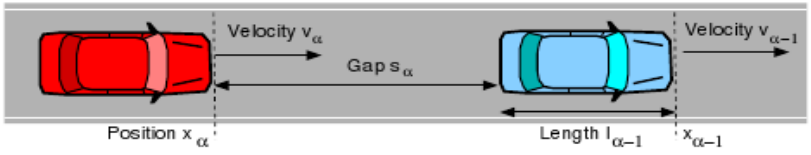

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Le Monde

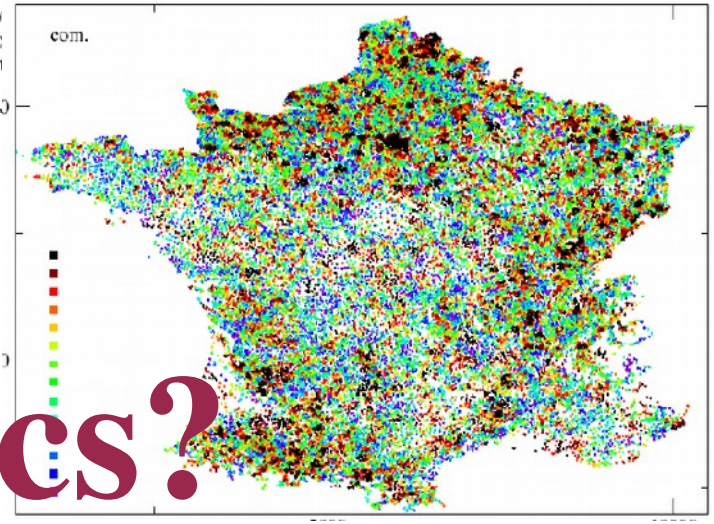
Pourquoi des élections si serrées ?

Mexique, Italie, Allemagne : les scrutins se décident à quelques voix près. Un scientifique explique

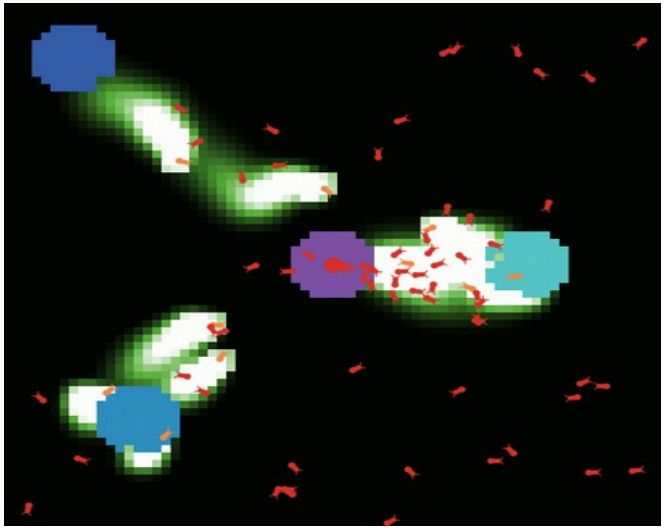
Serge [redacted]

Physicien au CNRS, membre du Centre de recherche en épistémologie appliquée (CREA) de l'Ecole polytechnique

Le Mexique se tro
paradoxe démoc
l'on a toujours cr
car totalement



Sociophysics?



