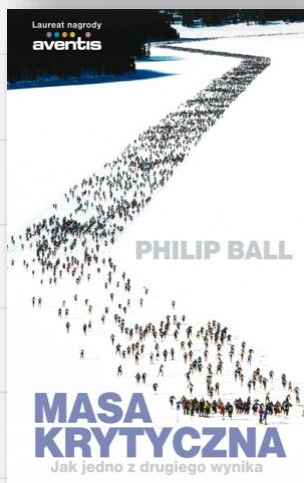
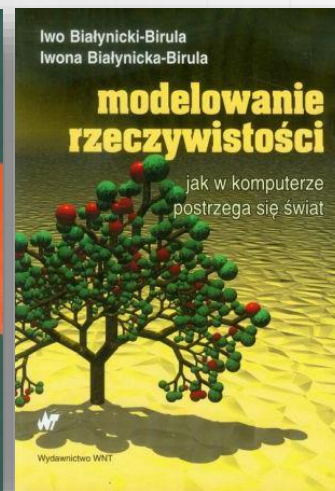
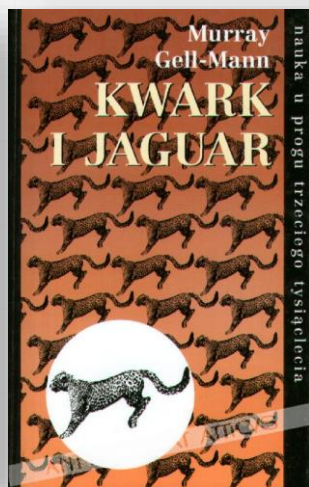
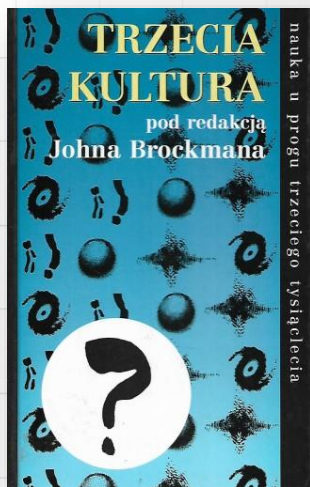


# Fizyka w naukach ekonomicznych i społecznych

**Katarzyna Sznajd-Weron**

Katedra Fizyki Teoretycznej

# Socjofizyka i Ekonofizyka



- Sociophysics, S. Galam 1982
- Econophysics, H. Eugene Stanley 1995





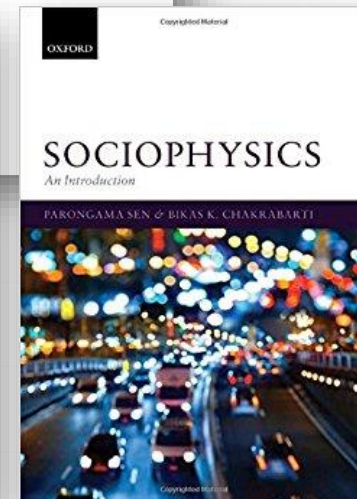
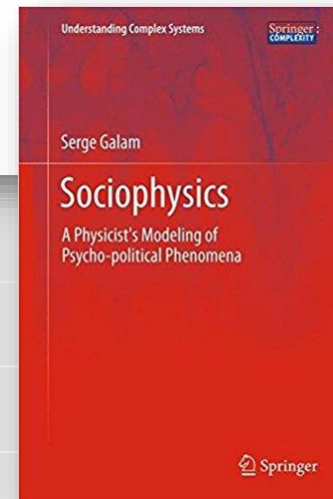
# Socjofizyka 1982, 2000, 2008, 2013

*Journal of Mathematical Sociology*, 1982, Vol. 9, pp. 1-13  
0022-250X/82/0901-0001\$06.50/0  
© 1982 Gordon and Breach, Science Publishers, Inc.  
Printed in the United States of America

## SOCIOPHYSICS: A NEW APPROACH OF SOCIOLOGICAL COLLECTIVE BEHAVIOUR. I. MEAN-BEHAVIOUR DESCRIPTION OF A STRIKE

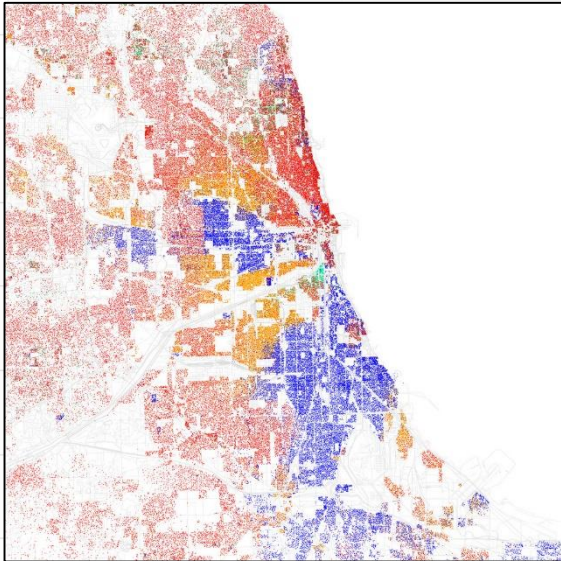
SERGE GALAM, YUVAL GEFEN (FEIGENBLAT) and  
YONATHAN SHAPIR

