Article:

Zhu, Q.L. and Willett, P. (2011) Bibliometric analysis of Chinese superconductivity research, 1986-2007. ASLIB Proceedings , 63 (1). pp. 101-119. ISSN 0001-253X

https://doi.org/10.1108/00012531111103803

Published paper

Zhu, Q.L., Willett, P. (2011) *Bibliometric analysis of Chinese superconductivity research, 1986-2007*, ASLIB Proceedings, 63 (1), pp. 101-119
http://dx.doi.org/10.1108/00012531111103803

Bibliometric Analysis of Chinese Superconductivity Research, 1986-2007

Qilun Zhu[1]

Western Bank Library, University of Sheffield, Sheffield S10 2TN, UK

Peter Willett[2]

Department of Information Studies, University of Sheffield, 211 Portobello Street, Sheffield S1 4DP, UK

Structured abstract

Purpose: To carry out a bibliometric analysis of the development of Chinese research in superconductivity since the advent of high-temperature superconductivity (HTS) in the mid-Eighties, and to compare Chinese research with that of its international competitors.

Design/methodology: Use of publication, citation, journal, subject category and institutional data from the *Web of Science* database.

Findings: Chinese HTS research has grown steadily in importance over the period with a significant increase in peer-recognition, as measured by citations from non-Chinese researchers. A comparison with superconductivity research in England, France, Germany, Japan, Russia and the USA shows that the impact of the Chinese work is growing relative to the other countries, with a cluster analysis showing that the current bibliometric status of Chinese research is most similar to that of England, France and Russia.

Originality/value: This is both the first bibliometric study of Chinese research in superconductivity and the first bibliometric comparison of different countries' research in superconductivity since the advent of HTS. Cluster analysis provides an interesting way of identifying analogous international bibliometric profiles.

Keywords: Bibliometrics, China, citation analysis, superconductivity

Classification: Research paper

---

[1] Formerly: Library of Institute of Physics, Chinese Academy of Sciences, Beijing, China

[2] To whom all correspondence should be addressed: email p.willett@sheffield.ac.uk

INTRODUCTION

The resistance of most substances to the passage of an electrical current slowly declines in line with a decrease in temperature. However, at very low temperatures, some substances undergo a transition from their normal resisting state to a totally non-resisting state, so that they then allow an electric current to circulate indefinitely. This phenomenon of superconductivity was first identified by Onnes in 1911, an achievement that was recognised by the award of the Nobel Prize for Physics in 1913.

It was thought for many years that superconductivity only manifested itself at temperatures close to absolute zero, hence limiting the potential applications of the phenomenon. This view changed when Muller and Bednorz, working at IBM's Zurich Research Laboratory, identified the first substance that exhibited "high-temperature" superconductivity (hereafter generally referred to as HTS) (Bednorz and Mueller, 1986). In this context, "high" was still only 35 K, but the significance of the discovery resulted in them being awarded the Nobel Prize for Physics in 1987. Since then, there has been an intensive search for substances exhibiting superconductivity at higher and higher critical temperatures, so as to permit applications such as power transmission and cellular communications equipment; the current leader is a mercury thallium barium calcium copper oxide compound with a critical temperature of no less than 138 K (Jacoby, 2008).

There have been several bibliometric analyses of superconductivity research (Arunachalam and Singh, 1984; 1985; Cardona and Marx, 2006; Chu, 1992a; Chu, 1992b; Chu, 1998; Garfield, 1988; 1990; Nadel, 1981). For example, Cardona and Marx (2006) studied the impact of the work of Vitaly Ginzburg, one of the most influential scholars in superconductivity research, and Chu (1992a, 1992b) discussed communications between Chinese and non-Chinese superconductivity scientists, noting that the Chinese scientists were less visible than their overseas counterparts. There have also been many bibliometric studies demonstrating the impact of Chinese research in science (see, e.g., (Guan and Ma, 2007; Kostoff, 2008; Zhou and Leydesdorf, 2006; 2007)) and social science (Zhou *et al*., 2009). However, there have been no studies of which we are aware that describe China's international impact in HTS, despite the fact that it has been at the forefront of research in the area since the pioneering work of Zhao et al. on yttrium barium copper oxides (Zhao *et al*., 1987). The only relevant work is a study by Chu covering just the earliest Chinese research (1987-89) (Chu, 1998), while studies comparing different nations' contributions in superconductivity predate the HTS era (Arunachalam and Singh, 1984; 1985). Here, we report a detailed bibliometric analysis of Chinese HTS research for the period 1986-2007; in addition, we compare the nature and impact of the Chinese work with that of other countries that make significant contributions to this important area of modern physics.

METHODS

Our analyses are based on publication and citation data extracted from the Science Citation Index component of the *Web of Science* produced by Thomson Reuters. Other possible sources include Google Scholar and Scopus; however, we have chosen to use just the *Web of Science* since Bakkalbasi *et al*. (2006) have shown previously that this database provides more citation data than do the other two for condensed matter physics, of which HTS is an important part.

Searches were carried out on the Science Citation Index part of the *Web of Science* during July 2008 for

TS=(superconduct*) AND CU=(China)

with a timespan of 1986-2007, where TS is a topic search that retrieves occurrences of the search term in the title, abstract, author keyword or KeyWords Plus sections of an article. The citations for the resulting publications were noted, after exclusion of all self-citations, and subject analyses were carried out using the Journal Citation Report (JCR) classification scheme.

CHINESE RESEARCH

Basic data

The *Web of Science* search retrieved a total of 7,241 publications for the period 1986-2007, these including not just articles but also notes, letters, reviews, editorial materials, meeting abstracts, and corrections. The subsequent analyses are based on the 6,977 articles, which hence comprise 96.3% of the search output. We focus here on the articles since they represent original research contributions, and hence citations to them represent the impact of that research. The second largest group of publications were reviews, which do not report original research and which also have a very different citation profile from journal articles (for the search outputs here the mean number of citations *per* article and *per* review were 3.42 and 27.98, respectively).

The 6,977 articles had attracted a total of 15,735 citations by July 2008, after removal of 14,103 self-citations. The growth in publications and citations is shown in Figure 1, where it will be seen that there has been a steady growth in publications across the review-period, whilst the citation counts began to climb steeply after about 2001. The steep climb of 2001-2007 is further analyzed in terms of citations per publication in Figure 2, with detailed data collected in April 2009 and calculated using a 2-year timeframe recommended by Thomson Reuters (http://thomsonreuters.com/business_units/scientific/free/essays/impactfactor/).