Institut des Systèmes Complexes
Complex Systems Institute
Rhône-Alpes
IXXI

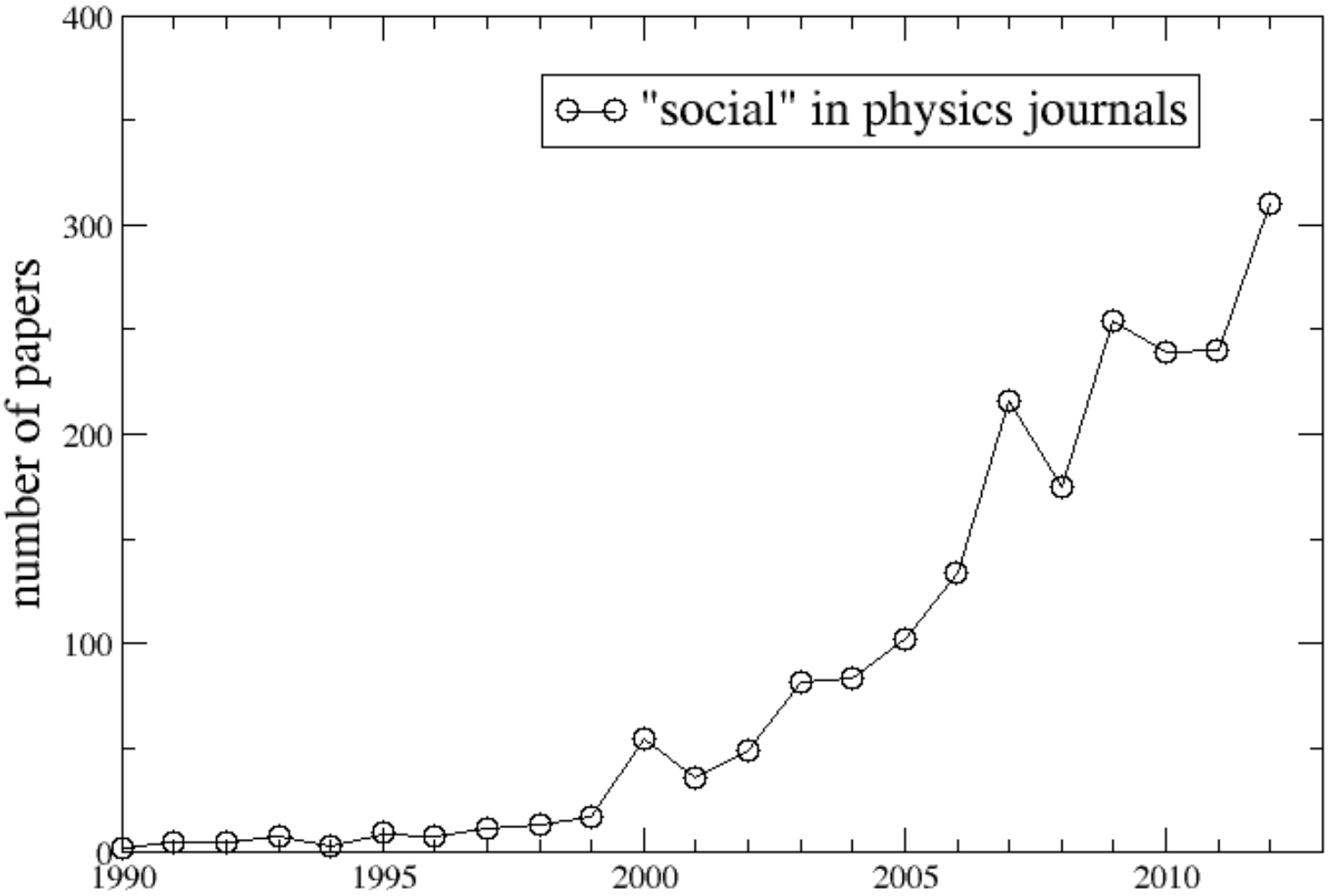
Deux types d'approche

- Société virtuelle simplifiée où l'on comprend effets, causalités en détail
  - Modèles simplistes (style Ising : Schelling, Mirta)
  - Modèles plus réalistes (fourmis, trafic, épidémio...)

- Analyse de données réelles
  - Réseaux, data mining, dynamique

- Croissance car avalanche de données sociales
  - Web, réseaux sociaux, téléphones, cartes crédits, Vélov...

Un domaine scientifique en croissance



mais petit ! (nanotube : 11 000 articles en 2008, simulations 100 000 !)

Des régularités sociales à la physique statistique

- Poisson prouve la loi des grands nombres dans : "Recherches sur la probabilité des jugements en matière criminelle..., précédées des Règles générales du calcul des probabilités" (1837)
- Physiciens/données sociales, 19ème : Halley, Fourier, Poisson, Laplace... proches du pouvoir politique/économique : régularités sociales ! (taux suicide, mortalité stables)
- Quételet : la loi Normale passe de 'erreur sur vraie valeur' à 'distribution d'objets réels', indispensable à Maxwell
- Maxwell lit Quételet et "Histoire anglaise" de Buckle, science historique partant des lois statistiques (mortalité..., 1857)
- Maxwell s'en inspire pour renoncer au rêve Newtonien : suivre dans le détail tous les mouvements individuels des molécules, et en venir à connaissance via les distributions, les moyennes

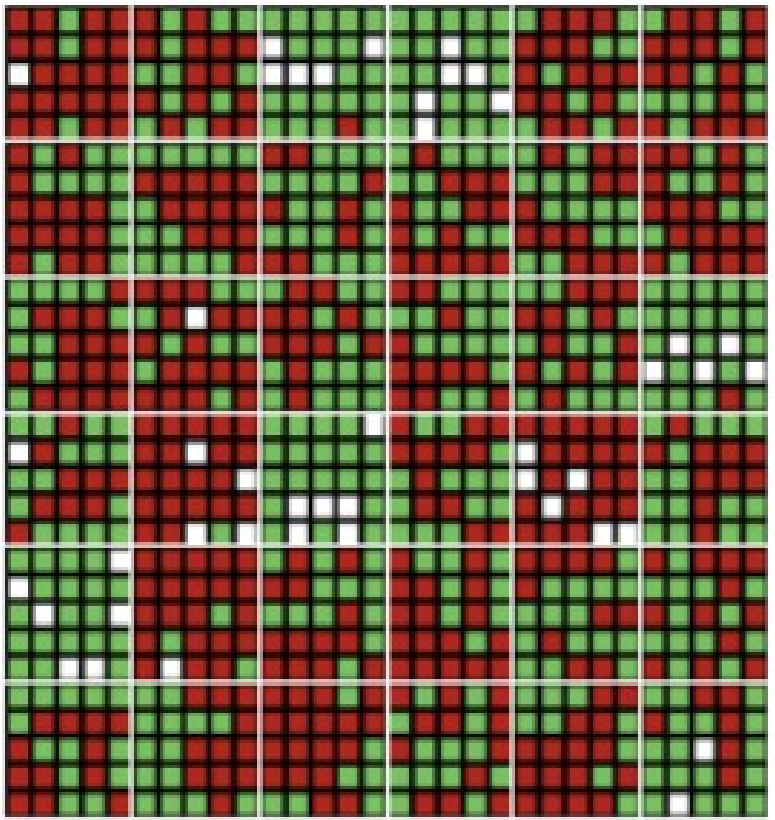
Lien entre préférences individuelles et structure sociale

Physique et économie, respect des spécificités !

