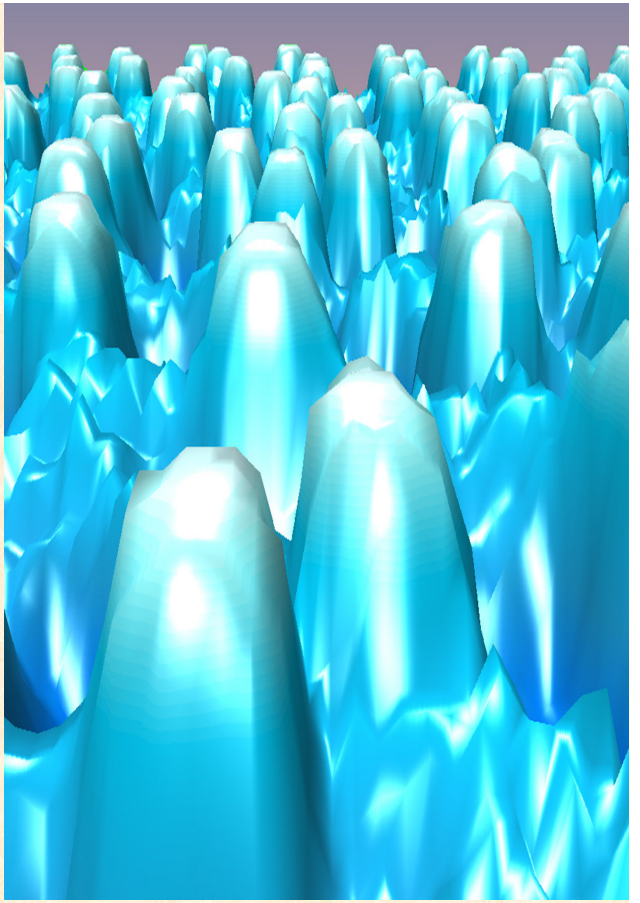
Magnetic ordering in a social structure



Krzysztof Kułakowski

AGH University of Science and Technology
Kraków, Poland

3 Ogólnopolskie Sympozjum FENS, Wrocław 2007

„Whoever reflects on this cannot but marvel that the philosophers should have bent all their energies to the study of the world of nature, which, since God made it, He alone knows; ...

...and that they should have neglected the study of the world of nations, or civil world, which, since men made it, men could come to know.„

[Giambattista Vico, Scienza Nuova]

abstract

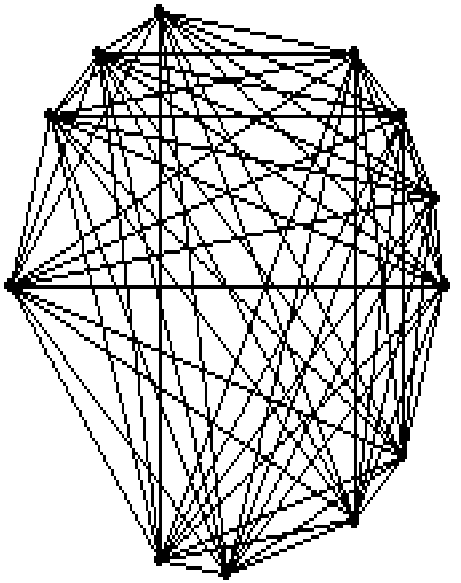
We discuss some selected attempts to describe collective consequences of social interactions in terms of a phase transition. Attention is paid to the structure of social networks. The case of the hierarchical network is considered as a recent example. This network is a mathematical realization of the concept of weak ties. Consequences of the scale-free noise in a social environment are also discussed.

Non-scientists tend to think that science works by deduction. But actually science works mainly by metaphor. And what's happening is that the kind of metaphors people have in mind are changing.

[W. Brian Arthur, SFI]

metaphor I:	society	⇔ network
metaphor II:	collective action	⇔ ordering
metaphor III:	environment	⇔ noise

3 Ogólnopolskie Sympozjum FENS, Wrocław 2007



The Italian community of Boston's West End, for example, was unable to even *form* an organization to fight against the "urban renewal" which ultimately destroyed it.

[M. Granovetter, The Strength of Weak Ties, 1973]

