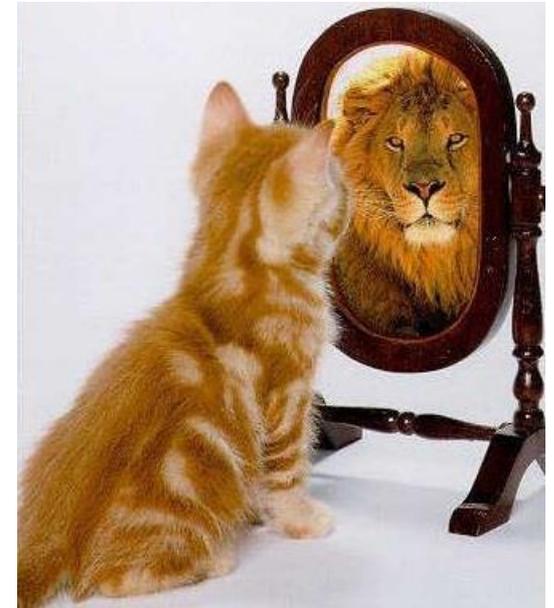
Latin class of prof. Zb. Minakowski, LO in Otwock, 1957



Latin class of prof. Zb. Minakowski, LO in Otwock, 1957

Sex = biological differences,
gender = matter of culture, social classification
[Ann Oakley, 1972]

I am not who you think I am;
I am not who I think I am;
I am who I think you think I am
[?]



...it is only recently when I grasped that punching boys
is not the only thing which I can do with them...
[a girl of 11]

Example of an experiment:
triads of 4 ½ -old children in a 'laboratory'



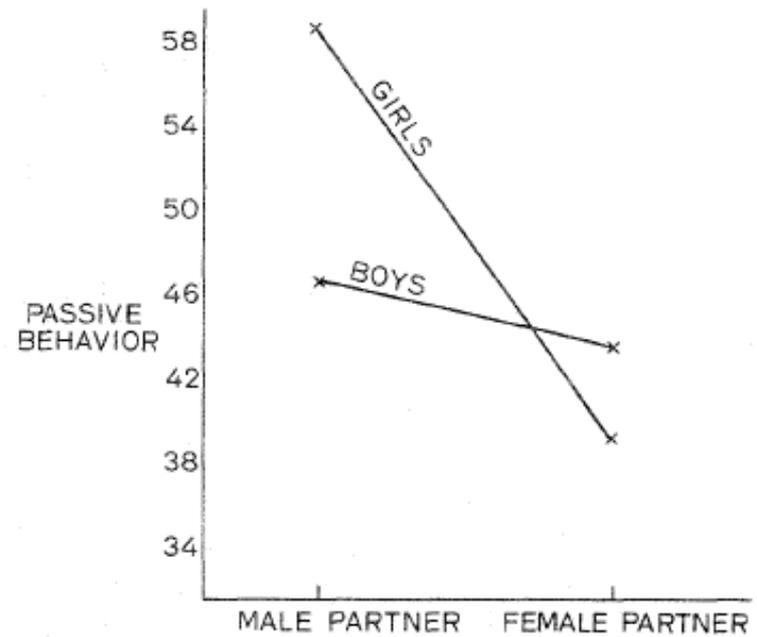
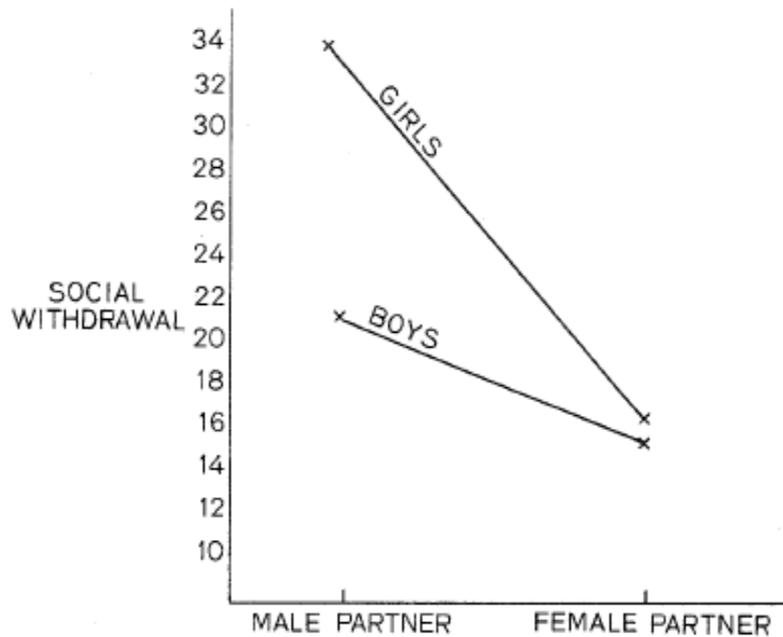
+ thick Carpet (1/2 sessions)

Percent of time periods, when children engaged in:

	boys (n=30,25)	girls (n=22,16)
rough & tumble play	14.3, 20.0	4.7, 3.3
trampoline	9.2, 11.5	15.2, 19

[Janet A. DiPietro, Rough and tumble play: A function of gender, Developmental Psych., 1981]

