Scientometric Mapping of Vacuum Research in Nuclear Science & Technology: A Global Perspective

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Abstract. This paper attempts to analyse the growth and development of Vacuum research in Nuclear Science and Technology, as reflected in publication output covered by International Nuclear Information System (INIS) database during 2002-2006. A total of 12027 papers were published in the field of vacuum science. United States topped the list with 1936 (16.10%) publications followed by Japan with 1770 (14.70 %) publications, The highest number of publications (3276) were published in 2004. The average number of publications published per year were 2405.4. The highest number of publications were in ‘Physics of Elementary Particles and Fields’ with 2644 (21.98%) publications .The authorship and collaboration trend is towards multi-authored papers. The highly productive institutions were: Japan Atomic Energy Research Institute (Japan) with 366 publications, University of Tokyo (Japan) with 274 publications, Hiroshima University (Japan) with 245 publications, Osaka University Japan (Japan) with 224 publications and Chinese Academy of Science (P-R-China) with 223 publications. The most preferred journals for publication were: Journal of Vacuum Science and Technology-A with 857 papers, Physical Review –D with 765 papers, Journal of High Energy Physics with 500 papers, Thin Solid Films with 311 papers, Journal of Electron Spectroscopy and Related Phenomena with 309 papers, and AIP Conference Proceedings with 308 papers.

1. Introduction

Research and application of vacuum science and technology are spread across various fields of research and industry. Over the years, there is tremendous growth of vacuum techniques. The vacuum techniques have many applications in metallurgy, thin films, electron beam welding of special materials, space science, accelerators, electron devices, semiconductor technology etc.

Research publications are clearly one of the quantitative measures for the basic research activity in a country. It must be added, however, that what excites the common man, as well as the scientific community, are the peaks of scientific and technological achievement, not just the statistics on publications. There are also other kinds of research and technology development-mission oriented, industry-oriented, country-specific, etc. Progress in these cannot be obviously measured by counting only the number of publications [1]. Scientometrics is a discipline which analyses scientific publications and citations appended to the papers to gain an understanding of the structure of science, growth of science at global level, performance of a country in a particular domain, performance of institutions, departments/divisions, and scientific eminence of an individual scientist. It also helps in knowing the information seeking behaviour of scientists and engineers by way of identifying where
they publish and what they cite. The bibliometric and scientometric techniques used to study various quantitative and qualitative aspects of scientific endeavours have been studied [2-3]. Many scientometric studies have appeared in the literature to focus on the performance of science in various domains [4-17]. Scientometric studies are useful in ascertaining which methods have been mostly employed for various analytical determinations as well as predicting which methods will continue to be used in the immediate future and which appear to be losing favour with the scientific community [18].

2. Objectives
The main objective of the study is to present the growth of literature and make the quantitative assessment of role of vacuum research in nuclear science and technology by way of analyzing various features of research output such as geographical distribution of publications, publication productivity and domain-wise activity index, authorship and collaboration pattern, language-wise distribution of publications, institution-wise distribution of publications, the channels of communications used by the scientists, the quality of research, and the high frequency keywords appeared in Indexer Assigned-Descriptors (DEI).

3. Materials and Methods
The data source for the study was INIS on disc (CD ROM), published by the INIS Secretariat at IAEA Head Quarters at Vienna, Austria. INIS is the world’s leading and most comprehensive abstracting and indexing service providing information on all aspects of peaceful applications of nuclear science and technology. Records pertaining to Vacuum research were downloaded using CD-ROM published in the years 2002-2006 using suitable search strategy (‘Vacuum’ in Title, Abstract, and DEI Fields). A total of 12027 records were downloaded. The bibliographic details for each record included author, author’s affiliation, title, type of document, source of publication, year of publication, keywords, language of the article, country of publication etc. Further all the bibliographic details were transferred to spread sheet application. The data was analysed as per objectives of the study. The duplicate records retrieved were physically verified and excluded for further analysis.