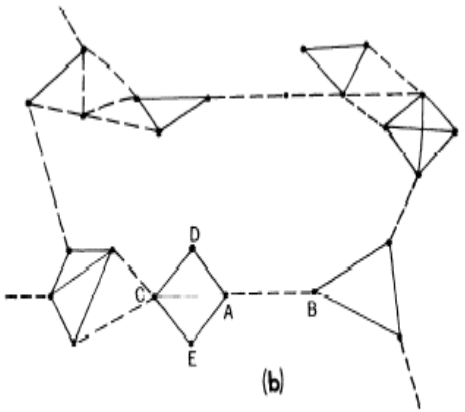
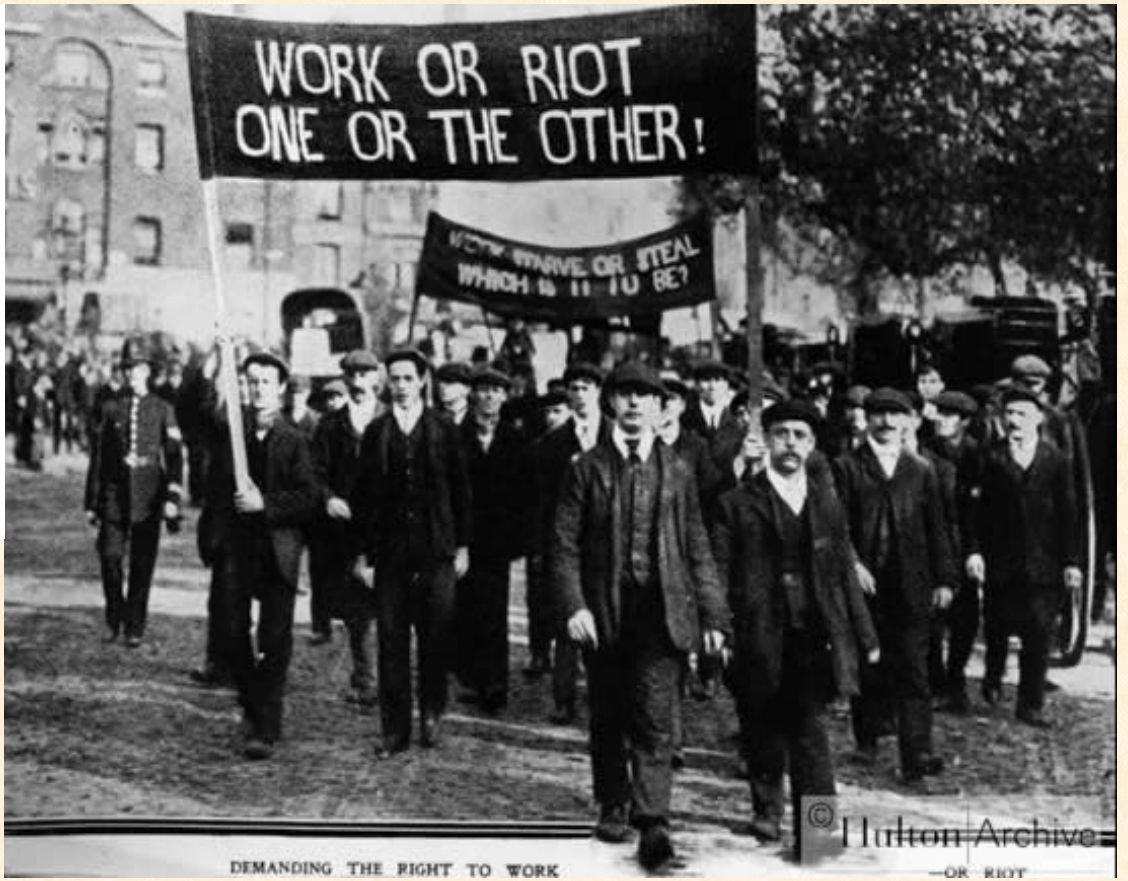
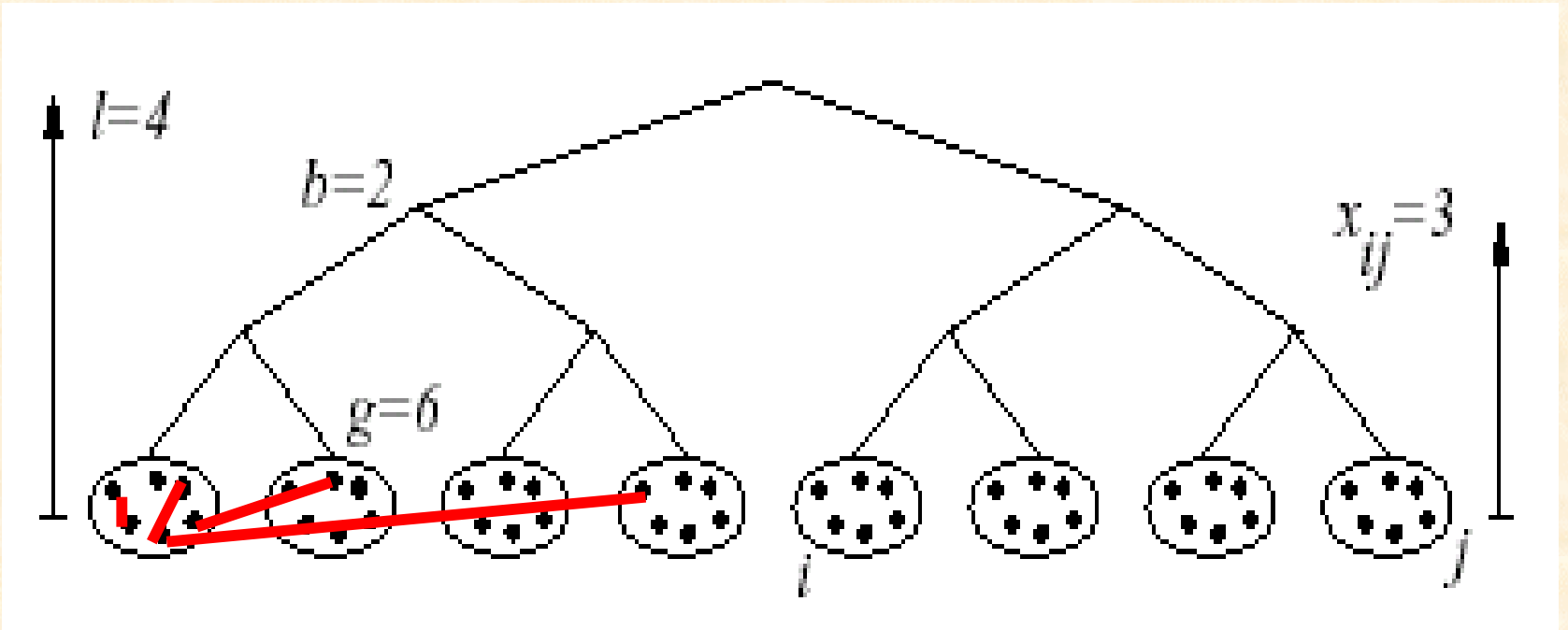


FIG. 2.—Local bridges. *a*, Degree 3; *b*, Degree 13. ——= strong tie; – – –= weak tie.