S Grauwin, E Bertin, R Lemoy & PJ
PNAS **106**, 20622 (2009)

SG, F Goffette-Nagot & PJ, J of Pub Economics (2011)

Schelling's model of segregation (1971, simplified)



City $\equiv Q$ blocks composed of H cells

Mean density ρ_0 of particles fixed

State of the system $x \equiv \{\rho_q\}$

Agents are sensitive to the composition of their neighborhood
$\Rightarrow$ utility $u(\rho_q)$

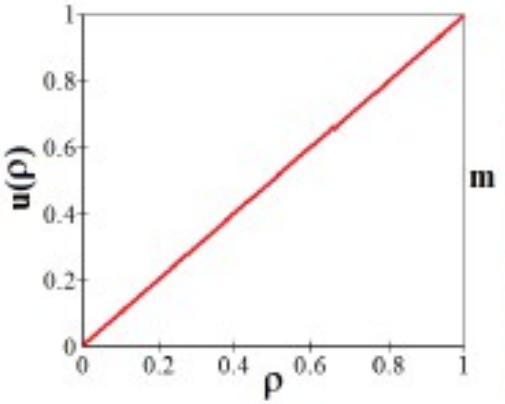
Dynamical rule

- At each iteration, an agent and a vacant cell are chosen at random
- The agent moves in that vacant cell with probability :

$$Pr\{move\} = \frac{1}{1 + e^{-\Delta u / T}}$$

- $\Delta u = u_{after} - u_{before}$
- $T > 0$: intensity of the random "noise" (quality of the location, amenities...)

Example



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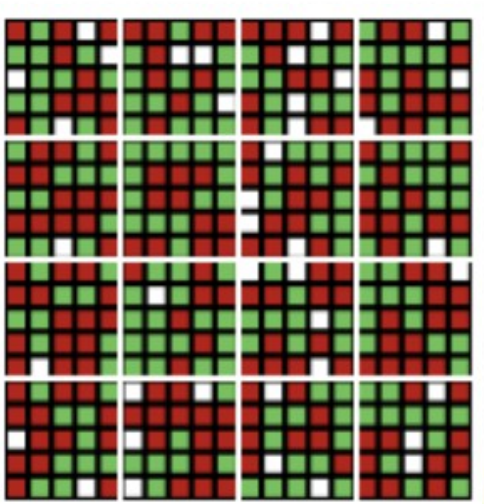
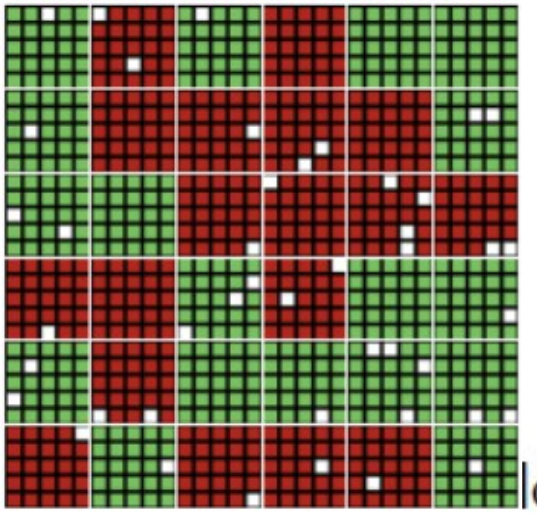
m



high T

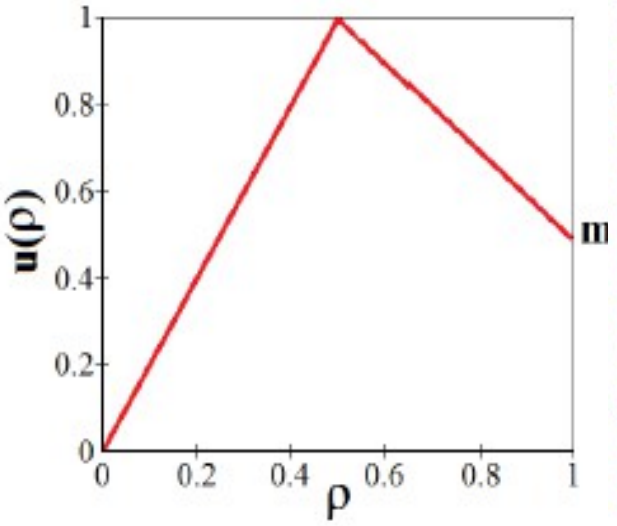


low T

Similarity with Ising ?

Stauffer and Solomon, arXiv :physics/0701051v1 "Schelling could have based his work on a long history of physics research (and Ising model)... but in 1971 Schelling did now yet know this physics"

CAUTION !



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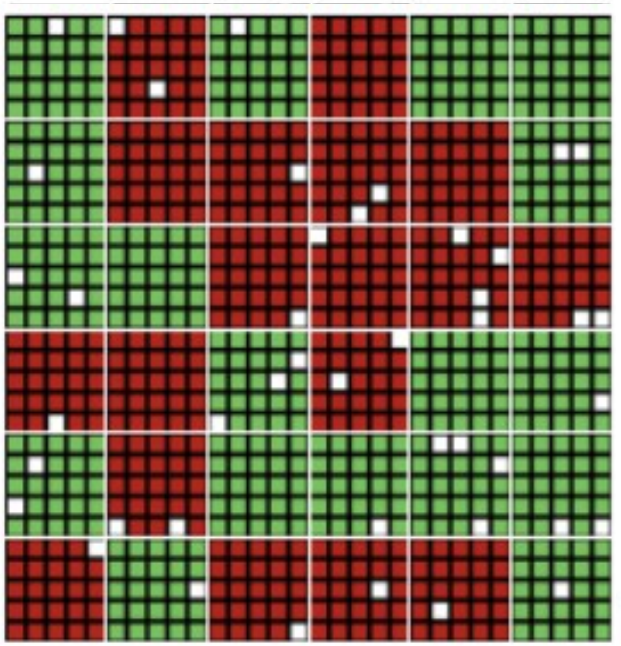


low T

% same color

Not so simple...