*Department of Physics and Astronomy  
Tel-Aviv University  
Ramat-Aviv, Israel*

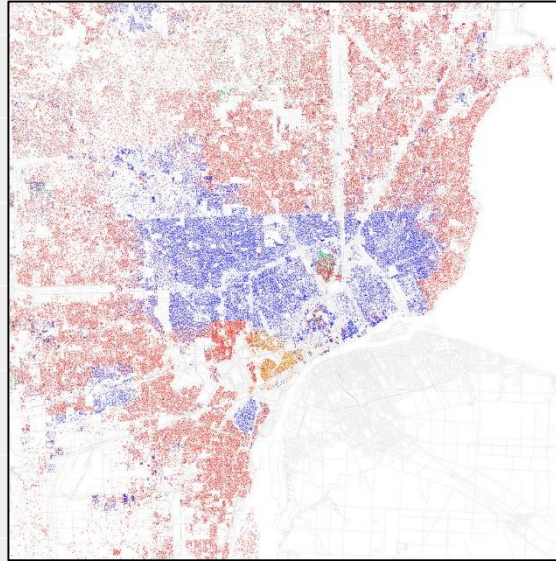


# Po co ludzi traktować jak cząstki?

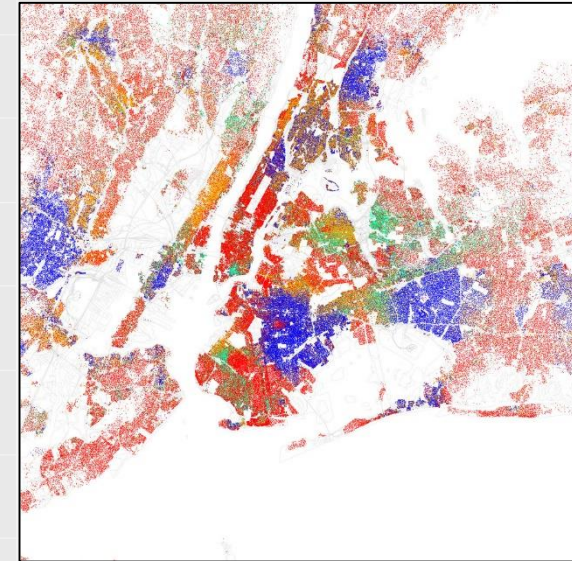
Mapy podziałów etnicznych w amerykańskich miastach, rok 2010



Chicago



Detroit



New York City

Legenda: ■ Biali ■ Czarni ■ Azjaci ■ Latynosi

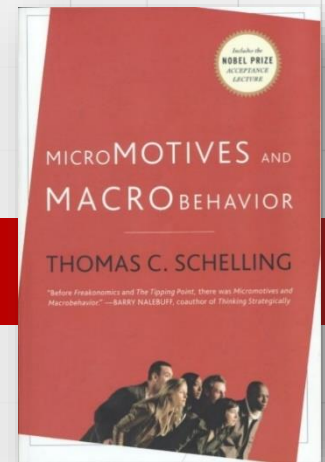
1 punkt = 25 mieszkańców

Eric Fischer, inspiracja: Bill Rankin, 2009

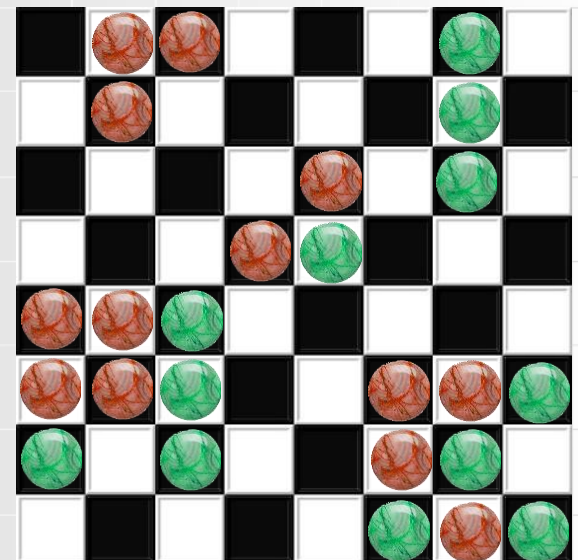
(<https://www.flickr.com/photos/walkingsf/sets/72157626354149574/>)

Dane z Census 2010. © OpenStreetMap, CC-BY-SA

# Model Schellinga (1971)




- Agenci mogą być tylko dwóch typów
- Początkowo rozmieszczeni są losowo na sieci
- Agent jest nieszczęśliwy jeżeli nie ma w otoczeniu przynajmniej  $T$  takich samych jak on
- Nieszczęśliwy agent ucieka



Schelling, T.C. *Dynamic Models of Segregation*,  
Journal of Math. Sociology 1: 143-186 (1971)