4. Results and Discussion
4.1 Country-wise Distribution of Publications in Vacuum Research in Nuclear Science and Technology
There were as many as 110 countries and eight international organizations engaged in research in the field of vacuum science and technology in nuclear science and technology producing 12027 publications. Figure 1 lists top twenty countries actively pursuing research in this field. USA is the top producing country with 1936 (16.10%) publications of the total output, followed by Japan with 1770 (14.70 %) publications, Germany with 1147 publications (9.57 %), Russian Federation with 971 (8.07 %) publications, China with 808 (6.72%) publications, France with 502 (4.17 %) publications, United Kingdom with 474 (3.94%) publication, Italy with 471 (3.38%) publications, Austria with 406 (3.38%) publications and India with 400 (3.33%)publications.
4.2 Publication Productivity
During 5 years (2002-2006) a total of 12027 publications were published in the field of vacuum research in nuclear science and technology. There were 2198 papers published in 2002. The highest number of papers (3276) were published in 2004. The average number of publications published per year was 2405.4. Table 1 gives year-wise growth of publications published during the period under study. The highest growth rate 37.18 was observed in 2004 and the lowest growth rate –48.88 was observed in 2006. This may be due to the time lag of input of records to the INIS database. It was estimated that about 70 percent of total publications published during the particular year are input in 12 months period and remaining 30 percent of publications are spread over 2-3 years or more as the database has a open provision for input of records [11].

Table 1. Year-wise cumulative growth of publications during 2002-2006

| Publication Year | Number of Papers | Percentage | Growth Rate 2002-2006 |
|------------------|------------------|------------|-----------------------|
| 2002             | 2198             | 18.28      | -                     |
| 2003             | 2388             | 19.86      | 8.64                  |
| 2004             | 3276             | 27.24      | 37.18                 |
| 2005             | 2685             | 22.32      | -18.40                |
| 2006             | 1480             | 12.31      | -44.88                |
| Total            | 12027            | 100.00     | -                     |

4.3 Subject Category-wise Distribution of Publications
The publications in vacuum science and technology have been spread over thirty one main subject categories as per INIS subject categories. The highest number of publications were in ‘Physics of Elementary Particles and Fields’ with 2644 (21.98%) publications followed by ‘Condensed Matter Physics, Superconductivity and Super fluidity’ with 1985 (16.50%) publications, ‘Materials Science with 1705 (14.18%), Plasma Physics and Fusion Technology’ with 1637 (13.61%) publications, ‘Particle Accelerators’ with 915 (7.61%) and Atomic and Molecular Physics’ with 914 (7.60%) publications. Table 2 provides subject category-wise distribution of publications.
Table 2. Year-wise Distribution of Publications as per INIS Subject Categories