Concepts from physics and economics

Physics	Economics
Particles	Agents
Energy of a particle ϵ	Individual utility u
Total energy E	Collective utility $U = \sum u$
Dynamics : minimization of system's total (free) energy	Dynamics : maximization of agents' individual utility

Dynamical rule

- Change continuously between individual and collective dynamics :

$$Pr\{move\} = \frac{1}{1 + e^{-C/T}}$$

- $C = \Delta u + \alpha(\Delta U - \Delta u)$
- α : tax/cooperativity parameter

  $\alpha = 0 \longrightarrow$ "economics", individual dynamics

  $\alpha = 1 \longrightarrow$ "physics", collective dynamics
- How to predict the global state for a given utility $u(\rho)$?
- No state function ? !

Our solution : Link function

- There exists a **global** (state) function $L(x)$ such that, for each move

$$\Delta u = \Delta L$$

L links micro (individual moves) to macro (state function) !

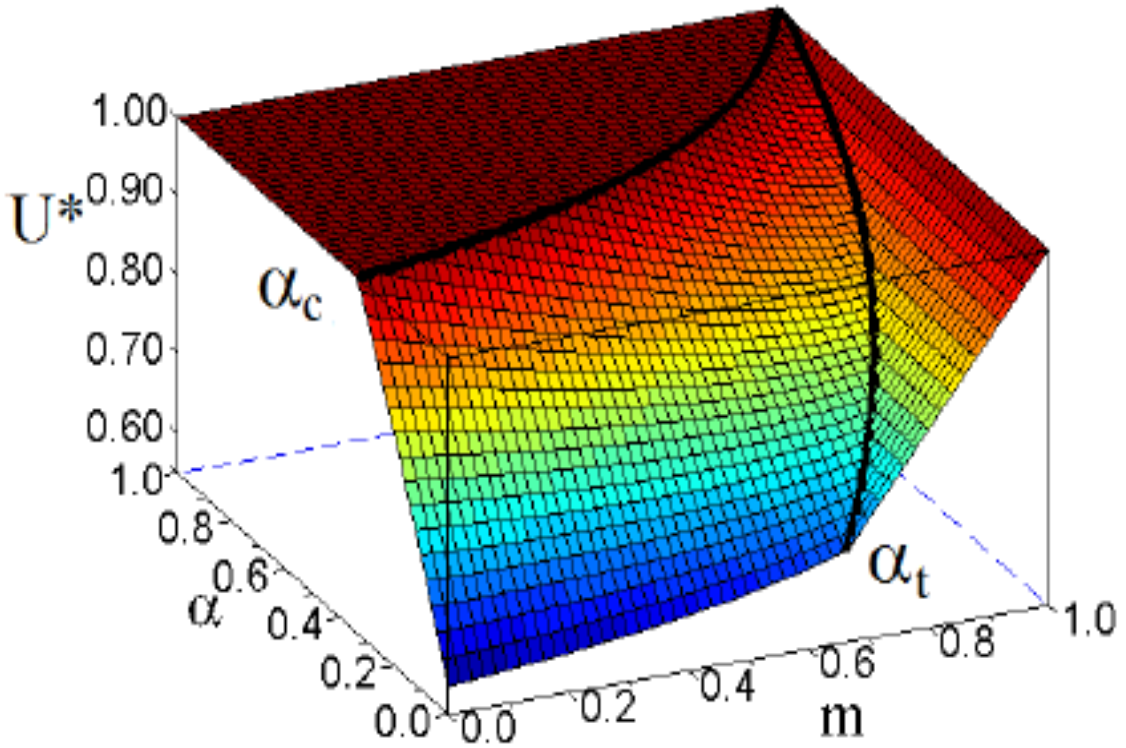
- $L(x) = \sum_q \sum_{m=1}^{n_q} u(m/H)$ *(simplifiée)*

- $\Pi(x) = \frac{1}{Z} e^{F(x)/T}, \quad F(x) = \alpha U(x) + (1-\alpha) L(x) + TS(x)$

$F(x)$: Generalized "free collective utility"

Resolution : $H, Q \gg 1$ + standard phase separation methods
Stationary state maximizes $F(x)$ (not U !)

Collective utility - analytical result !



$$U^* = U/U_{max} = U/(\rho_0 HQ)$$

Conclusion

Conceptual differences between individual and collective dynamics

- L extends free energy to deal with individual dynamics
- First analytical solution of (a simplified) Schelling model
- Paradigmatic example of unexpected macro behavior (40 citations/year)
- Interdisciplinary fruitful for both disciplines if respect of specificities !

JP Bouchaud (review, J Stat Phys, 2013) : the most striking example in this review … is the clear quantitative demonstration ***[Grauwin]****, that the invisible hand can fail at solving simple coordination problems*

Conceptually ok : but have we learnt something about society ?