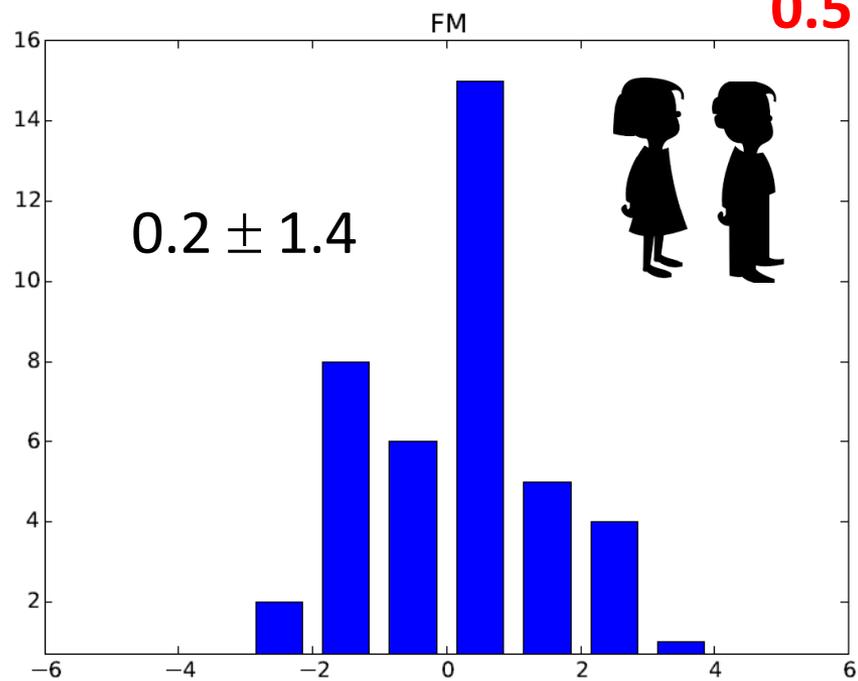
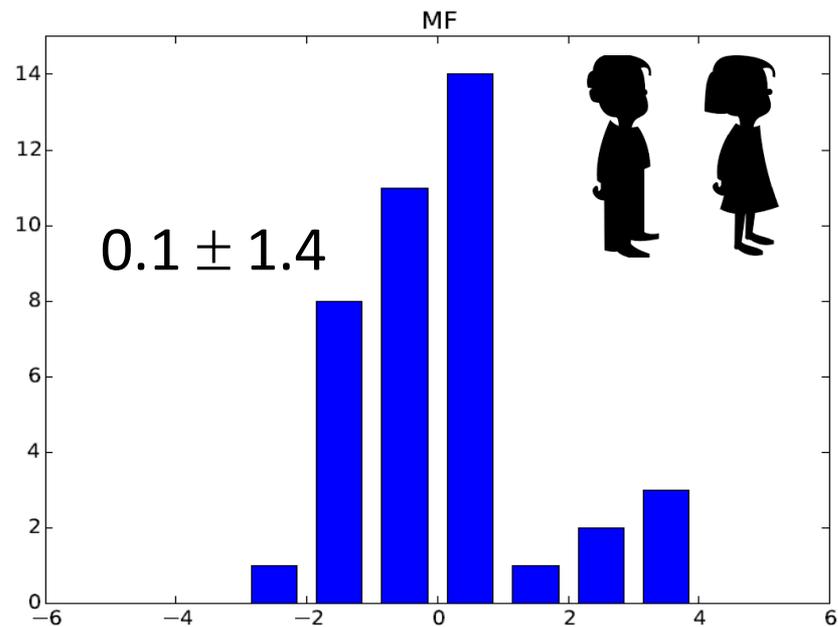
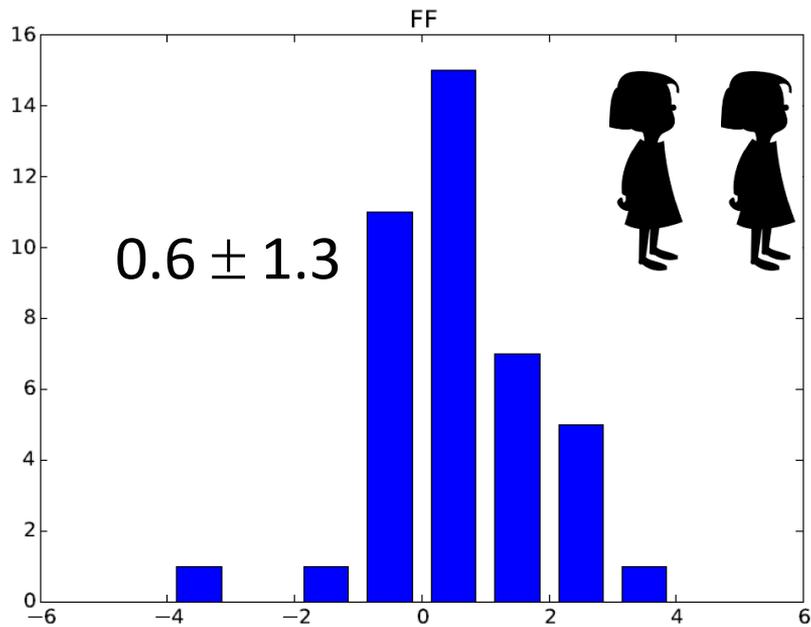
Behavior of children in pre-school



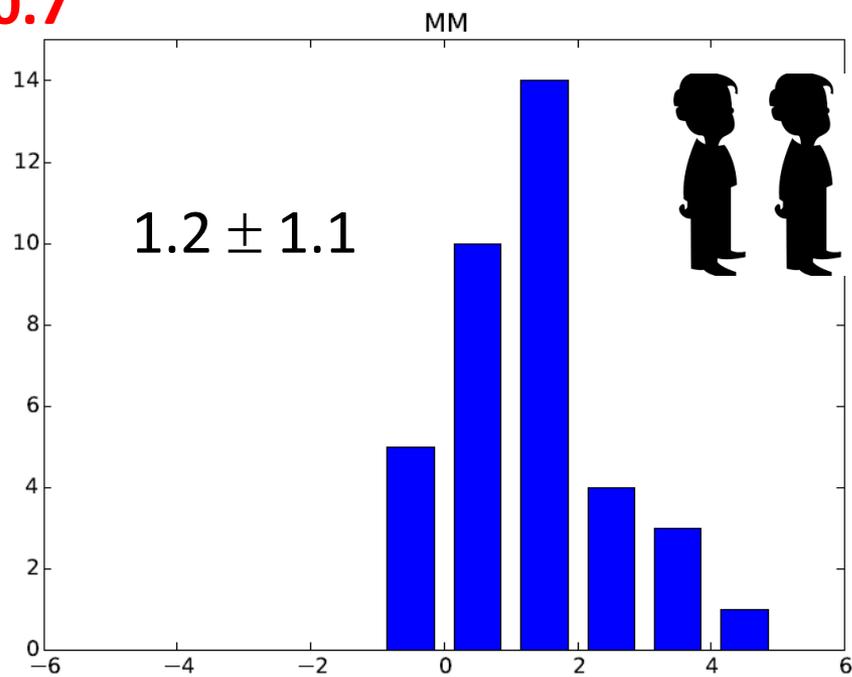
[C. N. Jacklin, E. E. Maccoby, Social behavior at 33 months in same-sex and mixed-sex dyads, Child Development, 1978]

Age	Rate of playing with the same : opposite sex
4.5 years	3:1
6.5 years	11:1

[E. E. Maccoby, C. N. Jacklin, Gender segregation in childhood, in Advances in child development and behavior, Acad. Press, NY 1987]



0.5 ± 0.7



Cognitive dissonance

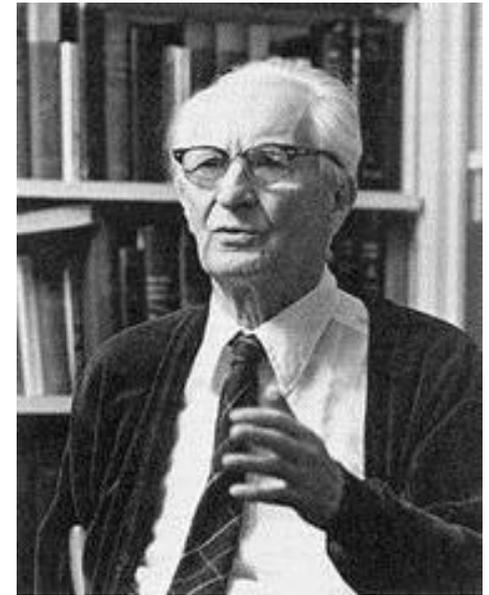
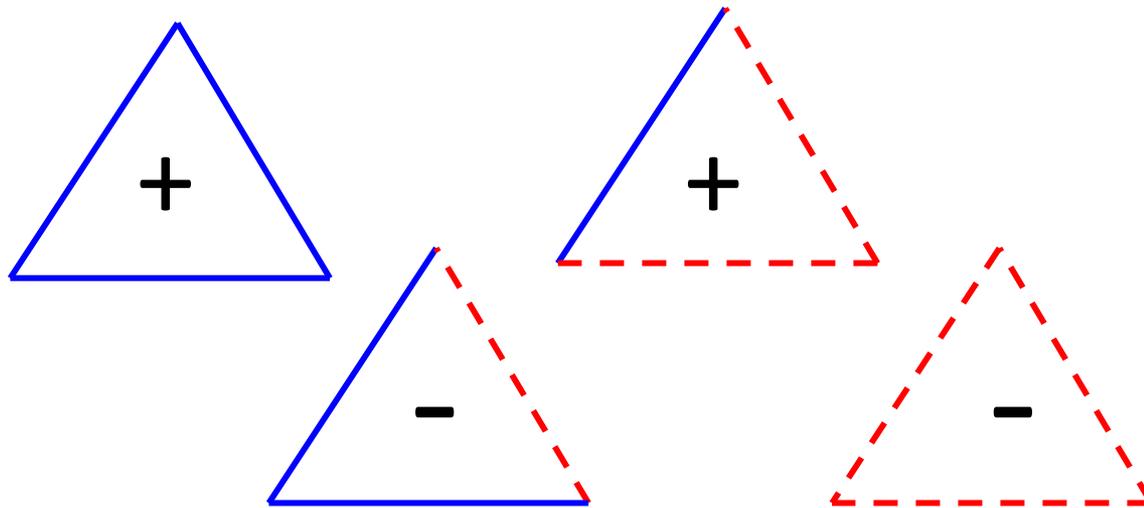
is the mental stress or discomfort experienced by an individual who holds two or more contradictory beliefs, ideas, or values at the same time, or is confronted by new information that conflicts with existing beliefs, ideas, or values.



