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SCIENTOMETRICS

Aspects of the scientific cooperation of Estonia and Germany in view of bibliometry

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Abstract. We provide a brief investigation of the Estonian–German scientific collaboration in terms of quantity and quality of the scientific output and impact based on the *Web of Science* (WoS) and the *Essential Science Indicators* (ESI) of *Thomson Reuters*. An overview of the overall scientific productivity of Estonia and a ranking of the countries of cooperation is given. The most active affiliations and research fields involved into the cooperation of the two countries are identified. We analyse in particular the development of the output (i.e. the number of joint publications) of the Estonian–German cooperation and of the impact (i.e. the number of their citations) since around 1972. Finally, the most frequently cited Estonian–German joint papers in the field of Physics and Astronomy are listed.

Key words: scientometry, bibliometry, German–Estonian scientific cooperation, scientific impact, time development, scientific productivity, Web of Science.

INTRODUCTION

Scientific exchange and collaboration between Estonia and Germany have a strong tradition. For long, the University in Tartu (Dorpat) was effectively a German university[1]. Especially in the 19th century, when Tartu (Dorpat) University was the only German-language university in the Russian Empire, there was a frequent exchange of students and professors (and with them ideas) in both directions. Quite a number of renowned and leading scientists of their time who taught and worked in Tartu (Dorpat) had received their full or at least a considerable part of their higher education at some German university or had spent a part of their scientific career in Germany. On the other hand, German universities profited from well trained students and scientists who originated from the Baltic area and who had studied and gained their degrees not least in Tartu (Dorpat). In 1919 the University of Tartu of the Republic of Estonia was formed and faculty members from Scandinavian neighbours but also from Germany were invited to join and complete the national teaching staff. After the Second World War the Estonian–German scientific exchange almost disappeared. For

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[1] On the occasion of the opening of the German–Estonian academic week in Tartu President Lennart Meri stated: 'Die Universität Tartu (Dorpat) hat schon jahrhundertelang in vielen Bereichen mit deutschen Universitäten zusammengearbeitet. Eigentlich ist das nur die halbe Wahrheit. Die Universität Tartu (Dorpat) war doch selbst eine deutsche Universität' (Staatspräsident Lennart Meri zur Eröffnung der deutsch-estnischen akademischen Woche Academica in Tartu (Dorpat) am 15.09.1997 [1]).

several decades collaboration with Estonian scientists was extremely difficult but nevertheless stayed alive[2].

The question we address in this study is how scientific collaboration between Estonia and Germany has developed after Estonia regained independence in 1991. We concentrate our investigation on the natural sciences and try to evaluate the collaboration by measuring scientific output (papers) and impact (citations) by means of standard bibliometric methods. We are especially interested in how characteristic figures have developed with time. The databases and tools provided by *Thomson Reuters* (see below) and *Elsevier* (*Scopus*) have facilitated and stimulated the usage of bibliometry for evaluating science. Bibliometric methods have been proven useful for the analysis of a single publication, ensembles of papers published by a specific researcher, a specific journal, or a whole country.

Recently, an analysis of the performance of the Estonian science in comparison to its neighbours Latvia and Lithuania based on bibliometric indicators appeared in this journal [3]. It turned out that in terms of numbers of the joint scientific publications Germany ranks third after Finland and Sweden but before the USA, England, and Russia. This analysis provided also some evidence that one potential factor behind the relative success of Estonian science could be the partnership with scientifically more advanced countries, e.g. with Germany.

In contrast to this analysis, our study stretches back to pre-1997 publications. A clear majority of the total joint Estonian–German scientific publications cover topics of natural sciences and only about 5% deal with Social Sciences, Arts, and Humanities. The emphasis of Estonia's scientific collaboration with Germany is clearly in the fields of Condensed Matter Physics, Astronomy, and Chemistry. The collaborations with Finland and Sweden concentrate more on Environmental Sciences, Biochemistry, and Neuroscience. Additionally, we identify the major collaborative partner institutions both in Estonia and Germany. A short comparison of the Estonian–German with the Latvian–German and Lithuanian–German scientific collaboration with regard to the research fields is included. Finally, we look at the impact reflected by the citation counts and investigate the development of the number of citations of the joint Estonian–German publications with time.