| Subject Categories                                                                 | Publication Year | Total Papers | Percentage |
|----------------------------------------------------------------------------------|------------------|--------------|------------|
|                                                                                 | 2002  | 2003  | 2004  | 2005  | 2006  |             |            |
| Physics of Elementary Particles and Fields                                      | 571   | 608   | 587   | 534   | 344   | 2198        | 21.98      |
| Condensed Matter Physics, Superconductivity and Superfluidity                   | 360   | 383   | 874   | 272   | 96    | 1985        | 16.50      |
| Materials Science                                                                | 232   | 312   | 484   | 385   | 292   | 1705        | 14.18      |
| Plasma Physics and Fusion Technology                                            | 307   | 355   | 294   | 347   | 334   | 1637        | 13.61      |
| Particle Accelerators                                                            | 163   | 218   | 214   | 220   | 100   | 915         | 7.61       |
| Atomic and Molecular Physics                                                     | 107   | 75    | 261   | 412   | 59    | 914         | 7.60       |
| Classical and Quantum Mechanics, General Physics                                | 139   | 113   | 196   | 181   | 103   | 732         | 6.09       |
| Instrumentation Related To Nuclear Science and Technology                        | 67    | 75    | 131   | 72    | 42    | 387         | 3.22       |
| Nuclear Physics and Radiation Physics                                           | 44    | 49    | 49    | 64    | 18    | 224         | 1.86       |
| Inorganic, Organic, Physical and Analytical Chemistry                           | 53    | 44    | 51    | 21    | 121   | 218         | 1.81       |
| Radiation Chemistry, Radiochemistry and Nuclear Chemistry                       | 28    | 33    | 14    | 14    | 10    | 99          | 0.82       |
| Radiology and Nuclear Medicine                                                  | 25    | 17    | 18    | 24    | 11    | 95          | 0.79       |
| Specific Nuclear Reactors and Associated Plants                                 | 11    | 19    | 17    | 22    | 10    | 79          | 0.66       |
| Management of Radioactive Wastes, and Non-Radioactive Wastes From Nuclear Facilities | 14  | 20    | 9     | 11    | 10    | 64          | 0.53       |
| Isotopes and Radiation Sources                                                  | 17    | 6     | 21    | 7     | 3     | 54          | 0.45       |
| Engineering                                                                      | 10    | 10    | 14    | 12    | 5     | 51          | 0.42       |
| Applied Life Sciences                                                            | 8     | 13    | 9     | 8     | 5     | 43          | 0.36       |
| Radiation Protection and Dosimetry                                              | 13    | 5     | 8     | 8     | 3     | 37          | 0.31       |
| Nuclear Fuel Cycle and Fuel Materials                                           | 6     | 16    | 7     | 6     | 1     | 36          | 0.30       |
| Environmental Sciences                                                          | 6     | 3     | 8     | 6     | 4     | 27          | 0.22       |
| Radiation, Thermal, and Other Environmental Pollutant Effects On Living Organisms and Biological Materials | 6   | 5     | 5     | 8     | 2     | 26          | 0.22       |
| General Studies of Nuclear Reactors                                             | 4     | 5     | 3     | 3     | 2     | 17          | 0.14       |
| Geosciences                                                                      | 4     | 1     | 9     |       | 14    |             | 0.12       |
| General and Miscellaneous                                                        | 1     | 1     | 2     | 2     | 1     | 7           | 0.06       |
| Hydrogen                                                                         | 1     | 4     |       | 5     |       | 0.04       |
| Biomass Fuels                                                                    | 1     | 1     |       | 3     |       | 0.02       |
| Energy Planning, Policy and Economy                                             | 1     | 2     | 3     |       |       | 0.02       |
| Oil Shales and Tar Sands                                                        | 1     | 1     | 2     |       |       | 0.02       |
| Direct Energy Conversion                                                        | 2     |       |       |       |       | 0.02       |
| Solar Energy                                                                     | 1     |       |       |       |       | 0.01       |
| Nuclear Disarmament, Safeguards and Physical Protection                           | 1     |       |       |       |       | 0.01       |
| Total                                                                            | 2198  | 2388  | 3276  | 2685  | 1480  | 12027       | 100.00     |
4.31 Subject Category-wise Activity Index of Top Ten Subject Categories

On cumulating individual productivity of various domains, it was revealed that only ten subject categories out of thirty-one domains have contributed 11361 (94.96%) publications. Analysis of the growth and decline in the productivity using normalised activity of ten major subject categories, showed that the domains ‘Materials Science’, ‘Plasma Physics and fusion Technology’ and ‘Classical and Quantum Mechanics, General Physics’ witnessed rise and rest of the subject categories witnessed decline in their activity during 2002-2006. Table 3 provides year-wise activity index of ten major subject categories.