Atomistic explanations

• Physique statistique: part de micro stable, pour "déduire" le macroscopique : des atomes aux propriétés des solides, des utilités individuelles à la ségrégation globale

• Expliquer en physique = ramener à phénomènes plus stables, plus généraux (noyaux, électrons ou atomes/matériaux ok !) Mais utile pour bio, socio : gènes, classe sociale ?

• We should not imagine that each individual is originally equipped with its own power, that he would then provide to common institutions. Instead, it is from the common power that each individual takes his individual power : we can think thanks to a - necessarily common - language.

(Y Citton, Mythocraties, éd. Amsterdam, 2010)

Atomistic explanations

Simulating macro as emerging from the interactions among micro works because the properties of micro-agents, the rules of interaction and the nature of macro-structures are conveniently *simplified* to fit each with other

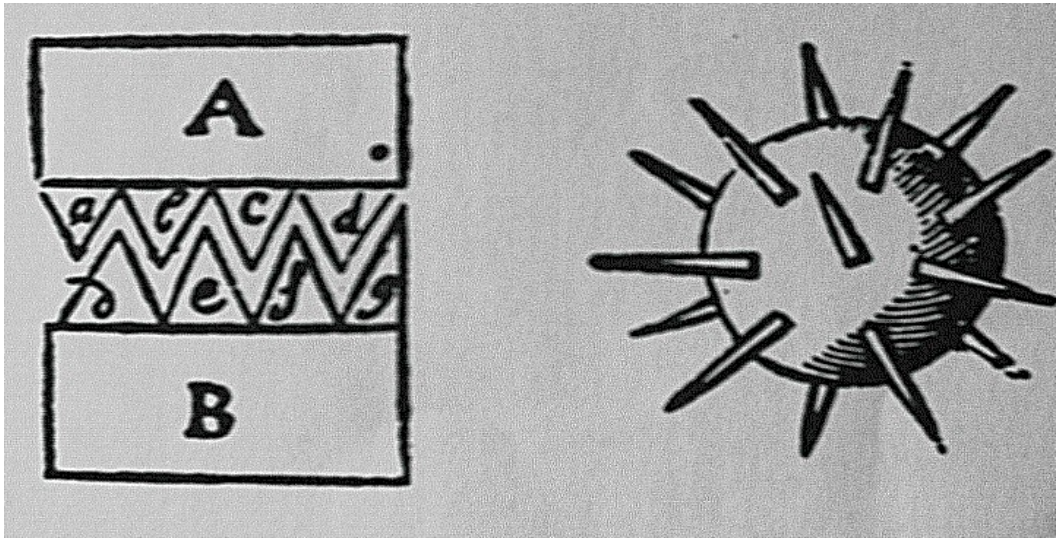
But why simulate the link between *artificial extremes*, when we can deploy the imbroglios of heterogeneous entities and map their roles **empirically**?

Micro-macro distinction

not relevant for social?