Leon Festinger, 1919-1989

*[L. Festinger, A Theory of Cognitive Dissonance, Stanford UP 1957;
E. Aronson, The Social Animal, 1972;
www.simplypsychology.org/cognitive-dissonance.html]*

Heider balance



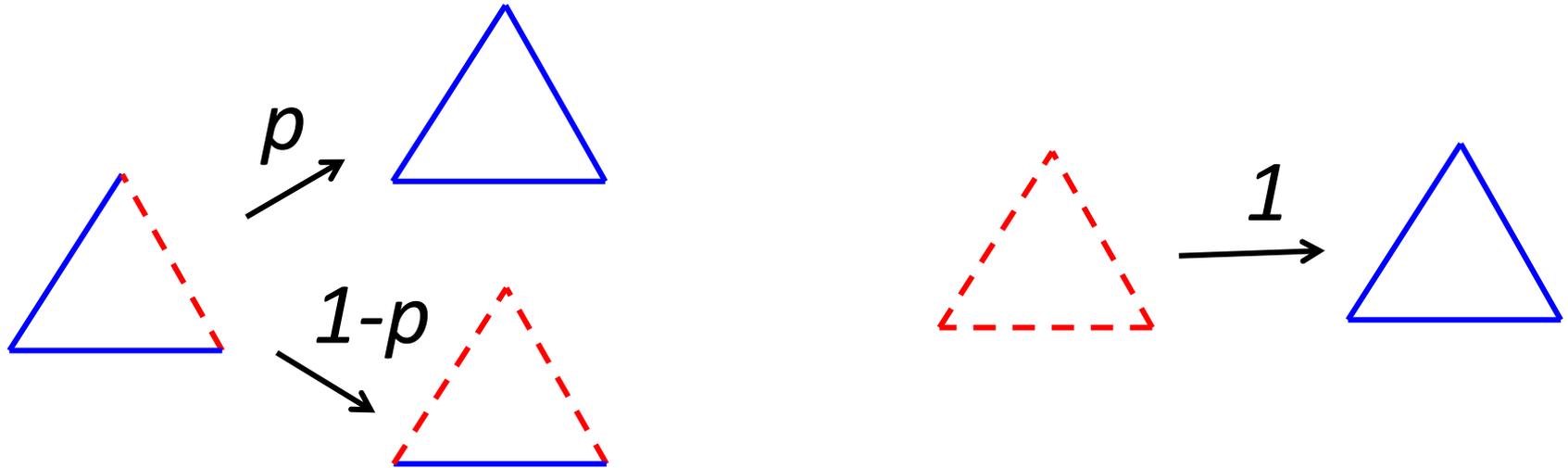
Fritz Heider, 1896-1988

A friend of my friend is my friend
A friend of my enemy is my enemy
An enemy of my friend is my enemy
An enemy of my enemy is my friend

[F. Heider, Attitudes and Cognitive Organization, The Journal of Psychology 21 (1946) 107]
[E. Aronson, V. Cope, My enemy's enemy is my friend, J. of Personality & Soc. Psych. 8 (1968) 8]
[compendium.open.ac.uk/]

Discrete algorithms on complete graphs:

1. **Local Triad Dynamics (LTD)** : acts on randomly selected triads

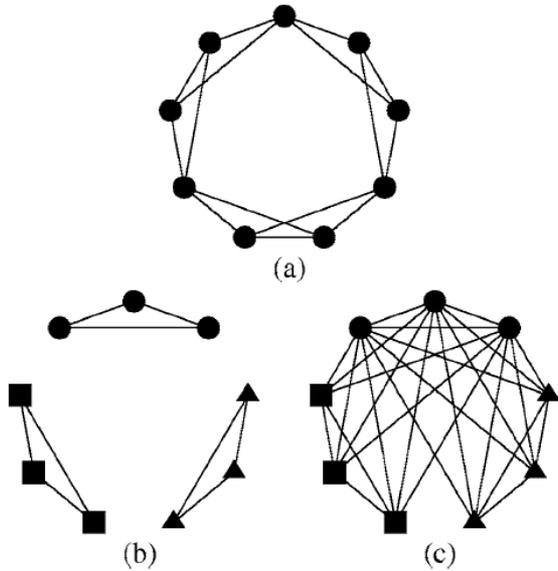


2. **Constrained Triad Dynamics (CTD)** : monitored number # of imbalanced triads

- select randomly a tie; if changed, how # is changed?
- if # decreased, OK
- if # increased, withdraw the change
- if # the same, $p(\text{change})=1/2$

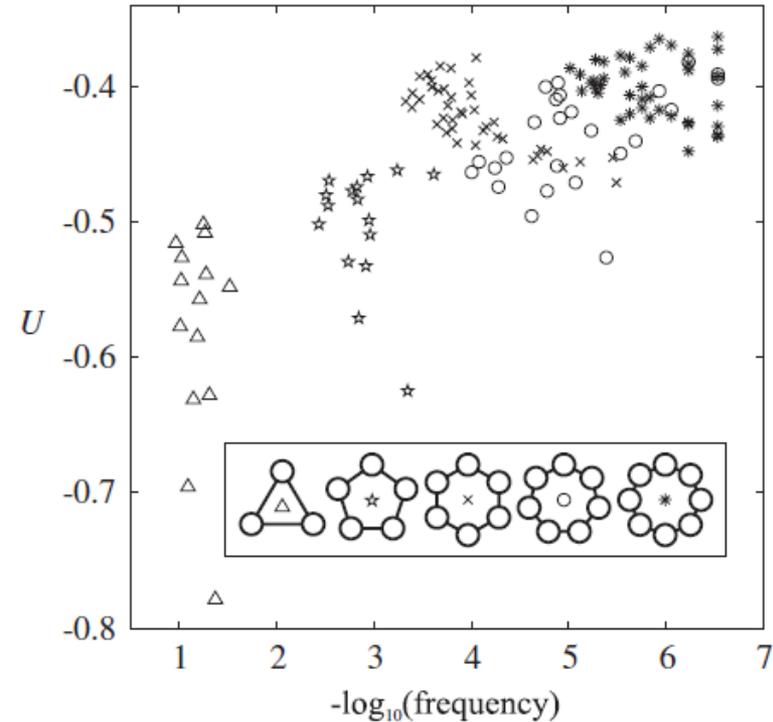
LTD: - always produces a balanced state, but which one?
 - the dissonance can increase

