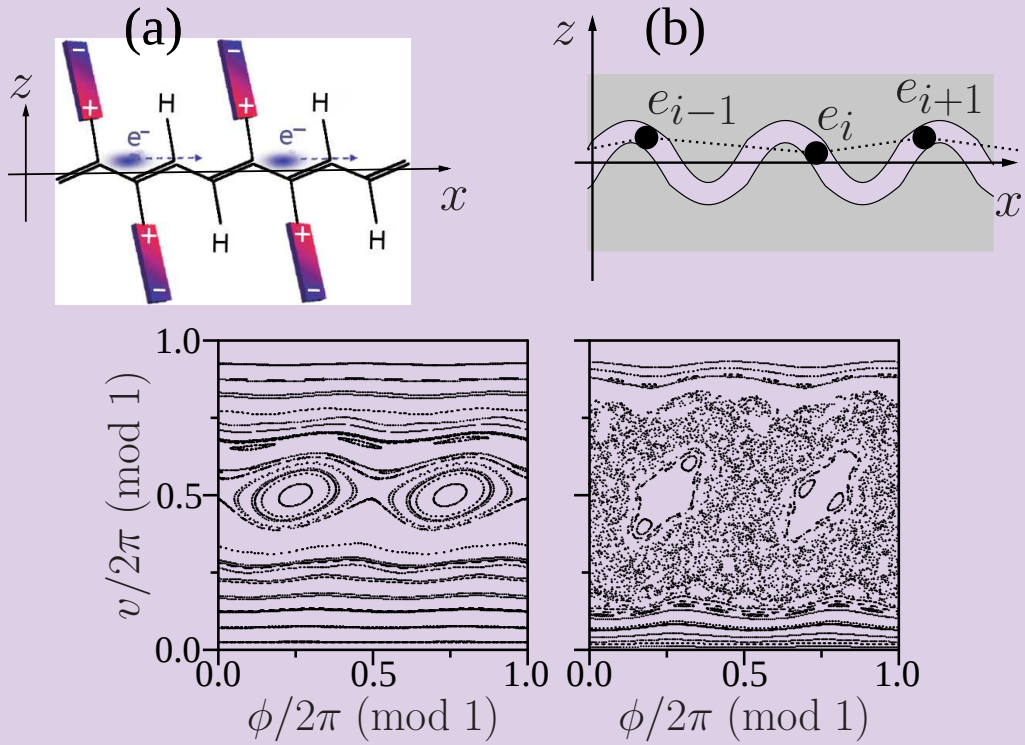
Wigner crystal in snaked nanochannels

Dima Shepelyansky (CNRS, Toulouse)
www.quantware.ups-tlse.fr/dima

with Oleg Zhirov (Budker Inst. of Nuclear Physics, Novosibirsk)

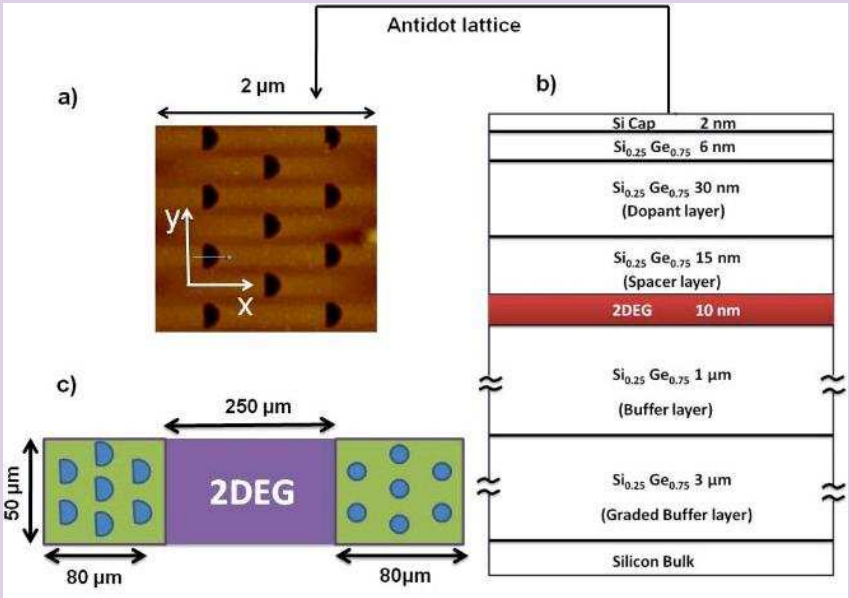


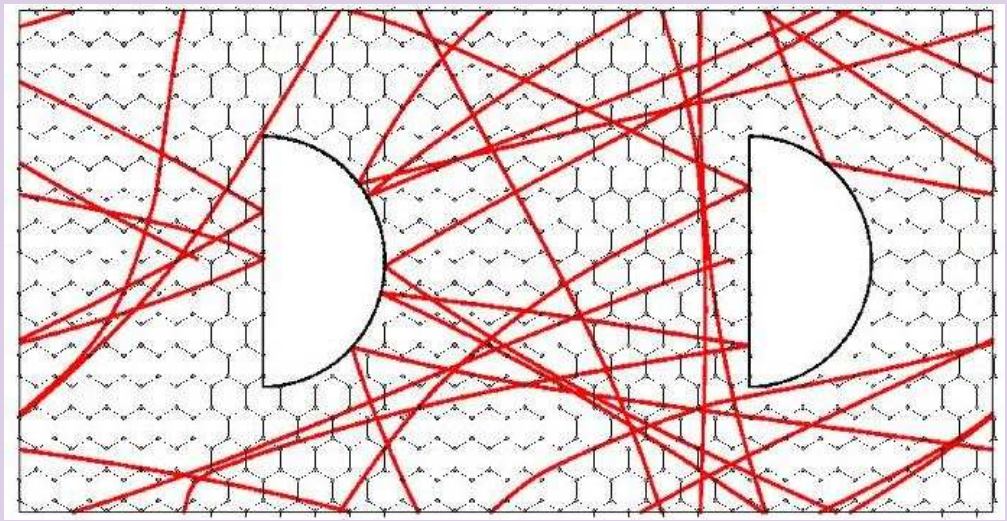
Wigner snake sliding arXiv:1102.1277 (2011) to apear at EPJB

Ratchet transport in asymmetric nanostructures

Dima Shepelyansky (CNRS, Toulouse)
www.quantware.ups-tlse.fr/dima

within ANR PNANO NANOTERRA project





electron transport created by microwave field
J.-C.Portal *et al.* Nanotechnology v.22, p.245401 (2011)
relativistic graphene ratchet L.Ermann, DLS EPJB v.79, p.357 (2011)

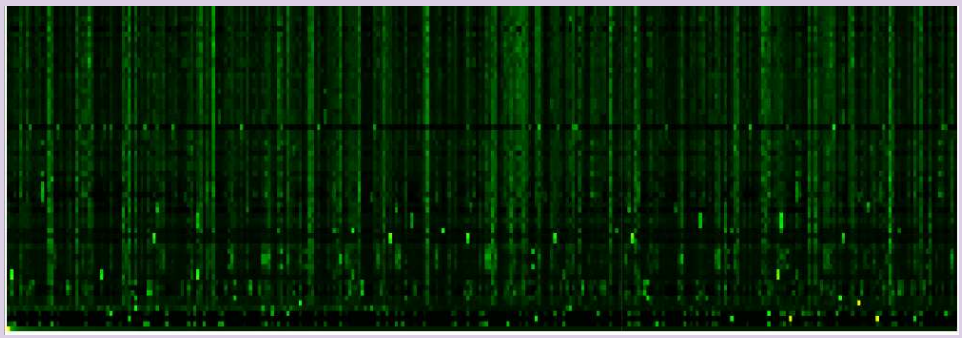
Google Matrix of the World Trade Network

Dima Shepelyansky (CNRS, Toulouse)
www.quantware.ups-tlse.fr/dima

with Leonardo Ermann (ANR-CNRS, Toulouse) => arXiv:1003.5027

"The knowledge of a trade is worth a handful of gold"

Through mechanisms still only partially understood,
Google finds instantaneously the page you need.



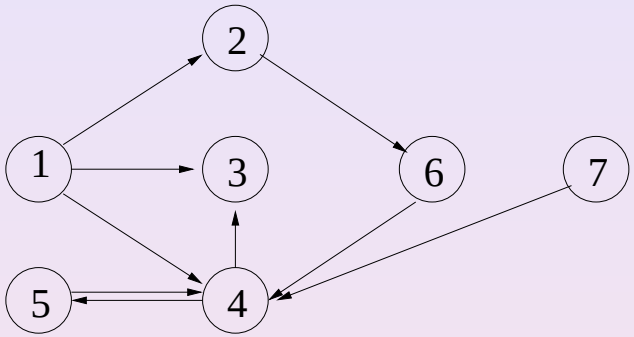
Story started in 1998 (now $N \sim 10^{11}$ nodes)

S. Brin and L. Page, Computer Networks and ISDN Systems **30**,107 (1998).

How Google works

Markov chains and Directed networks

Weighted adjacency matrix



$$\mathbf{S} = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \frac{1}{3} & 0 & 0 & 0 & 0 & 0 & 0 \\ \frac{1}{3} & 0 & 0 & \frac{1}{2} & 0 & 0 & 0 \\ \frac{1}{3} & 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & \frac{1}{2} & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

For a directed network with N nodes the adjacency matrix $\mathbf{A}$ is defined as $A_{ij} = 1$ if there is a link from node j to node i and $A_{ij} = 0$ otherwise. The weighted adjacency matrix is

$$S_{ij} = A_{ij} / \sum_k A_{kj}$$

In addition the elements of columns with only zeros elements are replaced by $1/N$.