English was the primary language of both the original Chinese articles (95.7%) and the citations to those articles (96.8%). Apart from English, the original articles were written in Chinese, German and

Japanese, with the citations in all these languages plus Czech, French, Korean, Portuguese, Russian, Spanish, Ukrainian and Welsh. The Chinese articles are hence clearly read throughout the international research community.

Subject areas and source journals

The original articles cover 69 of the JCR subject areas, and the citing articles cover 140 areas. The areas providing at least 1% of the articles or citations are listed in Table 1, where it will be seen that there is a considerable degree of overlap between the two, especially at the tops of the lists. For example, the first three subject categories when one considers the assignment of subject categories to the source publications (Publications column) are ranked second, first and third when one considers the assignment of subject categories to the articles citing those publications (Citations column). The subject areas listed in the table are hardly surprising given the nature of superconductivity, with the bulk of them being in physics and with mathematics, chemistry and engineering also represented. A much wider range of disciplines is represented in the total of 69 subject areas covering the set of publications. In addition to the broad areas noted in Table 1, materials, health and life sciences are well represented as are, to a lesser extent, the geosciences and computer science. Similar comments apply to the set of 140 subject areas covering the citing publications; however, the greater number (over twice as many areas) means that a wider range of disciplines is represented, with citations not only from the environmental sciences but also, albeit at very low frequencies, from the social sciences.

The original articles were published in 422 journals; and the citations in 1,042 journals. The journals providing at least 1% of the articles or citations are listed in Table 2, together with the journal impact factors (these are not available for *Acta Physica Sinica* and *Journal of Superconductivity* in the 2007 edition of JCR). There is again a high degree of overlap between original articles and citing articles with eleven of those listed having at least 1% of both articles and citations. If we regard these as the core journals for Chinese HTS research, it is of interest to determine the importance of this research as compared to HTS research in general. We have approximated the latter by taking the three top subject areas from Table 1: Physics Applied; Physics Condensed Matter; and Physics, Multidisciplinary. The mean of the JCR impact factors for these three areas (and hence for HTS in general) was 2.12. The mean impact factor obtained by averaging the individual impact factors for the eleven core journals noted previously was 2.44, i.e., notably higher. Accordingly, we may conclude that articles on, and citations to, Chinese HTS research appear in journals that have higher impacts than typical journals in those parts of physics that cover HTS research.

Key research institutions

The articles were written by authors in a total of 1,391 different Chinese and collaborating institutions, 13 of which provided at least 100 articles, as listed in Table 3. It will be seen that the Chinese Academy of Sciences is by far the most productive, contributing almost one-third of the original articles; moreover, this institution received 6,819 of the citations (43.3%) to Chinese original articles, confirming that this is by some way the most important centre for HTS research in China. That said, it is not possible using the analysis tools available in *Web of Science* to discriminate between the many individual institutes that comprise the Chinese Academy of Sciences.

The 15,735 citations came from a total of 4,408 institutions all over the world, with those providing at least 300 citations listed in Table 4. It will be seen that there is only a single non-Asian institution here – the Russian Academy of Sciences – although two non-Asian institutions – Princeton University and the University of Cincinnati - both provided as many as 252 citations. Non-Asian recognition of Chinese research is much more evident if the citations are analysed by country, rather than by institution, as shown in Table 5 (which lists the countries providing more than 300 citations). Hardly surprisingly, China provides the largest single number of citations, followed by USA and Japan, and with European countries (France, Germany, Italy, Russia, etc.) providing significant numbers of citations additional to those provided by other large Asian/Pacific contributors (such as Australia, India, and South Korea).

International collaborations

2,041 of the set of 6,977 original articles were the result of international collaborations, these involving a total of 53 collaborating countries. Citations to the original articles come from articles authored in 104 different countries, and we may hence conclude that China has established a significant role for itself on the international stage. 1,211 of the collaborative articles have a Chinese address for the author to whom reprint requests should be addressed. In the case of multi-author papers, the named author will normally be somebody who has made substantial contributions to the paper, and we may hence conclude that China has played a substantial role in 59.3% of the collaborative articles (to the extent that author affiliations can be equated with author nationalities). The most important collaborating countries, defined as those being involved in at least 1% of the original articles, are listed in Table 6. These main collaborating countries all figure prominently in the list of citing countries shown in Table 5: thus the main international impact of Chinese HTS research is on its principal research collaborators.

COMPARISON WITH OTHER COUNTRIES

Basic data

Thus far, we have considered only the HTS research that has been carried out by Chinese scientists, and seen evidence of its impact in the field. However, to obtain a more detailed view of the impact of this research on the development of the subject, it is necessary to compare the characteristics of this Chinese research with those of the research carried out in other leading countries. To this end, searches were carried out for articles on the Science Citation Index part of the *Web of Science* during July 2008 for

TS=(superconduct*) AND CU=(*xxx*)

with a timespan of 1986-2007 for a range of countries, *xxx*. These searches gave the following results (bracketed number is the number of articles published by that country in the period 1986-2007): England (5,675), France (7,901), Germany (11,363), Japan (24,319), Russia (7,893) and USA (28,340). These sets of articles, and the 6,977 Chinese articles discussed previously, are considered further below.

The growth in publications over the period 1986-2007 is shown in Figure 3, which has been drawn as a five-year running average to smooth the annual scatter in the data. It will be seen that only China has seen a steady growth in productivity since the new millennium: indeed, having started with very few publications, it has now overtaken England, France and Russia, although it still lags behind Germany, Japan and the USA.

Subject areas and source journals

The original articles for the seven countries cover between 59 (Russia) and 124 (USA) of the JCR subject areas, with a fair degree of overlap in the most populated subject areas. Table 7 lists those 17 subject areas that included at least 1% of the articles from at least one of the countries and that included at least 1,000 articles from across the seven countries. The three most common areas are: Physics, Applied; Physics Condensed Matter; and Physics, Multidisciplinary (as was the case with the Chinese research in Table 1). It will be seen that there is a high degree of commonality across the countries and subject areas and this is also the case if we consider citations rather than publications (data not shown). We have noted when discussing Table 1 the wide range of less frequently occurring subject areas covered by Chinese publications, and similar comments apply to the data in Table 7, with single-occurrence subject areas including topics as diverse as Entomology, Law, Music and Water Resources.