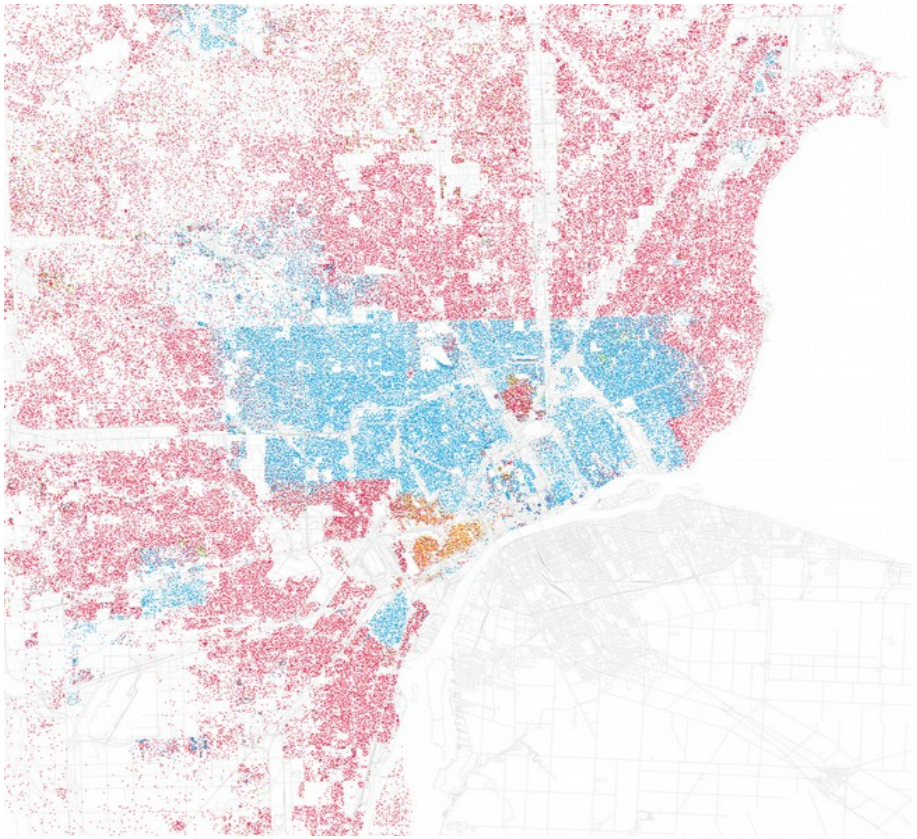
"Interactions" not local

in space nor time

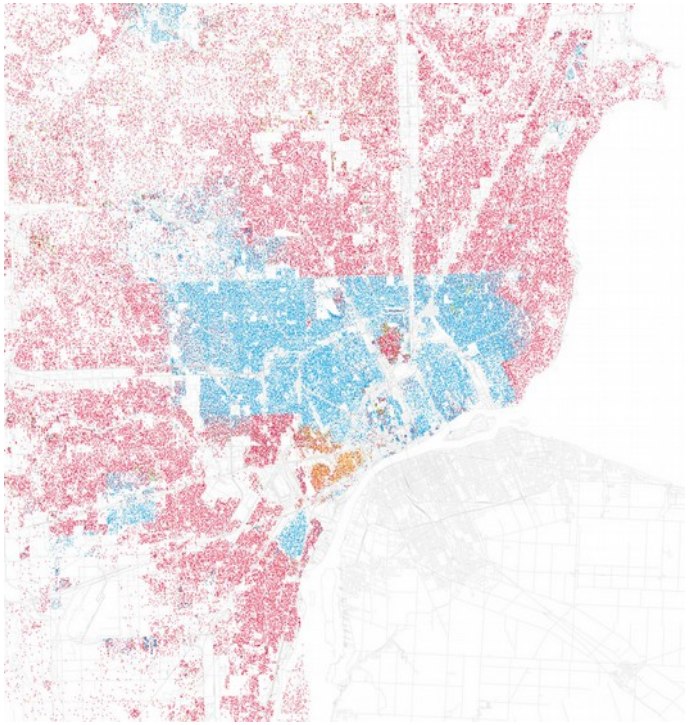


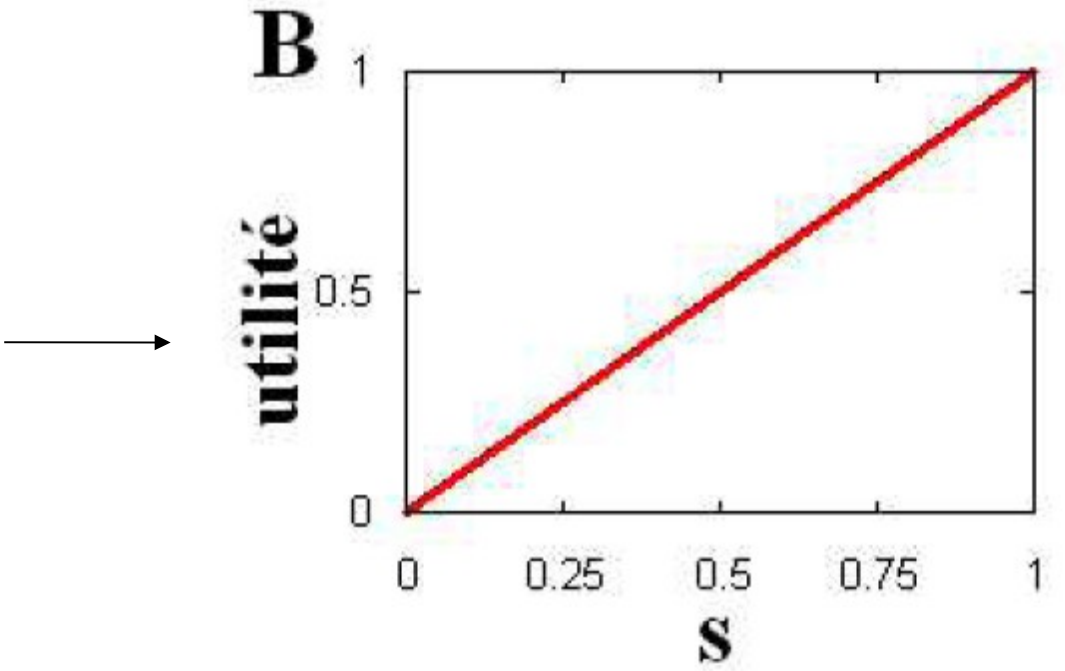
« atomes » des Cartésiens, 1700

« Alternative » to *atomistic* explanations : macro smaller than its parts ? Example of racial segregation



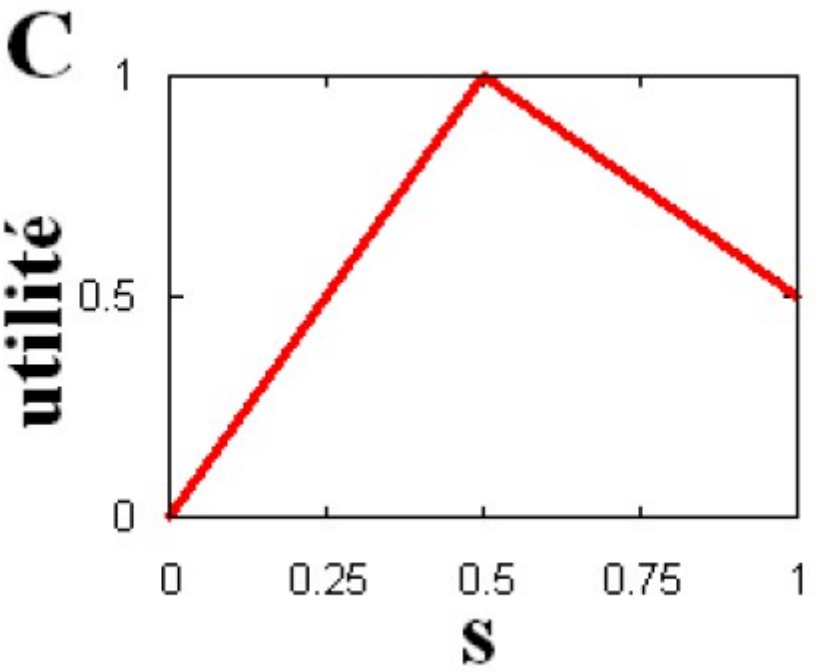
Detroit : non-Hispanic white is red, black is blue, Hispanic is orange and Asian is green (toutes les couleurs !)