How Google works

Google Matrix and Computation of PageRank

$\mathbf{p} = \mathbf{S}\mathbf{p} \Rightarrow \mathbf{p}$= stationary vector of $\mathbf{S}$; can be computed by iteration of $\mathbf{S}$.

To remove convergence problems:

- Replace columns of 0 (dangling nodes) by $\frac{1}{N}$:

  In our example, $\mathbf{S} = \begin{pmatrix} 0 & 0 & \frac{1}{7} & 0 & 0 & 0 & 0 \\ \frac{1}{3} & 0 & \frac{1}{7} & 0 & 0 & 0 & 0 \\ \frac{1}{3} & 0 & \frac{1}{7} & \frac{1}{2} & 0 & 0 & 0 \\ \frac{1}{3} & 0 & \frac{1}{7} & 0 & 1 & 1 & 1 \\ 0 & 0 & \frac{1}{7} & \frac{1}{2} & 0 & 0 & 0 \\ 0 & 1 & \frac{1}{7} & 0 & 0 & 0 & 0 \\ 0 & 0 & \frac{1}{7} & 0 & 0 & 0 & 0 \end{pmatrix}$.

- To remove degeneracies of $\lambda = 1$, replace $\mathbf{S}$ by **Google matrix**

  $\mathbf{G} = \alpha\mathbf{S} + (1-\alpha)\frac{\mathbf{E}}{N}$; $Gp = \lambda p$ => Perron-Frobenius operator

- α models a random surfer with a random jump after approximately 6 clicks (usually $\alpha = 0.85$); PageRank vector => p at $\lambda = 1$ ($\sum_j p_j = 1$).

- CheiRank: $\mathbf{S}^*$ with inverted link directions proposed at A.D.Chepelianskii arXiv:1003.5455 (2010)

Models of real networks

Real networks are characterized by:

- **small world property**: average distance between 2 nodes $\sim \log N$
- **scale-free property**: distribution of the number of incoming or outcoming links $P(k) \sim k^{-\nu}$ $(\nu \sim 2.1(in); 2.7(out))$

Can be explained by a twofold mechanism:

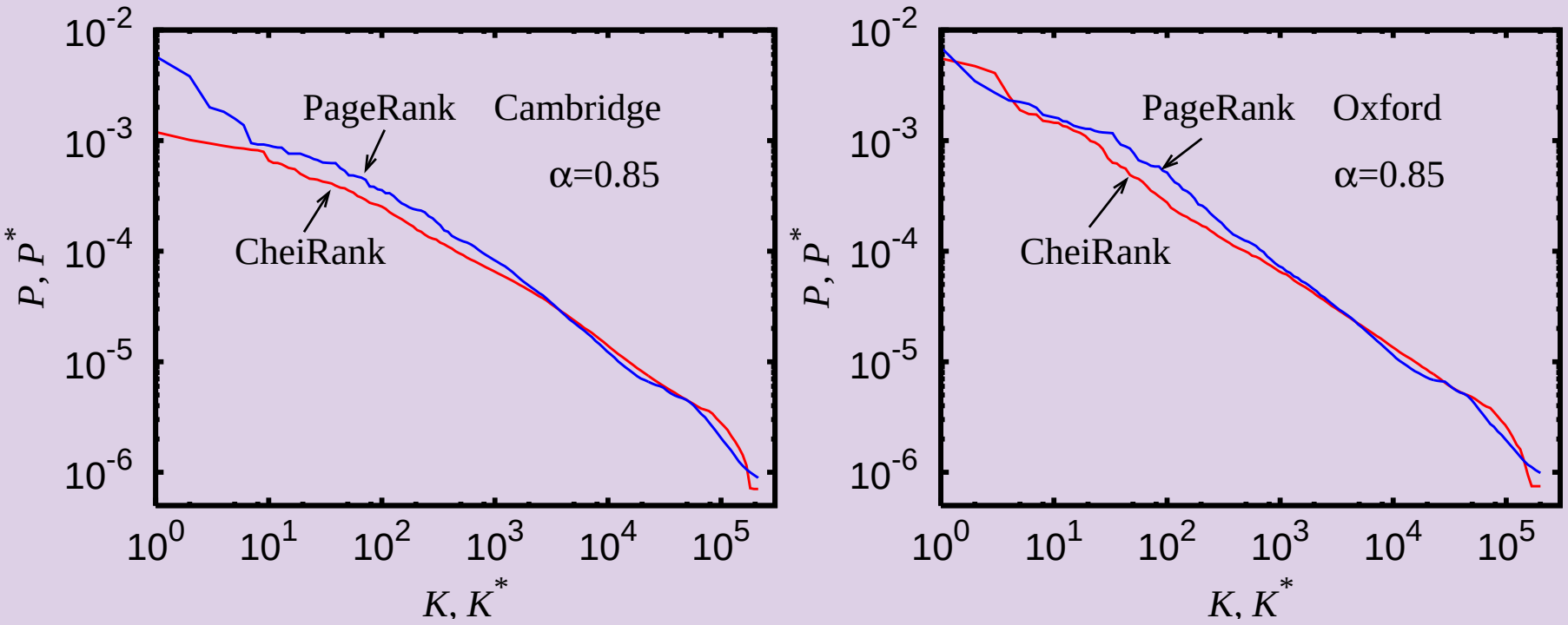
- Constant growth: new nodes appear regularly and are attached to the network
- Preferential attachment: nodes are preferentially linked to already highly connected vertices.

PageRank vector for large WWW (proportional to ingoing links):

- $p_j \sim 1/j^{\beta}$, where j is the ordered index
- number of nodes N_n with PageRank p scales as $N_n \sim 1/p^{\nu}$ with numerical values $\nu = 1 + 1/\beta \approx 2.1$ and $\beta \approx 0.9$

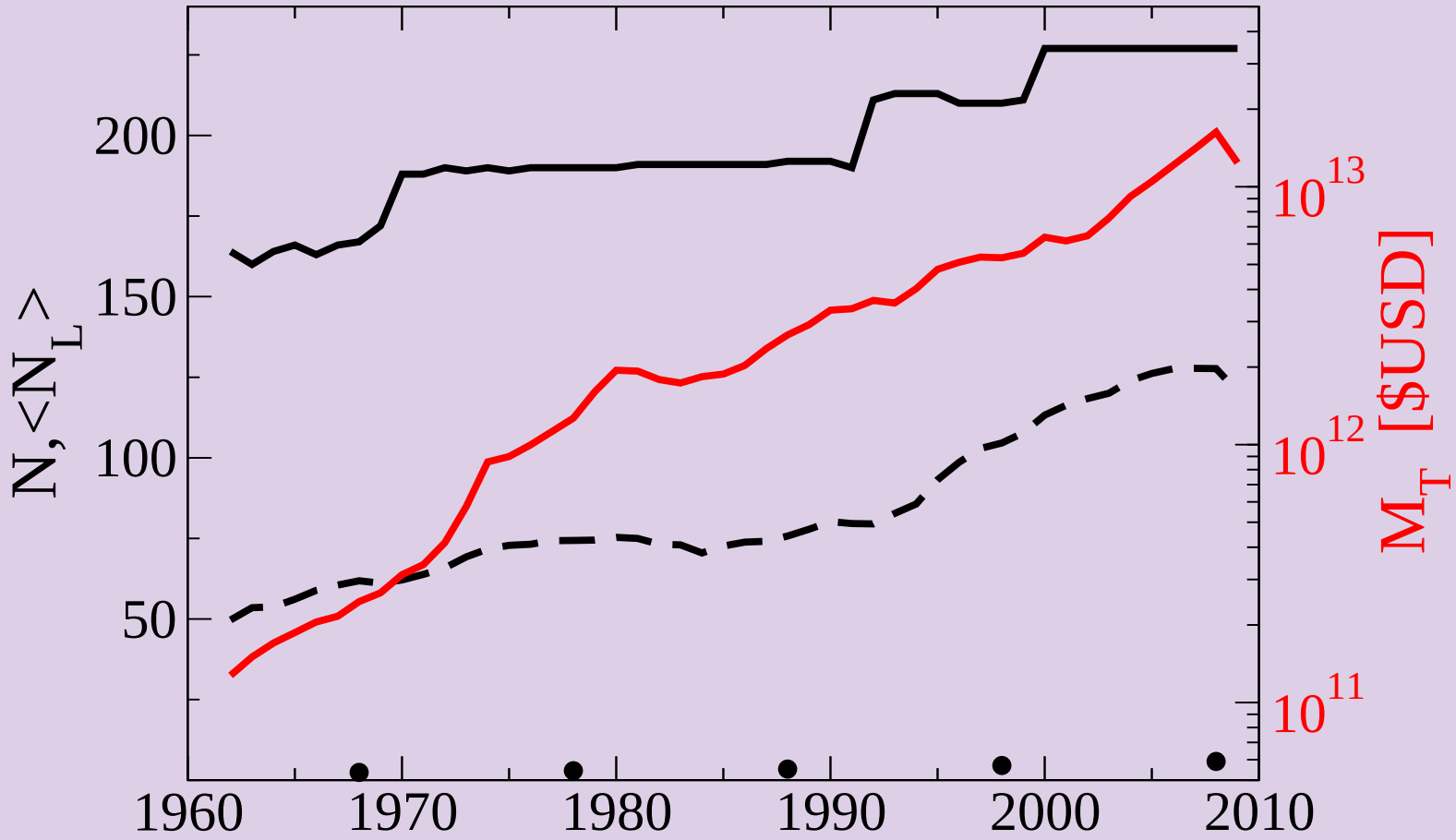
CheiRank vector is proportional to outgoing links $\beta \approx 0.6$

PageRank probability



Univ. Cambridge and Oxford (2006) $\alpha = 0.85$, $N \approx 200000$.