CTD: - stable imbalanced states („jammed states“)



Examples of jammed states for N = 9 nodes
 (negative ties not shown)

$$U = -\binom{N}{3}^{-1} \sum_{ijk} S_{ij} S_{jk} S_{ki}$$



jammed states for N=26

[T. Antal, P.L. Krapivsky, S. Redner, *Dynamics of social balance on networks*, *PRE* 72 (2005) 036121]
 [S. A. Marvel, S. H. Strogatz, J. M. Kleinberg, *Energy landscape of social balance*, *PRL* 103 (2009) 198701]

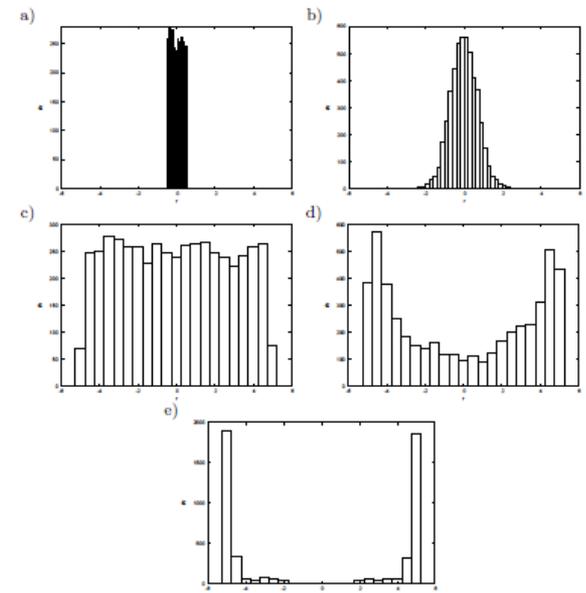
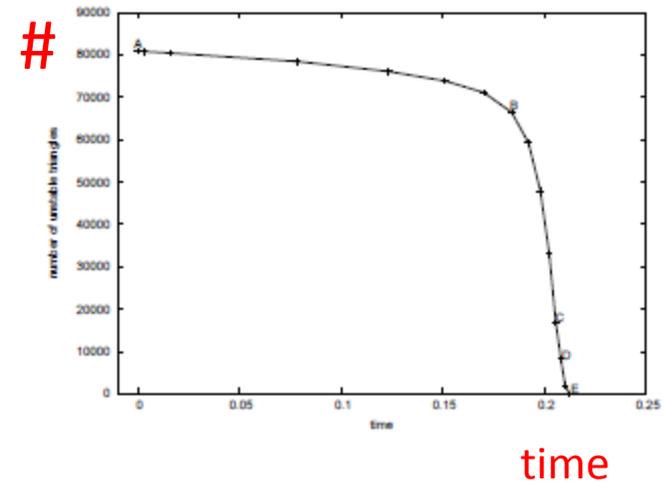
Proposition of a deterministic evolution:

$$\frac{dx_{ij}}{dt} = G\left(\frac{x_{ij}}{R}\right) \sum_k x_{ik} x_{kj}$$

$G(x) = 1 - x^2$
keeps x_{ij}
in the range $(-R, R)$

positive
only if
 x_{ik} & x_{kj}
both friendly
or both
hostile

For $G(x)=1$, jammed states do not appear (Marvel *et al*).



Do asymmetric ties allow for the Heider equilibrium?

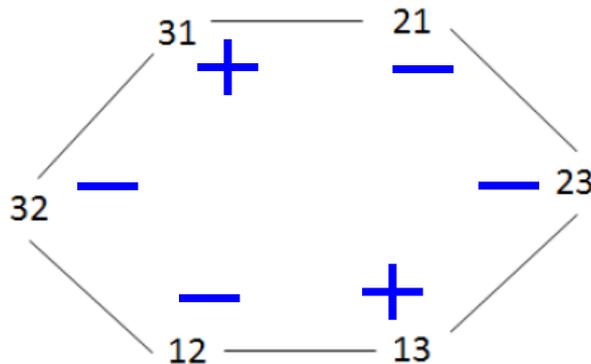
Equations of motion
$$\frac{dx(i, j)}{dt} = G(x(i, j)) \sum_{k \neq ij} x(i, k)x(k, j)$$

where $G(x) = \Theta(1 - x)\Theta(1 + x)$

Stability conditions:
$$x(i, j) = \text{sign} \sum_{k \neq i, j} x(i, k)x(k, j)$$

Heider equilibrium conditions:
$$x(i, j)x(i, k)x(k, j) > 0$$

N = 3 :

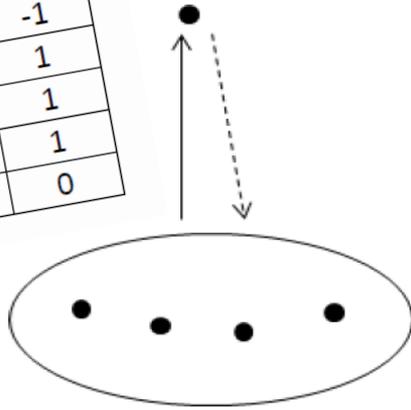


Each link is a product of its neighbors => stability induces symmetry,
symmetry induces equilibrium.

$N = 5$: 2^{20} states, 96 of them are stable, **only** 16 of them in equilibrium

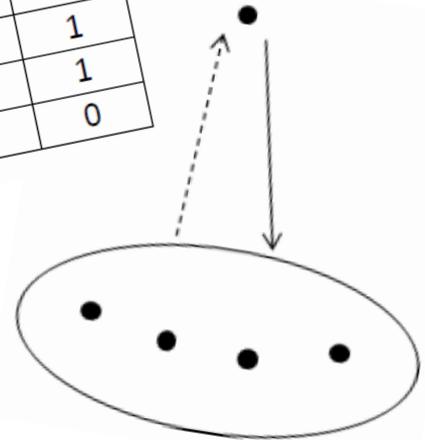
0	-1	-1	-1	-1
1	0	1	1	1
1	1	0	1	1
1	1	1	0	1
1	1	1	1	0

5



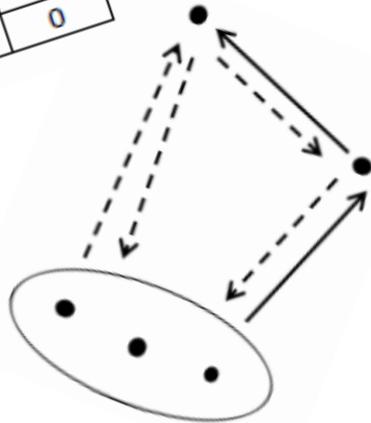
0	1	1	1	1
-1	0	1	1	1
-1	1	0	1	1
-1	1	1	0	1
-1	1	1	1	0

5



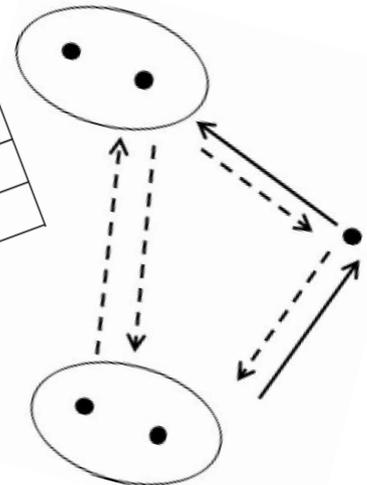
0	1	-1	-1	-1
-1	0	1	1	1
-1	-1	0	1	1
-1	-1	1	0	1
-1	-1	1	1	0