# Na szczęście są komputery i ...

C=95%, T=30%



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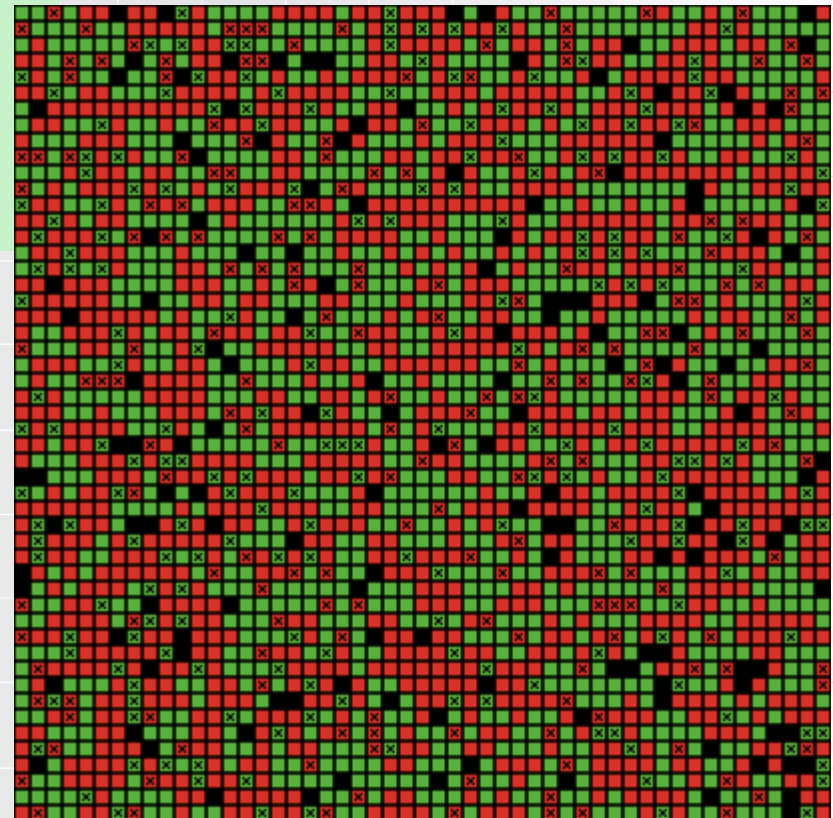
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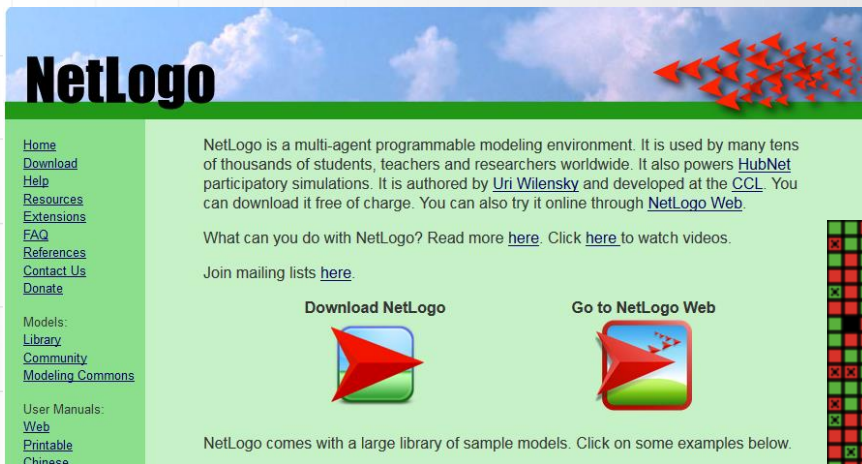