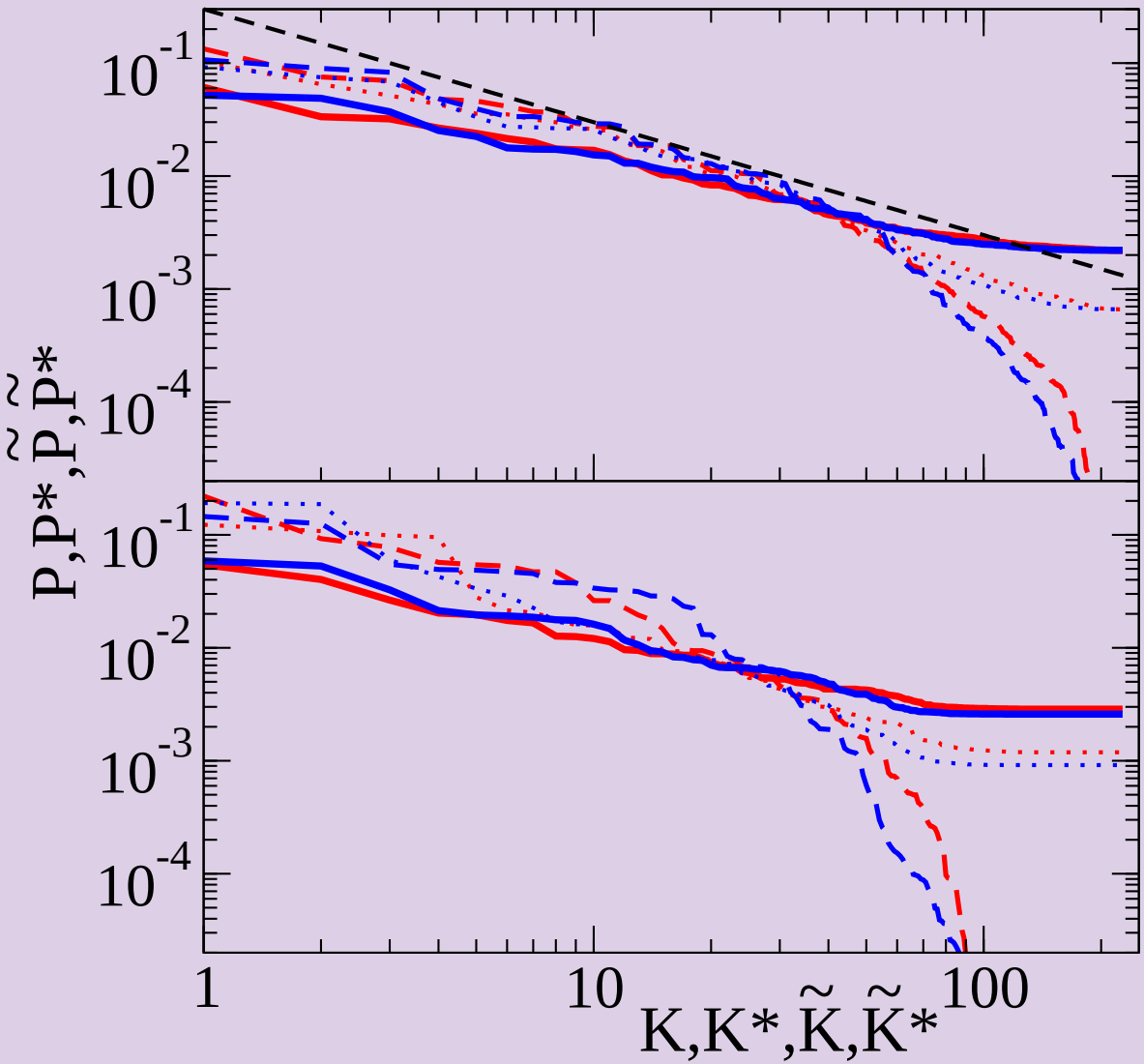
World trade & United Nations
COMTRADE 1962-2009



Nomber of countries, links and mass volume in USD

L.Ermann, DLS arxiv:1103.5027 (2011)