[2] For example, in 1970 the Institute of Physics and Astronomy of the Academy of Sciences of the Estonian SSR on the initiative of K. Rebane organized a seminar on 'Selected Problems in the Theory of Impurity Centers in Crystals' in Tallinn with 25 participants from foreign countries. For more details see the seminar proceedings [2], kindly provided to us by Prof. N. N. Kristoffel. It appears to us that many of the nowadays still active Estonian–German collaborations in the field of Solid-State Physics emerged from this meeting.

METHODOLOGY

The data presented here are based on the *Thomson Reuters* citation indexes (http://scientific.thomsonreuters.com/products/wos/) accessible under the *Web of Science* (WoS), in particular the *Science Citation Index* (SCI). In addition, the *Social Sciences Citation Index* (SSCI) available since 1956, the *Arts & Humanities Citation Index* (A&HCI) available since 1975, the *Conference Proceedings Citation Index, Science* (CPCI-S), and the *Conference Proceedings Citation Index, Social Science & Humanities* (CPCI-SSH), both available since 1992, have been consulted.

The WoS provides two search modes: the *General Search* mode gives access to the articles published since 1900 (no books and no conference proceedings are included unless they appeared in journals) and which are covered by the so-called WoS source journals. Currently there are about 9000 WoS source journals selected by the staff of *Thomson Reuters* as contributing significantly to the progress of science. The *Cited Reference Search* mode gives access to all references, i.e. citations which appeared in source journal articles.

To ensure coherency of the dataset, the data presented here are exclusively based on the *Thomson Reuters* databases. Other literature databases like the database of the American *Chemical Abstracts Service* (CAS) or the database for *Physics, Electronics and Computing* (INSPEC) are not interdisciplinary enough with regard to the literature coverage and furthermore do not include the addresses of the coauthors but only of either the first author or the corresponding author. Therefore, these databases are less suitable for selecting country specific publications across the various scientific disciplines.

ESTONIA – TOTAL NUMBER OF SCIENTIFIC PUBLICATIONS

The publications within the natural sciences disciplines are predominantly published as journal articles. Therefore, these research fields are covered fairly well by the source journals of the WoS citation indexes, in particular those of the *Science Citation Index* (SCI) [4]. The number of articles published in the WoS source journals has become a standard measure for scientific output (productivity), although books, popular publications, research reports, and most conference proceedings are not included. At the date of search (25.03.2009) the citation indexes accessible under the WoS revealed altogether 17 779 publications with at least one author based in Estonia (i.e. Estonia or ESSR as address search terms). The time evolution of the number of publications is shown in Fig. 1. There are a total of 52 pre-1965 papers listed in the WoS (outside the time window of

Fig. 1), mostly published in the fields of Biology and Physiology. The time evolution of the relative number of publications compared to the total number of publications in each year covered by the SCI is shown for comparison. The time-dependent overall number of publications covered by the WoS is not searchable because of the WoS system limits of 100 000 items per search. However, the total numbers based on the SCI (rather than on all citation indexes) are available via the database provider STN International (http://www.stn-international.de/). The SCI covers more than 80% of the Estonian publications and thus may be taken as reference here.

Figure 1 shows a distinct upward bend after 1991–1993 both with regard to the absolute numbers and compared to the growth of the publications covered by the SCI. Since the restitution of the Republic of Estonia in 1991 there is roughly a linear increase of the publication productivity by about 60 publications per year, significantly more than in the time before. There is remarkably no reduction of publications in the years around 1991.

The ensemble of the 17 779 papers published by at least one author based in Estonia was analysed with respect to the countries of coauthors and the research fields by using the WoS analyse function. Table 1 reveals that Germany appears on rank four behind the USSR, Finland, and Sweden as cooperating countries but before the USA, England, and Russia. Note that the author addresses (including the countries of authors) are not fully covered by the WoS prior to around 1972. The Estonian publications were selected using the author address search field but were analysed using the country of author search field available under the WoS analyse function. The lack of Estonia as a country or territory in the WoS before 1995 somewhat lowers the numbers. The analysis revealed that the most vivid fields of Estonia's overall collaborative activity were Condensed Matter Physics, Biochemistry & Molecular Biology, and Environmental Sciences.

