

Bibliometrics and Scientometrics: Concepts and New Developments for the Identification of Emerging R&D-Issues

Edgar Schiebel

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Introduction to Bibliometrics

What is bibliometrics?

- There are two terms which are nowadays used almost simultaneously for quantitative and evaluative science studies.
 - Prichard (1969) explained the term bibliometrics as “the application of mathematical and statistical methods to books and other media of (textual) communication”
 - Nalimov and Mulchenko (1996) defined scientometrics as “the application of those quantitative methods which are dealing with the analysis of science viewed as an information process”.

Source: Wolfgang Glänzel, *esss*, 2011

Primary tasks of early bibliometrics

- Monitoring, describing and modelling of the *production, dissemination and use of knowledge, including information seeking*, library circulation and scholarly communication, was originally in the foreground.
- First applications were developed to optimize library accession and circulation, to improve bibliographic databases and to extend information services.

Source: Wolfgang Glänzel, *esss*, 2011

Bibliometrics and Science Policy

- Nowadays science, science policy became a driving force in the evolution of scientometrics.
 - Need for supplementing research evaluation with quantitative methods and of linking funding to performance indicators.
 - The application to science policy has brought a new perspective, and resulted in re-interpretation of bibliometric conceptions.

Source: Wolfgang Glänzel, esss, 2011

Research Evaluation

- Measures of different aspects of research output are called “**indicators**”.
Most basic indicators are determined for
 - publication output (as measure of productivity: *number of publications*),
 - co-authorship (as measure of collaboration: *shares of national and international collaborations, number of partners*) and
 - citation rates (as measure of impact: *citation rate, H-Index, Impact Factor*)

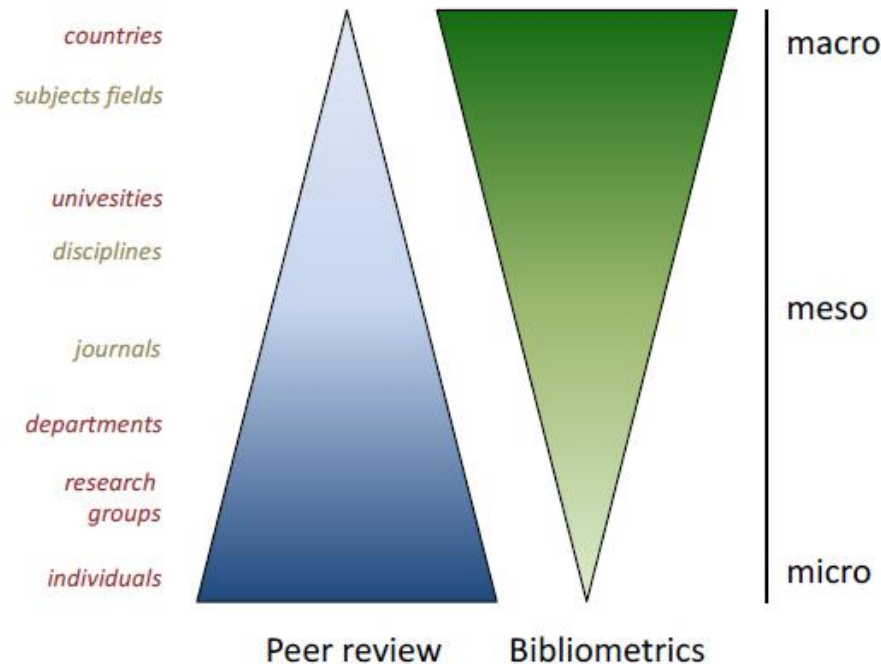
Source: Wolfgang Glänzel, *esss*, 2011

Science Mapping: advanced relational bibliometrics

- Advanced measures are “network indicators” and derived from the analysis of co-authorship and citation networks, etc.
- Relational bibliometric approaches like
 - co-citation analysis and
 - bibliographic couplingare used to identify (*emerging*) research issues
- Concepts like the Research Portfolio indicates high or low research activity and time dynamics in research fields

Peer Review and Bibliometrics

The weight of qualitative (peer evaluation) and quantitative (bibliometrics) methods as function of the aggregation level



Source: Wolfgang Glänzel, esss 2011





















(Data) Sources for Bibliometrics

- ISI Web of Knowledge, Social Science Citation Index, Science Citation Index
- Scopus from Elsevier
- Other national and international initiatives for indexed documents
- Journal and Country Rank – SCImago is a research group from the Consejo Superior de Investigaciones Cientificas (CSIC), University of Granada

Scimago: Country Ranking

Region: Latin America.

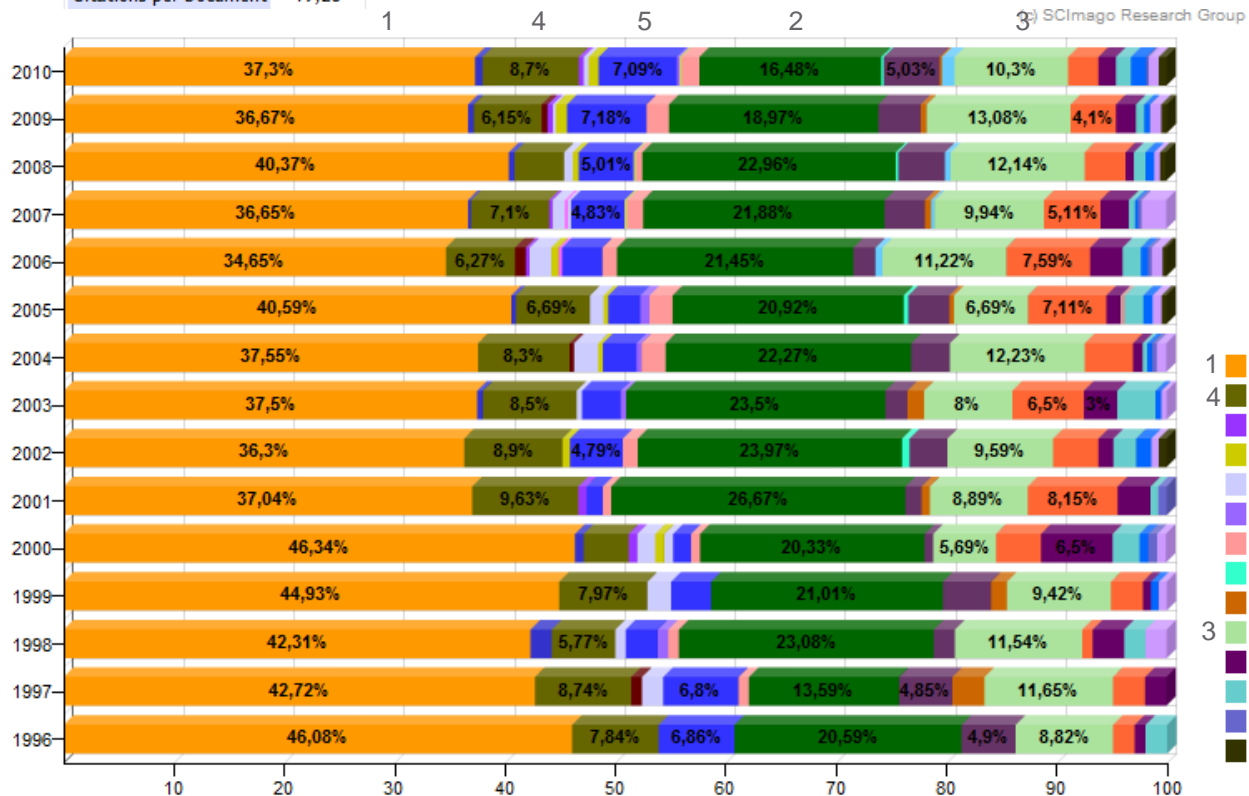
Period: 1996-2010.

	Country	Documents	Citable documents	Citations	Self-Citations	Citations per Document	H index
1	 Brazil	325.549	315.102	2.203.616	716.178	8,98	253
2	 Mexico	124.320	120.830	926.074	206.334	8,92	193
3	 Argentina	93.075	90.135	814.586	185.945	9,85	183
4	 Chile	49.931	48.479	468.897	91.514	12,03	162
5	 Colombia	22.764	22.068	138.167	21.538	9,37	105
6	 Venezuela	21.589	21.031	149.208	23.519	7,64	111
7	 Cuba	19.225	18.592	85.857	21.180	5,00	78
8	 Puerto Rico	8.452	8.236	102.674	8.170	13,78	106
9	 Uruguay	7.297	7.050	75.682	11.436	12,74	90
10	 Peru	6.241	5.929	61.065	7.070	13,09	87
11	 Costa Rica	5.002	4.843	58.687	7.262	13,35	88
12	 Ecuador	3.291	3.158	30.236	4.156	11,76	67
13	 Jamaica	2.793	2.616	20.901	2.720	8,62	49
14	 Trinidad and Tobago	2.789	2.619	16.571	1.664	7,30	49
15	 Panama	2.643	2.507	50.970	5.557	26,32	91
16	 Bolivia	2.039	1.979	20.632	2.411	12,11	52
17	 Guatemala	1.122	1.055	10.488	654	10,96	42
18	 Barbados	927	849	8.403	630	10,15	42
19	 Guadeloupe	845	810	7.117	730	10,14	36
20	 El Salvador	794	772	4.833	137	7,93	32

Scimago: Bibliometric Analysis for Panama

	1996-2010
H Index	91
Documents	2.643
Citable Documents	2.507
Citations	50.970
Self Citations	5.557
Citations per Document	19,28