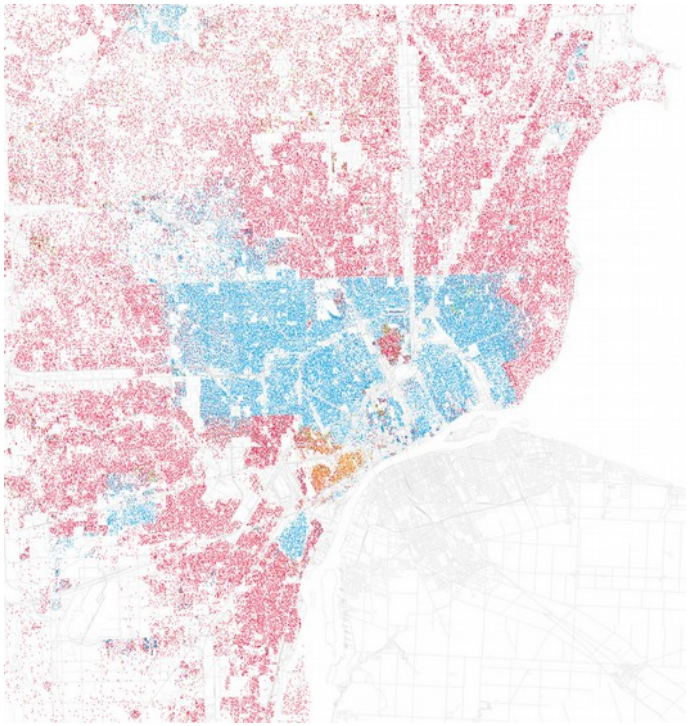




Micro ↔ macro, sociologie *à la Durkheim* (caricature) :
1. Régularité statistique (ségrégation macro, stable)

2. Explication : norme intériorisée par individus (macro→ micro), préférence (inconsciente ?) vers ségrégation

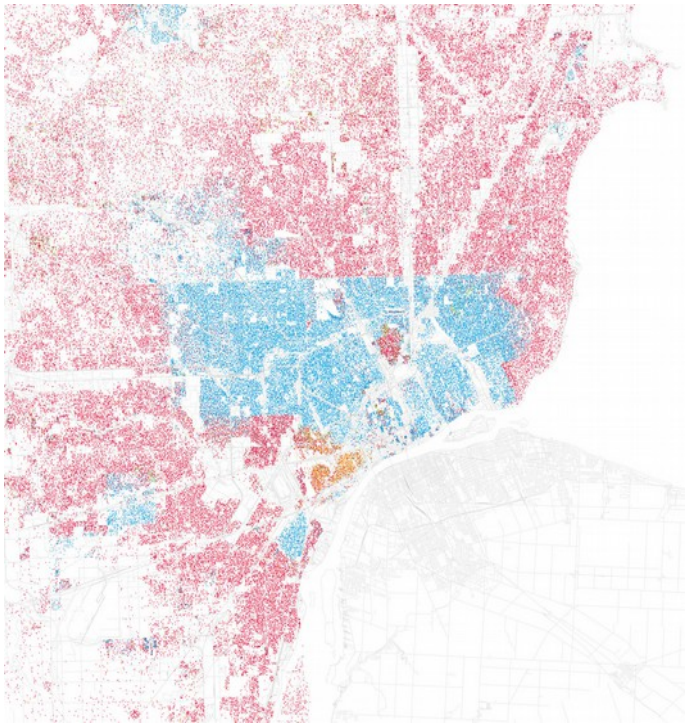




Micro/macro en économie/socio-physique :
Chaque 'atome social' va maximiser son utilité individuelle (d'où vient-elle?)

Préférence individuelle pour mixité mène à... ségrégation ! (Schelling, Grauwin et al 2009) Macro → micro : attention !