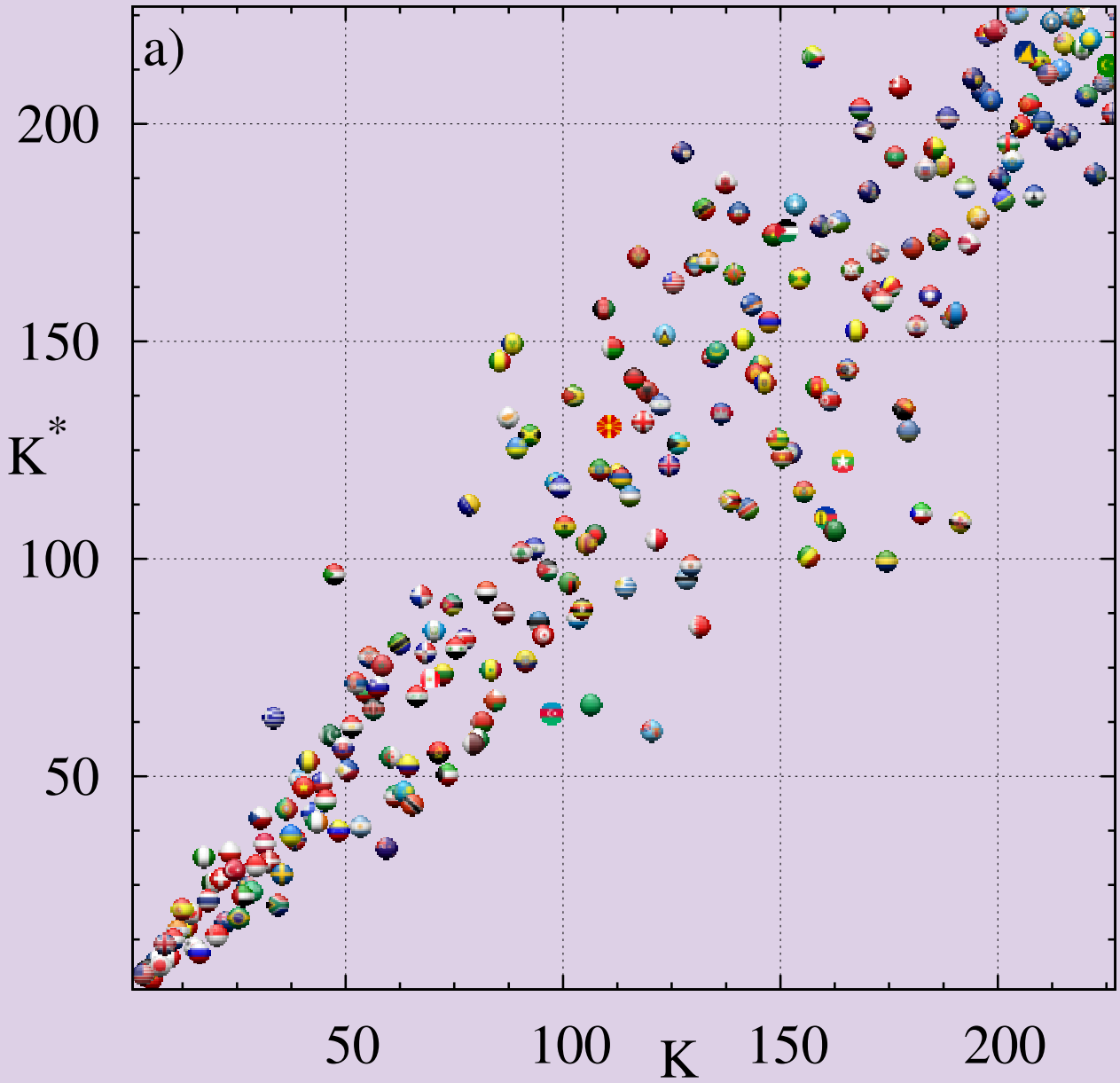
PageRank, CheiRank of World Trade



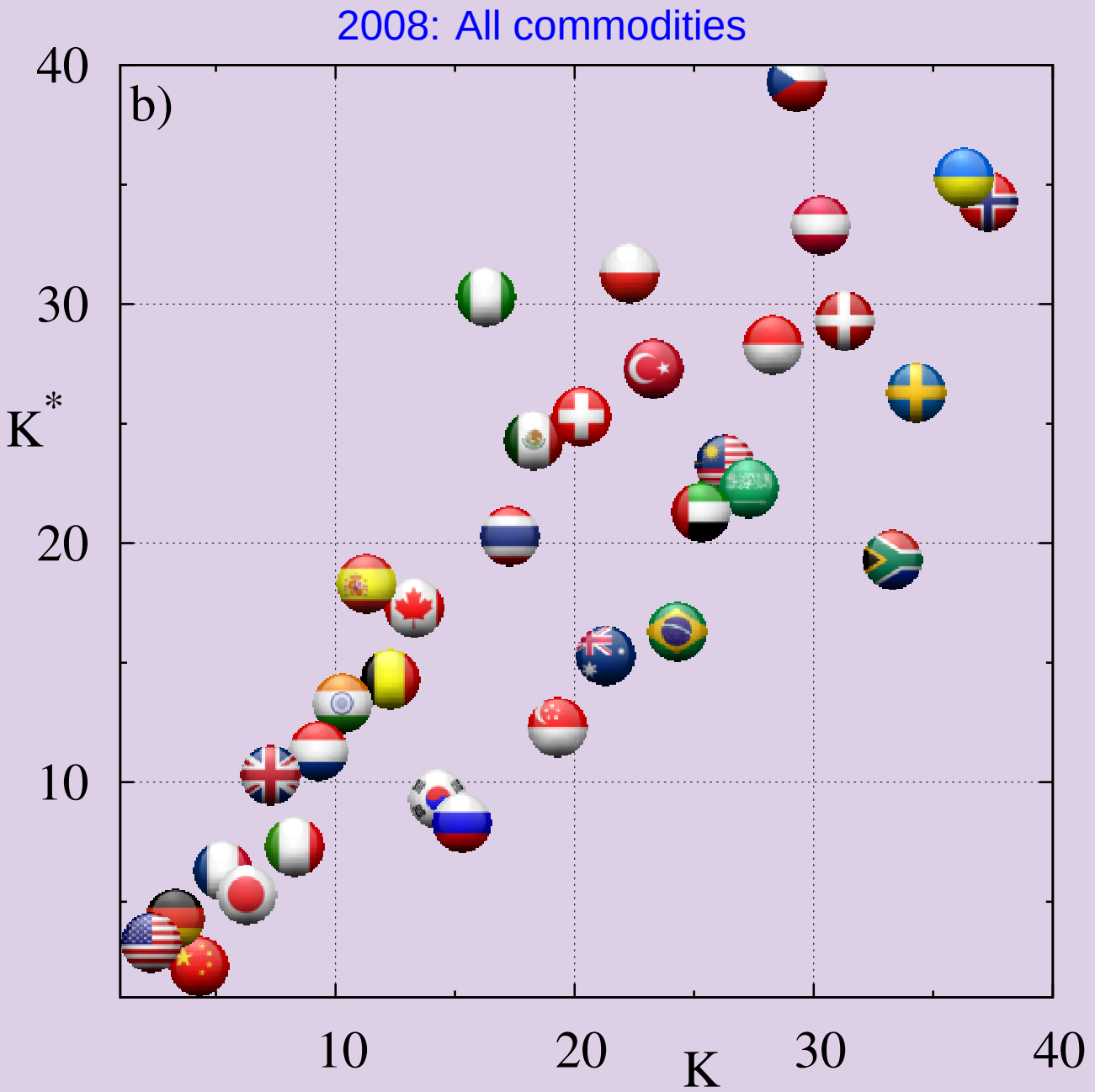
2008: Probabilities of PageRank $P(K)$ (red), CheiRank $P^*(K^*)$ (blue) for all commodities (top) and crude petroleum (bottom) (dashed curves are for ImportRank, ExportRank), 227 countries