40



0	1	-1	-1	-1
1	0	0	-1	-1
1	1	0	0	-1
-1	-1	1	0	1
-1	-1	1	1	0

30



Main idea:

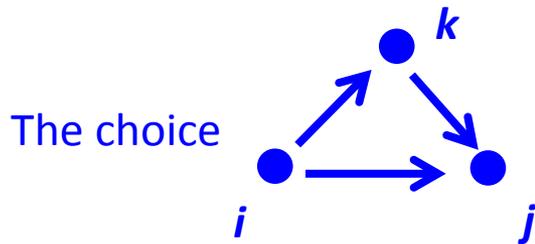
to include a mechanism of direct reciprocity:
„I like you as much as you like me”



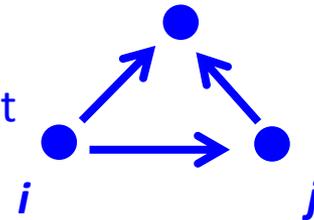
New proposition for asymmetric ties:



$$\frac{dx(i, j)}{dt} = \frac{1 - \alpha}{n - 2} \sum_{k=1}^{n-2} x(i, k)x(k, j) + \alpha [x(j, i) - x(i, j)]$$



allows for asymmetry, but

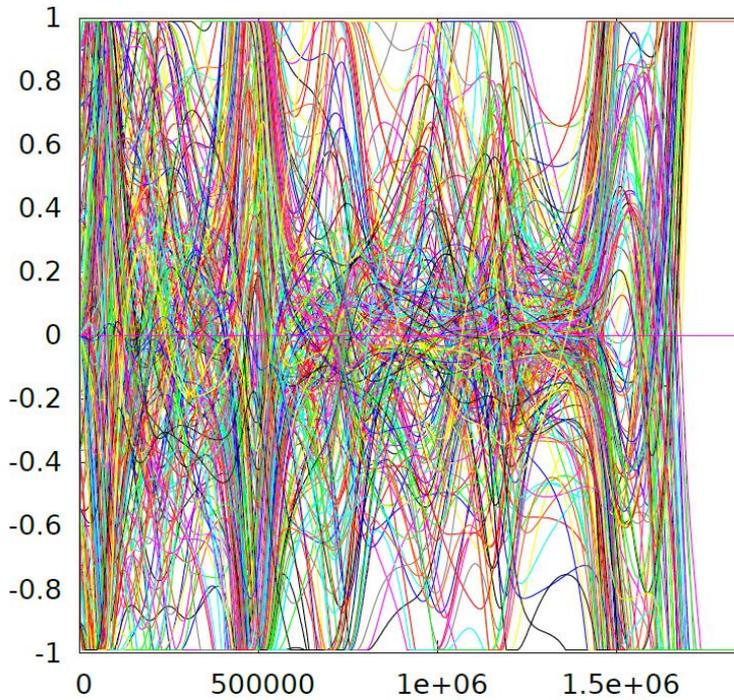


does not.