General bibliometric indicators



Documents by subject areas

- 1 Agricultural and Biological Sciences
- 4 Biochemistry, Genetics and Molecular Biology
- Chemical Engineering
- Computer Science
- Dentistry
- Economics, Econometrics and Finance
- Engineering
- Health Professions
- Materials Science
- Medicine
- Neuroscience
- Pharmacology, Toxicology and Pharmaceutics
- Psychology
- Veterinary
- Arts and Humanities
- Business, Management and Accounting
- Chemistry
- Decision Sciences
- 5 Earth and Planetary Sciences
- Energy
- 2 Environmental Science
- Immunology and Microbiology
- Mathematics
- Multidisciplinary
- Nursing
- Physics and Astronomy
- Social Sciences

Science Mapping based on relational bibliometrics

Example for a data set of publications

Quan:	1
Authors:	Bauer, G; Davies, JK; Pelikan, J
Corporate Affiliations:	Euphid Theory Working Grp; Euphid Consortium
Title:	The EUHPID Health Development Model for the classification of public health indicators
Source:	HEALTH PROMOTION INTERNATIONAL
Language:	English
Descriptors:	public health model; classification system; indicators
Identifiers:	PROMOTION
Abstract:	The European Community Health Promotion Indicator Development Model has been developed as the basis for.....
References:	Ref 1, Ref 2, Ref 3,...
...	
Quan:	2
Authors:	Bauer, G; Davies, JK; Pelikan, J; Noack, H; Broesskamp, U; Hill, C
Corporate Affiliations:	EUHPID Consortium
Title:	Advancing a theoretical model for public health and health promotion indicator development - Proposal from the EUHPID consortium
...	

Networks: co-authorship

Publications with authors

Publication A	Publication B
Einstein	Bohr
Bohr	Curie
Meitner	Heisenberg
	Meitner
	Rutherford



bipartite matrix M

	Publication A	Publication B
Bohr	1	1
Curie	0	1
Einstein	1	0
Heisenberg	0	1
Meitner	1	1
Rutherford	0	1

Co-occurrence matrix: $M \times M^T$

	Bohr	Curie	Einstein	Heisenberg	Meitner	Rutherford
Bohr	2	1	1	1	1	2
Curie	1	1	0	1	1	1
Einstein	1	0	1	0	1	0
Heisenberg	1	1	0	1	1	1
Meitner	2	1	1	1	2	1
Rutherford	1	1	0	1	1	1



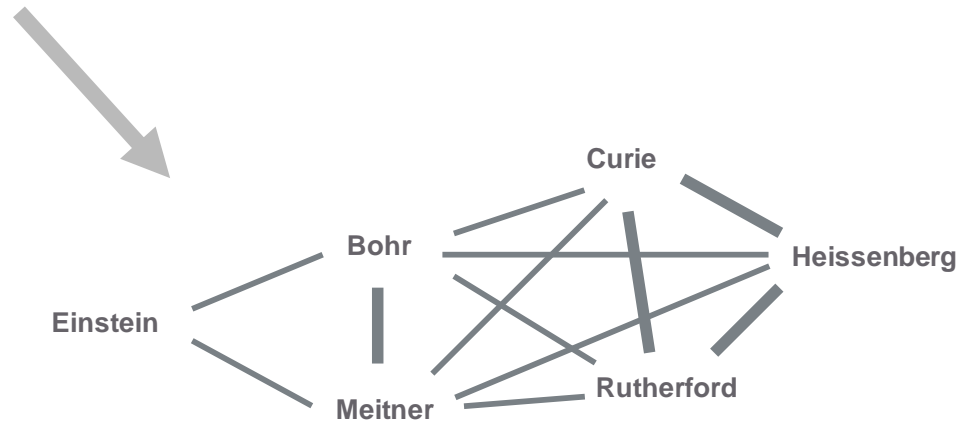
Similarity matrix: Jaccard index

$J_{ij} = c_{ij} / (c_i + c_j - c_{ij})$ *Example:*
 with
 i: Meitner j: Curie
 c_{ij} : cooccurrence of authors i and j $c_i = 2, c_j = 1, c_{ij} = 1$
 c_i : occurrence of author i
 c_j : occurrence of author j $J_{ij} = 1 / (2 + 1 - 1) = 0.5$

Visualisation of co-author networks

Similarity matrix: J_{ij}

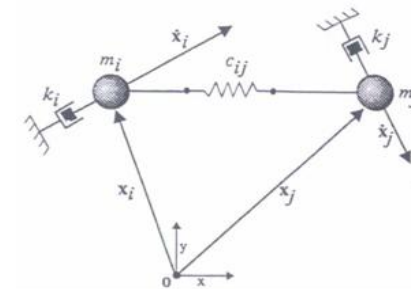
	Bohr	Curie	Einstein	Heisenberg	Meitner	Rutherford
Bohr	1,0	0,5	0,5	0,5	1,0	0,5
Curie	0,5	1,0	0,0	1,0	0,5	1,0
Einstein	0,5	0,0	1,0	0,0	0,5	0,0
Heisenberg	0,5	1,0	0,0	1,0	0,5	1,0
Meitner	1,0	0,5	0,5	0,5	1,0	0,5
Rutherford	0,5	1,0	0,0	1,0	0,5	1,0



Spring model for the two dimensional visualisation

Equitiy of forces

$$\begin{aligned}
 \vec{f}_{m_i} + \vec{f}_{k_i} + \vec{f}_{e_{ij}} &= 0 & -m_i \cdot \ddot{\vec{x}}_i - k_i \cdot \dot{\vec{x}}_i + e_{ij} \cdot \Delta \vec{x}_{ij} &= 0 \\
 \vec{f}_{m_j} + \vec{f}_{k_j} + \vec{f}_{e_{ij}} &= 0 & -m_j \cdot \ddot{\vec{x}}_j - k_j \cdot \dot{\vec{x}}_j + e_{ij} \cdot \Delta \vec{x}_{ij} &= 0
 \end{aligned}
 \quad \text{or}$$



Iteration equations for a numerical solution

$$x_1^{(t+1)} = x_1^{(t)} + \frac{\Delta t}{k_1} \cdot \sum_{j \neq 1} e_{1j} \cdot \cos \alpha_{1j} \cdot |\Delta \vec{x}_{1j}|$$

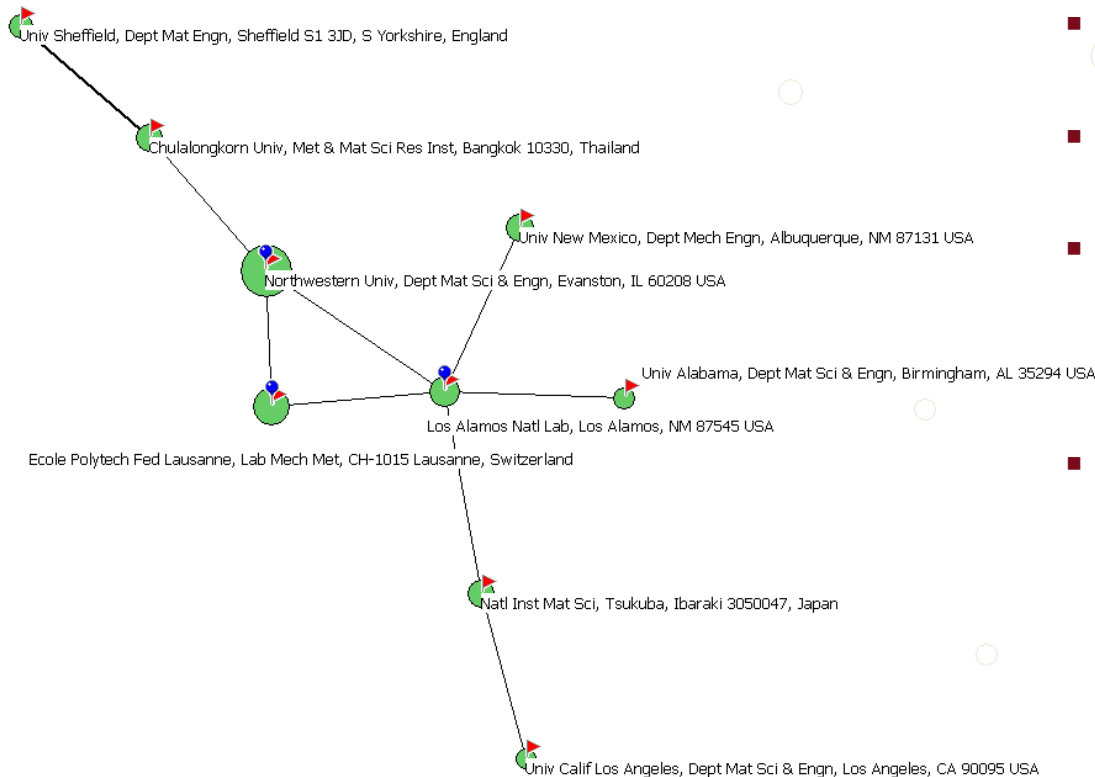
$$x_2^{(t+1)} = x_2^{(t)} + \frac{\Delta t}{k_2} \cdot \sum_{j \neq 2} e_{2j} \cdot \cos \alpha_{2j} \cdot |\Delta \vec{x}_{2j}|$$

⋮

$$x_n^{(t+1)} = x_n^{(t)} + \frac{\Delta t}{k_n} \cdot \sum_{j \neq n} e_{nj} \cdot \cos \alpha_{nj} \cdot |\Delta \vec{x}_{nj}|$$