Ranking of World Trade

2008: All commodities

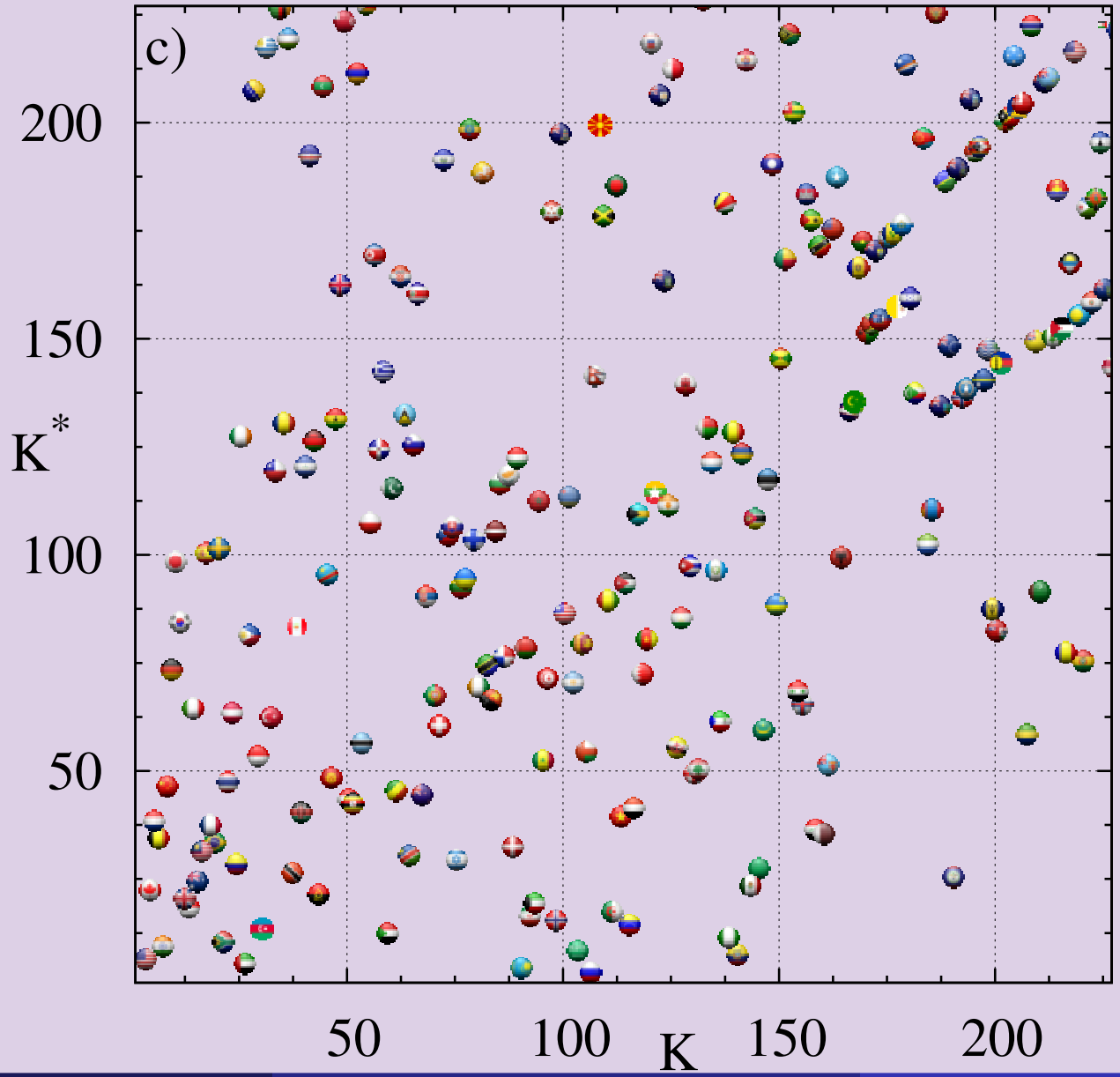


Ranking of World Trade

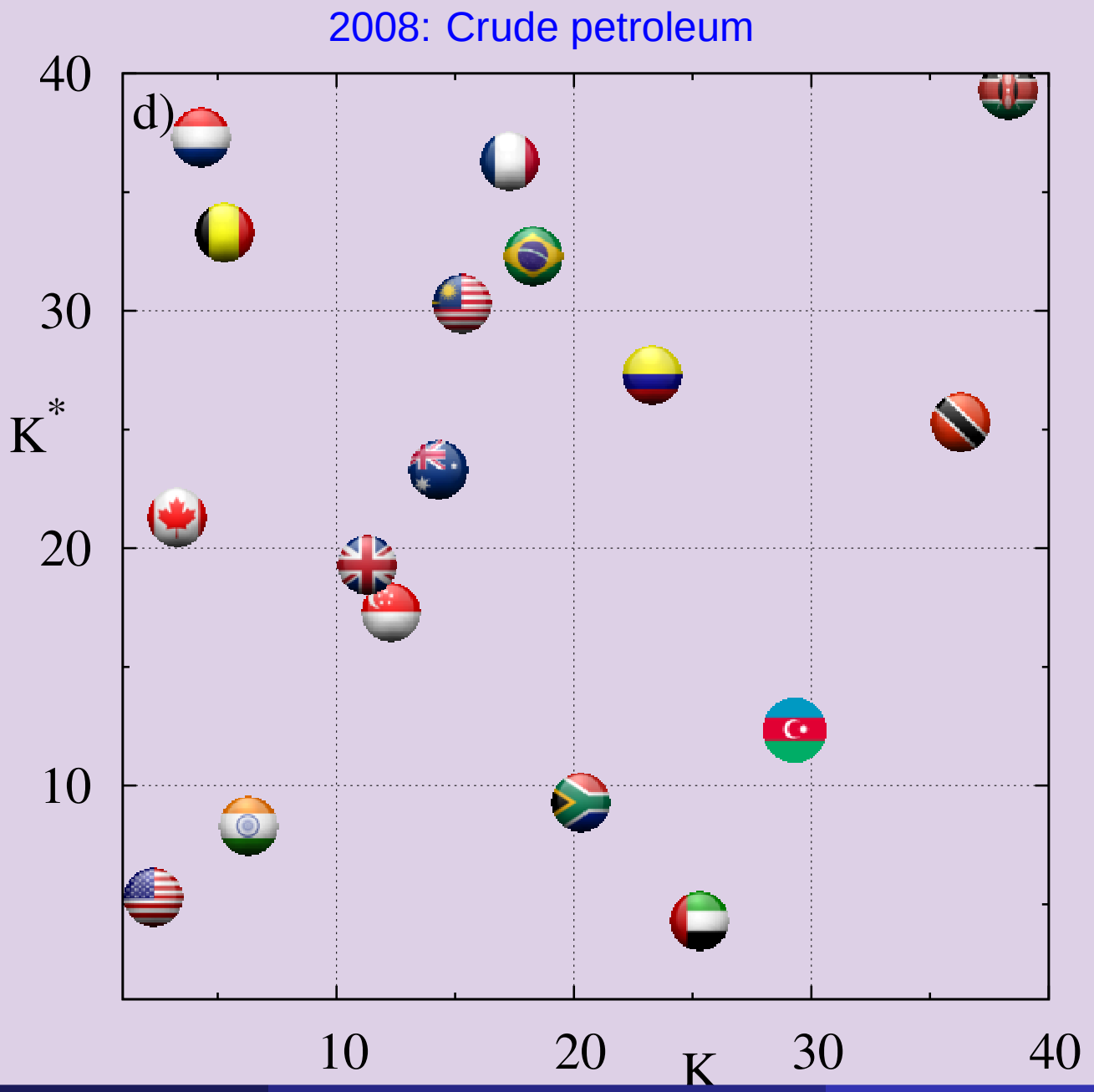


Ranking of World Trade

2008: Crude petroleum

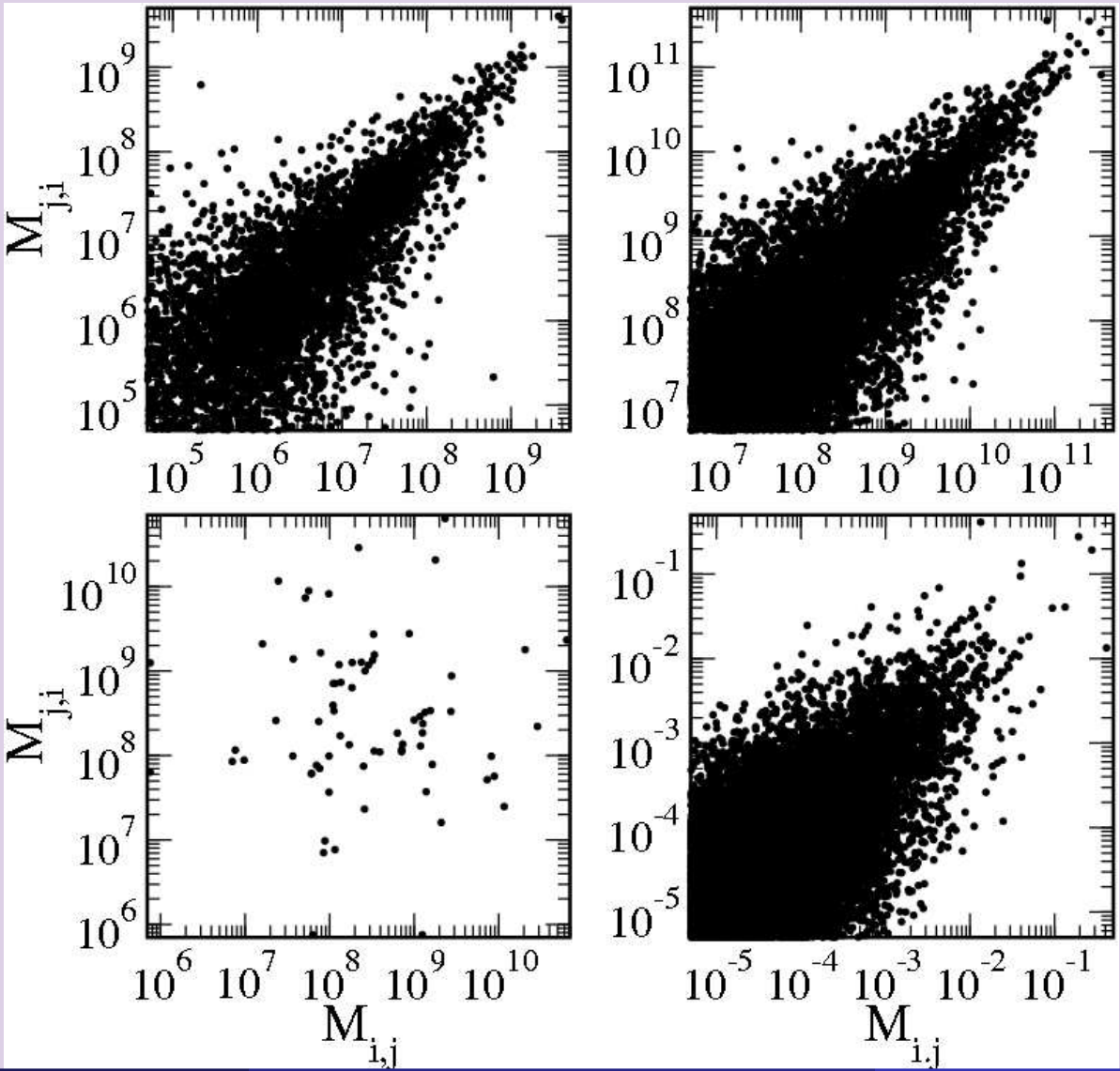


Ranking of World Trade



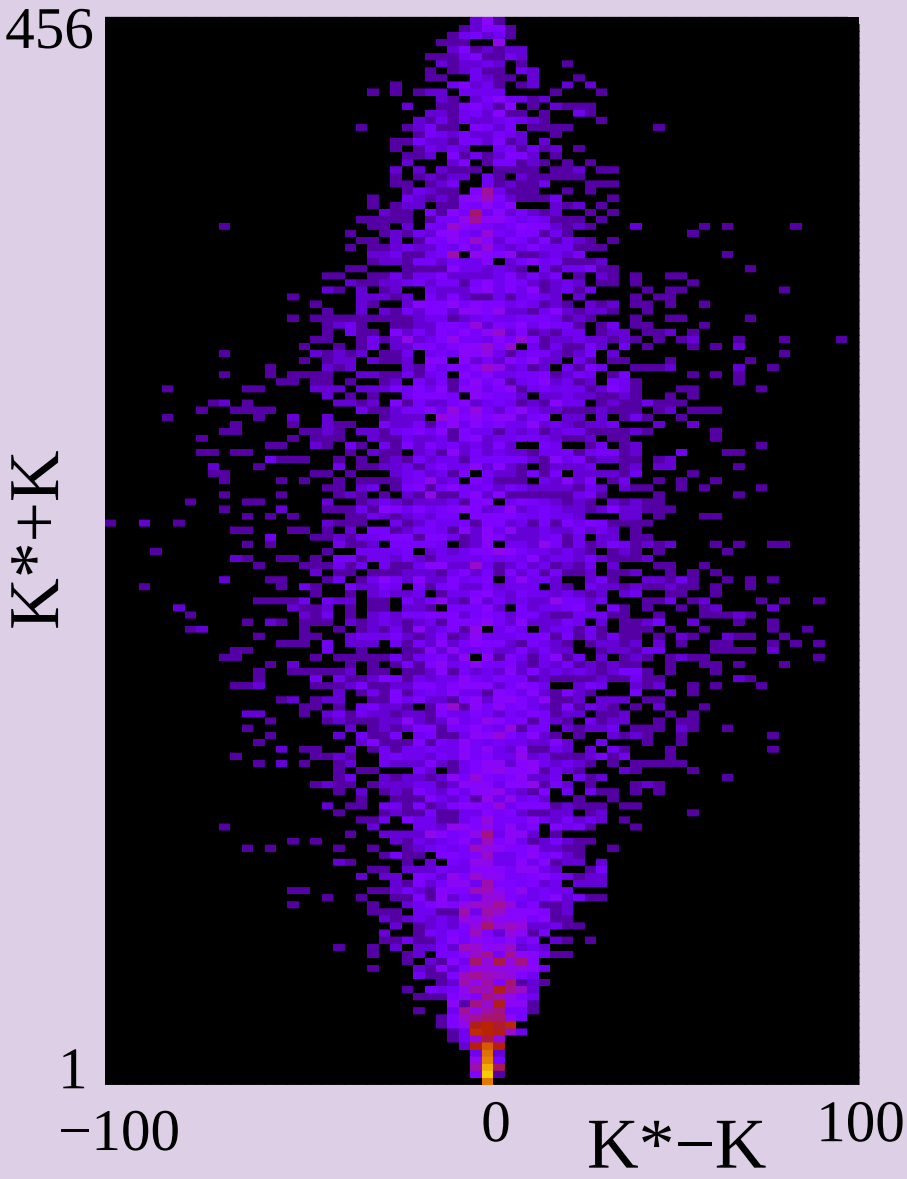
Mass flow on World Trade Network (WTN)