An analysis of the sources of the articles published by the seven countries shows that some of the journals are popular places for publication across all of the countries, e.g., *Physica C*, *Physical Review B*, and *IEEE Transactions on Applied Superconductivity*. These core journals are listed in Table 8, where a core journal is taken to be one in which each country has published at least 1% of its HTS articles and which has published at least 1,000 articles from across the seven countries. A comparison of this with Table 2 shows that much China HTS research is published in journals that are published in China but that do not attract large numbers of articles from other countries, e.g., *Chinese Physics*, *Chinese Physics Letters*, and *Chinese Science Bulletin*. In all, over 12% of the Chinese articles appeared in such national journals; in like vein, over 13% of the Japanese and over 16% of the Russian articles were in national journals. The national focus of the Japanese journals is particularly evident in Table 8, where Japanese research provides over 90% of the listed papers for both the *Japanese Journal of Applied Physics* and the *Journal of the Physical Society of Japan*.

Key research institutions

We have already noted that the Chinese Academy of Sciences is the leading organization for HTS research in China, as denoted by its number of original articles in the period 1986-2007. Table 9 lists the top institutions for the seven countries studied in this part of the paper, together with the numbers of articles from these institutions, and mean citation rates for these source articles, with the latter variable measured not just for the entire period 1986-2007 but also for 2001-2007 (the searches here were carried out in November 2008). It will be seen that articles from the Chinese Academy of Sciences receive the smallest number of citations on average (as well as the smallest total number of citations) from amongst these elite institutions, several of which, like the Academy, encompass multiple locations and/or organizations. We wish to focus here on the right-hand part of the table where a comparison of the columns for 1986-2007 and for 2001-2007 shows that the latter citation rate has increased relative to four of the other six institutions. This means that the more recent Chinese articles are having relatively more impact than did the earlier ones, which provides further support for the view that Chinese work is becoming of greater importance to HTS research than was previously the case. This relative increase in importance is still greater if attention is restricted to the most-cited publications, specifically those contributing to each country's *h*-index (data not shown).

Citations

The study of Chinese citations covered the period 1986-2007; however, the *Web of Science* citation tools can only provide citation reports for sets of less than 10,000 original publications, whereas both Japan and the USA have published more than this number of articles during 1986-2007. The comparative citation analyses have hence been carried out on a subset of the original publications: specifically those articles published in the period 2001-2007 and categorized in the three top subject areas of Table 7. The use of this restricted timeframe also means that China is not unduly disadvantaged in terms of relative citation counts, since the chosen period does not include the earlier years when Chinese research productivity was much lower.

Table 10 lists the source articles, total citations, and mean citations per article, for the seven countries. It will be seen that China has the lowest total citations (but with a higher mean than Japan); it also has the lowest *h*-index (data not shown) indicating that even the most highly cited Chinese articles currently have less impact than those of their major competitors. However, this situation may well change in the future, given the increased impact of Chinese publications that has been noted in Figure 2.

Tables 11-13 list the 22 most important citing countries, the 16 most important subject areas, and the 12 most important citing journals; here, the most important country is defined as a country that has contributed at least 1% of the citations to at least one of the seven countries and that has provided at least 1,000 citations in total, and similarly so for the most important subject areas or citing journals. The relationships between the countries are discussed further in the final section of this paper, but we additionally note here the data in Table 12. The number of subject areas for the citing papers here ranges from 69 (France) to 114 (USA), and with 75 for China. It will be seen that there is a fair degree of commonality in subject coverage as there was with the publication subject areas in Table 7; and the less-common subject areas here again range widely across the broad range of academic disciplines.

International collaborations

Table 14 lists international collaborations involving the seven countries. It will be seen that China has the smallest total number of collaborative publications, these representing only 29.3% of the total Chinese publications for the period 1986-2007. This is the lowest percentage for all of the countries (with Japan very close at 29.5%): the highest such percentages are France with 85.70% and both England and Germany with 81.1%. All the countries have collaborated with each other, normally most strongly with the USA: the only exception is Russia, which has Germany as its closest partner. Other countries that are heavily involved in collaborations include Canada, Italy, the Netherlands and Switzerland. International collaboration in a publication is often beneficial in terms of attracting citations (Adams et al., 2007; Roberts, 2006). Thus, considering the 50 most-cited Chinese during the period 1986-2007, 34 of them involve international collaborations, i.e., 68.0%. All of the other countries have percentages in excess of 50% (ranging from Japan with 51.3% to Russia with 94.6%), with the exception of the USA (25.8%).

Hierarchic cluster analysis

Previous sections have compared the status of Chinese HTS research with that in six other leading science countries using a range of types of data. Previous suggestions for comparing countries include indicators such as the ISSRU set (Schubert *et al*., 1989), the CWTS set (at http://www.socialsciences.leiden.edu/cwts/research/bibliometric-counts/bibliometric-indicators.html), and the international standard set (Moed *et al*., 1995): here, we discuss the use of cluster analysis for this purpose. Specifically, we apply hierarchic agglomerative cluster analysis to ascertain which country is (or which countries are) most similar to China in bibliometric terms.

The use of cluster analysis on a set of objects, in this case the seven countries, typically requires a (normally multivariate) representation of the objects, a measure of similarity or distance between all possible pairs of such representations, and the application of a clustering method to the resulting matrix of inter-objects similarities (Everitt *et al*., 2001). In this work, the clusters were identified using squared Euclidean distance and the group average hierarchic agglomerative clustering method as implemented in the SPSS statistical package; another such method, Ward's method, gave very similar results to those presented here. Tables 7, 8, 12 and 13 provided the input data for the cluster analyses, which will be illustrated by the data in Table 7. Here, each country was represented by a 17-element integer vector, each of which contained the number of publications by that country in one of the 17 chosen subject areas (i.e., those that included at least 1% of the articles from at least one of the countries and that included at least 1,000 articles across all seven countries). The basic frequency data for each country was standardized to zero mean and unit standard deviation, and then the distance between each pair of countries computed by means of the squared Euclidean distance between the corresponding pair of standardized vectors. The resulting inter-country distance matrix was then processed using the group average method, and the resulting classification illustrated diagrammatically by the dendrogram shown in Figure 4(a), where the horizontal scale shows the distance (normalised into the range 0-25 for display purposes) at which each new cluster is formed. The dendrogram representation hence provides a compact, visual representation of the data in Table 7, and helps to make explicit the inter-country relationships that are implicit in the large body of data in the table.