- Node is a mass point
- Mass: number of publications
- Elasticity: Jaccard index
- Mechanics: equations of motion as a system of differential equations
- Initial conditions: random
- numerical solution for the position of objects in the x,y-space

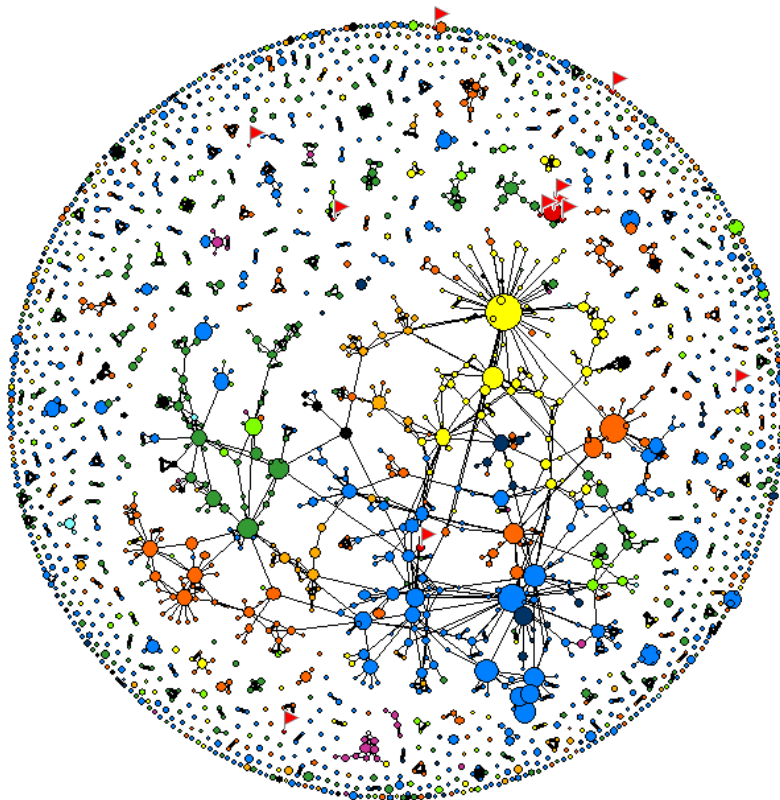
Example: Co-Affiliations Network „Ceramic Particle-Reinforced Metal“



- Nodes: authors' affiliations, size – number of publications
- Edges: Jaccard index as elasticity value
- Data: time span : 2004 – 2010, 8984 publications, whole network: 421 authors with more than 2 publications
- The picture represents a partial network

Collaboration in „Welding and Joining“

Map for Affiliations of Authors



Affiliations from Austria

- Graz Tech Univ, Inst Mat Sci Welding & Forming, Graz, Austria [20];
- Montanuni Leoben, Dept Met, 8700 Leoben, Austria [4];
- Fronius Int GmbH, Wels, Austria [3];
- Graz Tech Univ, Inst Electron Microscopy, Graz, Austria [3];
- EV Grp, A-4780 Schaerding, Austria [1];
- Graz Tech Univ, Graz, Austria [1];
- Mat Ctr Leoben, Leoben, Austria [1];
- Siemens Transportat Syst, Graz, Austria [1];
- Univ Vienna, Inst Theoret Phys, Vienna, Austria [1];
- Verbund Austrian Hydro Power, Vienna, Austria [1];
- Vienna Tech Univ, Christian Doppler Lab Early Stages Precipitat, Vienna, Austria [1];

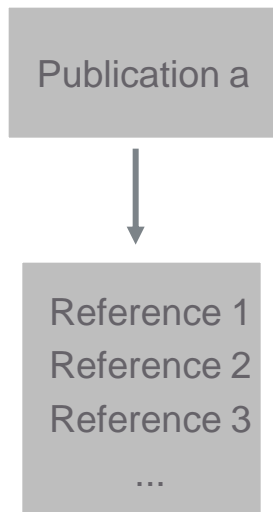
AUSTRIA	11	
GERMANY	105	
remaining europe	389	
USA	750	
remaining north america	65	
south america	27	
JAPAN	174	
SOUTH KOREA	114	
remaining asia	315	
africa	9	
oceania	42	

Network of author's affiliations in publications; edges are Jaccard indices of cooccurrences; circle size: number of publications; time: 2001 bis 2011; retrieval date: 17.03 2011, number of publications: 4.143; nodes: 2.002; edges: 1.362

Knowledge Bases and Research Fronts

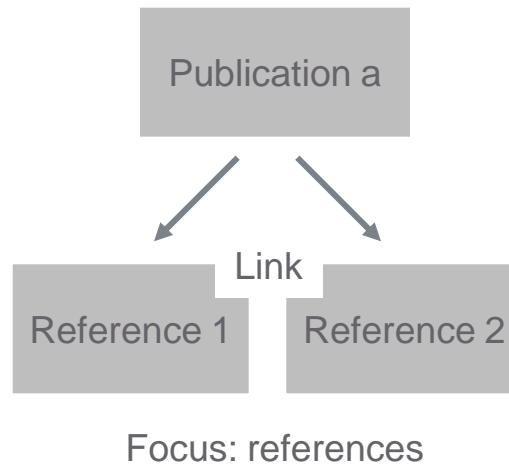
Research Fronts and Knowledge Bases – Bibliographic Coupling and Co-Citation

citation



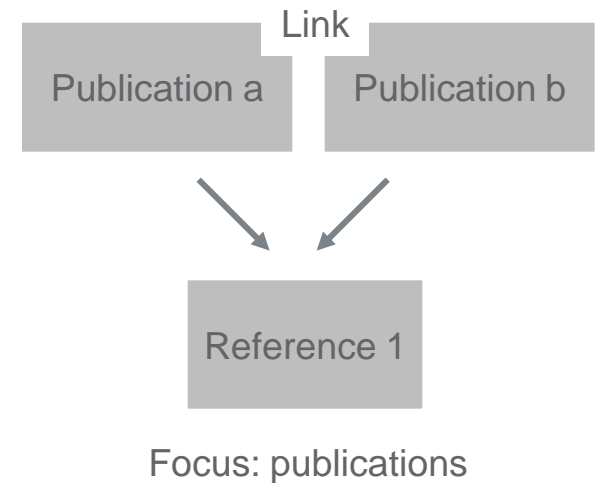
knowledge bases

co-citation



research fronts

bibliographic coupling



Statistical Approaches to Identify Clusters and agglomerations

- Hierarchical Clusteranalysis
- MDS: Multi-Dimensional Scaling
- Spring-Models (AIT - Masspoint Model)

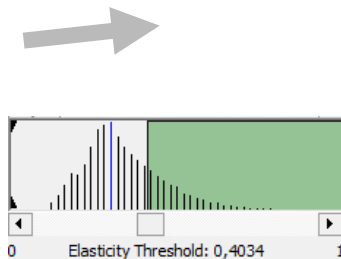
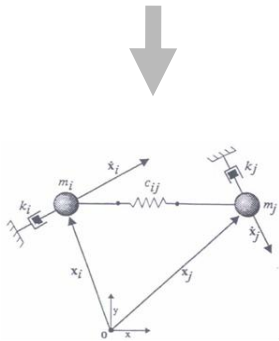
Co-Occurrence Map of Bibliographically Coupled publications

Similarity matrix: ij

	Bohr	Curie	Einstein	Heisenberg	Meitner	Rutherford
Bohr	1,0	0,5	0,5	0,5	1,0	0,5
Curie	0,5	1,0	0,0	1,0	0,5	1,0
Einstein	0,5	0,0	1,0	0,0	0,5	0,0
Heisenberg	0,5	1,0	0,0	1,0	0,5	1,0
Meitner	1,0	0,5	0,5	0,5	1,0	0,5
Rutherford	0,5	1,0	0,0	1,0	0,5	1,0

Area of high density of publications

Co-occurrences and Jaccard index



Spring model: elasticity ~ Jaccard; Jaccard > 0 -> positive forces; Jaccard < 0 negative forces;

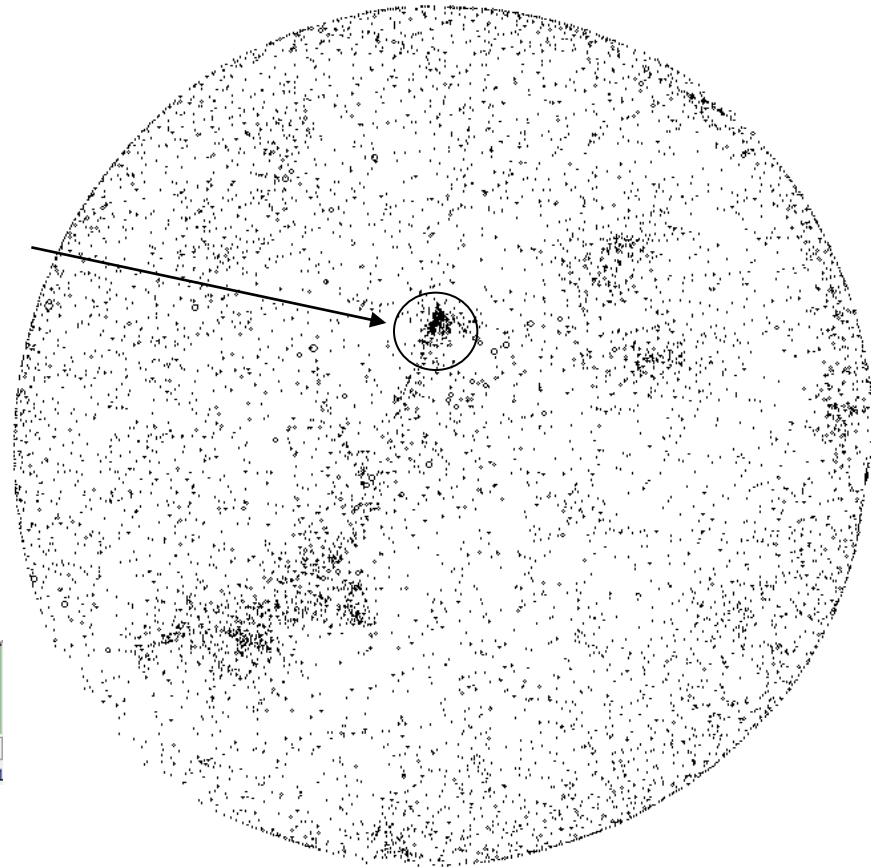


Figure: Map of bibliographically coupled publications. similarity measure: number of common references normalised by the Jaccard index, projection by a spring model; 7,761 publications on battery research in the period from 2004 to 2010, Jaccard > 0 -> positive forces; Jaccard < 0 negative forces; BibTechMon™ - AIT Austrian Institute of Technology GmbH