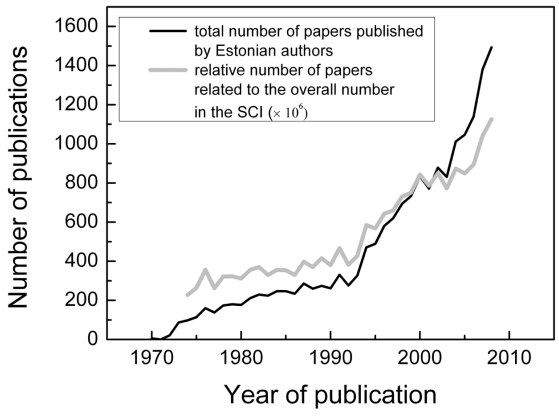

Fig. 1. Solid black line: Time evolution of the overall scientific productivity of Estonia (papers with at least one author from Estonia) as covered by the WoS citation indexes. Solid grey line: The same data divided by the worldwide total number of papers counted by the SCI for the respective year of publication. *Source*: WoS and SCI under STN.

Table 1. Distribution of the papers with at least one author based in Estonia across the contributing countries (only countries with at least 100 records are listed)

Rank	Country of author	Number of papers	% papers
1	USSR	2411	13.6
2	Finland	1424	8.0
3	Sweden	1375	7.7
4	Germany*	1030	6.4
5	USA	1001	5.6
6	England	622	3.5
7	Russia	519	2.9
8	France	500	2.8
9	Italy	400	2.2
10	Netherlands	310	1.7
11	Denmark	273	1.5
12	Spain	259	1.5
13	Norway	258	1.5
14	Poland	240	1.3
15	Canada	212	1.2
16	Latvia	188	1.1
17	Switzerland	187	1.1
18	Lithuania	180	1.0
19	Belgium	153	0.9
20	Japan	153	0.9
21	Hungary	149	0.8
22	Czech Republic	148	0.8
23	Australia	119	0.7
24	Scotland	111	0.6
25	Austria	102	0.6

* Federal Republic of Germany and German Democratic Republic are included here.

SCIENTIFIC COOPERATION AS REFLECTED BY PUBLICATION ACTIVITY

All Baltic countries and Germany

Some interesting information results from a comparison of the cooperation of Germany with the three Baltic countries. Out of the 17 779 Estonian scientific publications 1134 (6%) are published in cooperation with at least one coauthor from Germany. The majority of the joint publications have been published after 1991. This is comparable to the number of joint publications of Germany with Latvia (921) and Lithuania (1065). Similar to the collaboration with Estonia, the joint papers published in collaboration of German researchers

with Latvian and Lithuanian colleagues are also mainly focused on Physics, Chemistry, and Materials Science.

Estonia and Germany

The 1134 joint Estonian–German publications were analysed with regard to the various research fields again by using the WoS analyse function. Figure 2 displays the time evolution of the papers coauthored by Estonian and German researchers. The time evolution of the relative number of publications compared to the total number of Estonian publications in each year covered by the SCI is shown for comparison.

Table 2 lists the affiliations of the Estonian and German coauthors contributing to a joint publication. Note that the author addresses (affiliations, countries) are badly covered by the WoS prior to around 1972 and that until present institutional names are hardly standardized by the WoS producer. The table reveals that the majority of the scientific collaboration originates from the University of Tartu. In Germany, the universities of Hamburg, München (TU), Würzburg, and Bayreuth are the leading cooperation partners.

Table 3 reveals a clear dominance of Condensed Matter Physics, Astronomy, Applied Physics and other sub-disciplines of Physics as being the research fields of about one third of the 1134 joint Estonian–German publications. Accordingly, the most frequently appearing journals are *Physical Review B* and *Astronomy & Astrophysics*.