[M. Granovetter, ibid



The case of Charlestown, a working-class community which successfully organized against the urban renewal plan of the same city (Boston) against which the West End was powerless, is instructive in this respect: unlike the West End, it had a rich organizational life, and most male residents worked within the area

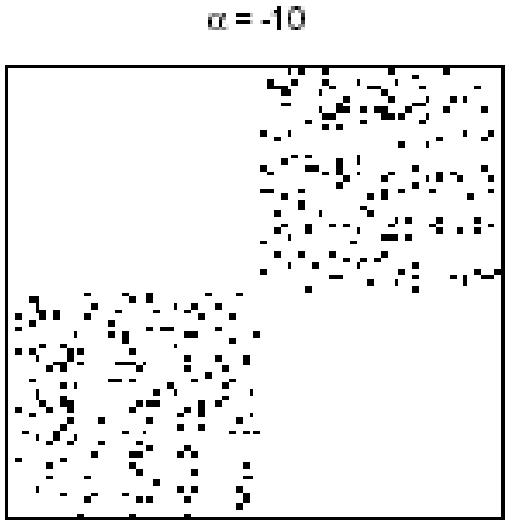


The frame for the random hierarchical network
D.J.Watts, P.S. Dodds, M. E. J. Newman, Science 2002

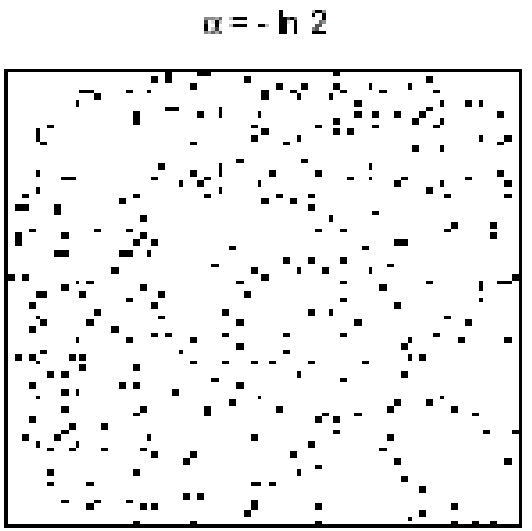
Probability of a link between nodes at a distance x

$$P(x) \propto \exp(-\alpha x)$$

α - a measure of tendency of like to associate with like

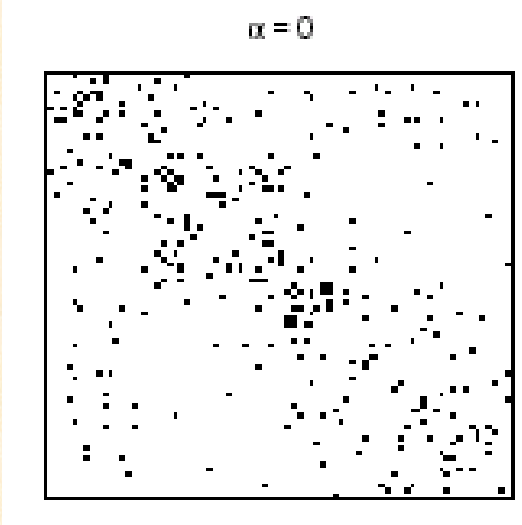


no links to neighbours

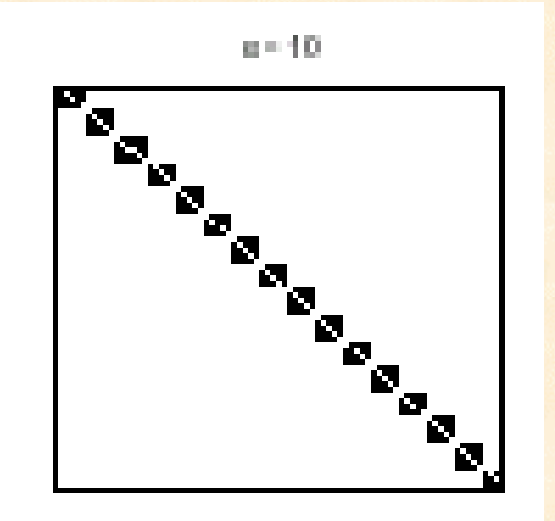


the Erdös-Renyi network

[M. Wołoszyn D. Stauffer, K.K., EPJ B 2007]