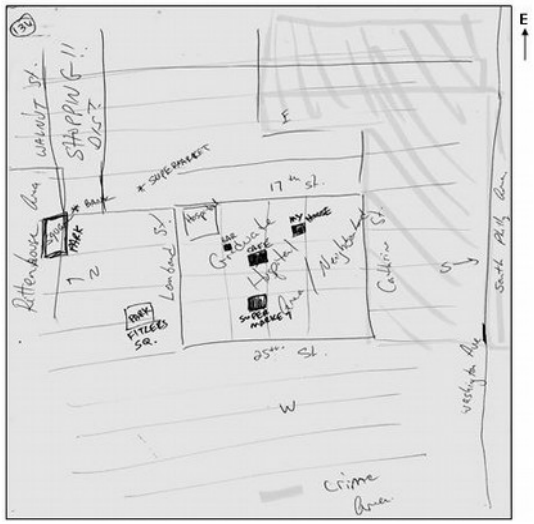
Physique : maximiser (énergie) globale



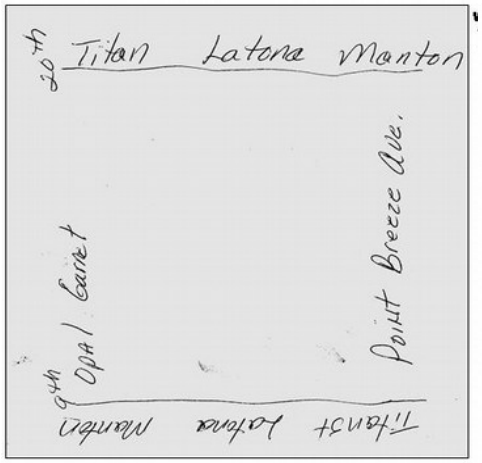
Macro (ville, quartier) est complexe et grand, fait d'interconnexions entre parties homogènes (micro, simples)

Vision alternative : macro est plus petit que les parties (coll B Latour, médialab, Sciences Po, Paris)

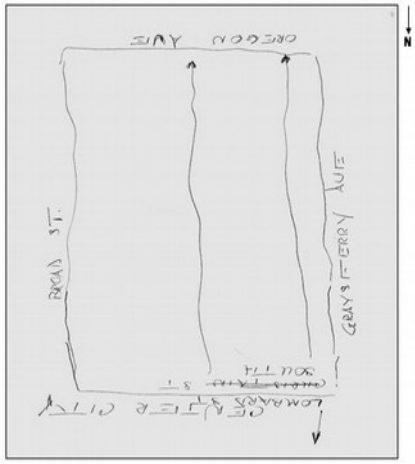
Macro comme cohérence partielle et construite



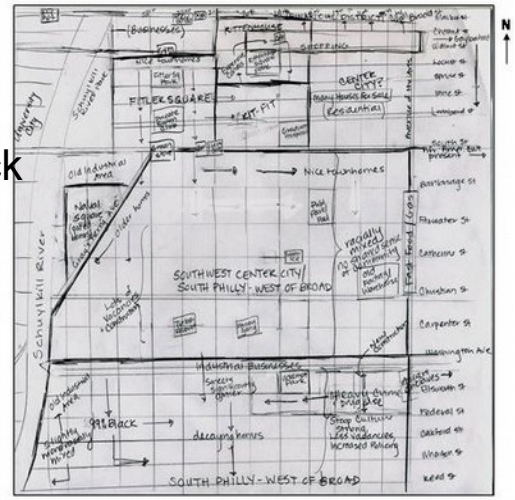
Melissa, 30-year-old
White female



Alan, 62-year-old
retired Black



Denise, 37-year-old Black

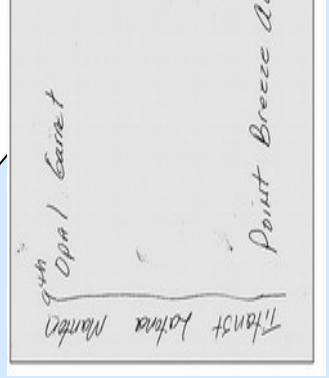


My personal map

Translation of Melissa's map onto **standard map** provided by Philadelphia NIS (Macro)

From J Hwang
Sociology Department
Stanford University

Example : each person has its own vision of his neighborhood (and « his » segregation) :coherent macro ?



Alan

retired

black

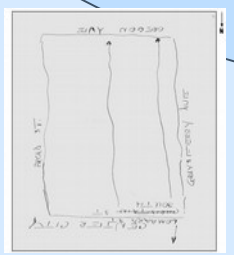
Melissa

30 years

White

female

37 years



Black

Neighborhood = Whole = standard map
Smaller than parts, intersection,
partial coherence, *made*

Denise

Sociophysics useful ?

- Modèles jolis (pertinents?) ou outils d'analyse de données (sales)?
- Cognitive issues :
  - « social atom », drastic (and too convenient) simplification
  - simple models buy internal validity at the cost of external validity, use "thin concepts", homonymous with everyday concepts, but "little of their behaviour from the real world is imported into the model" (Cartwright 1999)
  - useful conceptually, better than economics, or when human action "channelled" : traffic, epidemiology...
  - "Tragedy of the commons" modeled by *robots* (rational and selfish individuals, game theory, no creativity) : overexploitation of the common good. But empirical work (Ostrom) : cooperation, creative adaptation to social/ecological context, find arrangements to successfully manage the commons.

Sociophysics useful ?

- Political issues :
  - Black box, unlegitimate expertise (Galam *Le Monde*, Schelling and « urban segregation, a fatality », Pour la science 2006)
  - models = social engineering, legacy of WWII (why physicists?)
  - "our knowledge of [social] mechanisms [..] is essential for self-optimization of the society as a whole." (Barabasi, Nature, 2007; *FuturICT* projet européen 1G€)
  - The "whole/macro" has to be decided in common
- Besoin de nouveaux outils formels pour tirer parti de l'avalanche de données sociales : quelle nouvelle « (physique) statistique » ?
  - Dangers de la centralisation des données sociales (Snowden)
  - Utilisation réflexive des analyses de données sociales?

Institut **pluridisciplinaire** Hubert Curien

“Créé en 2006, l'IPHC est un exemple de réussite de la pluridisciplinarité : trois laboratoires de culture scientifique différente (physique subatomique, chimie et eco-physiologie) regroupés en un institut unique.”

Unité scientifique ou administrative ?