Research Fronts and Knowledge Bases

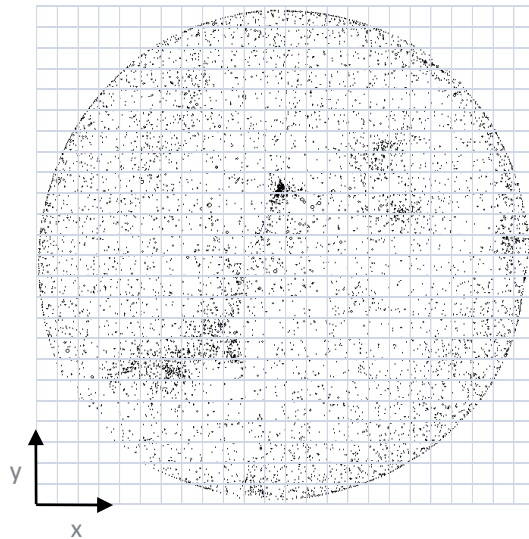
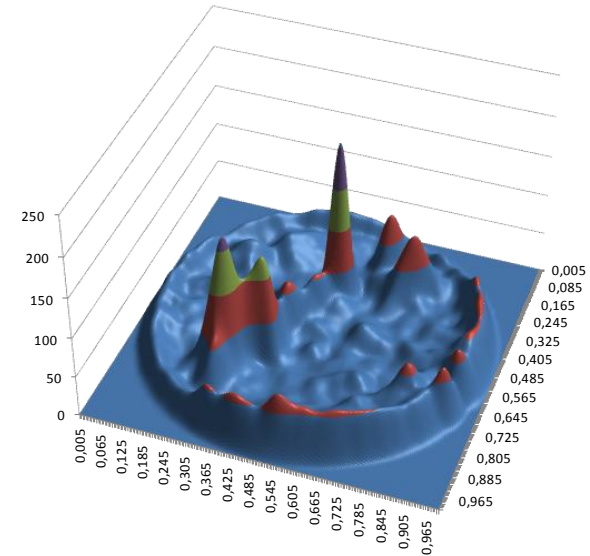
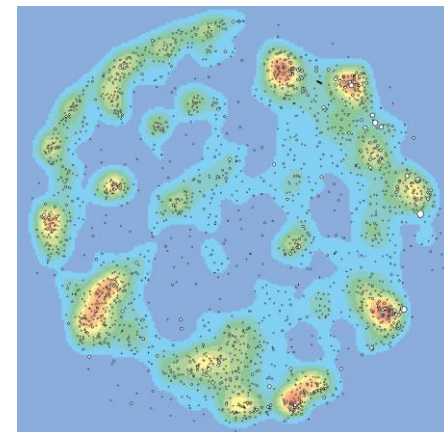


Figure: digital grid over the bib.coupl pub. map; x: 0.46, 2.06; y: 0.45, 2.06; delta x: 0.01: 100x100 raster elements

Bibliographic coupling:
Research Fronts



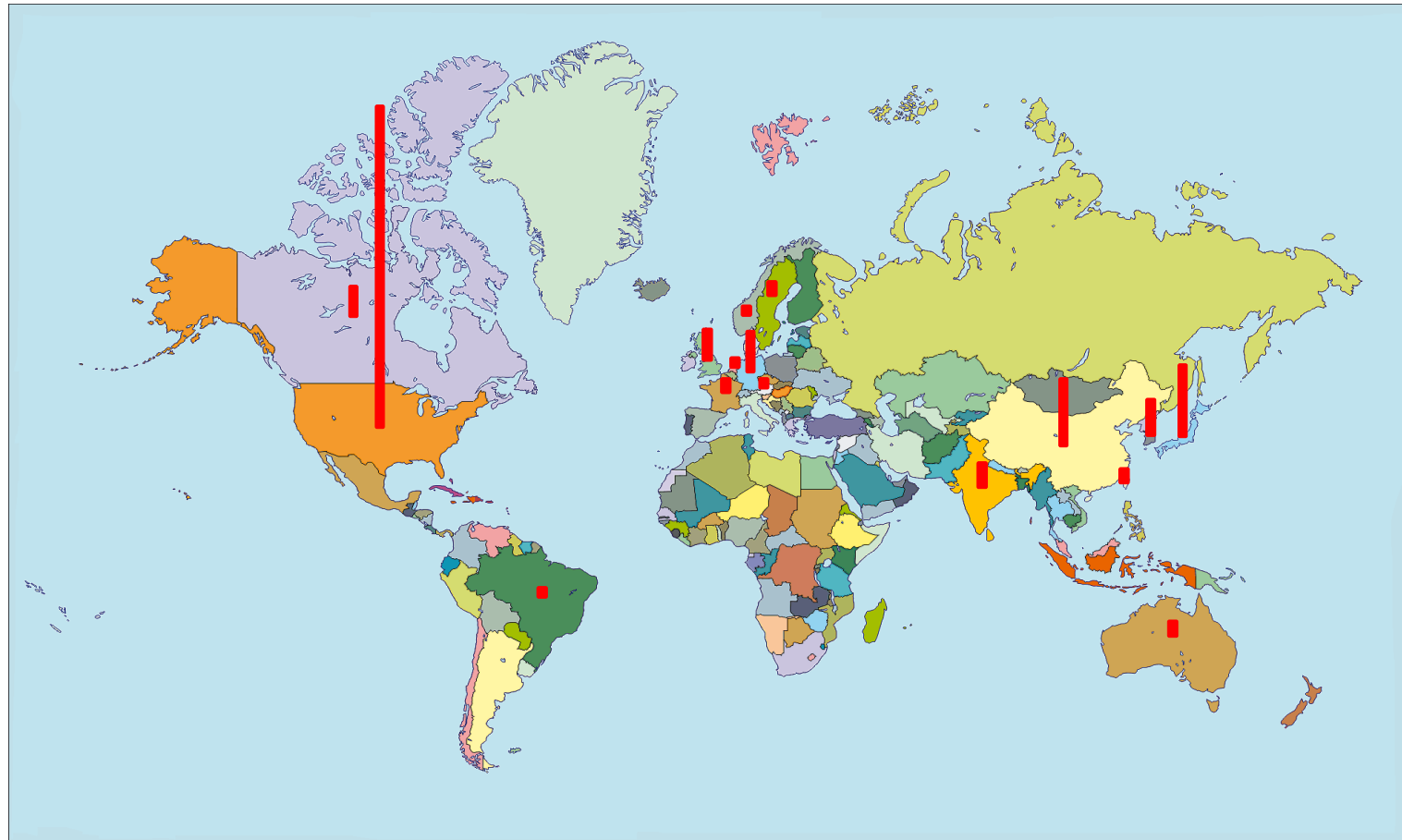
Co-Citation:
Knowledge Bases



Problems with the Citation Based Approach and AIT-Model

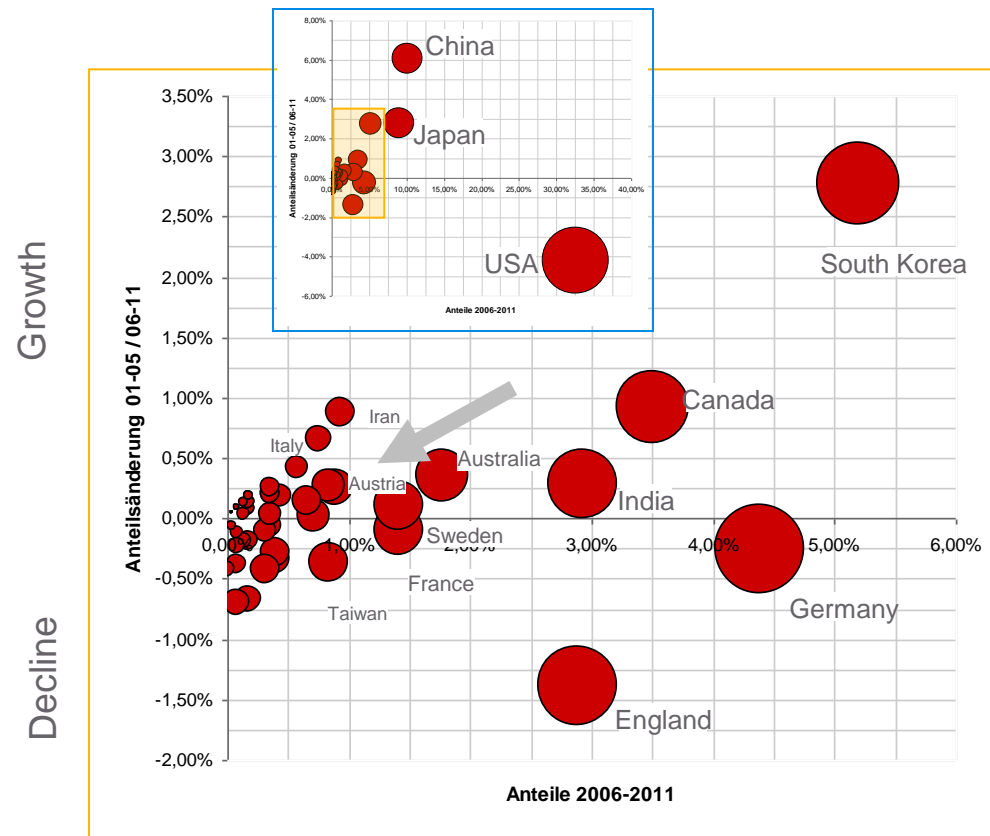
- Similarity between publications only measured by citations but not by content information
 - Solution: hybrid concept of combined textual and citation information
- Restricted computer capacities for more than 15.000 objects
 - Solution: Selection of publications with relevance for the structure