Exemplary evolution of ties

$$\alpha = 0.0$$

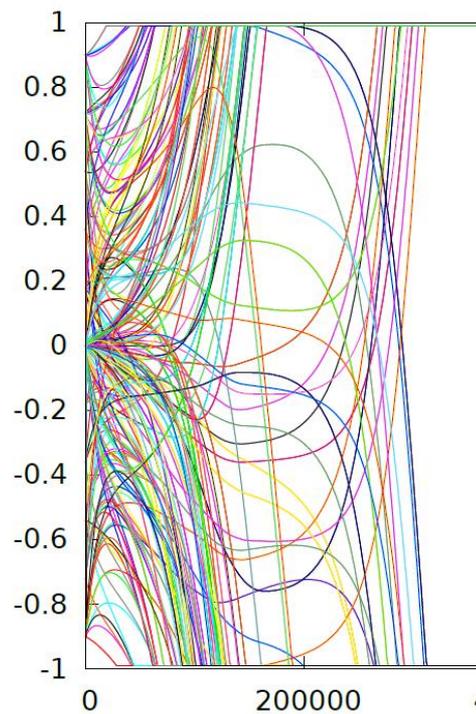
$x(i,j)$



time

$$\alpha = 0.5$$

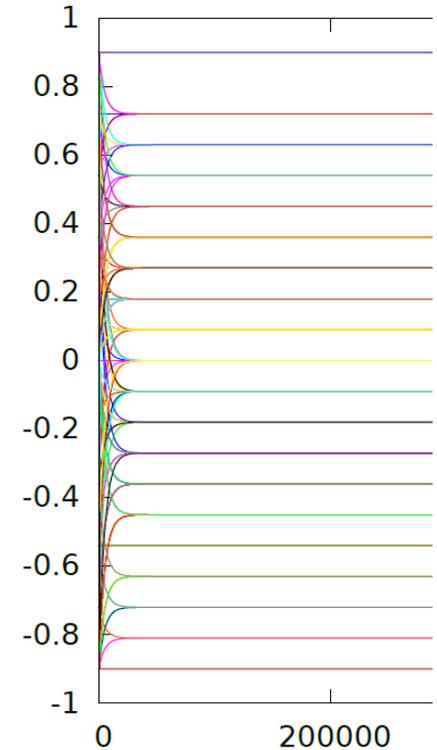
$x(i,j)$



time

$$\alpha = 1.0$$

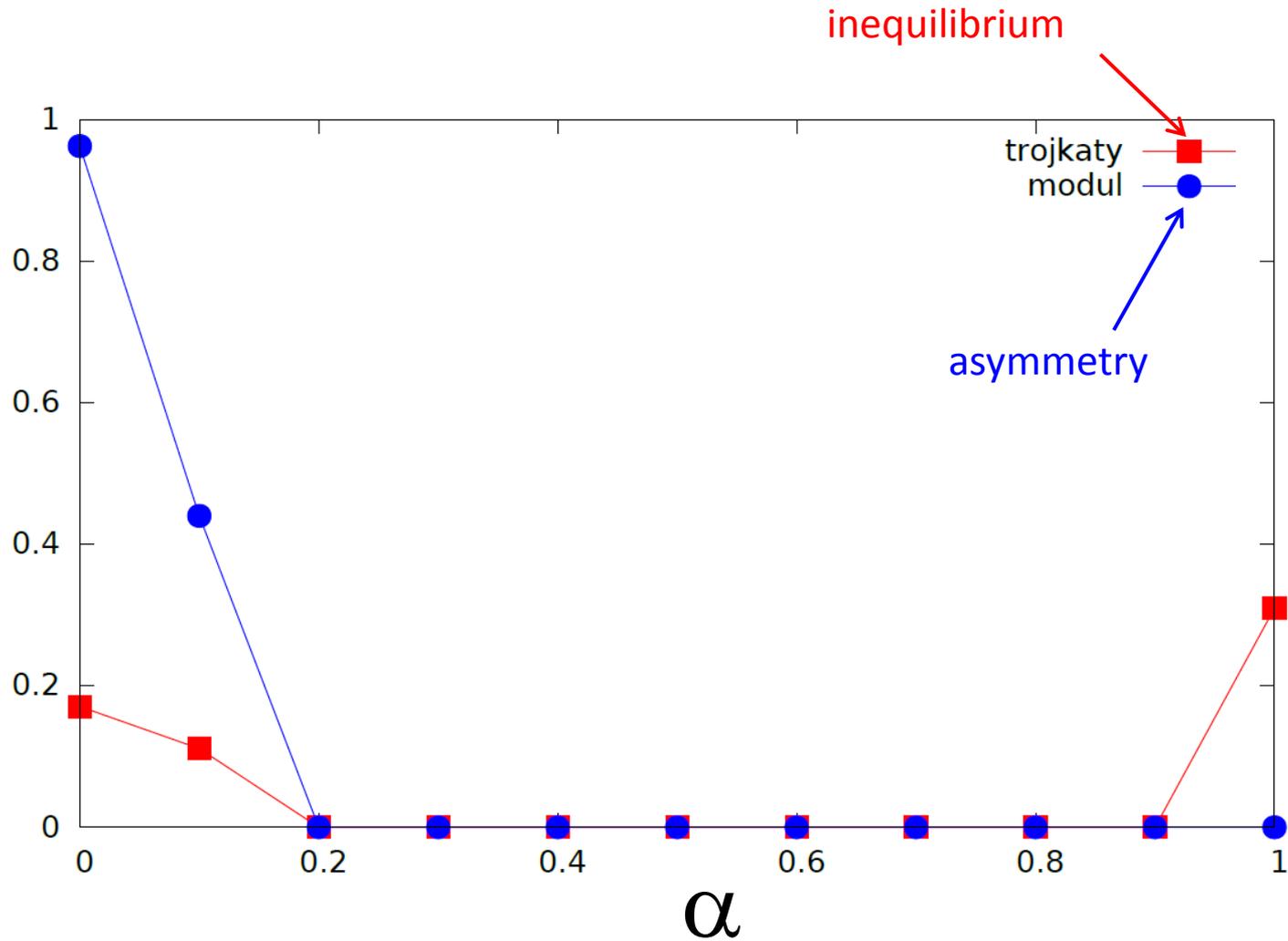
$x(i,j)$



time

The solution is stationary in all investigated cases.

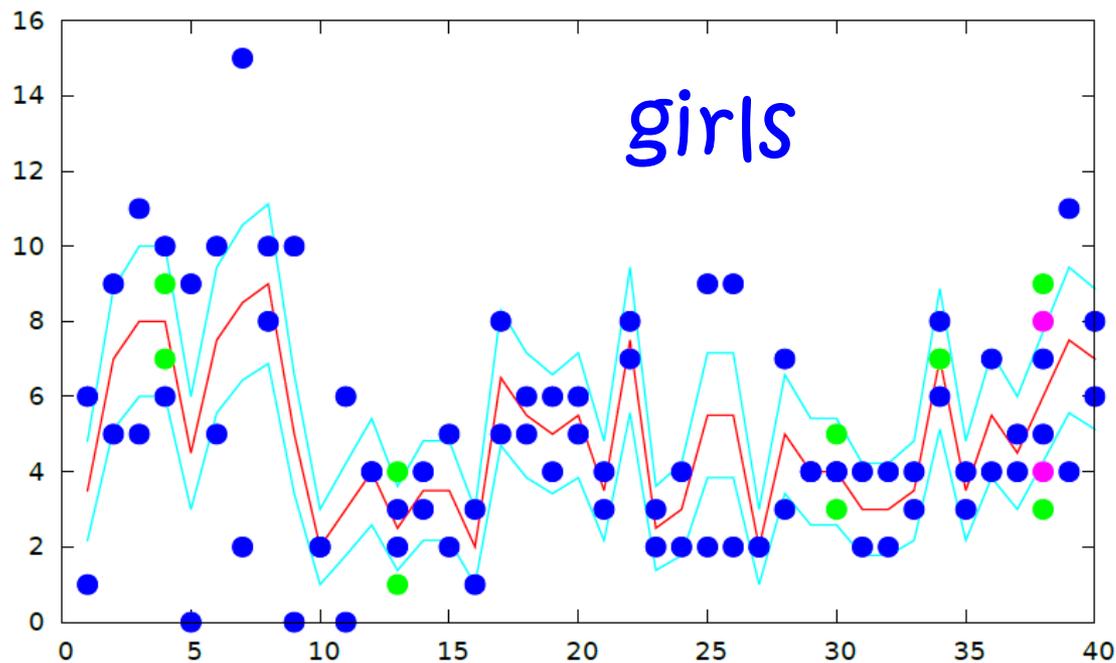
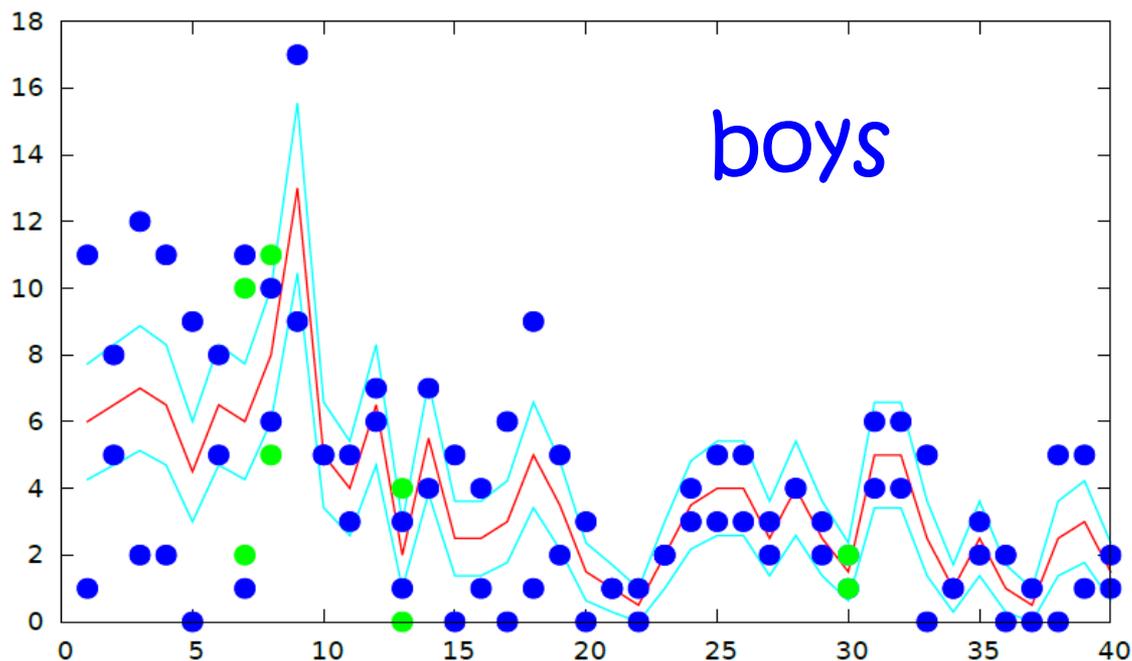
A typical solution in a stationary state



Basically, the stationary solution does not depend on α .