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# Na szczęście są komputery

C=95%, T=30%



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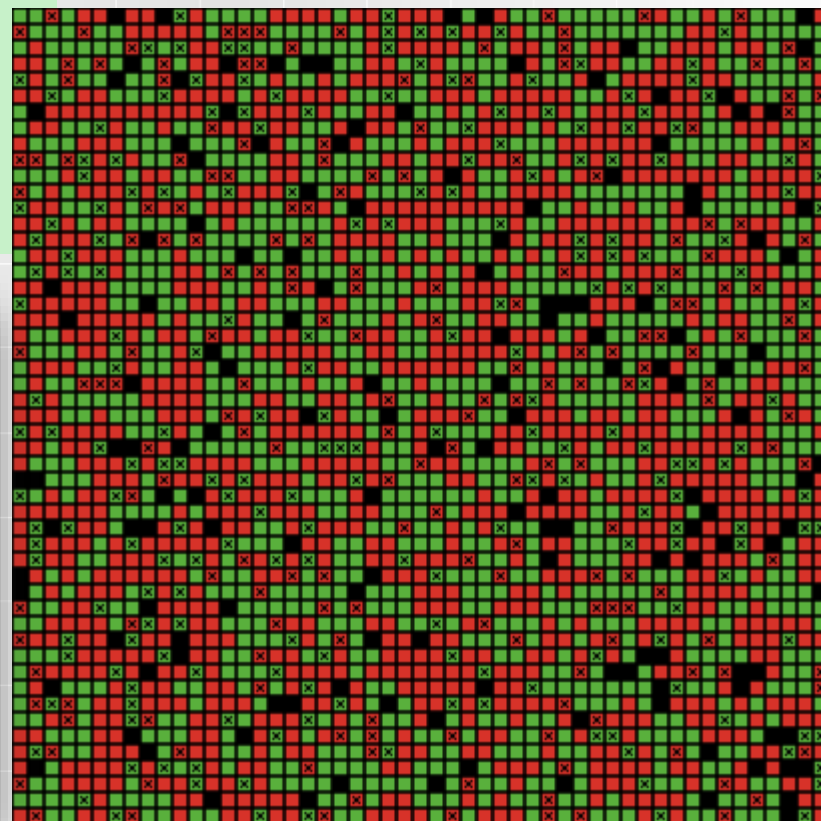
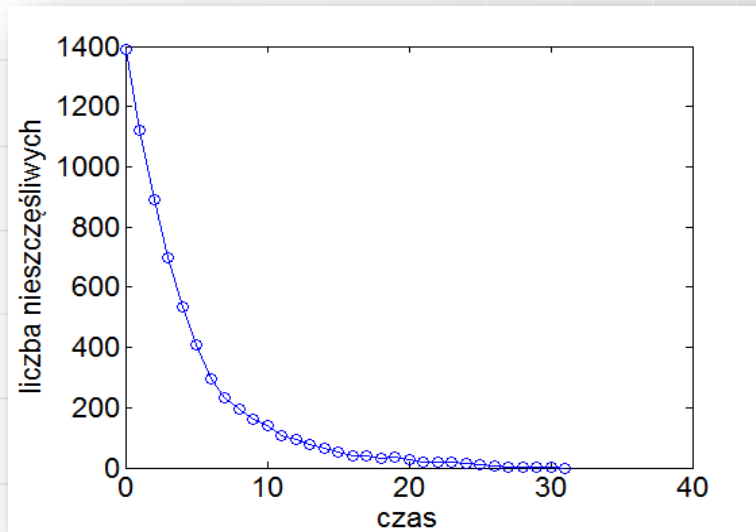
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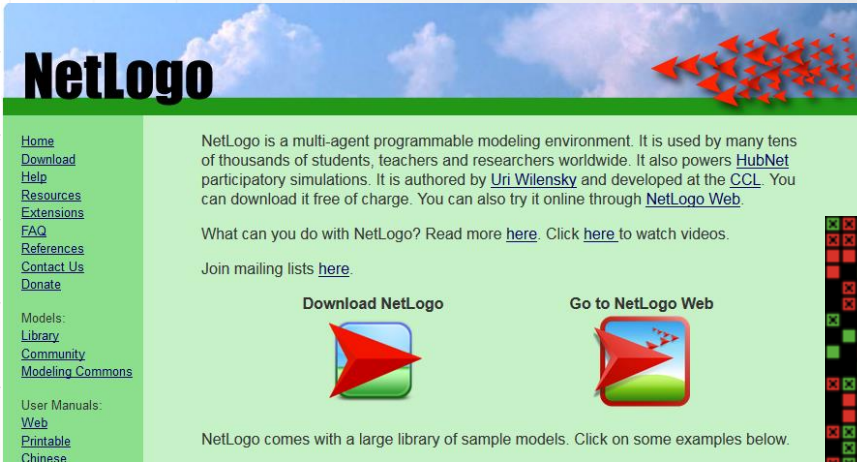
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# Ostra segregacja