Global Research Activities on Joining Technologies



Data: 4143 publications in Journals and Conferences in Joining Technologies 2001 bis 2011

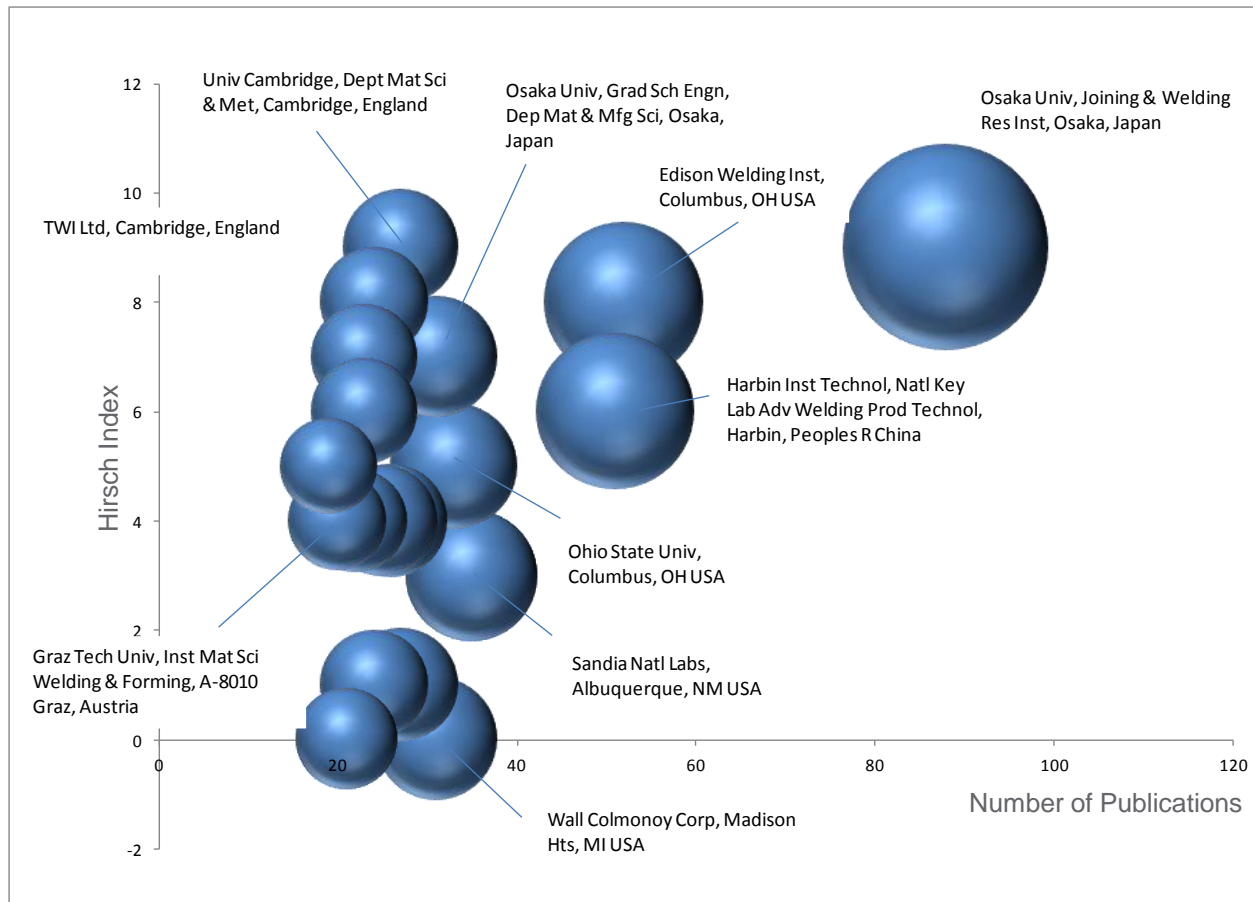
Country Portfolio –Research on Joining Technologies



- Dominance of the USA, is loosing shares
- Asia coming up: China, Japan, South Korea

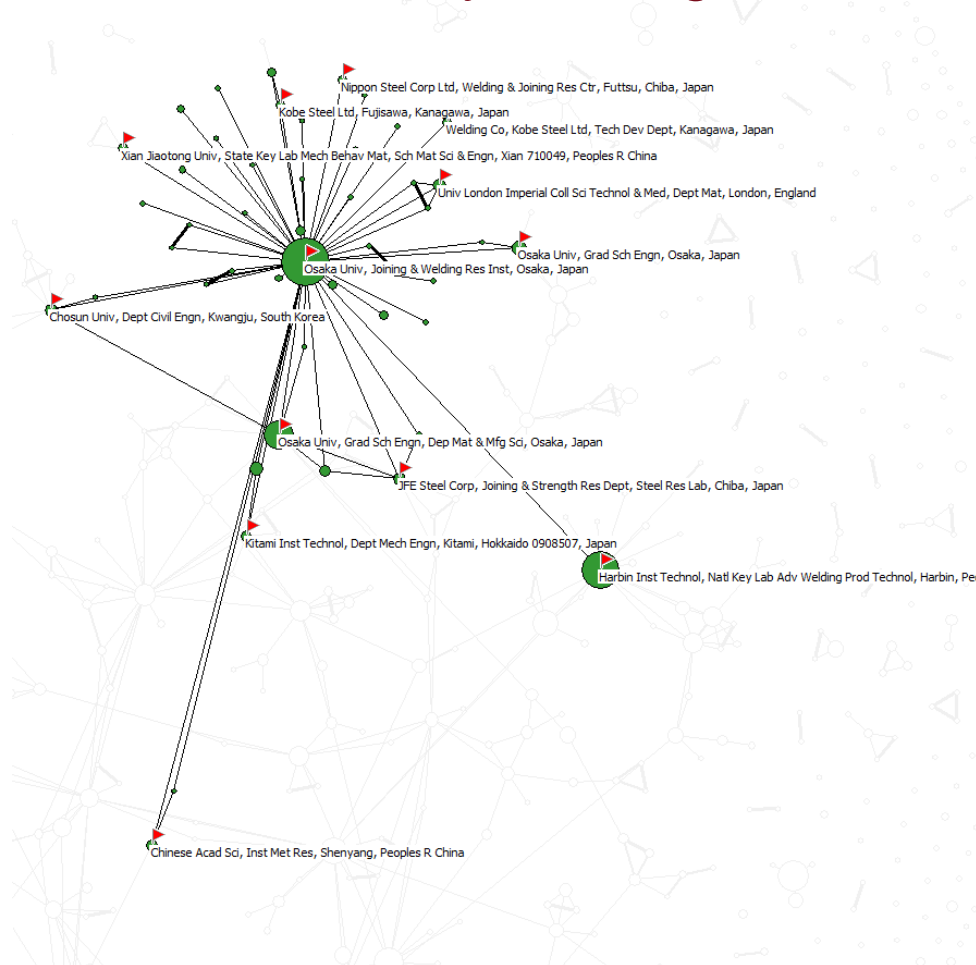
y-axis: Change of shares of all publications bt p1: 2001-2005 and p2: 2006-2011, 4143 publications; circle size: number of publications 2006-2011

Selected Research Organisations (by Number of Publications and H-Index)



Data: 4143 publications in Journals and conferences about joining technologies 2001 bis 2011