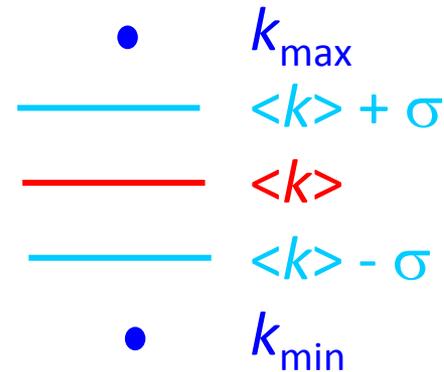
For each class,
the partition
is compared
with

$$p(k_{\max}) = 2^{-k} \binom{k}{k_{\max}}$$



$$k_{\max} + k_{\min} = k = 2\langle k \rangle$$

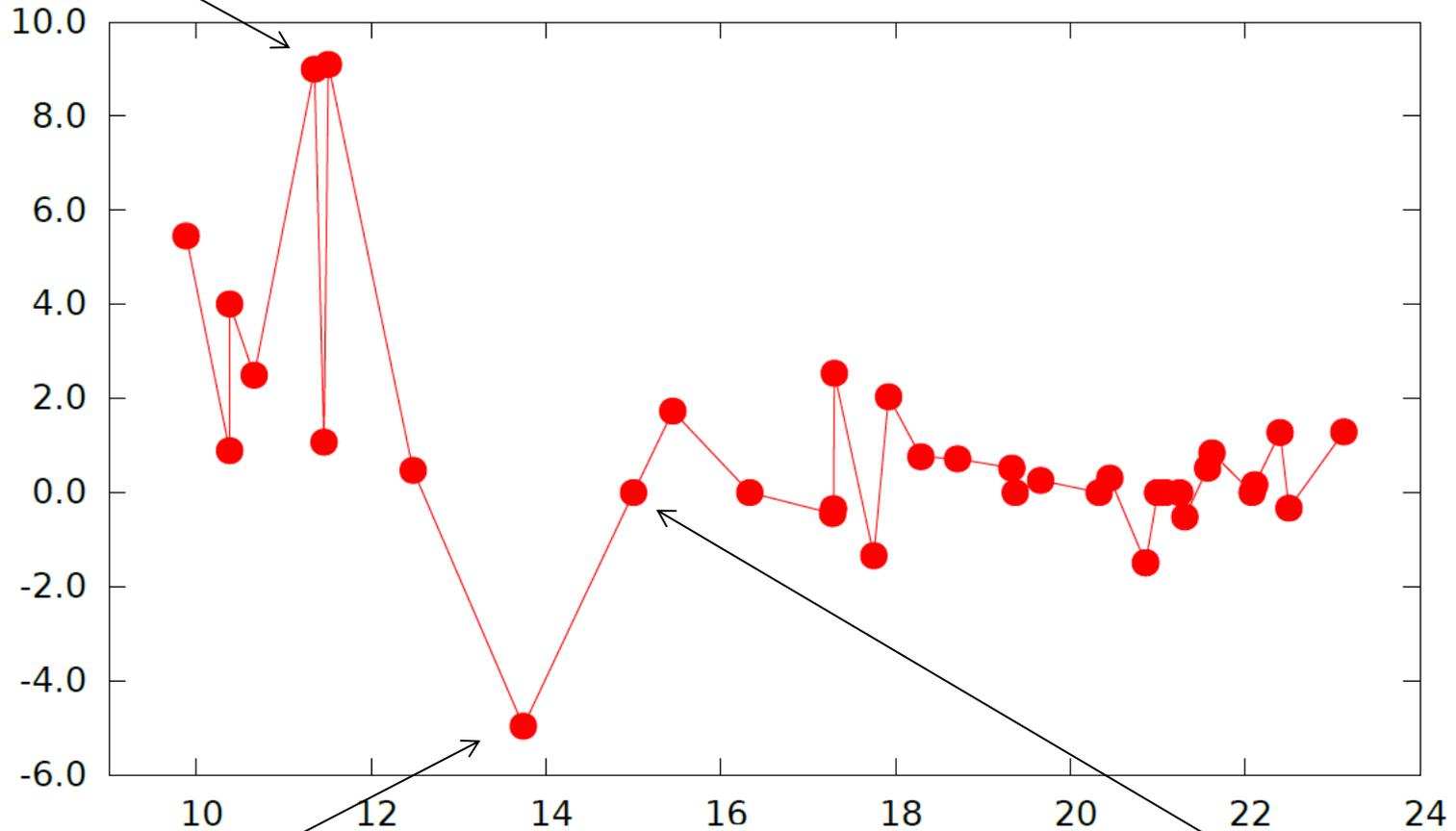
$$\sigma^2 = k/4$$



$$G \equiv (k_{\max} - \langle k \rangle) / \sigma$$

Index of gender segregation $J_k = \frac{(k_1 - \langle k \rangle)(\langle m \rangle - m_1)}{\sigma_k \sigma_m} = J_m$

9+0 vs 0+9



10+17 vs 0+9

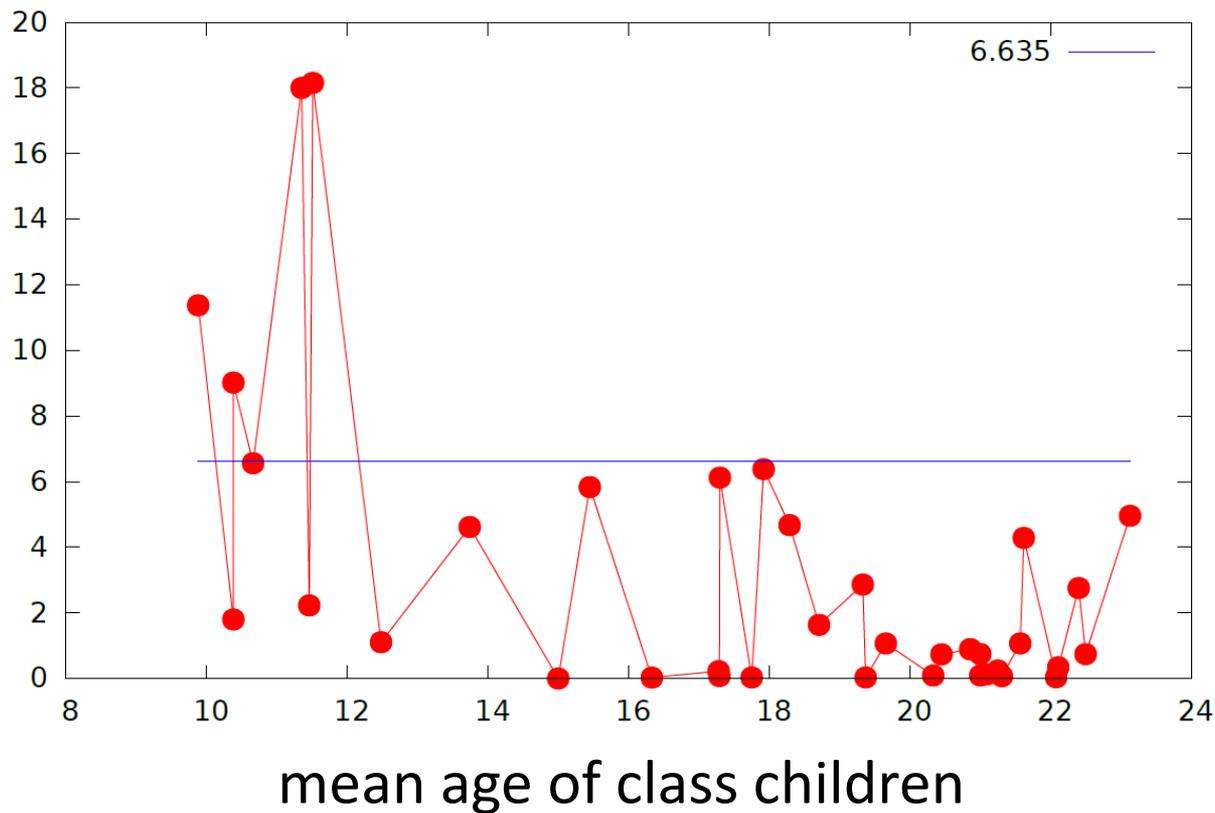
mean age of class children

2+5 vs 2+5

A test of statistical significance

$$X^2 = \frac{(k + m)(k_1 m_2 - k_2 m_1)^2}{km(k_1 + m_1)(k_2 + m_2)} > 6,635 \quad ? \quad \text{for statistical significance } 0,99$$