The currently 66 joint Estonian–German publications covered by the *Social Sciences Citation Index* (SSCI) and the *Arts & Humanities Citation Index* (A&HCI) are mainly focused on Psychiatry and Psychology.

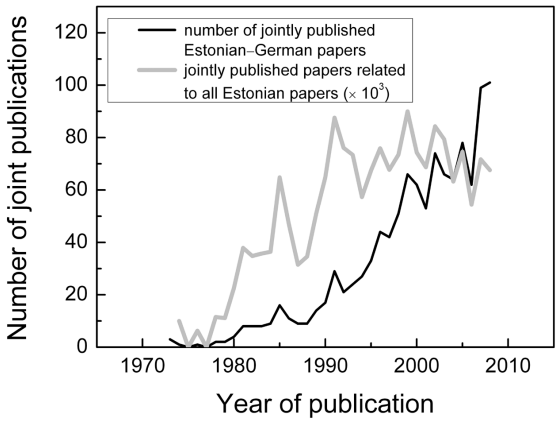

Fig. 2. Solid black line: Time evolution of the currently 1134 joint Estonian–German publications. Total: 1134, SCI: 1132, CPCI-S: 180, SSCI plus A&HCI: 66 papers. The time evolution of the relative number of publications compared to the total number of Estonian publications in each year is shown for comparison (solid grey line). *Source*: WoS.

Table 2. Distribution of the currently 1134 joint Estonian–German publications across the author affiliations (only affiliations with at least 20 papers are listed)

Rank	Institution	Number of joint papers	% joint papers
1	University of Tartu[a]	467	41.2
2	Estonian Academy of Sciences[b]	185	16.3
3	University of Hamburg	91	8.0
4	Tallinn University of Technology[c]	86	7.6
5	Tartu Observatory[d]	86	7.6
6	Estonian University of Life Sciences[e]	63	5.6
7	Academy of Sciences of GDR	59	5.2
8	National Institute of Chemical Physics & Biophysics[f]	53	4.7
9	Univeristy of Helsinki	45	4.0
10	Technical University of München	37	3.3
11	Estonian Biocentre	35	3.1
12	Russian Academy of Sciences	34	3.0
13	University of Würzburg	32	2.8
14	University of Oxford	31	2.7
15	University of Bayreuth	28	2.5
16	Astrophysics Institute of Potsdam	27	2.4
17	Lund University	27	2.4
18	University of Mainz	25	2.2
19	University of Kiel	24	2.1
20	University of Stuttgart	24	2.1
21	Free University of Berlin	23	2.0
22	University of München	20	1.8

[a] University of Tartu and Tartu State University appear as separate entries and have been pooled together.

[b] Academy of Sciences of the ESSR has been added to the Estonian Academy of Sciences.

[c] Tallinn Technical University has been added to Tallinn University of Technology.

[d] Tartu Astrophysics Observatory has been added to Tartu Observatory.

[e] Estonian Agricultural University has been added to Estonian University of Life Sciences.

[f] Institute of Chemical Physics & Biophysics has been added to National Institute of Chemical Physics & Biophysics.

Table 1 shows that in terms of number of publications Finland and Sweden are Estonia's major scientific cooperation partners in Europe. In contrast to the collaboration with German scientists, the emphasis of the scientific cooperation of Estonia with Finland and Sweden is on the fields of Biochemistry, Environmental Sciences, and Medicine.

Table 3. Distribution of the currently 1134 joint Estonian–German publications across the WoS subject areas (only areas with at least 20 papers are listed)

Rank	WoS subject area	Number of papers	% papers
1	Physics, Condensed Matter	116	10.2
2	Astronomy & Astrophysics	93	8.2
3	Biochemistry & Molecular Biology	80	7.1
4	Genetics & Heredity	65	5.7
5	Physics, Applied	58	5.1
6	Chemistry, Physical	56	4.9
7	Nuclear Science & Technology	47	4.1
8	Plant Sciences	47	4.1
9	Environmental Sciences	42	3.7
10	Physics, Atomic, Molecular & Chemical	42	3.7
11	Ecology	37	3.3
12	Oncology	35	3.1
13	Biophysics	34	3.0
14	Materials Science, Multidisciplinary	34	3.0
15	Mathematics	32	2.8
16	Chemistry, Multidisciplinary	28	2.5
17	Mathematics, Applied	28	2.5
18	Physics, Particles & Fields	27	2.4
19	Optics	24	2.1
20	Spectroscopy	24	2.1
21	Cell Biology	23	2.0
22	Chemistry, Inorganic & Nuclear	22	1.9
23	Instruments & Instrumentation	22	1.9
24	Marine & Freshwater Biology	22	1.9
25	Physics, Multidisciplinary	21	1.9