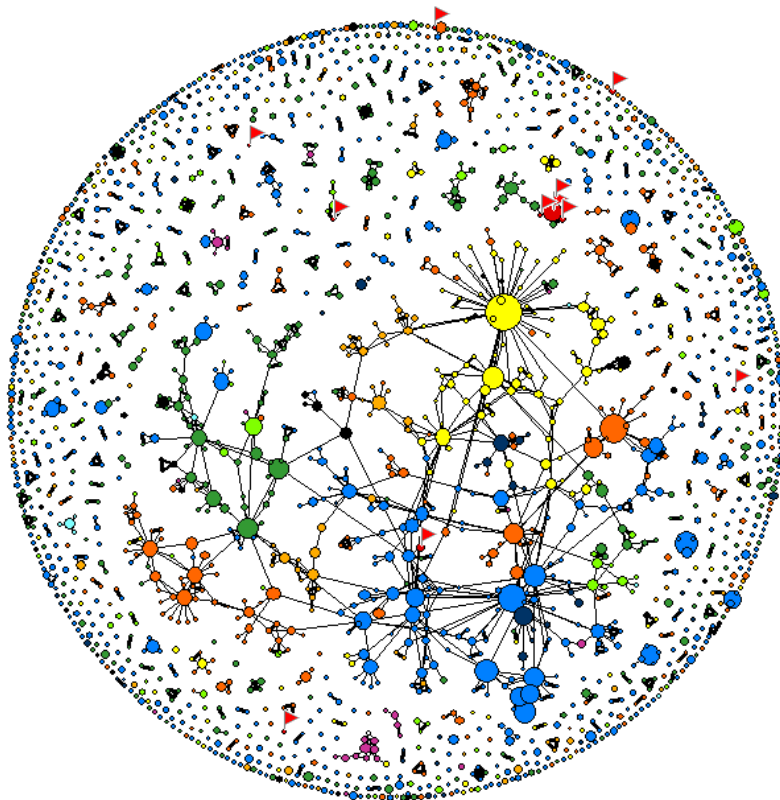
Network of the Osaka University Joining & Welding Institute, Japan



- Osaka Univ, Joining & Welding Res Inst, Osaka, Japan
- Daihen Corp, Welding & Mechatron Div, Osaka 5660021, Japan
- Cent Met Res & Dev Inst, Cairo, Egypt
- Harbin Inst Technol, Natl Key Lab Adv Welding Prod Technol, Harbin, Peoples R China
- Xian Jiaotong Univ, State Key Lab Mech Behav Mat, Sch Mat Sci & Engr, Xian 710049, Peoples R China
- JFE Steel Corp, Joining & Strength Res Dept, Steel Res Lab, Chiba, Japan
- Kobe Steel Ltd, Fujisawa, Kanagawa, Japan
- IHI Corp, Yokohama, Kanagawa, Japan

Collaboration in „Welding and Joining“

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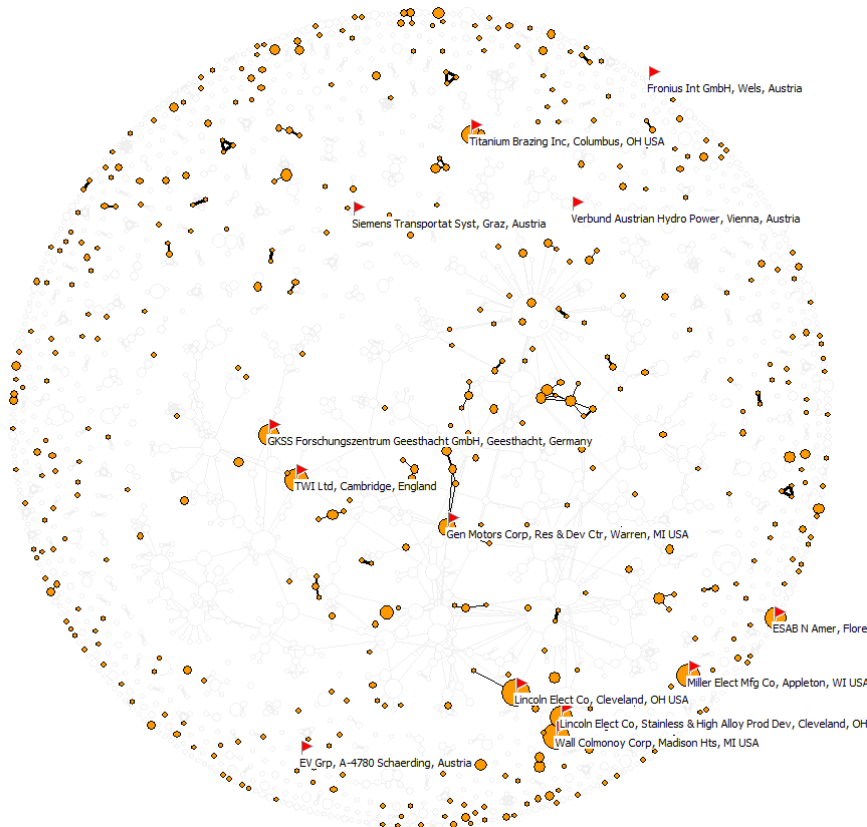
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remaining asia	315	
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oceania	42	

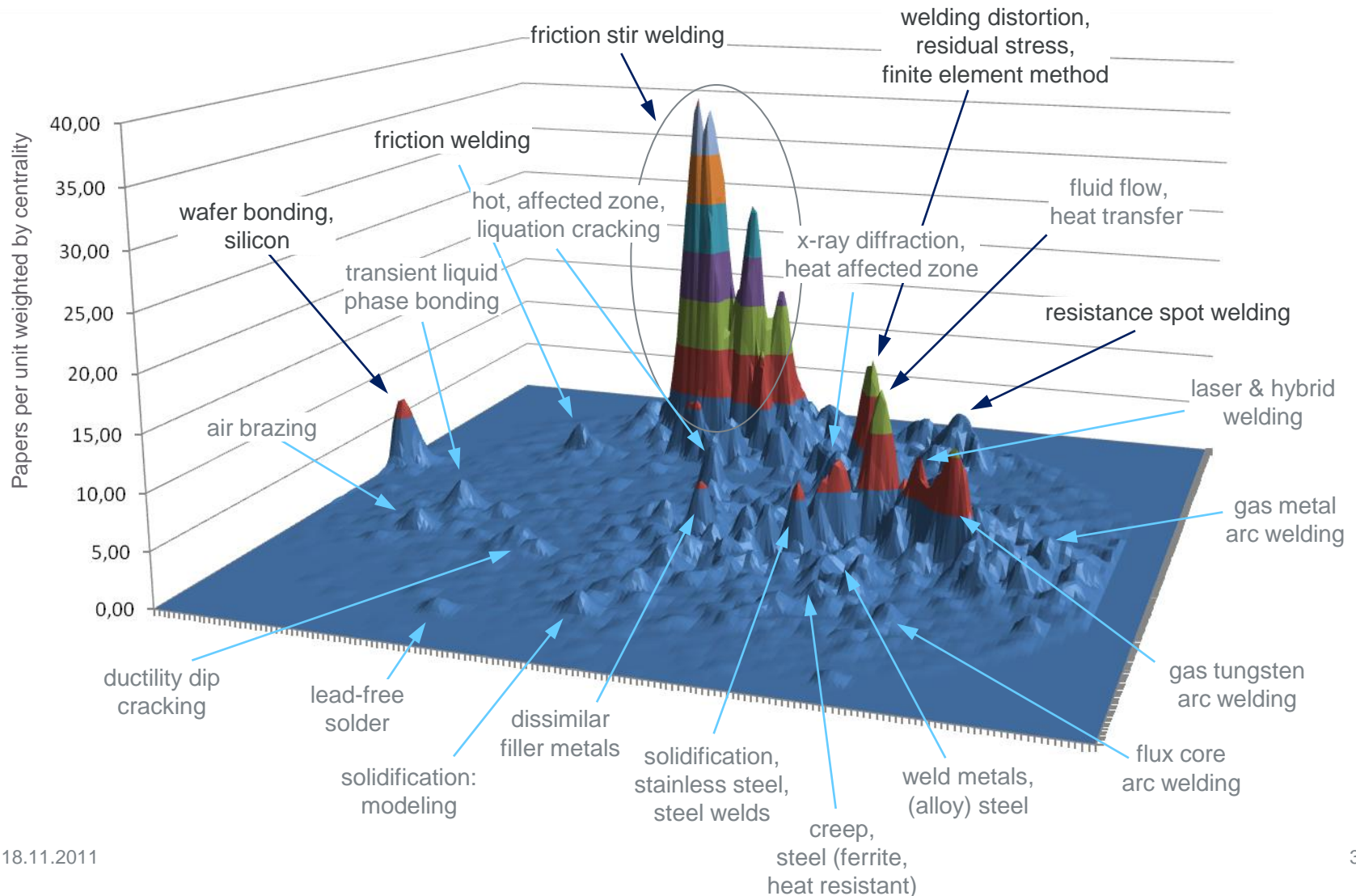
Network of author's affiliations in publications; edges are Jaccard indices of cooccurrences; circle size: number of publications; time: 2001 bis 2011; retrieval date: 17.03 2011, number of publications: 4.143; nodes: 2.002; edges: 1.362