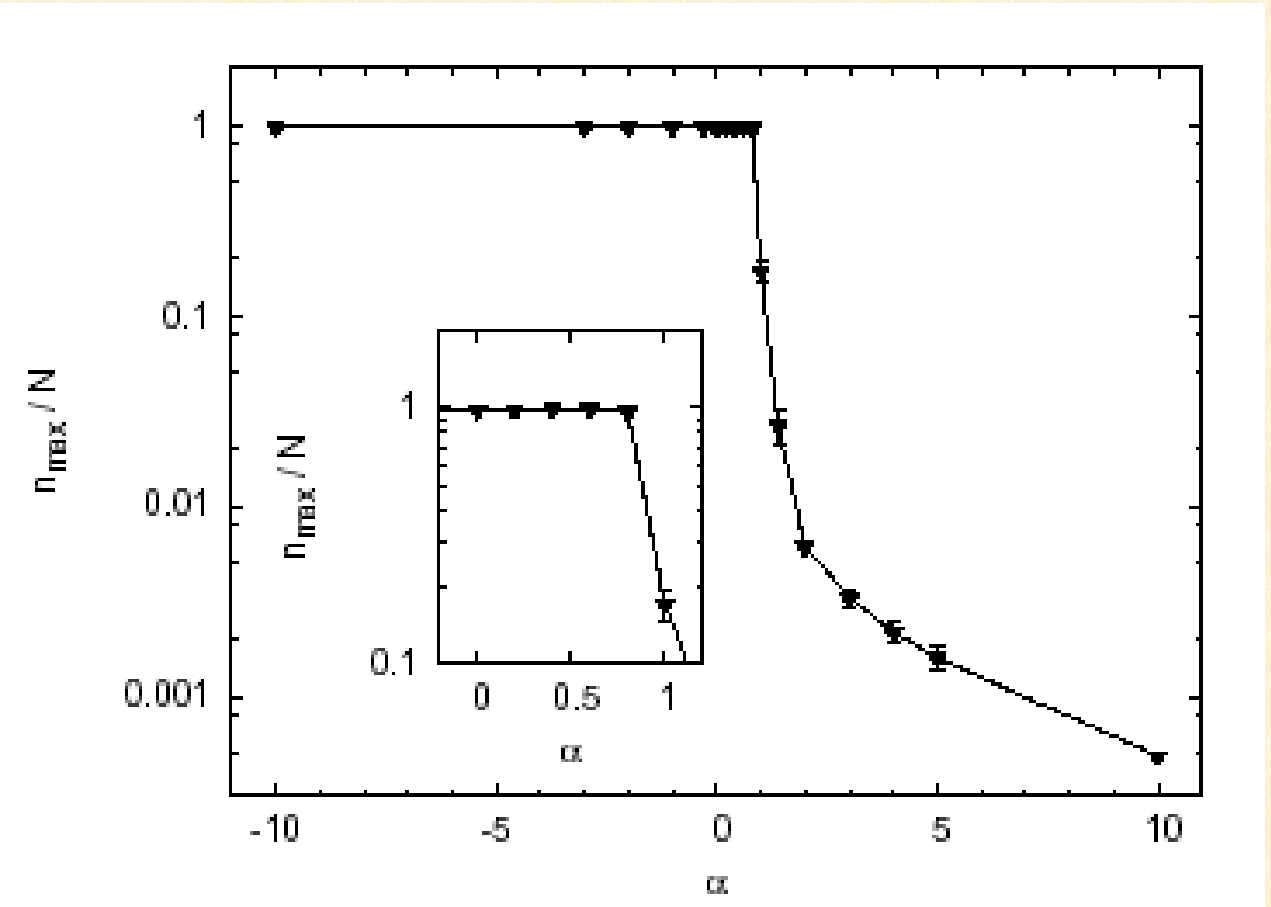


hierarchical random network



a set of separated clusters

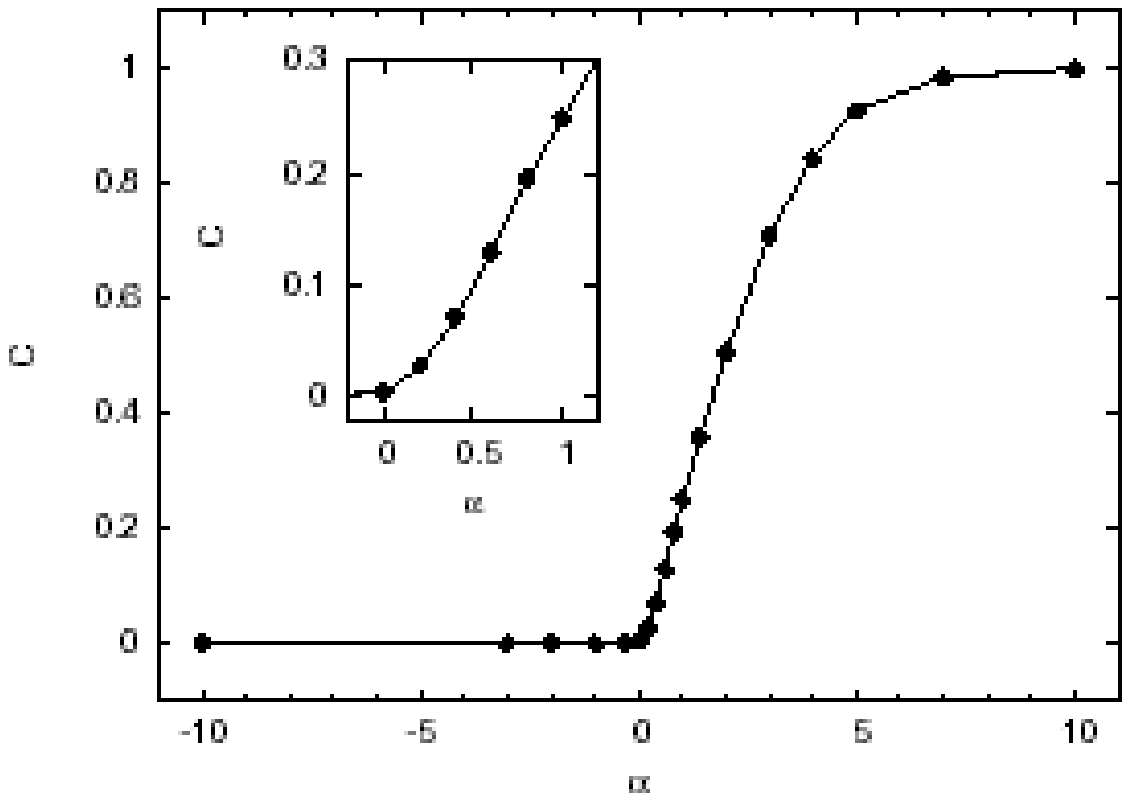
Size of the largest component



α

[M. Wołoszyn, D. Stauffer, K.K., EPJ B 2007]