C=80%, T=60%



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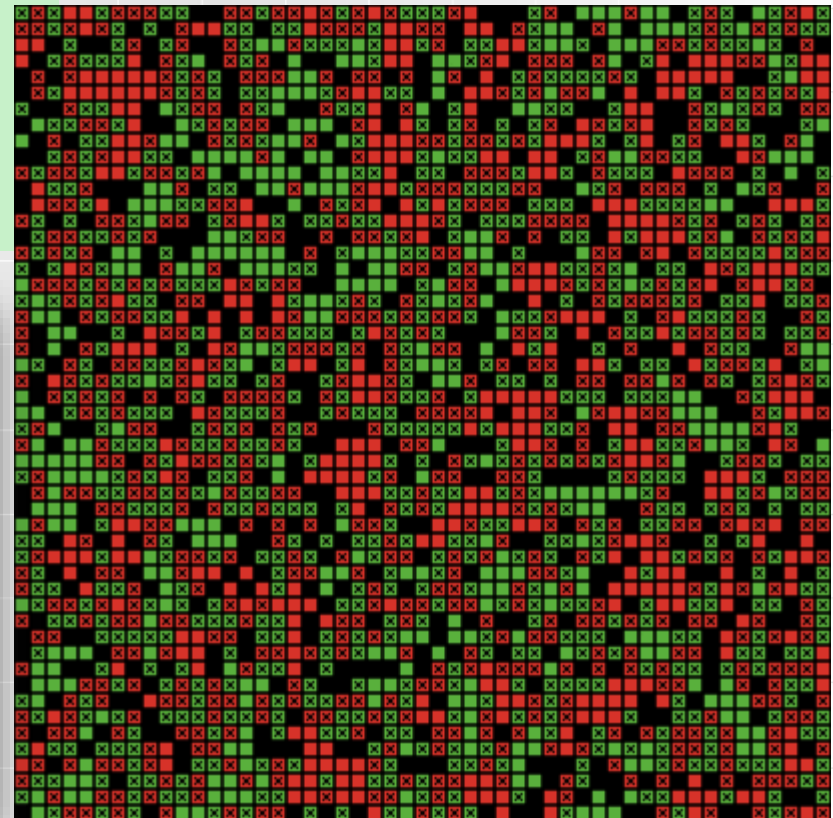
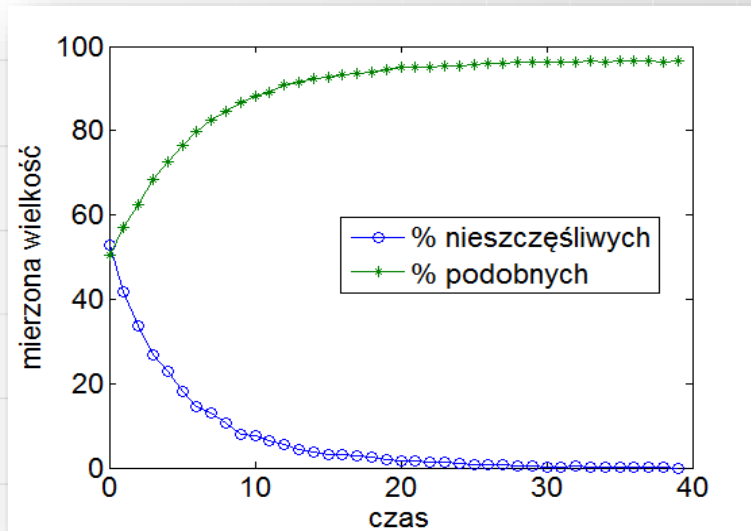
NetLogo is a multi-agent programmable modeling environment. It is used by many tens of thousands of students, teachers and researchers worldwide. It also powers [HubNet](#) participatory simulations. It is authored by [Uri Wilensky](#) and developed at the [CCL](#). You can download it free of charge. You can also try it online through [NetLogo Web](#).

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# Jaka nauka płynie z modelu?

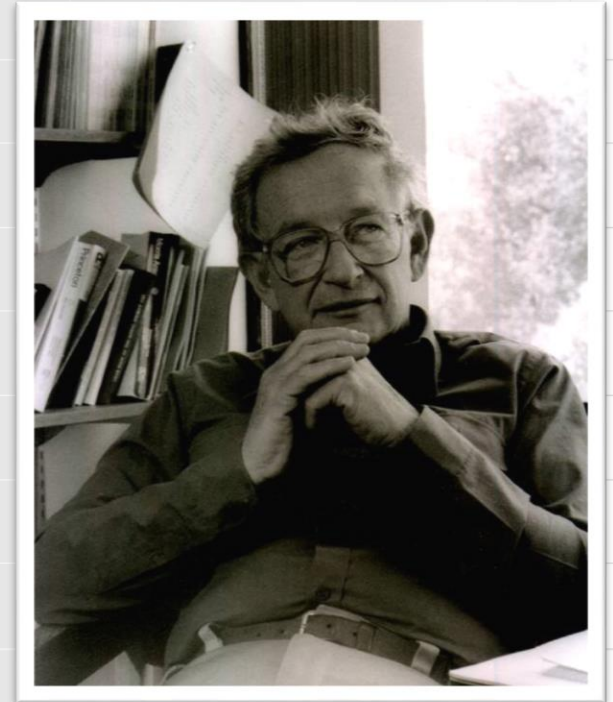
## Podsumujmy

- Model segregacji ze względu na pewną cechę (wiek, zamożność, ...)
- Nikt nie preferuje ścisłej segregacji
- Ostra segregacja mimo „łagodnych” preferencji
- Mikro motywy i makro zachowanie



# „Więcej znaczy inaczej”

- Philip Warren Anderson,  
***More Is Different***,  
Science, New Series 177  
(Aug. 4, 1972), pp. 393-396
- 1977 nagroda Nobla z fizyki  
prace nad nieuporządkowanymi  
układami magnetycznymi