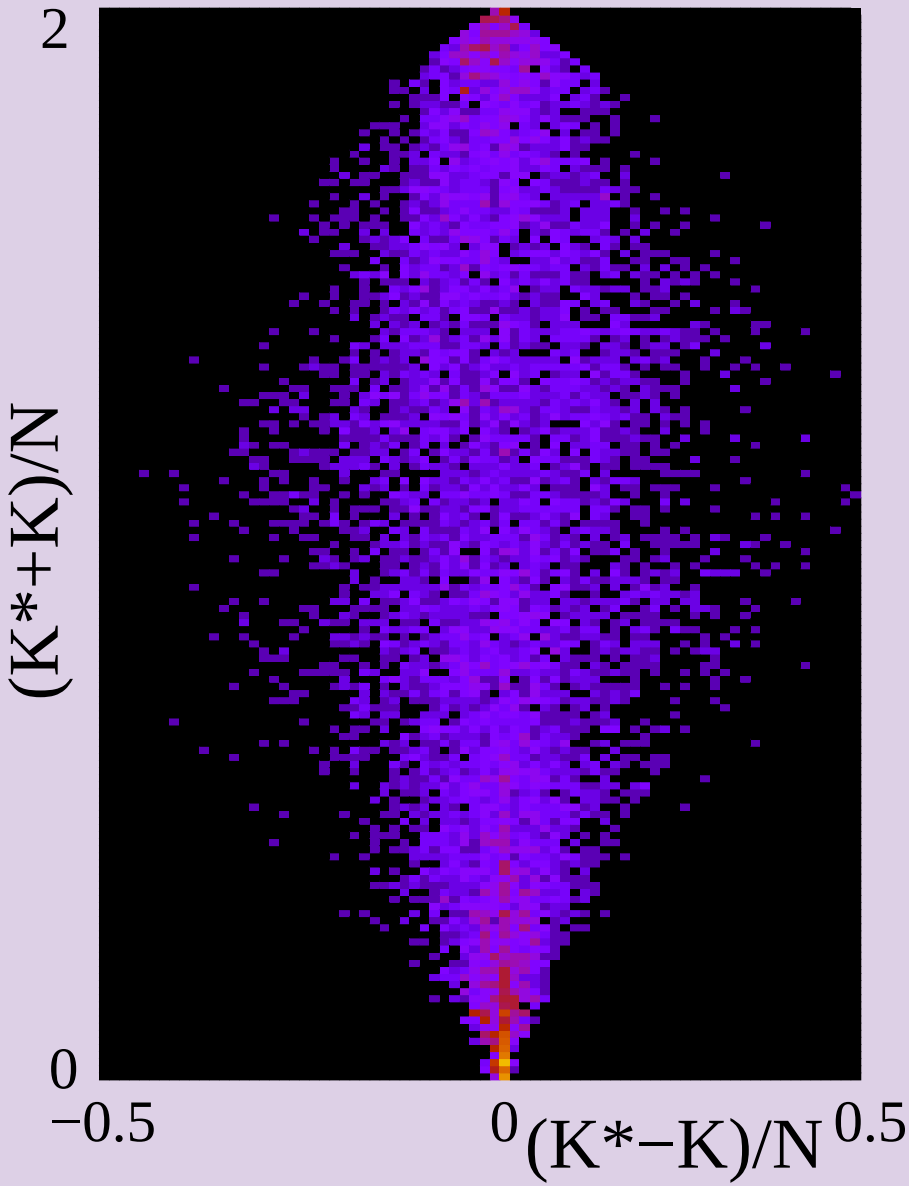
RMT model $M_{ij} = \epsilon_i \epsilon_j / ij$ (all commod. 1962/2008 left/right top; petroleum left bottom; model right bottom)