Companies in international Networks of Research on Joining Technologies

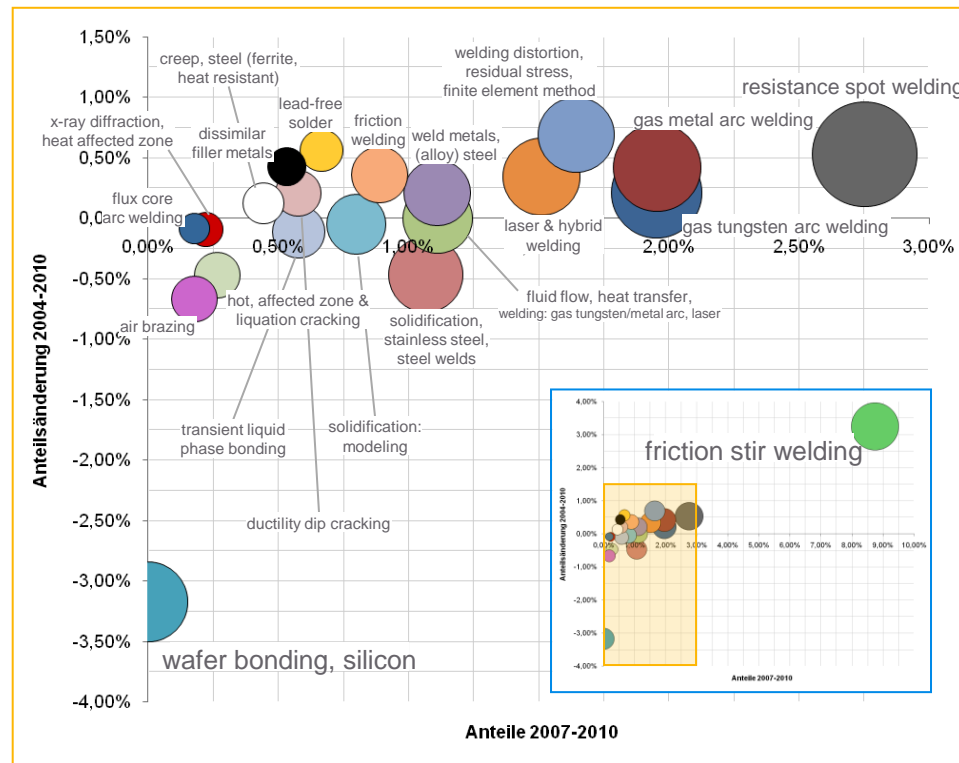


Lincoln Elect Co, Cleveland, OH USA [56]; Wall Colmonoy Corp, Madison Hts, MI USA [31]; Miller Elect Mfg Co, Appleton, WI USA [24]; TWI Ltd, Cambridge, England [24]; AlcoaTec Wire Corp, Traverse City, MI USA [21]; GKSS Forschungszentrum Geesthacht GmbH, Geesthacht, Germany [19]; Titanium Brazing Inc, Columbus, OH USA [16]; Gen Motors Corp, Res & Dev Ctr, Warren, MI USA [13]; Rockwell Sci Co, Thousand Oaks, CA USA [8]; Sperko Engrn Inc, Greensboro, NC USA [6]; Nippon Steel Corp Ltd, Welding & Joining Res Ctr, Steel Res Labs, Futtsu, Chiba, Japan [6]; MAGMA Giessereitechnol GmbH, Aachen, Germany [6]; Ford Motor Co, Dearborn, MI USA [6]; BIAS Bremer Inst Angew Strahltechn GmbH, Bremen, Germany [6]; CenterLine Windsor Ltd, Res & Dev, Windsor, ON, Canada [6]; JFE Steel Corp, Joining & Strength Res Dept, Steel Res Lab, Chiba, Japan [5]; Volvo Aero Corp, Trollhattan, Sweden [5]; Sumitomo Met Ind Ltd, Applicat Technol Res & Dev Dept, Corp Res & Dev Labs, Amagasaki, Hyogo, Japan [5]; Hobart Bros Co, Troy, OH USA [5]; Concurrent Technol Corp, Johnstown, PA USA [5]; Haynes Int Inc, Kokomo, IN USA [5]; Huys Ind Ltd, Toronto, ON, Canada [5]; Nelson Stud Welding Inc, Elyria, OH USA [4]; Abbott Furnace Co, St Marys, PA USA [4]; Lucas Milhaupt Inc, Cudahy, WI USA [4]; Hyundai Motor Co, Hwaseungsi, Gyeonggi-do, South Korea [4]; Daihen Corp, Welding & Mechatron Div, Osaka, Japan [4]; Boeing Co, St Louis, MO USA [4]; Hitachi Ltd, Hitachi Res Lab, Ibaraki, Japan [4]; ... **Fronius Int GmbH, Wels, Austria [3]; ... EV Grp, A-4780 Schaerding, Austria [1]; Siemens Transportat Syst, Graz, Austria [1]; Verbund Austrian Hydro Power, Vienna, Austria [1]; ...**

Research Fronts in Joining Technologies

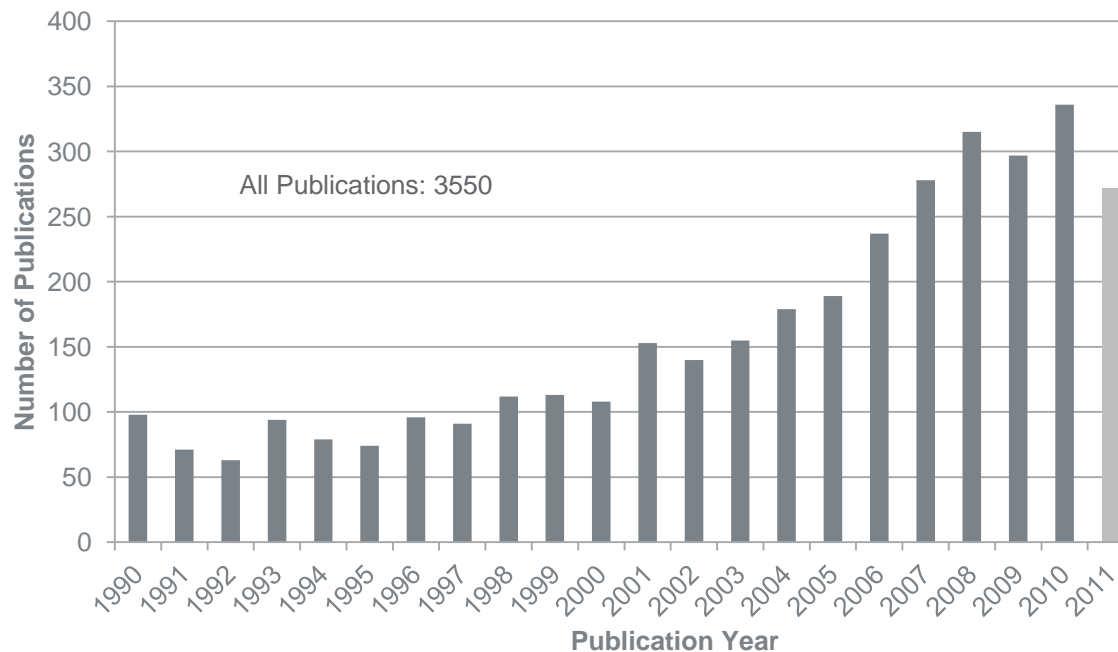


Research Portfolio for Joining Technologies



4143 publications in 2004-2010, retrieval date 12 03 2011, circle size is proportional to the number of publications

Research Activities in Panama (1990 to 2011)



Data source: ISI Web of Knowledge, Science Citation Index and Social Science Citation Index; retrieval date: 16.11.2011, total number of publications: 3550; retrieval strategy: at least one author has an affiliation from Panama

Science Map of Published Research Activities in Panama (1990 to 2011)

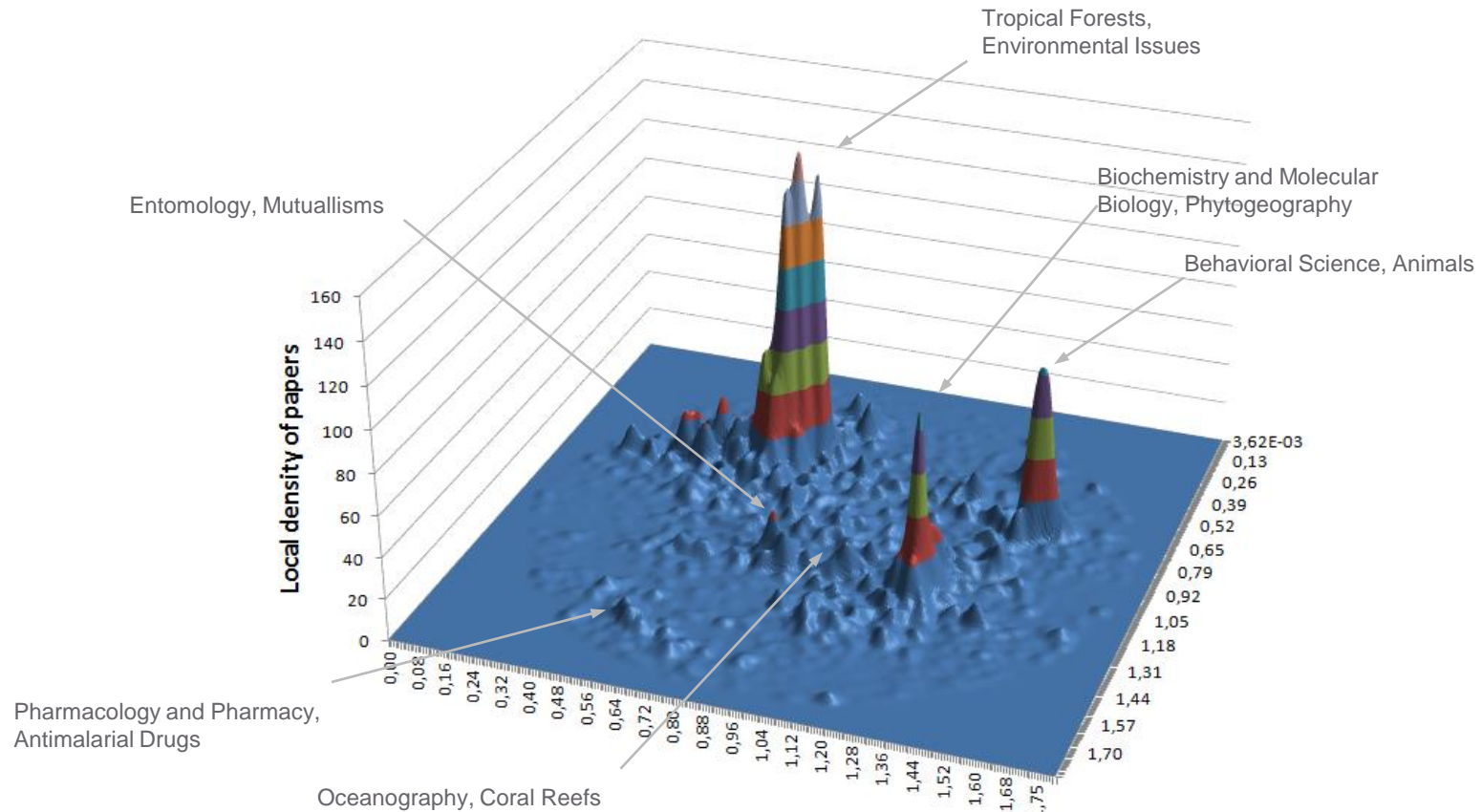


Figure: density map of bibliographically coupled publications, cos-weighted moving average filter ,3.550 publications with at least one author from Panama 1990 to 2011