SCIENTIFIC IMPACT AS REFLECTED BY CITATIONS

The size and the impact of publications vary considerably. Accordingly, the number of papers published by a researcher, a research institute, or a whole country is insufficient as a measure of scientific productivity or research performance and does not allow judging on the importance, influence, or even the quality of the work. An increasingly popular way to estimate the impact of a researcher, a research institute, or a country is to count the number of times their specific articles have been cited. The number of citations is often considered as a measure of the attention a scientific work has attracted and of its importance or usefulness within the scientific community. Like counting publications, counting citations does not provide an ultimate measure of the final importance and quality of publications, and as with counting the number of publications, counting the number of citations contains strengths and shortcomings. Nevertheless, citation numbers are increasingly used for research evaluation. One strength of citation numbers is certainly that in contrast to expert advisory committees (peer review), not only a few but a large number of anonymous scientists – essentially the whole community – within a field of research evaluates a specific paper. The aspects and the problems involved when using citation counts have been intensely debated in the literature and hence there is no need to repeat this discussion here [5].

Figure 3 shows the total number of citations per year of the 1134 Estonian–German papers jointly published since 1970 that are available under the WoS *Citation Report*. By definition, the number of citations for a particular year accumulates the attention paid to all publications published prior to the citing year and hence the number of citations generally tends to increase super-linearly. The slopes (impact acceleration) of such 'sales curves' can be taken as age-independent indicators of the citation impact of researchers, research institutes or, as in the present case, of the publications of a specific cooperation, etc. A comparison of the slope of the jointly published Estonian–German papers with the number of all papers published by Estonian researchers is hampered here for two reasons: (1) The citations of the overall number of Estonian publications are not searchable in the WoS because the number of papers is above 10 000 and thus exceeds the system limits of the WoS *Citation Report* function. (2) The joint Estonian–German papers in some research fields are too small for a meaningful comparison. Therefore, the time curves of the total Estonian papers in the fields of Physics and Chemistry (rather than the impact time curves of the overall Estonian papers) are shown for comparison. However, these two research fields represent only about one third of the overall Estonian publications. The comparison can be justified by the fact that the average citation rates of these fields are more or less representative for all papers (see Table 4).

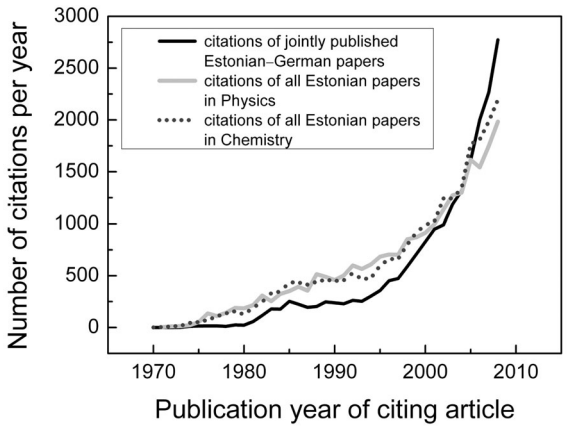

Fig. 3. Solid black line: Time evolution of the impact (citations per year) of the currently 1134 joint Estonian–German publications. The citations per year of all Estonian papers in the fields of Physics and Chemistry are shown for comparison (solid and dotted grey lines). *Source*: WoS.