The clustering coefficient



[M. Wołoszyn D. Stauffer, K.K., EPJ B 2007]

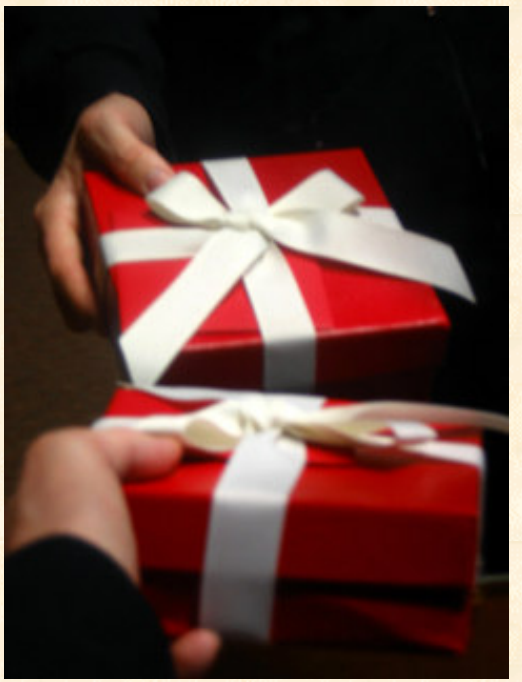
α

To summarize: for $0 < \alpha < 0.7$ our network is connected, random, hierarchical and clusterized.

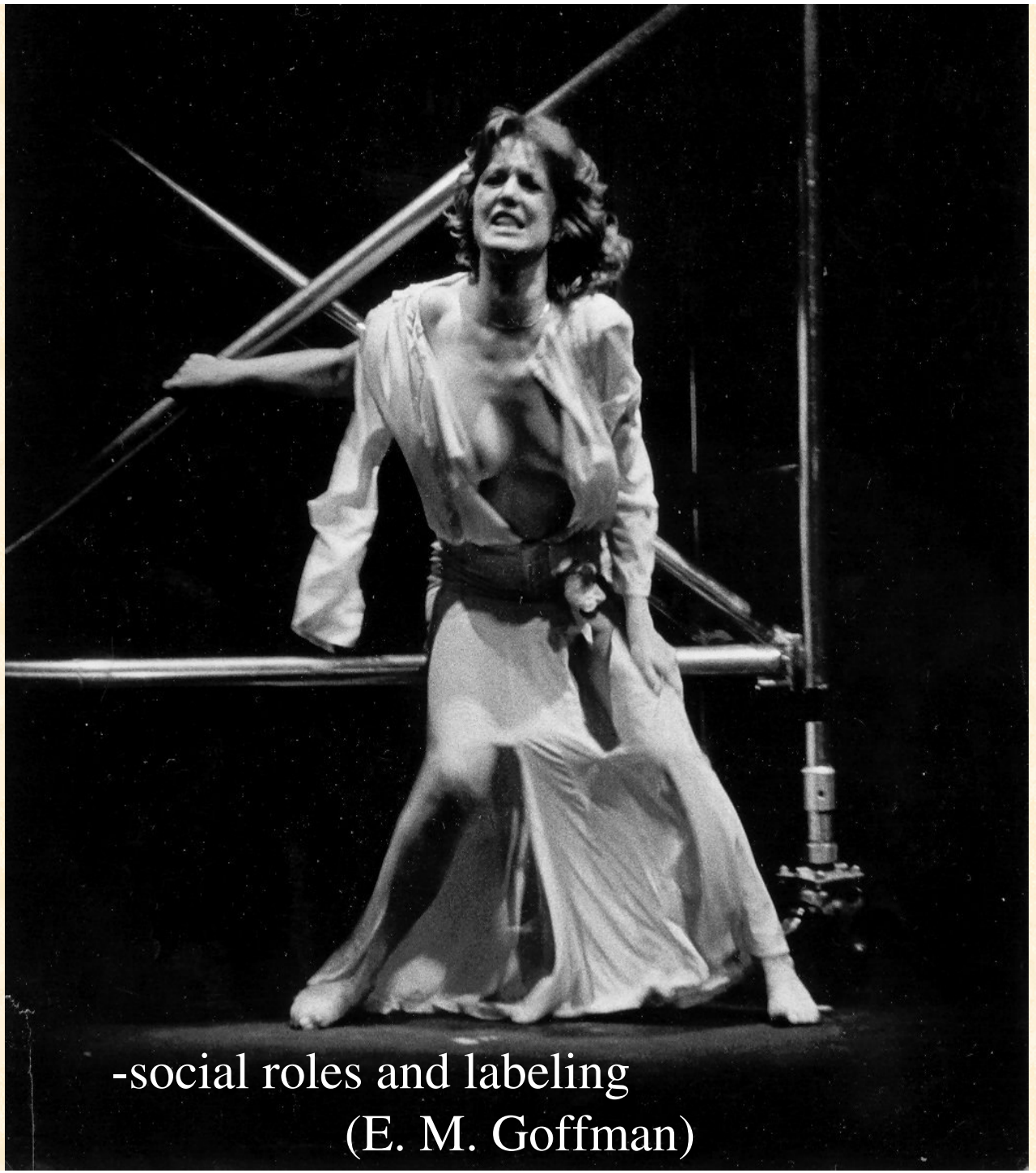
Theory: *4* **levels of social interactions**:

- behavioral (J. Dollard + N. E. Miller)

- social exchange (G. C. Homans)



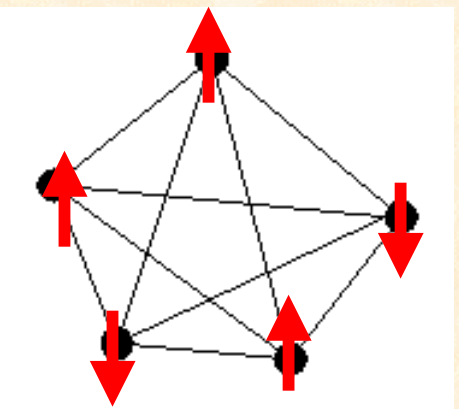
-symbolic interactionism
(C. H. Cooley + G. H. Mead)


-social roles and labeling
(E. M. Goffman)

To simulate social interactions ...

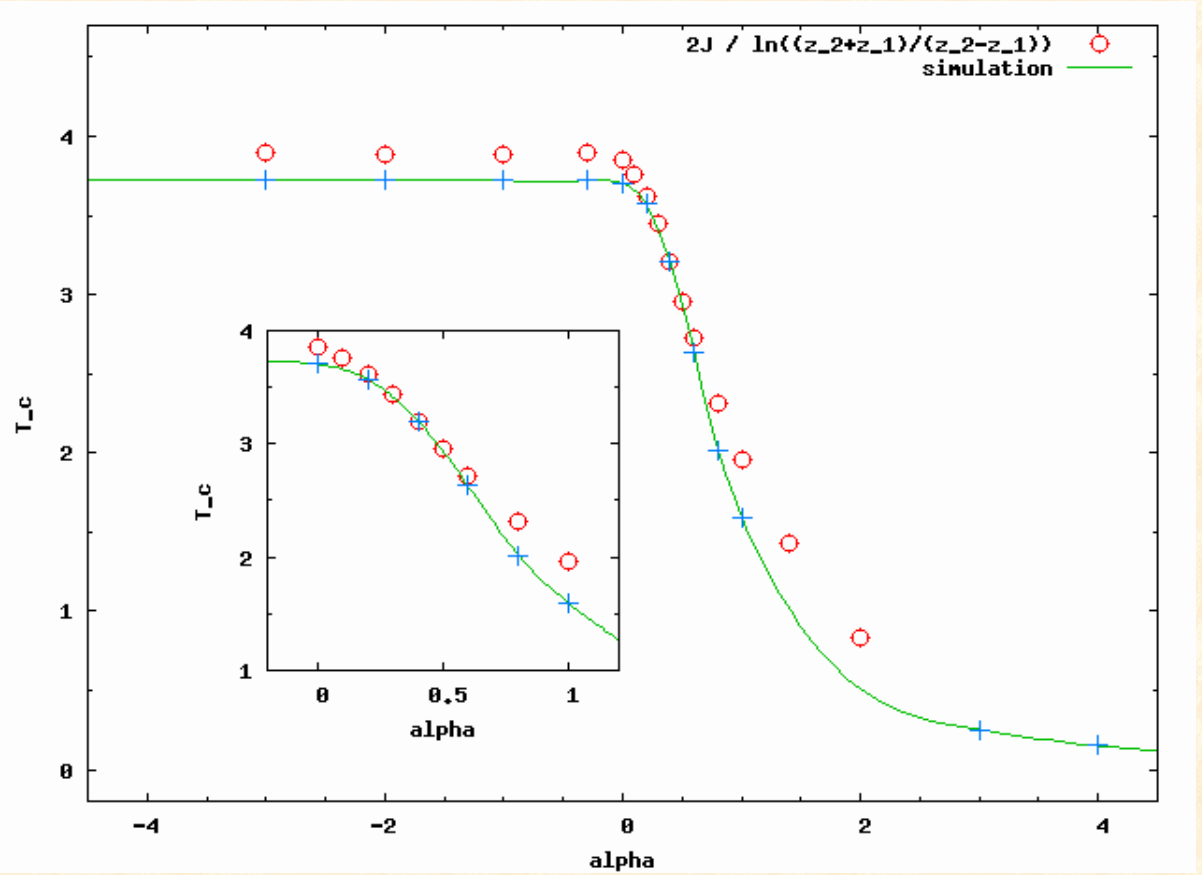
...we decorate each node *i* with spin $S_i = \pm 1$

and we set the spins to interact ferromagnetically along the links.



metaphor II: collective action ⇔ ordering

The Curie temperature



$$\frac{2J}{T_c} = \ln \frac{z_2 + z_1}{z_2 - z_1}$$

α

[M. Wołoszyn et al., EPJ B 2007]

metaphor III: environment ⇔ noise

Usually:

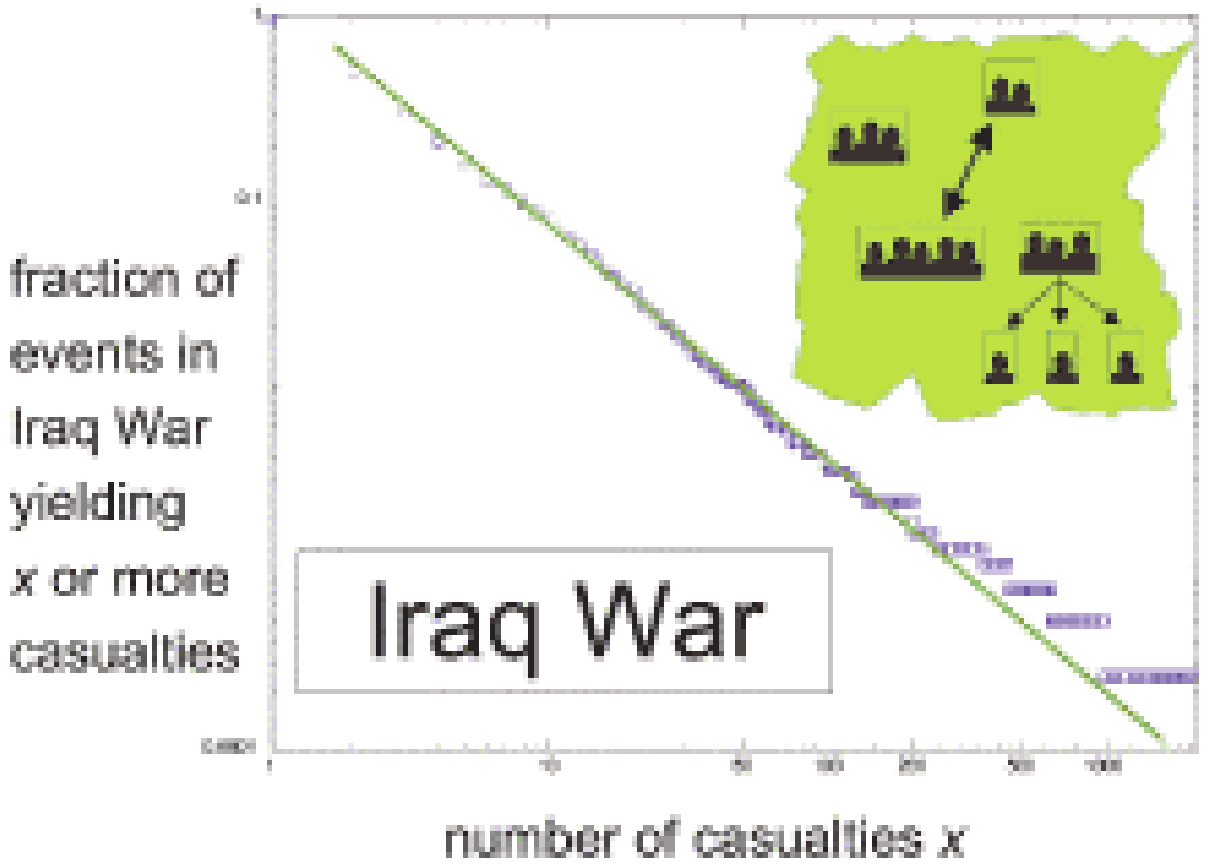
thermal equilibrium,
M-C heat bath algorithm

$$P(E) \propto \exp\left(\frac{-E}{k_B T}\right)$$

However:

CNN, Latest News, updated 11:12 a.m. EST, Sun November 18, 2007

- American among suspects in Italy killing
- Cyclone death toll hits 2,000
- Pressure mounts as vigil held for ex-cop's wife
- Parents: MySpace 'friend' behind girl's suicide
- 'SNL' show live from N.Y. but not on TV
- WKMG: Woman, horse killed in riding event jump
- Tawana Brawley back in the news
- Saudi rape victim gets longer sentence
- Would you like some pot with your burger?
- Japan defends latest whaling expedition
- Ticker: Candidate's wife on sex vs. money
- Father, son graduate as troopers
- Domino effect: Millions fall, record stands
- Here comes the bride, all dressed in ... mud?
- Vote for your favorite CNN Hero
- CNN Wire: Latest updates on top stories



[Neil F. Johnson, APS News, November 2006]