| Subject Categories                                      | Activity Index |
|----------------------------------------------------------|----------------|
|                                                          | 2002 | 2003 | 2004 | 2005 | 2006 |
| Physics of Elementary Particles and Fields               | 118.17 | 115.82 | 81.51 | 90.47 | 105.73 |
| Condensed Matter Physics, Superconductivity and Superfluidity | 99.24 | 97.18 | 161.65 | 61.38 | 39.30 |
| Materials Science                                        | 74.45 | 92.16 | 104.22 | 101.15 | 139.17 |
| Plasma Physics and Fusion Technology                     | 102.62 | 109.22 | 65.93 | 94.95 | 165.80 |
| Particle Accelerators                                    | 97.48 | 119.99 | 85.86 | 107.70 | 88.81 |
| Atomic and Molecular Physics                             | 64.06 | 41.33 | 104.84 | 201.91 | 52.46 |
| Classical and Quantum Mechanics, General Physics         | 103.90 | 77.75 | 98.30 | 110.76 | 114.35 |
| Instrumentation Related To Nuclear Science and Technology| 94.73 | 97.61 | 124.27 | 83.34 | 88.19 |
| Nuclear Physics and Radiation Physics                    | 107.48 | 110.17 | 80.31 | 127.98 | 65.30 |
| Inorganic, Organic, Physical and Analytical Chemistry    | 133.03 | 101.65 | 82.52 | 104.79 | 78.28 |
| Total Publications                                        | 2198 | 2388 | 3276 | 2685 | 1480 |

4.4 Nature of Collaboration

On analyzing the extent of collaboration in vacuum research in nuclear science and technology, it was found that only 15.80 percent publications (1900) involved single authors and 84.20 percent publications (10127) involved multi-authors during 2002-2006 indicating large collaborative and multidisciplinary nature of the field. Figure 2 gives the collaboration trend in the field. Three authored papers accounted for 17.26 percent followed by single authored papers with 15.79 percent, two authored papers with 15.14 percent and four authored paper with 14.12 percent. It was observed that papers with as many as 128 authors were identified.

![Figure 1. Authorship and collaboration pattern in Vacuum Research in Nuclear Science and Technology](image-url)
4.5 International Collaboration

In recent years, every country has realised the importance of scientific research for its growth and started initiating programmes which makes scientists to have more interactions with other scientists, both at national and international levels. There were 7304 (60.73%) publications with single country affiliation, 2433 (20.23 %) publications had collaboration with more than one country and 2290 (19.04%) publications with no country affiliation. Table 4 provides international collaboration pattern in Vacuum Science and Technology in Nuclear Science and Technology. The papers with two-country collaboration accounted for 77.39 percent of total international collaborative papers.

| Number of Countries | Number of Publications | Percentage |
|---------------------|------------------------|------------|
| Two                 | 1883                   | 77.39      |
| Three               | 441                    | 18.13      |
| Four                | 82                     | 3.37       |
| Five                | 21                     | 0.86       |
| Six                 | 4                      | 0.16       |
| Seven               | 2                      | 0.08       |
| Total               | 2433                   | 100.00     |

4.6 Institution-wise Distribution of Publications

There were more than 6000 institutions involved in research activity in the field of vacuum science and technology in nuclear science and technology. Table 5 provides productivity of top 20 institutions. Japan Atomic Energy Research Institute (Japan) topped the list with 366 publications, followed by University of Tokyo (Japan) with 274 publications, Hiroshima University (Japan) with 245 publications, Osaka University (Japan) with 224 publications, Chinese Academy of Science (P-R-China) with 223 publications, Tohoku University (Japan) with 191 publications, (Japan), Kyoto University with 184 publications, RIKEN (Japan) with 178 publications and Japan Synchrotron Radiation Research Institute (Japan).