Figure 4(a) contains essentially two clusters: China, England, France, Germany and Russia; and Japan and the USA. A similar picture is revealed in Figure 4(b), which uses the data from Table 8, i.e., the core journals for HTS publication. A different picture is revealed in Figures 4(c) and 4(d) when we turn to the citation data (i.e., Tables 12 and 13 containing the important citing subject areas and the important citing journals): here, China is still grouped with England, France and Russia, but Germany now forms a cluster with Japan, with the USA being notably different from all of the other countries. We hence conclude that the bibliometric status of Chinese HTS research is currently most similar to that of England, France and Russia; however, this may change given the strong growth in Chinese HTS research that is reflected in Figures 1-3.

CONCLUSIONS

In this paper, we have reported a bibliometric analysis of Chinese HTS research for the period 1986-2007. The research has grown steadily over the period, with a noticeable growth in the citation rate since about 2001. Research in China is analogous to that in the other six countries considered here (England, France, Germany, Japan, Russia and the USA) in terms of the JCR subject areas in which articles appear or are cited, in terms of international collaborators, and in terms of the core journals for the topic. A cluster analysis suggests that the bibliometric characteristics of Chinese HTS research currently resemble most closely those of England, France and Russia.

REFERENCES

Adams, J., Gurney, K. and Marshall, S. (2007), *Patterns of International Collaboration for the UK and Leading Partners*, Evidence Ltd., Leeds.

Arunachalam, S. and Singh, U.N. (1984), "Publication and citation patterns in the literature of a high metabolism area - the case of superconductivity in 1970", *Journal of Information Science*, Vol. 8 No. 3, pp. 93-102.

Arunachalam, S. and Singh, U.N. (1985), "Sophisticated science in a small country: a scientometric analysis of superconductivity research in Israel ", *Journal of Information Science*, Vol. 10 No. 4, pp. 165-171.

Bakkalbasi, N., Bauer, K., Glover, J. and Wang, L. 2006, 'Three options for citation tracking: Google Scholar, Scopus and Web of Science', in *Biomedical Digital Libraries*, available at: http://www.bio-diglib.com/content/3/1/7 (accessed 1st June 2009).

Bednorz, J.G. and Mueller, K.A. (1986), "Possible high TC superconductivity in the Ba-La-Cu-O system", *Zeitschrift für Physik B: Condensed Matter*, Vol. 64 No. 2, pp. 189-193.

Cardona, M. and Marx, W. (2006), "Vitaly L. Ginzburg - a bibliometric study", *Journal of Superconductivity and Novel Magnetism*, Vol. 19 No. 3-5, pp. 459-466.

Chu, H. (1992a), "Communication between Chinese and non-Chinese scientists in the discovery of high-Tc superconductors: 1. The formal perspective.", *Scientometrics*, Vol. 25 No. 2, pp. 229-232.

Chu, H. (1992b), "Communication between Chinese and non-Chinese scientists in the discovery of high-Tc superconductors: 2. The informal perspective ", *Scientometrics*, Vol. 25 No. 2, pp. 253-277

Chu, H. (1998), "Superconductivity research in China revised: a citation analysis of the literature published between 1987-1989 (in Chinese)", *R&D in World Science and Technology*, Vol. 20 No. 3, pp. 135-138.

Everitt, B.S., Landau, S. and Leese, M. (2001), *Cluster Analysis*, 4th edition edn, Edward Arnold, London.

Garfield, E. (1988), "The 1987 Nobel Prize in Physics: citations to K.A. Muller and J.G. Bednorz's seminal work mirror developments in superconductivity", *Current Contents*, 2nd May 1988, pp. 3-11.

Garfield, E. (1990), "The most-cited 1987 physical-sciences articles: superconductivity supersedes superstrings", *Current Contents*, 30th April 1990, pp. 3-14.

Guan, J.C. and Ma, N. (2007), "A bibliometric study of China's semiconductor literature compared with other major Asian countries ", *Scientometrics*, Vol. 70 No. 1, pp. 107-124.

Jacoby, M. (2008), "Superconductivity rekindles", *Chemical and Engineering News*, Vol. 86 No. 42, pp. 15-21.

Kostoff, R.N. (2008), "Comparison of China/USA science and technology performance", *Journal of Informetrics*, Vol. 2 No. 4, pp. 354-363.

Moed, H.F., De Bruin, R.E. and Van Leeuwen, T.N. (1995), "New bibliometric tools for the assessment of national research performance: database description, overview of indicators and first applications", *Scientometrics*, Vol. 33 No. 3, pp. 381-422.

Nadel, E. (1981), "Citation and co-citation indicators of a phased impact of the BCS Theory in the physics of superconductivity", *Scientometrics*, Vol. 3 No. 3, pp. 203-221.

Roberts, G. (2006), *International Partnerships of Research Excellence. UK-USA Academic Collaboration*, available at: http://www.wolfson.ox.ac.uk/UK-US-Academic-Collaboration/GarethRobertsIPoREx.pdf (accessed 1st June 2009).

Schubert, A., Glanzel, W. and Braun, T. (1989), "Scientometric datafiles. a comprehensive set of indicators on 2649 journals and 96 countries in all major science fields and subfields 1981-1985", *Scientometrics,* Vol. 16 No. ??, pp. 3-478.

Zhao, Z., Chen, L., Yang, Q., Huang, Y., Chen, G., Tang, R., Liu, G., Ni, Y., Cui, C., Chen, L., Wang, L., Guo, S., Li, S. and Bi, J. (1987), "Superconductivity above liquid-nitrogen temperature in Ba-Y-Cu oxides", *Kexue Tongbao*, Vol. 32 No. 10, pp. 661-664.

Zhou, P. and Leydesdorf, L. (2006), "The emergence of China as a leading nation in science", *Research Policy*, Vol. 35 No. 1, pp. 83-104.

Zhou, P. and Leydesdorf, L. (2007), "The citation impacts and citation environments of Chinese journals in mathematics", *Scientometrics*, Vol. 72 No. 2, pp. 185-200.

Zhou, P., Thijs, B. and Glanzel, W. (2009), "Is China also becoming a giant in social sciences?", *Scientometrics*, in the press.