New: a power-free noise with distribution

$$p(n) \propto 1/n$$

by flipping n spins at each timestep

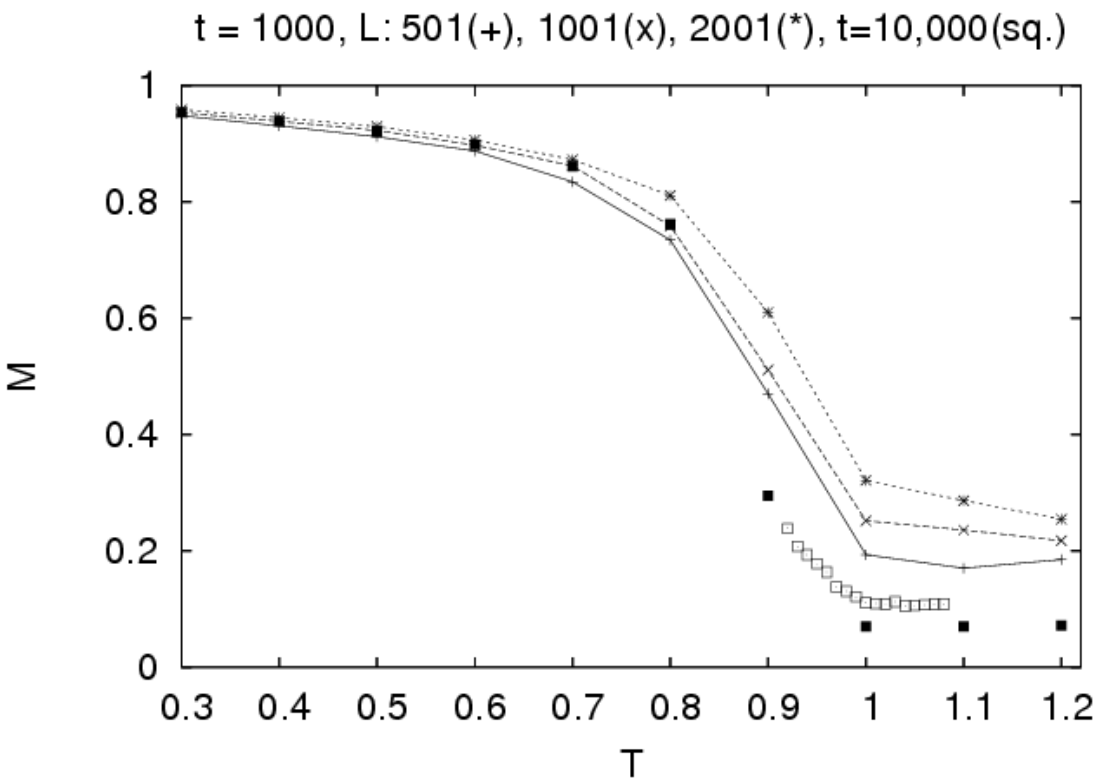
$$n = TL^{2r}$$

where r – a random number, $0<r<1$,
T – amplitude of noise

[D. Stauffer, KK, arXiv:0709.3811]

Result: the phase transition persists

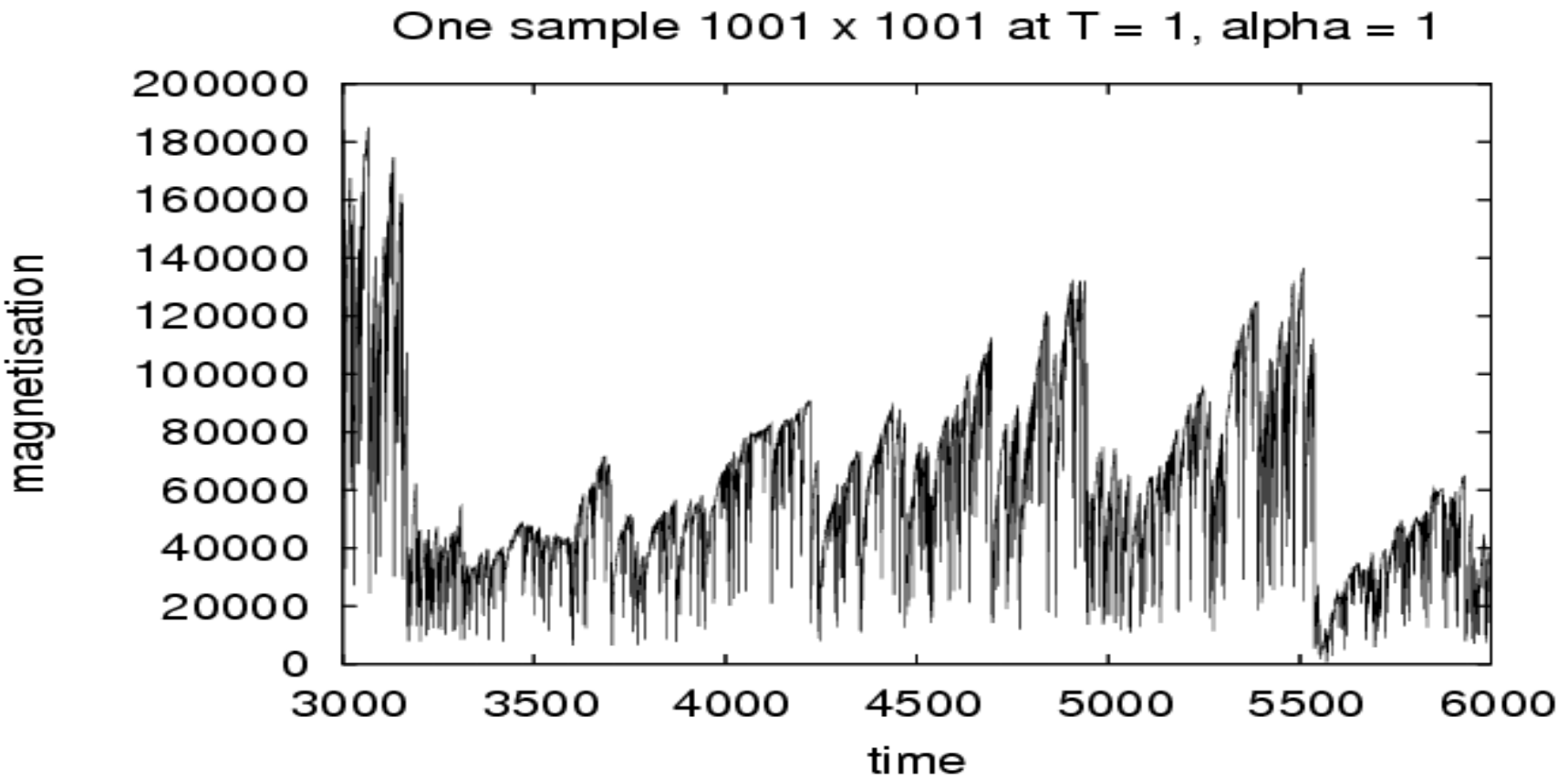
magnetization



amplitude of 1/f noise

[D. Stauffer, KK, arXiv:0709.3811]

magnetization



time

[D. Stauffer, KK, arXiv:0709.3811]

Conclusions:

metaphor I: society ⇔ network

good

metaphor II: collective action ⇔ ordering

bad

metaphor III: environment ⇔ noise

?