Global distribution for WTN

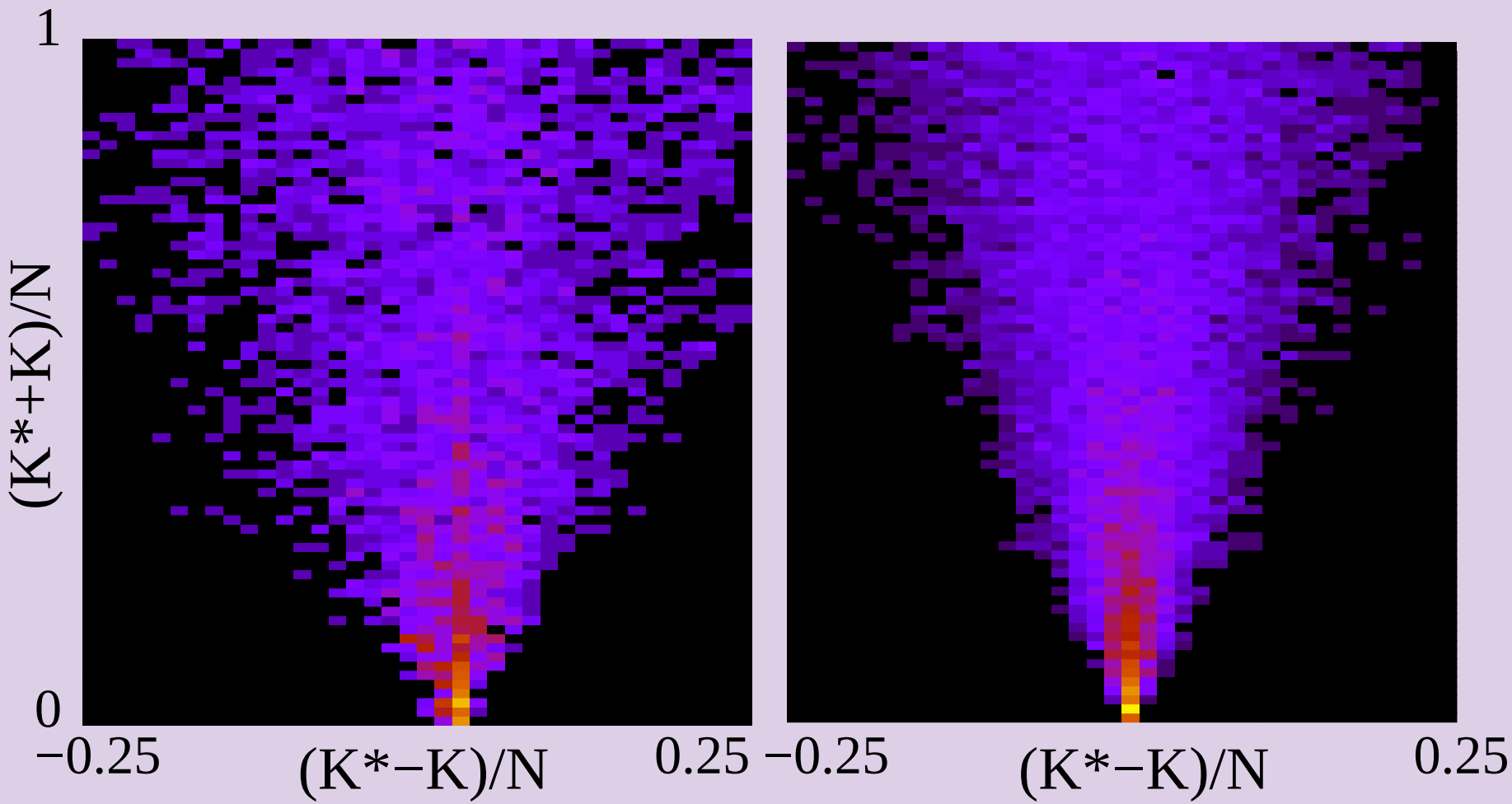
All commodities 1962-2009





Global distribution for WTN

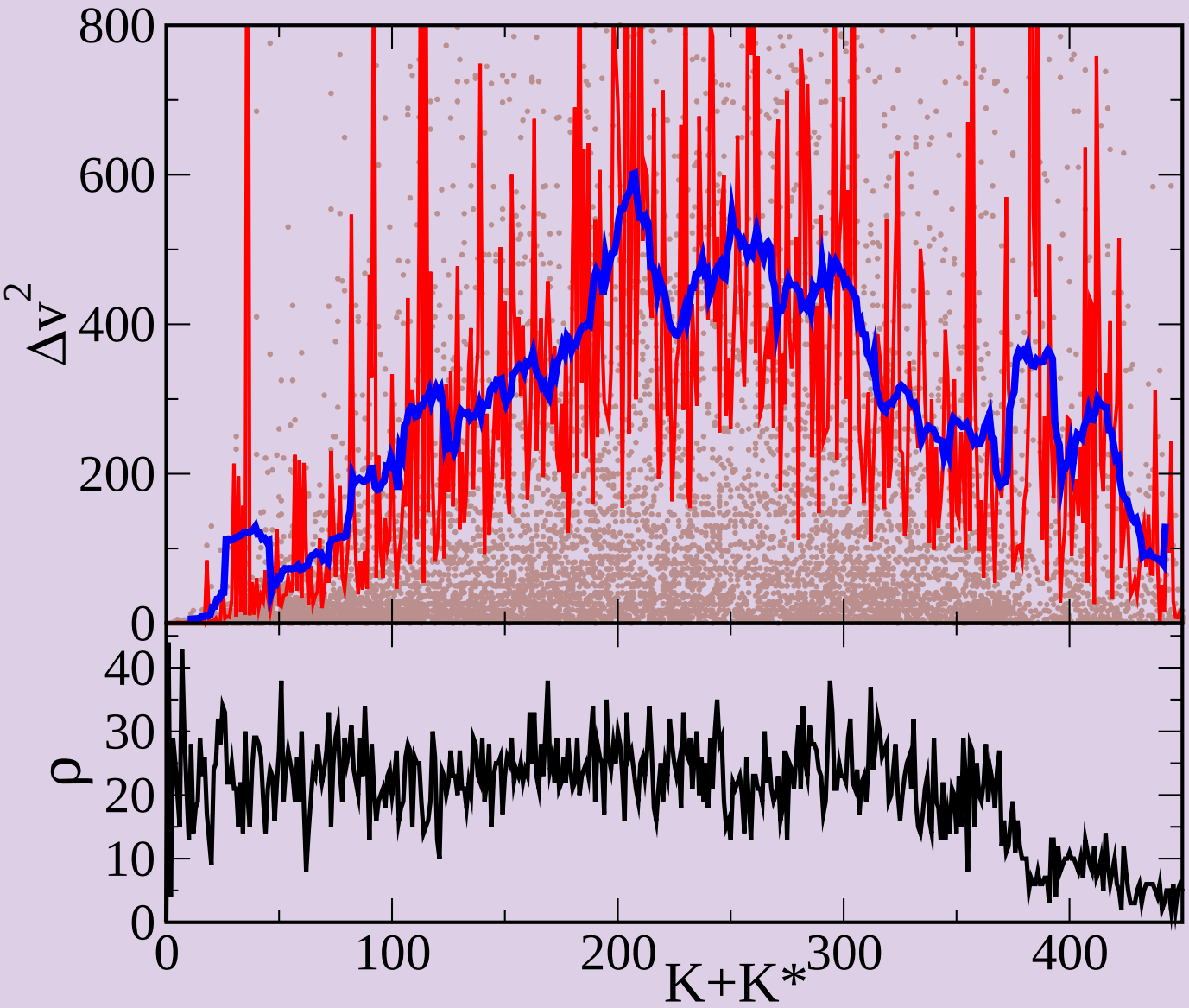
All commodities 1962-2009: left - zoom, right - RMT model



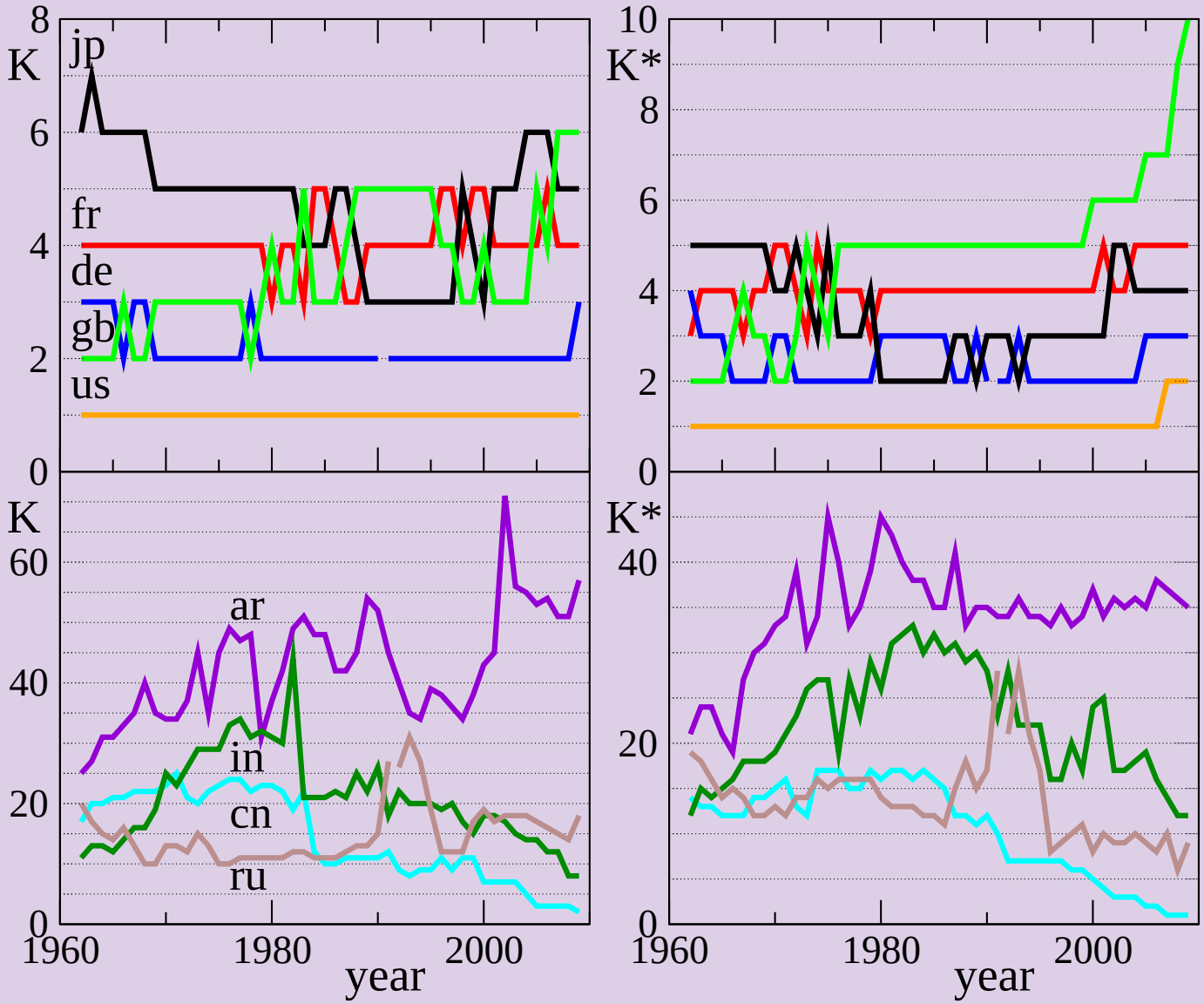
The poor stay poor and the rich stay rich

Velocity fluctuations for WTN

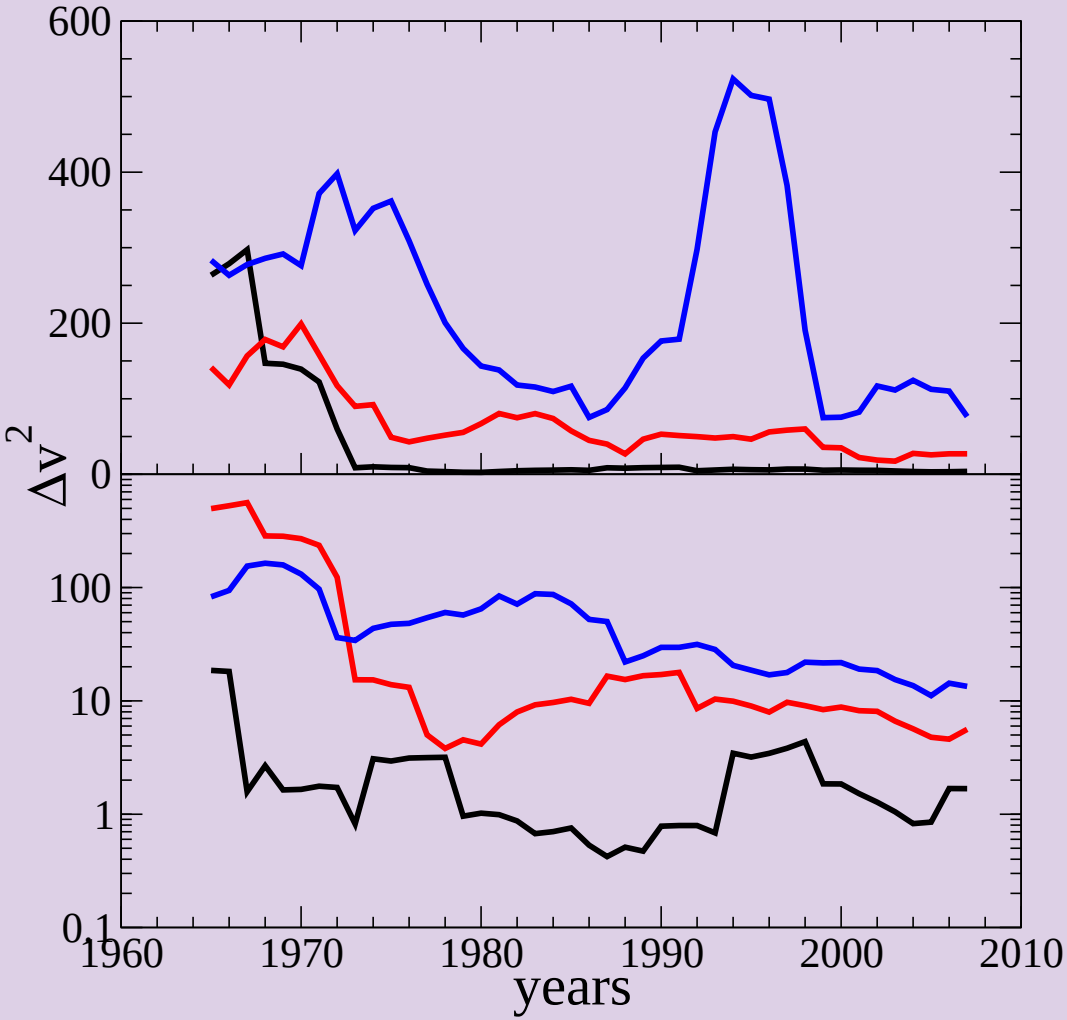
1962-2009: Rank velocity fluctuations $(\Delta v)^2 = (\Delta K)^2 + (\Delta K^*)^2$