Figure 1: Growth in Chinese publications and citations 1986-2007

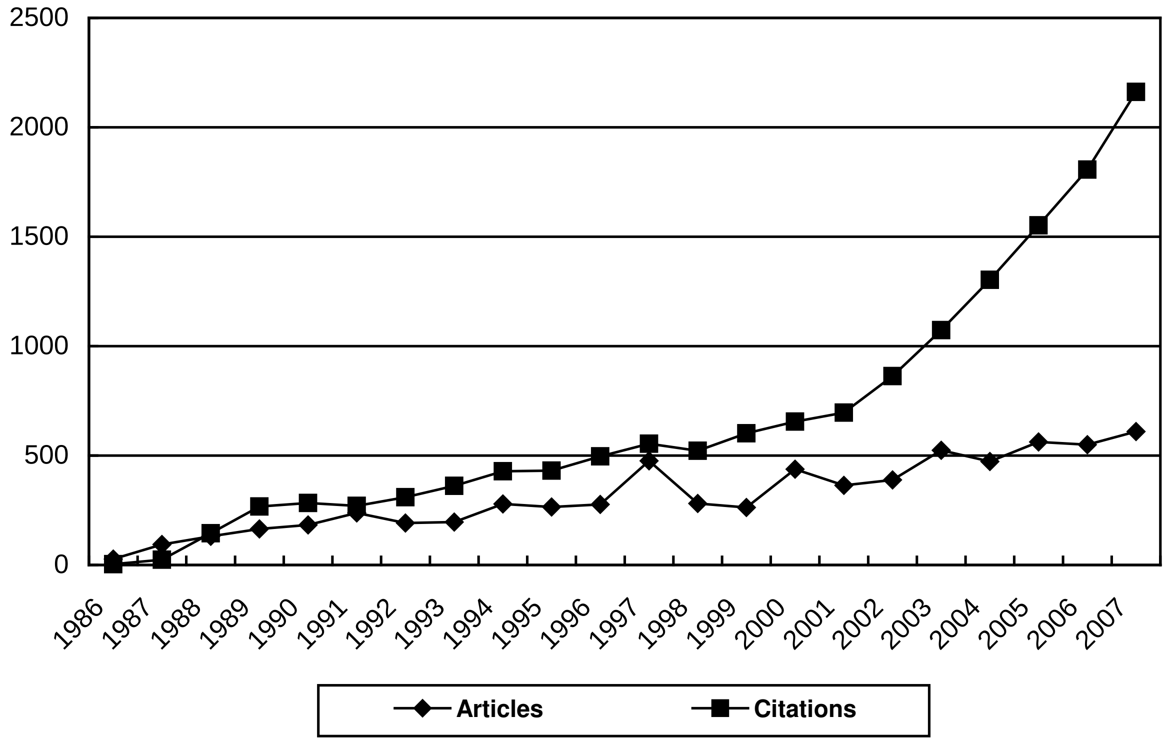


Figure 2: Growth in Chinese citations per publication 2001-07

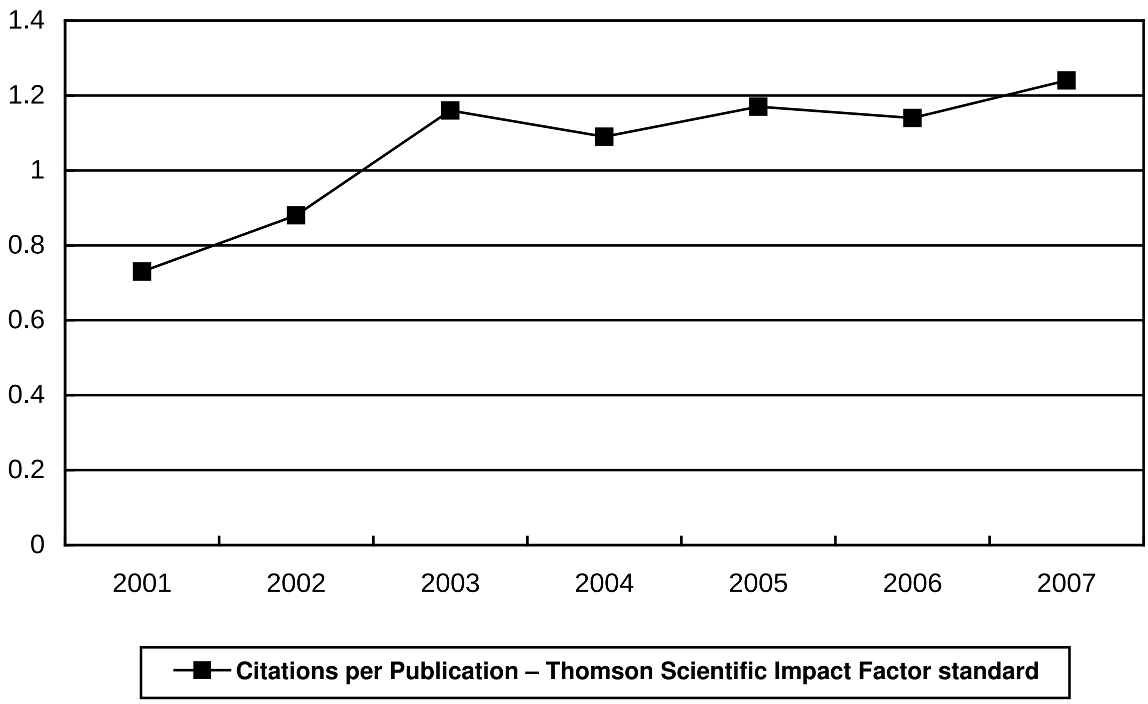


Figure 3: Growth in international publications 1986-2007

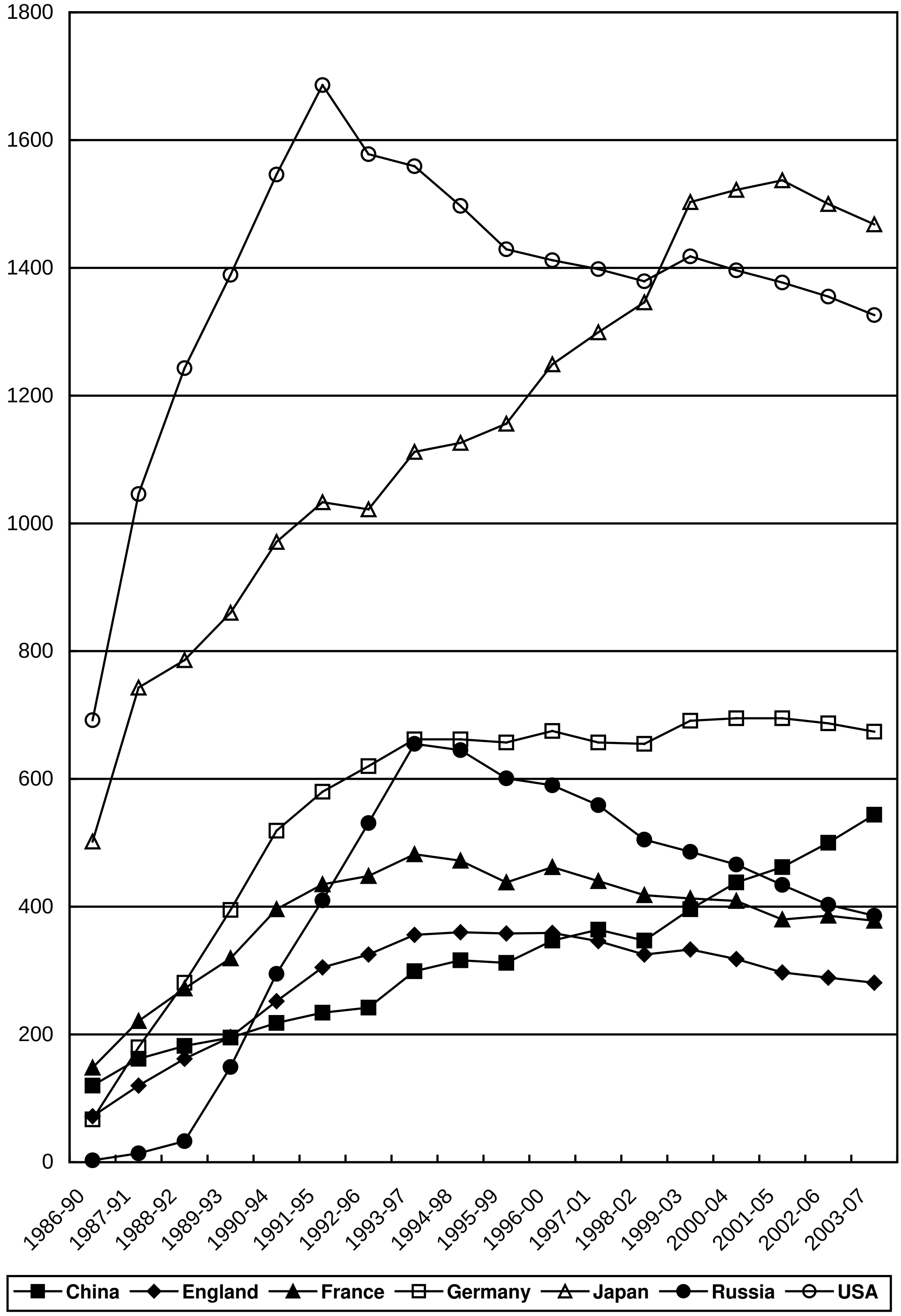