Science Map of Published Research Activities in Panama (Period 2002-2006 and Period 2007-2011)

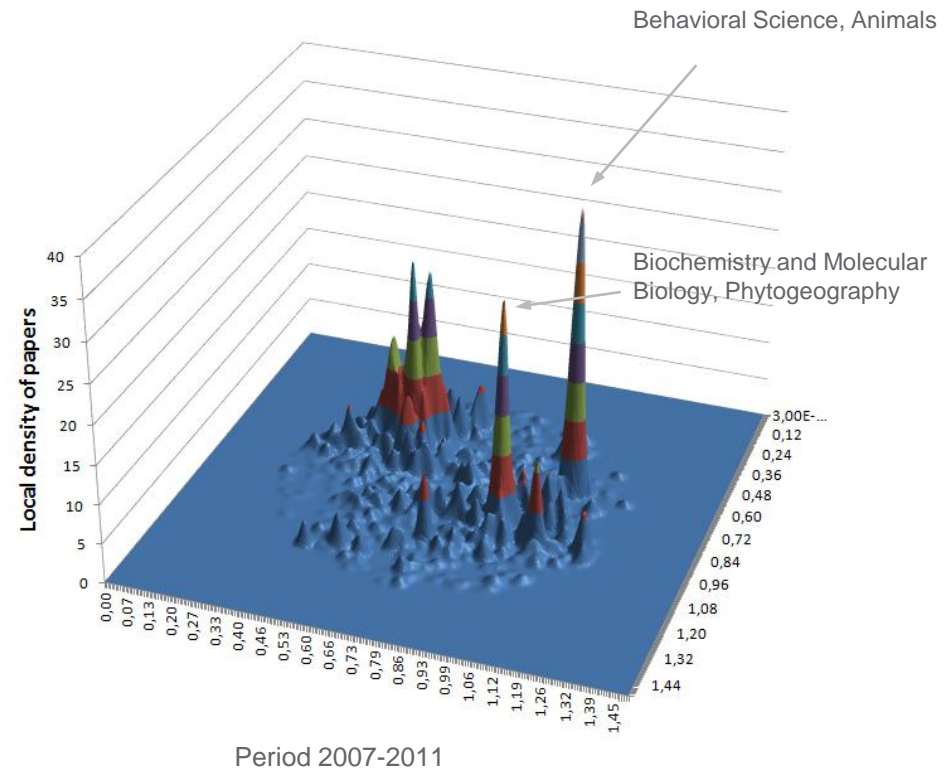
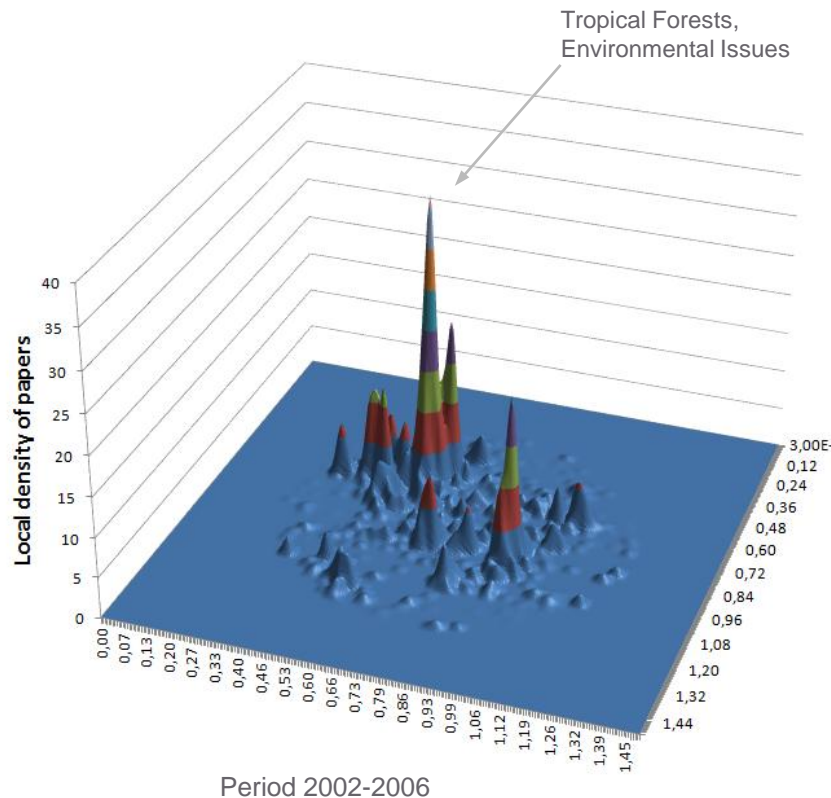


Figure: density map of bibliographically coupled publications, cos-weighted moving average filter ,3.550 publications with at least one author from Panama 1990 to 2011

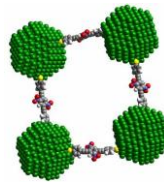
Thank you for your attention

Edgar Schiebel
edgar.schiebel@ait.ac.at

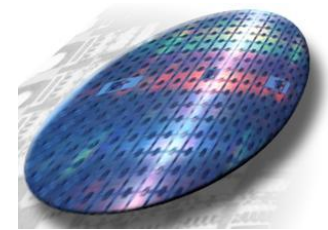
PROMTECH: Emerging Technologies

A Project on behalf of the NEST – New and Emerging Science and Technology Initiative
2002-2006 of the European Commission

Molecular Electronics



Microelectronic Elements

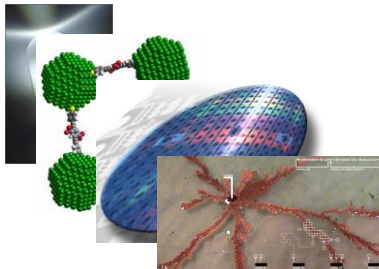


Light Emitting Diodes

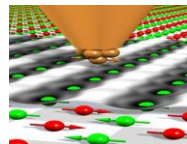


Scanning of the French CNRS-PASCAL Database
Identification of 45 Growing Technology Categories
Analysis of Emerging Research Issues)

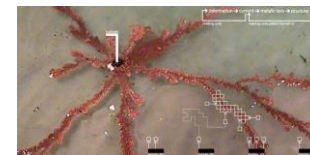
Additional 40 technologies



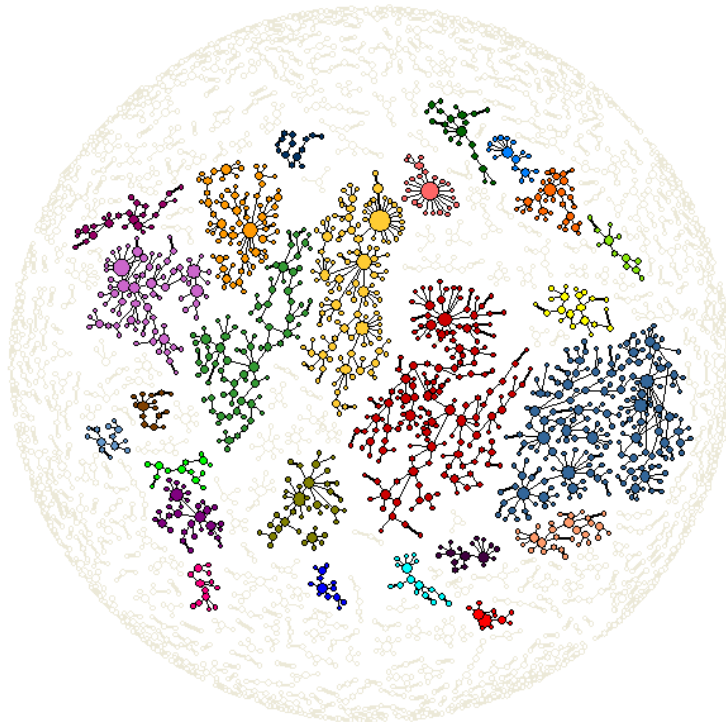
Magneto electronic



Electrochemical Devices



Effects of the Humboldt Stiftung Grants



Holders of grants and scholarships from the Humboldt-Stiftung

- Objectives of the Study
 - Networks of scientists induced by the Humboldt Program
 - Map of the network structure
- Method:
 - BibTechMon™
- Results:
 - Natural sciences (Physics, Chemistry, Biology,... tend to huge networks; formal sciences (mathematics,...) tend to small ones
 - Positive effects in research output (number of articles and impact factor), network effects for young scientists.