Rank evolution in time



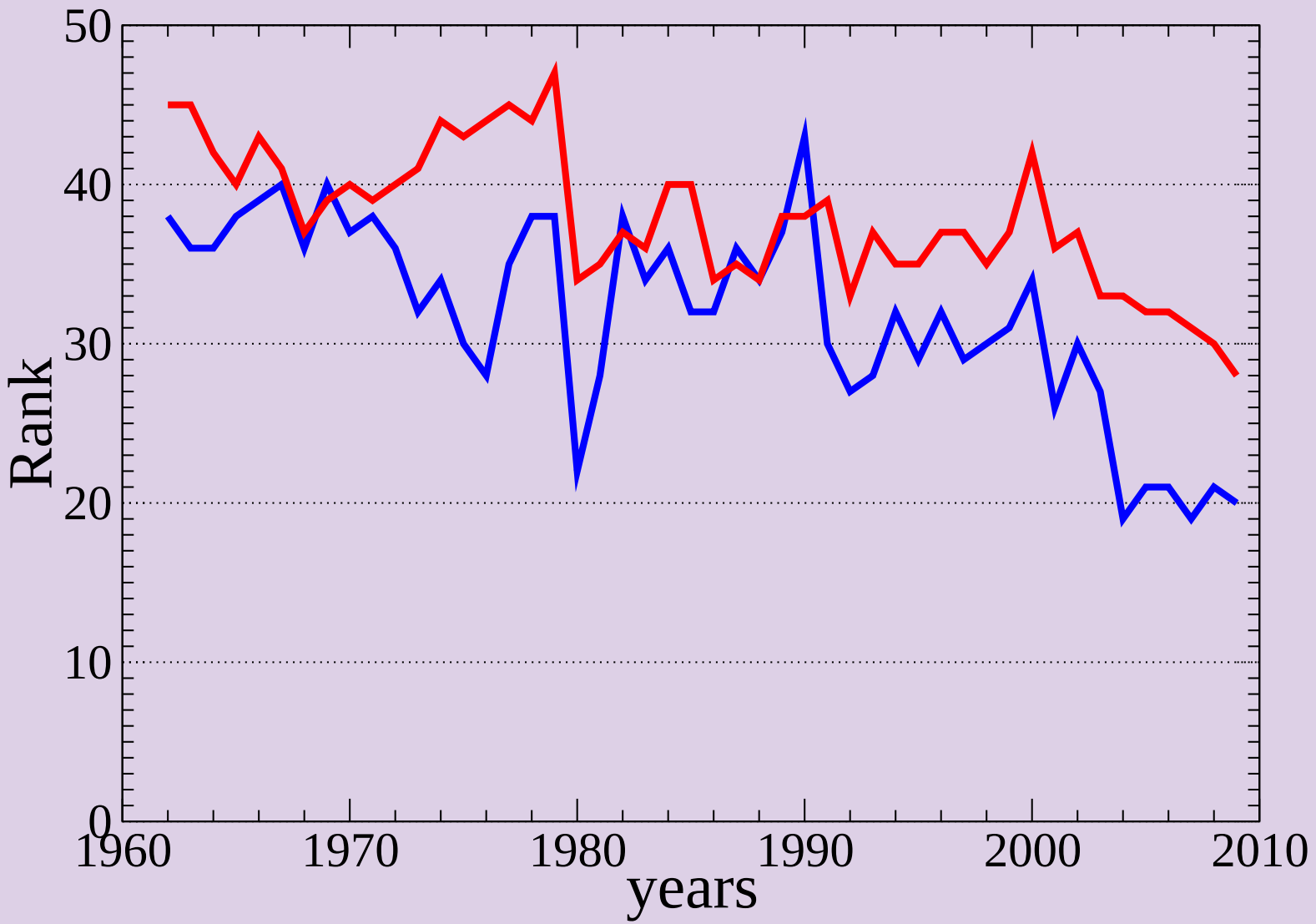
Rank evolution in time



Top: $1 \leq K + K^* \leq 40$; $41 \leq K + K^* \leq 80$; $81 \leq K + K^* \leq 120$;
Bottom: $1 \leq K + K^* \leq 20$; $21 \leq K + K^* \leq 40$; $41 \leq K + K^* \leq 60$

Rank of Poland

PageRank K and CheiRank K^*



Rank table 2008 (74% of countries of G20)

Table 1. Top 20 ranking for *all commodities* – 2008.

Ran	K	K^*	K_2	$\tilde{K}$	$\tilde{K}^*$
1	USA	China	USA	USA	China
2	Germany	USA	China	Germany	Germany
3	China	Germany	Germany	China	USA
4	France	Japan	Japan	France	Japan
5	Japan	France	France	Japan	France
6	UK	Italy	Italy	UK	Netherlands
7	Italy	Russian Fed.	UK	Netherlands	Italy
8	Netherlands	Rep. of Korea	Netherlands	Italy	Russian Fed.
9	India	UK	India	Belgium	UK
10	Spain	Netherlands	Rep. of Korea	Canada	Belgium
11	Belgium	Singapore	Belgium	Spain	Canada
12	Canada	India	Russian Fed.	Rep. of Korea	Rep. of Korea
13	Rep. of Korea	Belgium	Canada	Russian Fed.	Mexico
14	Russian Fed.	Australia	Spain	Mexico	Saudi Arabia
15	Nigeria	Brazil	Singapore	Singapore	Singapore
16	Thailand	Canada	Thailand	India	Spain
17	Mexico	Spain	Australia	Poland	Malaysia
18	Singapore	South Africa	Brazil	Switzerland	Brazil
19	Switzerland	Thailand	Mexico	Turkey	India
20	Australia	U. Arab Emir.	U. Arab Emir.	Brazil	Switzerland

Rank table 2008

Table 2. Top 20 ranking for *crude petroleum* – 2008.

Ran	K	K^*	K_2	$\hat{K}$	$\hat{K}^*$
1	USA	Russian Fed.	USA	USA	Saudi Arabia
2	Canada	Kazakhstan	India	Japan	Russian Fed.
3	Netherlands	U. Arab Emir.	Singapore	China	U. Arab Emir.
4	Belgium	USA	UK	Italy	Nigeria
5	India	Ecuador	South Africa	Rep. of Korea	Iran
6	China	Saudi Arabia	Canada	India	Venezuela
7	Germany	India	Australia	Germany	Norway
8	Japan	South Africa	U. Arab Emir.	Netherlands	Canada
9	Rep. of Korea	Nigeria	Colombia	France	Angola
10	UK	Sudan	Azerbaijan	UK	Iraq
11	Singapore	Azerbaijan	Malaysia	Spain	Libya
12	Italy	Venezuela	Brazil	Singapore	Kazakhstan
13	Australia	Norway	Belgium	Canada	Kuwait
14	Malaysia	Iran	Trinidad and Tobago	Thailand	Azerbaijan
15	Spain	Algeria	France	Belgium	Algeria
16	France	Singapore	Netherlands	Brazil	Mexico
17	Brazil	Kuwait	Kenya	Turkey	UK
18	Sweden	UK	Angola	South Africa	Qatar
19	South Africa	Angola	China	Poland	Oman
20	Thailand	Canada	Thailand	Australia	Netherlands

Google matrix with microwaves at IFPAN

PHYSICAL REVIEW E **81**, 046204 (2010)

Experimental investigation of the enhancement factor for microwave irregular networks with preserved and broken time reversal symmetry in the presence of absorption

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