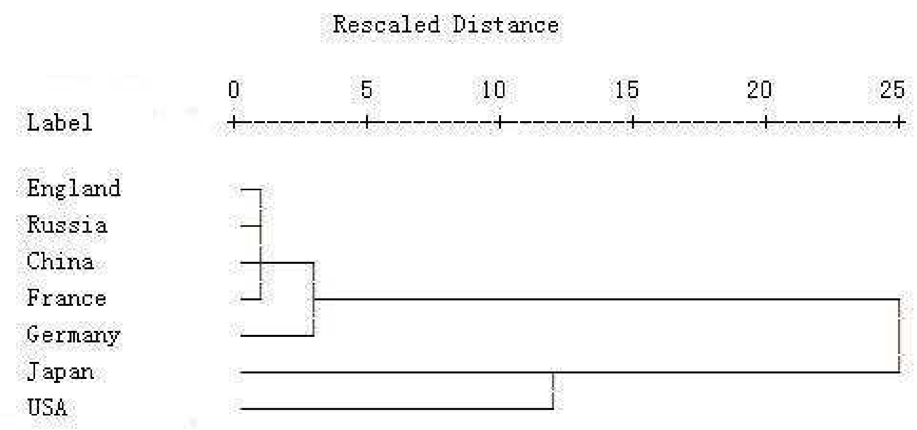
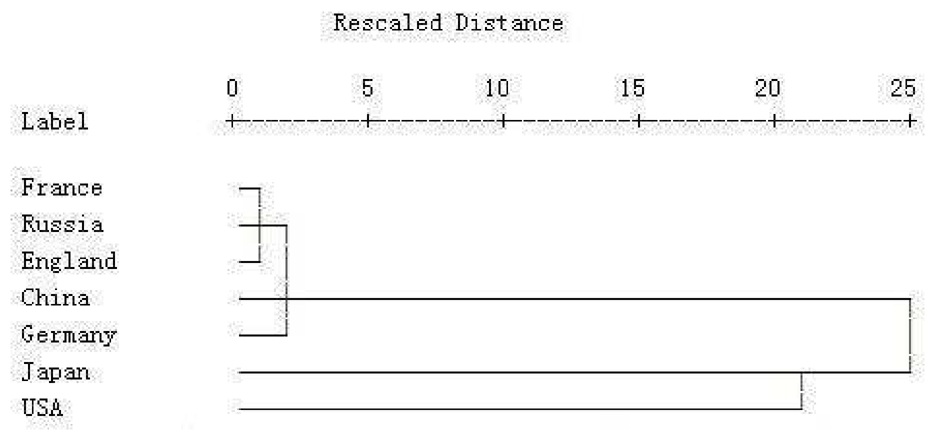


Figure 4. Group average classification of countries' research based on: (a) publications in subject areas; (b) core journals; (c) citing subject areas; (d) citing journals

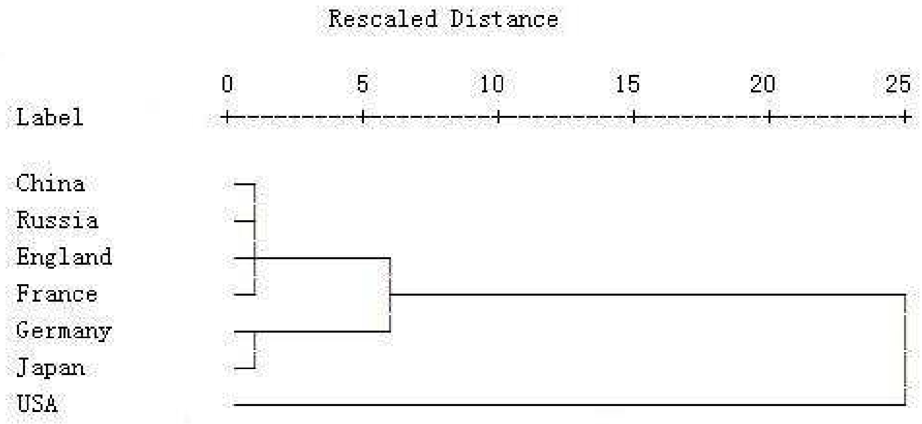
(a)