As Fig. 3 demonstrates, the total number of citations in each year of all papers published jointly by Estonian and German partners accelerated impressively reaching about 2800 citations in the year 2008. The plot shows the number of citations in each year of all articles from the year of appearance till the given publication year of the citing articles. An acceleration of the number of citations with time may be generally expected due to the cumulative character of the WoS *Citation Report* graph but is not always found. A linear increase or even a bending-off may also be observed. For example, if a researcher stops publishing towards the end of the career, the impact curve shows a significant waning and eventually a bending-off. In contrast, the time curve given in Fig. 3 shows an increasing slope, indicating that the joint Estonian–German publications attract unbroken attention. In order to investigate how this acceleration compares with the citation rate growth of all papers published by Estonian authors the acceleration of impact over the time of the Estonian papers in the fields of Physics and Chemistry is shown for comparison. The striking acceleration of the number of cited papers per year after 1993 compared to the rather constant impact development before is noteworthy.

Different disciplines have different citation habits (i.e. different average numbers of references per article) resulting in different average citation rates (average citations per article), which renders it rather difficult to compare citation rates of different scientific disciplines. For example, the average citation rates of Mathematics and Molecular Biology & Genetics differ by almost a factor of ten. Also, the average citation rates also reflect the popularity of a research field. Therefore, a comparison of citation counts across different research fields without normalization has to be regarded with great care.

In view of these difficulties, the papers published in the three main cooperative research fields (Physics, Chemistry, Biology) coauthored by Estonian and German researchers were analysed separately. The research field specific publications were selected using the corresponding WoS subject areas given under the WoS refine function. In Table 4 the average number of citations per paper (citation rate) of the joint Estonian–German papers for the three research fields and the time period 1998–2008 are given. The average citation rates of the overall Estonian publications of these research fields are listed for comparison. *Thomson Reuters* offers an in-depth analytical tool for ranking scientists, institutions, countries, and journals based on the WoS data of the last decade, the *Essential Science Indicators* (ESI) (http://scientific.thomsonreuters.com/products/esi/). The world average citation rates of the corresponding research fields given in the ESI-1998–2008 baselines were taken for further comparison (http://esi.isiknowledge.com/baselinespage.cgi).

Table 4. Average citation rates of the joint Estonian–German (E & G) papers and the total Estonian publications for three research fields and the time period 1998–2008. The overall average citation rates given in the ESI baselines are taken for further comparison. The number of papers is given in brackets. *Source*: WoS and ESI 1998–2008

Research fields as defined by ESI	E & G average citation rate 1998–2008	Estonian average citation rate 1998–2008	ESI average citation rate 1998–2008
Physics	7.77 (176)	6.37 (1328)	8.19
Chemistry	11.85 (66)	9.27 (996)	9.72
Biology & Biochemistry	16.84 (120)	10.32 (1367)	16.41
All Fields	14.70 (773)	7.96 (8987)*	9.91

* The two *Conference Proceedings Citation Indexes* could not be included here, because the 10 712 Estonian papers since 1998 exceed the WoS system limits concerning the *Citation Report* function.

Table 4 shows that the average citation rates of the joint Estonian–German papers compare favourably to the total Estonian publications and the world average within the same time period quoted in the ESI for the three main research fields (and also for the average of all 23 ESI research fields). Note that the ESI research fields are much broader subject categories than the WoS subject areas. The significance of the data is somewhat limited by the small number of joint papers since 1998.

Finally, the ten most highly cited joint Estonian–German papers within the fields of Physics and Astronomy as the two top ranked fields of cooperation (see Table 1) are given in Table 5. Note that such lists actually imply no real ranking because the various papers accumulated their citations over different time periods.

The paper of rank 5 illustrates the problems when selecting literature by using the WoS author address field. First, this paper was not included by the WoS listing, because the permanent Estonian address of one author (Hizhnyakov) was given in the paper only as a footnote and was therefore not transferred into the author address field by the WoS. The citation count of the paper of rank 7 in Table 5 is also remarkable: this technical report paper collected an impressive number of 66 citations within the first year after its publication.