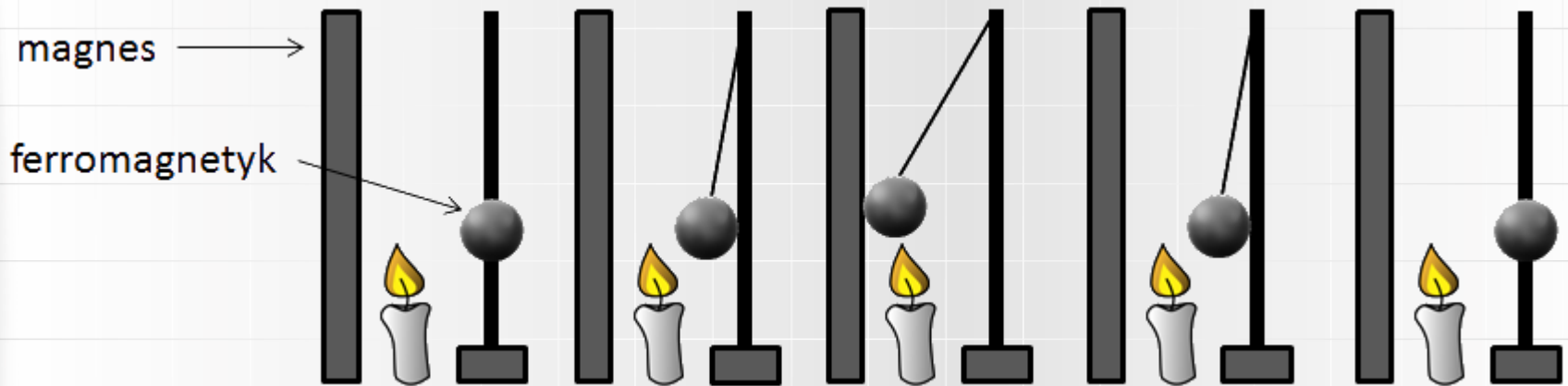


# Co ma z tym wspólnego fizyka?

## Przemiany fazowe

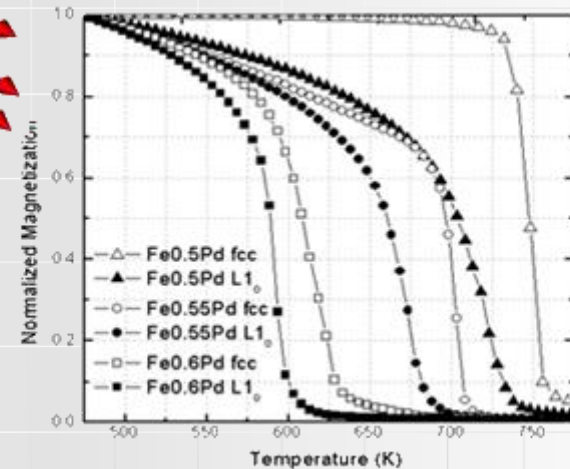
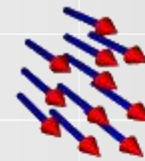


# Przemiana fazowa



© Katarzyna Sznajd-Weron

- Ferromagnetyk  $T \leq T_c$
- Paramagnetyk  $T > T_c$
- Jak to zrozumieć?



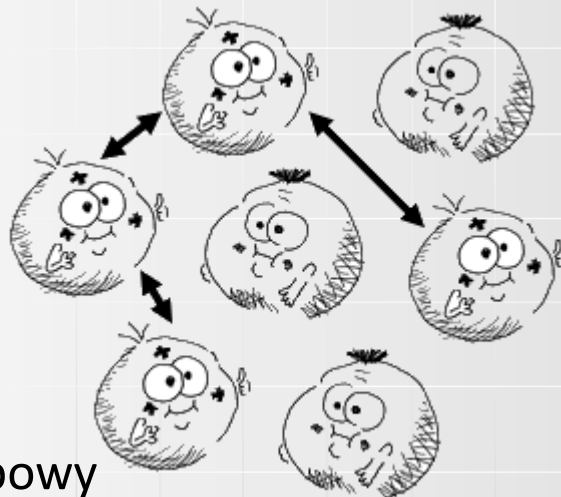
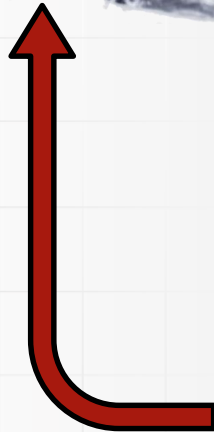
© Katarzyna Sznajd – Weron, 2017