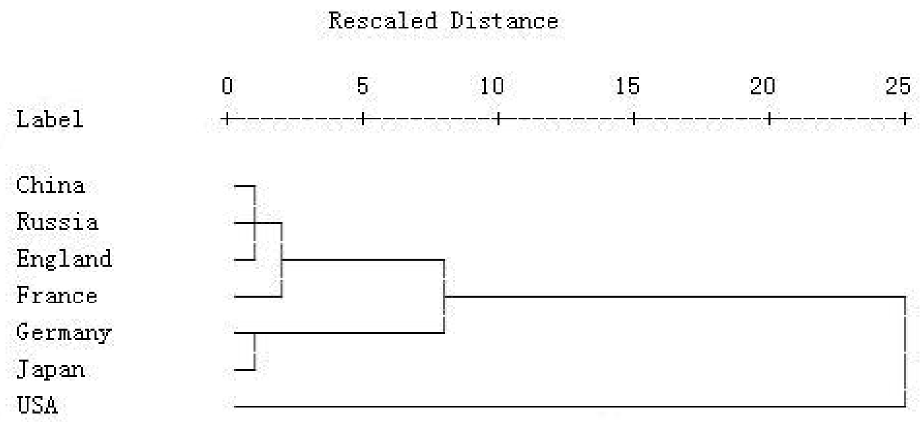
(b)



(c)


Rescaled Distance
0
5
10
15
20
25
Label
China
Russia
England
France
Germany
Japan
USA

(d)


Rescaled Distance
0
5
10
15
20
25
Label
China
Russia
England
France
Germany
Japan
USA

Subject Area	Publications	Citations
Physics, Applied	2890	4713
Physics, Condensed Matter	2259	5511
Physics, Multidisciplinary	1218	2473
Materials Science, Multidisciplinary	562	1628
Engineering, Electrical & Electronic	309	417
Physics, Mathematical	223	470
Chemistry, Physical	181	950
Metallurgy & Metallurgical Engineering	155	343
Multidisciplinary Sciences	151	<1%
Physics, Nuclear	119	402
Physics, Particles & Fields	116	553
Nuclear Science & Technology	113	192
Physics, Atomic, Molecular & Chemical	112	388
Physics, Fluids & Plasmas	106	<1%
Chemistry, Multidisciplinary	103	553
Mathematics, Applied	92	<1%
Thermodynamics	91	<1%
Optics	88	220
Mathematics	71	<1%
Astronomy & Astrophysics	<1%	260
Chemistry, Inorganic & Nuclear	<1%	349
Crystallography	<1%	240
Instruments & Instrumentation	<1%	216
Nanoscience & Nanotechnology	<1%	187
Materials Science, Coatings & Films	<1%	169

Table 1: Publications and citations in subject areas covered by Chinese HTS research

Source Title	Publications	Citations	Impact Factors
Physica C	1339	1716	1.079
Physical Review B	709	2378	3.172
Superconductor Science & Technology	362	675	2.547
Solid State Communications	273	299	1.535
Chinese Physics Letters	254	<1%	0.812
IEEE Transactions on Applied Superconductivity	184	267	1.551
Chinese Physics	181	<1%	2.103
Journal of Physics-Condensed Matter	176	315	1.886
Physics Letters A	173	180	1.711
Acta Physica Sinica	163	<1%	N/A
Communications in Theoretical Physics	140	<1%	0.676
International Journal of Modern Physics B	129	183	0.647
Journal of Superconductivity	120	<1%	N/A
Journal of Applied Physics	119	266	2.171
Chinese Science Bulletin	110	<1%	0.770
Applied Physics Letters	101	290	3.596
Physical Review Letters	100	619	6.944
Cryogenics	88	<1%	0.981
Physical Review D	<1%	207	4.696

Table 2: Core journals for Chinese HTS research

Institution	Publications
Chinese Academy of Sciences	2047
Nanjing University	888
University of Science & Technology of China	739
Beijing University	585
Tsinghua University	327
Zhejiang University	261
University of Hong Kong	240
Northwest Institute for Non-Ferrous Metal Research	228
China Center of Advanced Science & Technology	154
Fudan University	152
Shanghai Jiao Tong University	110
Beijing Normal University	109
General Research Institute for Non-Ferrous Metals	102

Table 3: Key Chinese institutions involved in HTS research

Institution	Citations
Chinese Academy of Sciences	1444
University of Tokyo	571
Tohoku University	483
University of Science & Technology of China	416
Nagoya University	400
Beijing University	368
Russian Academy of Sciences	365
Osaka University	330
Tokyo Institute of Technology	326
National Taiwan University	308

Table 4: Important citing institutions and numbers of citations

Country	Citations
China	3725
USA	3415
Japan	2500
Germany	1492
Russia	1077
India	960
France	891
Italy	742
South Korea	735
England	713
Switzerland	624
Poland	551
Australia	540
Canada	410
Austria	378
Spain	322

Table 5: Important citing countries and numbers of citations

Collaborating Country	Collaborative Publications
USA	555
Japan	390
Germany	200
Australia	155
France	86
South Korea	84
England	83
Italy	82

Table 6: Important collaborating countries

Subject Area	China	England	France	Germany	Japan	Russia	USA	Total
Physics, Applied	2890	2143	2632	4075	12130	2554	10731	37155
Physics, Condensed Matter	2259	2177	2916	4664	6767	2669	10224	31676
Physics, Multidisciplinary	1218	765	1284	1641	2961	1726	3987	13582
Engineering, Electrical & Electronic	309	548	426	855	2803	433	3172	8546
Materials Science, Multidisciplinary	562	521	910	830	1943	538	2180	7484
Chemistry, Physical	181	314	528	390	622	281	814	3130
Physics, Particles & Fields	116	178	145	413	329	231	936	2348
Instruments & Instrumentation	68	148	182	348	406	232	801	2185
Nuclear Science & Technology	113	85	156	383	539	169	672	2117
Chemistry, Multidisciplinary	103	128	170	147	581	91	541	1761
Physics, Mathematical	223	105	116	161	213	147	572	1537
Metallurgy & Metallurgical Engineering	155	60	200	225	428	132	314	1514
Physics, Atomic, Molecular & Chemical	112	99	122	220	324	74	490	1441
Multidisciplinary Sciences	151	101	114	84	157	96	618	1321
Physics, Nuclear	119	46	103	264	254	80	444	1310
Spectroscopy	35	76	98	218	231	155	493	1306
Thermodynamics	91	80	81	112	504	70	316	1254