(one degree of freedom)

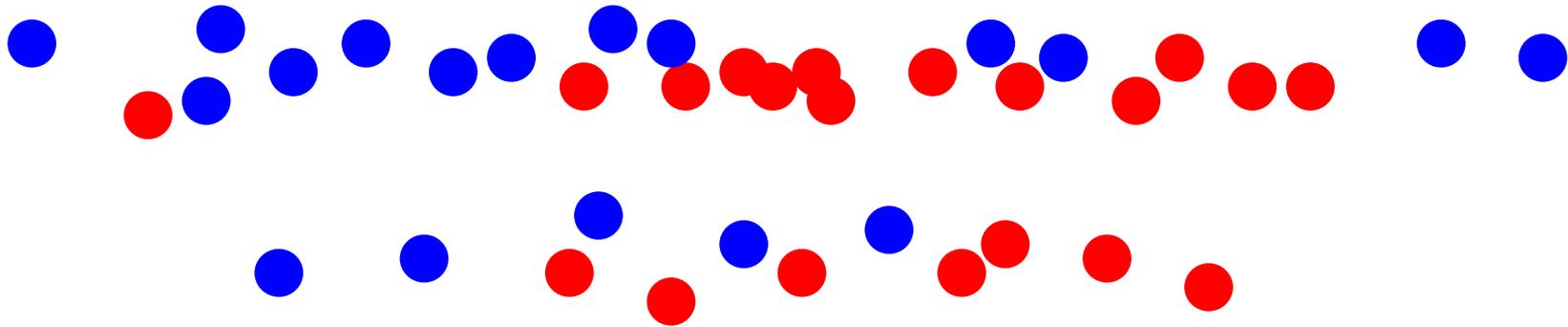


[N. Mantel, *J. of the Amer. Statistical Assoc.* 58, 690 (1963);

S. Brandt, *Statistical and Computational Methods in Data Analysis*, Springer, 1997, Table I.7]



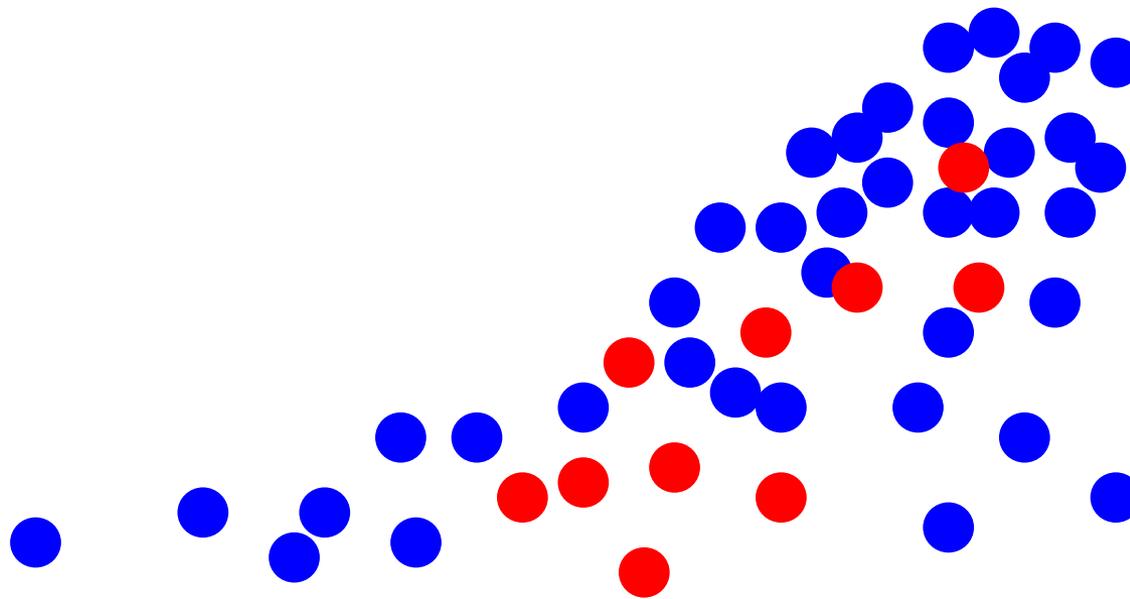
Polish students in CERN (CMS detector), 2012



Polish students in CERN (CMS detector), 2012



Summer School - Physics and Philosophy of Time, Lausanne, 2013





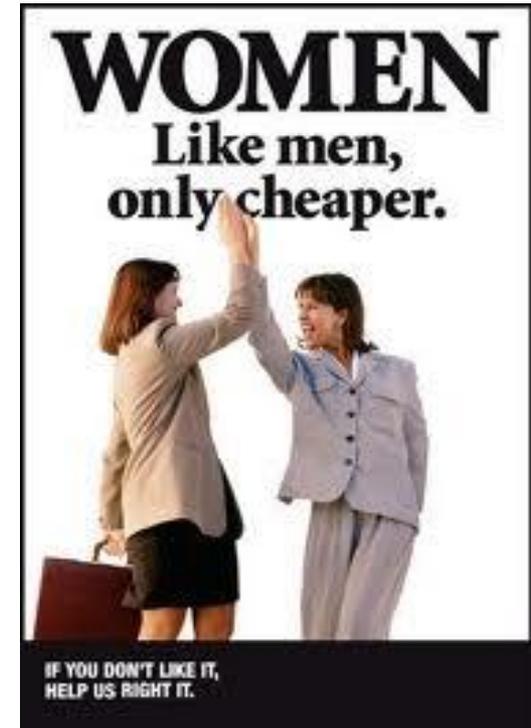
**Chemical Engineering Summerschool
Vienna University of Technology
Vienna, Austria - 2013**



***Memorandum of Understanding signing ceremony
between Ton Duc Thang University and Czech Technical University in Prague, 2014***

about the adults :

1. People **perceive gender differences** to be pervasive in interaction.
2. Actual studies of interaction among **equal-status, equal-power** peers indicate relatively **few gender differences** in behavior. Those that occur are concentrated in the socio-emotional, nonverbal domains that are commonly considered to be less central to instrumental outcomes. Equal status/power contacts between men and women may be the most problematic for the gender system, since they undermine both difference and inequality.
3. **Most interactions between men and women** occur within the structural context of role or status relationships that are **unequal**. Unequal role/status relationships between men and women produce many differences in interactional behavior that are commonly associated with gender.



[C. L. Ridgeway, L. Smith-Lovin, The gender system and interaction, Annu. Rev. Socio. 25 (1999) 191.]

Summary

- The model of removal of cognitive dissonance with direct reciprocity gives a stationary solution in the Heider equilibrium also for initially asymmetric ties
- The equations allow to evaluate the level of gender segregation in groups

more details in *Physica A* 439 (2015) 66

Thank you