Table 5. Ten most highly cited joint Estonian–German papers within the fields of Physics and Astronomy (340 papers since 1981). Date of search: 30.03.2009

1. Zeldovich, Y. B., Einasto, J., and Shandarin, S. F. Giant voids in the universe. *Nature*, 1982, **300**, 407–413 Times cited: 221
2. Leitherer, C., Alloin, D., Fritz von Alvensleben, U., et al. A database for galaxy evolution modeling. *Publ. Astron. Soc. Pac.*, 1996, **108**, 996–1017 Times cited: 167
3. Einasto, J., Klypin, A. A., Saar, E., and Shandarin, S. F. Structure of the superclusters and supercluster formation. III Quantitative study of the local supercluster. *MNRAS*, 1984, **206**, 529–558 Times cited: 146
4. Einasto, J., Einasto, M., Gottlöber, S., et al. A 120-Mpc periodicity in the three-dimensional distribution of galaxy superclusters. *Nature*, 1997, **385**, 139–141 Times cited: 128
5. Hizhnyakov, V. and Sigmund, E. High-T_C superconductivity induced by ferromagnetic clustering. *Physica C*, 1988, **156**, 655–666 Times cited: 113
6. Kremer, R. K., Sigmund, E., Hizhnyakov, V., et al. Percolative phase-separation in $La_2CuO_{4+\delta}$ and $La_{2-x}Sr_xCuO_4$. *Z. Phys. B* (*Condensed Matter*), 1992, **86**, 319–324 Times cited: 95
7. Bayatian, G. L., Chatrchyan, S., Hmayakyan, G., et al. CMS physics technical design report, volume II: Physics performance. *J. Phys. G*, 2007, **34**, 995–1579 Times cited: 66
8. Srdanov, V. I., Stucky, G. D., Lippmaa, E. and Engelhardt, G. Evidence for an antiferromagnetic transition in a zeolite-supported cubic lattice of *F* centers. *Phys. Rev. Lett.*, 1998, **80**, 2449–2452 Times cited: 66
9. Tucker, D. L., Oemler, A., Kirshner, R. P., et al. The Las Campanas Redshift Survey galaxy-galaxy autocorrelation function. *MNRAS*, 1997, **285**, L5–L9 Times cited: 63
10. Pelt, J., Kayser, R., Refsdal, S., and Schramm, T. The light curve and the time delay of QSO 0957+561. *Astron. Astrophys.*, 1996, **305**, 97–106 Times cited: 61
10. Massa, D., Fullerton, A. W., Nichols, J. S., et al. The *IUE* mega campaign: wind variability and rotation in early-type stars. *ApJ*, 1995, **452**, L53–L55 Times cited: 61

CONCLUSIONS

With respect to collaborative publications with researchers from foreign countries, joint scientific publications of Estonian with German researchers rank fourth after the USSR, Finland, and Sweden, but before the USA, England, and Russia. The emphasis of Estonia's scientific collaboration with Germany is mainly in the fields of Physics and Astronomy. After 1991 there is a clear increase in the number of papers per year of joint Estonian–German authorship. However, the relative number of joint publications as compared to the total number of Estonian publications in each year has been roughly constant since around 1990. The citation count per year of the overall papers published jointly by Estonian and German partners has accelerated impressively. The impact acceleration is significantly higher than that of the total Estonian papers in Physics and Chemistry. The average citation rates of the joint Estonian–German papers compare favourably to the total Estonian publications and the world average in the same time period quoted in the ESI for the three main research fields Physics, Chemistry, and Biology.

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Eesti ja Saksa teaduskoostöö aspektid bibliomeetria vaatekohast

Reinhard K. Kremer ja Werner Marx

On uuritud Eesti-Saksa teaduskoostöö mahtu ja kvaliteeti andmebaaside Web of Science ning Essential Science Indicators (Thomson Reuters) põhjal. On analüüsitud Eesti teadlaste ja teadusasutuste produktiivsust, tehes kindlaks nende kõige aktiivsemad välispartnerid. On esitatud Eesti-Saksa ühiselt avaldatud artiklite arvu ja tsiteeringute dünaamika alates 1972. aastast. On toodud nimekiri Eesti-Saksa kõige enam tsiteeritud artiklitest füüsika ja astronoomia valdkonnas.

Artikli laiendatud eestikeelne versioon avaldatakse ajakirjas Akadeemia.