Table 7: Publications in subject areas covered by international HTS research

Source Title	China	England	France	Germany	Japan	Russia	USA	Total
Physica C	1339	722	1219	1509	4802	976	2958	13525
Physical Review B	709	712	1070	1901	2055	896	5515	12858
IEEE Transactions on Applied Superconductivity	184	323	256	607	1787	284	1923	5364
Physical Review Letters	100	287	461	650	752	267	2418	4935
Physica B	30	220	331	498	1080	180	538	2877
Superconductor Science & Technology	362	388	184	344	715	192	487	2672
Applied Physics Letters	101	100	53	267	410	58	1288	2277
Japanese Journal of Applied Physics	30	13	11	11	1885	4	101	2055
Solid State Communications	273	64	203	210	335	119	447	1651
Journal of Applied Physics	119	65	86	174	308	54	799	1605
Journal of the Physical Society of Japan	6	8	16	17	1343	8	47	1445
IEEE Transactions on Magnetics	44	50	82	89	460	32	604	1361

Table 8: Core journals for international HTS research

Institution	Source articles	Mean citations	
		1986-2007	2001-2007
Chinese Academy of Sciences	2047	3.33	3.45
University of Cambridge	1376	10.20	11.80
Centre National de la Recherche Scientifique	1669	9.50	7.53
Max Planck Institute	1963	8.69	8.17
University of Tokyo	3643	9.38	9.01
Russian Academy of Sciences	3292	4.18	5.04
University of California	3876	13.33	10.97

Table 9: Key international institutions involved in HTS research

	China	England	France	Germany	Japan	Russia	USA
Source articles	2761	1641	2221	3925	9011	2364	7946
Total citations	5380	7912	10216	15521	16360	7248	26642
Mean citations	1.95	4.82	4.6	3.95	1.82	3.07	3.35

Table 10: Citations of different countries, based on source articles for 2001-2007 categorized in the three top subject areas of Table 7

Country	China	England	France	Germany	Japan	Russia	USA	Total
USA	1214	2211	2824	4120	4255	1850		16474
Japan	895	1492	1921	2944		1140	5214	13606
Germany	524	1134	1671		2156	1169	3796	10450
China		603	670	1202	1618	484	2605	7182
France	250	682		1320	1240	661	2124	6277
Italy	256	524	826	1114	876	552	1695	5843
Russia	245	419	702	1102	896		1607	4971
England	236		664	912	854	406	1569	4641
Switzerland	179	462	670	826	740	466	1207	4550
South Korea	254	268	269	584	764	216	1014	3369
Canada	194	346	392	541	602	221	955	3251
India	224	236	247	387	434	176	842	2546
Spain	120	214	373	480	325	215	765	2492
Netherlands	72	214	307	439	359	309	687	2387
Poland	119	214	281	464	359	216	688	2341
Ukraine	65	155	214	328	240	214	452	1668
Brazil	82	140	172	312	278	126	506	1616
Australia	134	181	148	206	292	97	460	1518
Sweden	63	122	159	285	212	175	418	1434
Israel	84	111	143	255	204	146	410	1353
Belgium	76	133	155	193	186	165	356	1264
Austria	55	93	156	241	186	107	325	1163

Table 11: Important citing countries and numbers of citations

Subject Area	China	England	France	Germany	Japan	Russia	USA	Total
Physics, Condensed Matter	2119	3740	4692	6867	7012	3169	10575	38174
Physics, Applied	1526	2386	2139	4081	4920	1755	7132	23939
Physics, Multidisciplinary	1113	1483	2274	3123	2898	1611	5388	17890
Materials Science, Multidisciplinary	500	528	709	1011	1264	389	1881	6282
Engineering, Electrical & Electronic	198	409	301	726	1045	298	1234	4211
Physics, Atomic, Molecular & Chemical	177	172	511	489	386	342	1134	3211
Chemistry, Physical	238	254	347	498	617	199	865	3018
Optics	137	148	428	417	333	366	1113	2942
Physics, Mathematical	139	194	261	419	356	186	843	2398
Physics, Particles & Fields	158	104	148	516	318	117	929	2290
Chemistry, Multidisciplinary	124	154	267	281	439	132	563	1960
Physics, Nuclear	140	27	121	281	188	96	516	1369
Metallurgy & Metallurgical Engineering	111	104	113	190	289	81	343	1231
Nanoscience & Nanotechnology	85	95	132	179	163	105	376	1135
Multidisciplinary Sciences	73	107	124	194	209	56	377	1140
Astronomy & Astrophysics	67	56	90	295	173	52	494	1227

Table 12: Important citing subject areas and numbers of citations

Source Title	China	England	France	Germany	Japan	Russia	USA	Total
Physical Review B	1100	2046	2755	3845	3552	1890	5681	20869
Physical Review Letters	315	670	1035	1277	1210	688	2300	7495
Physica C	387	639	554	1020	1303	496	1765	6164
Superconductor Science & Technology	281	483	266	631	820	235	877	3593
IEEE Transactions on Applied Superconductivity	135	309	228	524	793	189	903	3081
Journal of Physics-Condensed Matter	139	255	282	407	409	188	717	2397
Applied Physics Letters	139	202	162	379	350	171	791	2194
Physical Review A	95	96	329	285	211	246	759	2021
Journal of the Physical Society of Japan	99	151	284	342	384	128	594	1982
Physica B	70	147	261	352	488	114	549	1981
Journal of Applied Physics	123	153	155	293	285	88	568	1665
Journal of Magnetism and Magnetic Materials	40	86	165	210	238	60	337	1136

Table 13: Important citing journals and numbers of citations

Collaborating Country	China	England	France	Germany	Japan	Russia	USA	Total
USA	555	768	1035	1677	1881	818		6734
Germany	200	455	814		699	1144	1677	4989
Japan	390	426	524	699		390	1881	4310
France	86	435		814	524	497	1035	3391
Russia	40	229	497	1144	390		818	3118
England	83		435	455	426	229	768	2396
China		83	86	200	390	40	555	1354

Table 14: Important collaborating countries and numbers of collaborative articles