# Fizyka statystyczna

$$Entropia: S = k_B \log \Omega$$



Termodynamika  
– poziom makroskopowy

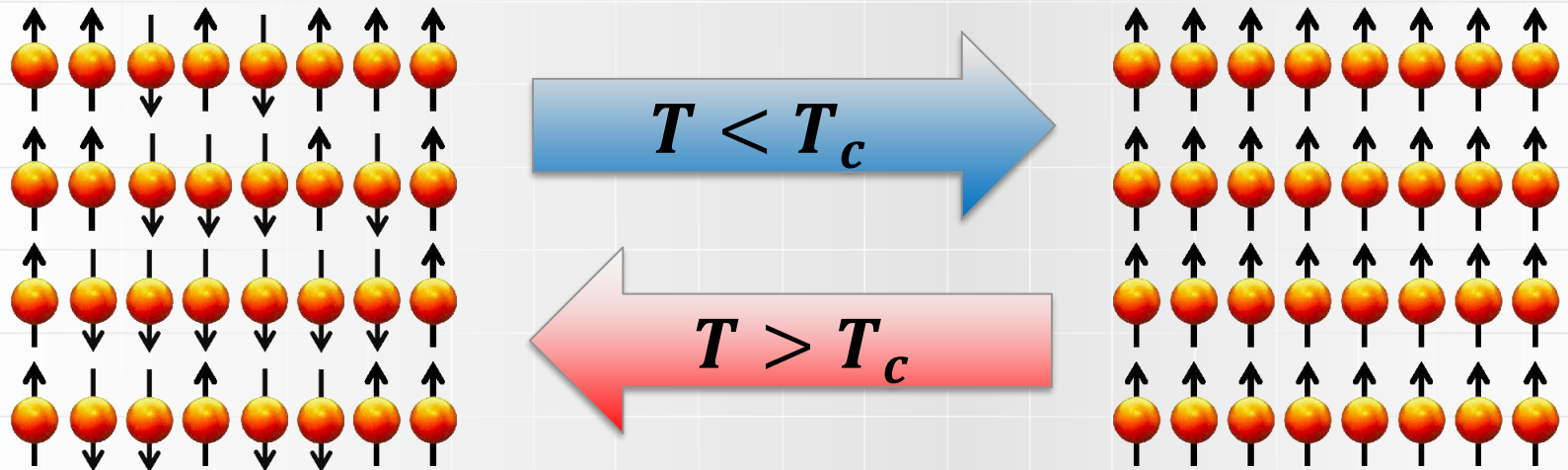


Fizyka statystyczna  
– poziom mikroskopowy



Grób Boltzmann na cmentarzu  
centralnym w Wiedniu

# Model Lenza-Isinga (1920-25)

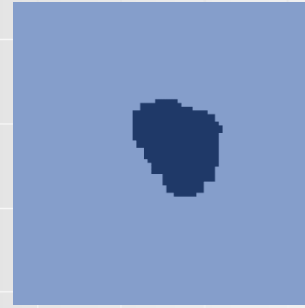
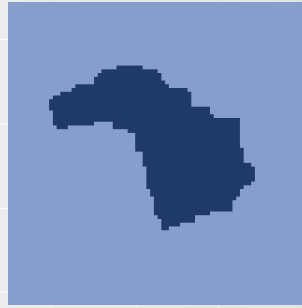
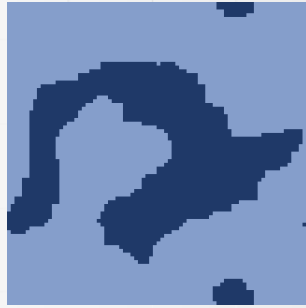
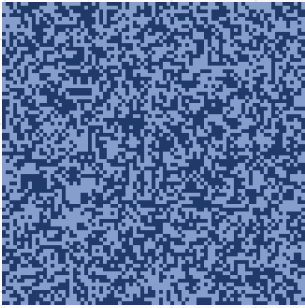


- Oddziaływanie między cząstkami – porządkuje
- Temperatura – rozburza („nerwowo”)
- Jak to policzyć? Algorytm Metropolis

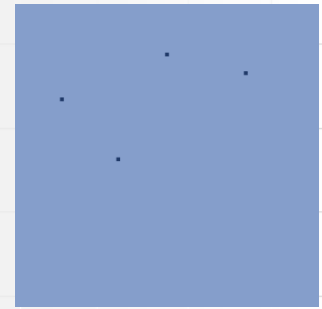
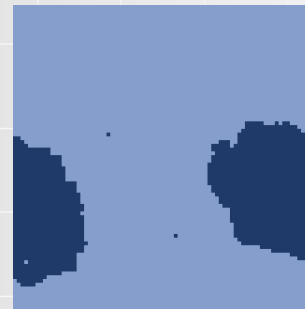
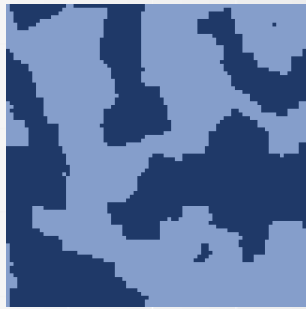
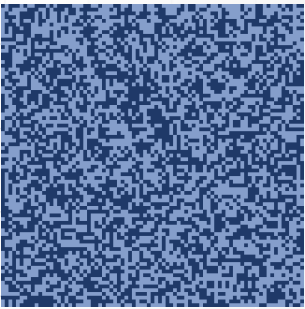


Czas

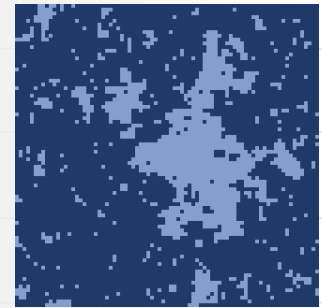
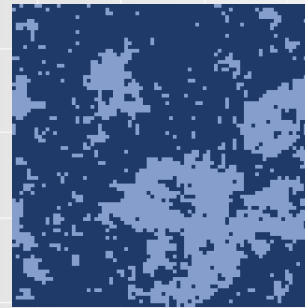
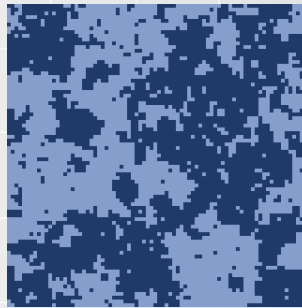
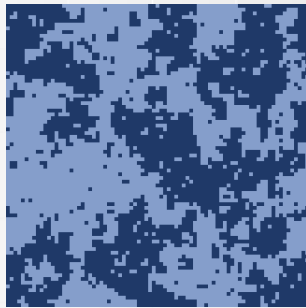
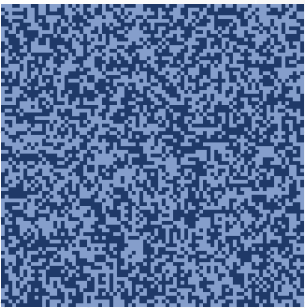
$T=0$



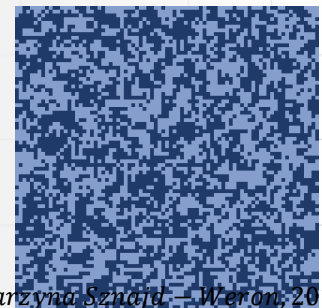
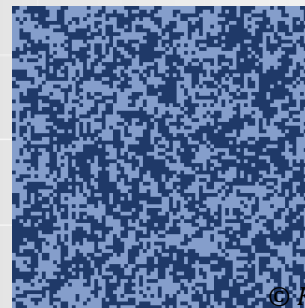
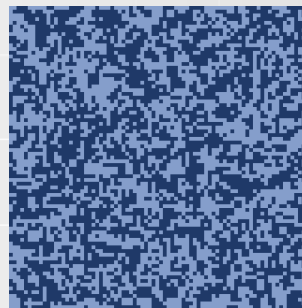
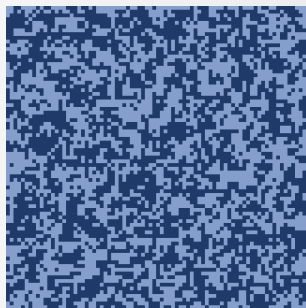
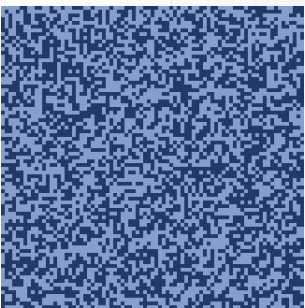
$T < T^*$



$T = T^*$

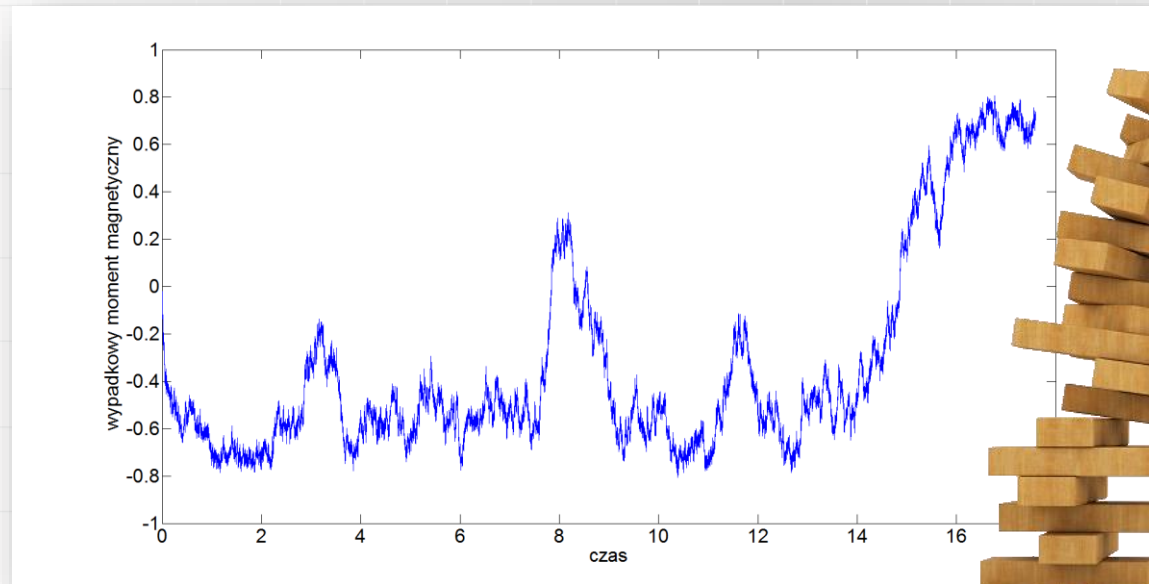


$T > T^*$



# Krytyczność w modelu Isinga

- Oddziaływanie – porządkuje
- Temperatura – losowe zmiany



- W niskich temperaturach → porządek
- W wysokich temperaturach → nieporządek





# Co się bada/modeluje?

- Rozprzestrzenianie się plotek, opinii
- Wybory polityczne
- Ruch drogowy i ewakuacja
- Ewolucja języka, kultury
- Ceny na rynkach finansowych
- Wybory konsumenckie (duopol, oligopol)
- Dyfuzja innowacji

# Wyzwania dla fizyka

- Fizyka statystyczna – układy złożone
- Teoria przemian fazowych – zjawiska kolektywne
- Wyzwania dla fizyka
  - Układy otwarte
  - Układy poza równowagą
  - Układy skończonego rozmiaru



# Spojrzenie fizyka na rzeczywistość

... nie tylko na układy społeczne



*Wszystko powinno być tak proste,  
jak to tylko możliwe, ale nie prostsze*



(c) Marcin Weron