| Rank | Institute                                           | Country                | Number of Publications |
|------|-----------------------------------------------------|------------------------|------------------------|
| 1    | Japan Atomic Energy Research Institute             | Japan                   | 366                    |
| 2    | University of Tokyo                                | Japan                   | 274                    |
| 3    | Hiroshima University                               | Japan                   | 245                    |
| 4    | Osaka University                                   | Japan                   | 224                    |
| 5    | Chinese Academy of Science                         | People's Republic of China | 223                  |
| 6    | Tohoku University                                  | Japan                   | 191                    |
| 7    | Kyoto University                                   | Japan                   | 184                    |
| 8    | RIKEN                                               | Japan                   | 178                    |
| 9    | Japan Synchrotron Radiation Research Institute     | Japan                   | 150                    |
| 10   | High Energy Accelerator Research Organisation      | Japan                   | 143                    |
| 11   | University of California                           | United States           | 137                    |
4.7 Language-wise Distribution of Publications
The vacuum scientists in nuclear science and technology have contributed more predominantly in English than any other languages as 10711 (89.05%) publications were in English followed by Russian with 502 (4.17%) publications, Japanese with 257 (2.13%) publications, Chinese with 192 (1.59%) publications and German with 157 (1.30%) publications.

4.8 Preference of Channels of Communication by the Scientists
Vacuum scientists communicated their research results through a variety of communication channels. It was observed that 72.07 percent of the literature was published in journals followed by 14.44 percent in miscellaneous literature, 19.35 percent in Reports, 3.91 percent in Books/Conferences and 0.25 percent in Translations.

4.9 Preference of Journals for Communication by the Scientists
The distribution of publications (8669) were spread over 408 journals. The leading journals preferred by the scientists were: Journal of Vacuum Science and Technology-A with 857 papers, Physical Review-D with 765 papers, Journal of High Energy Physics with 500 papers, Thin Solid Films with 311 papers, Journal of Electron Spectroscopy and Related Phenomena with 309 papers, and AIP Conference Proceedings with 308 papers. Table 6 provides journal-wise scattering of publications. Only twelve journals have published more than 50 percent of the publications.

Table 6. Major Journals Preferred by the Scientists for Publication

| Rank | Journal                                             | Total Papers | IF 2005 | Country          | Cumulative % |
|------|-----------------------------------------------------|--------------|---------|------------------|--------------|
| 1    | Journal of Vacuum Science and Technology-A          | 857          | 1.40    | USA              | 9.89         |
| 2    | Physical Review-D                                  | 765          | 4.85    | USA              | 18.71        |
| 3    | Journal of High Energy Physics                     | 500          | 5.94    | England          | 24.48        |
| 4    | Thin Solid Films                                   | 311          | 1.57    | Switzerland      | 28.07        |
| 5    | Journal of Electron Spectroscopy and Related       | 309          | 1.18    | The Netherlands  | 31.63        |
|      | Phenomena                                          |              |         |                  |              |
| 6    | AIP Conference Proceedings                         | 308          | -       | USA              | 35.18        |
| 7    | Nuclear Physics-B                                  | 280          | 5.52    | The Netherlands  | 38.41        |
| 8    | Physical Review-A                                  | 235          | 3.00    | USA              | 41.12        |
| 9    | Classical and Quantum Gravity                      | 209          | 2.94    | England          | 43.53        |
| 10   | Nuclear Instruments and Methods in Physics Research B | 205          | 1.18    | The Netherlands  | 45.90        |
| 11   | Nuclear Instruments and Methods in Physics Research A | 192          | 1.22    | The Netherlands  | 48.11        |
| 12   | Fusion Engineering and Design                      | 173          | -       | Switzerland      | 50.11        |
The journals publishing papers on vacuum science and technology were spread across 44 countries. Table 7 provides the countries publishing journals in vacuum science and technology in nuclear science and technology. Among the top ranking journals publishing the papers are from USA with 3188 (36.77%) publications in 53 journals followed by the Netherlands with 1619 (18.57%) publications in 23 journals, England with 1426 (16.45%) publications in 38 journals Switzerland with 655 (7.56%) publications in 10 journals, Russian Federation with 458 (5.28%) publications in 48 journals and Germany with 303 (3.50) publications in 27 journals. Only 15 countries have published more than 98 percent of the articles in 338 journals in the field.

| Country               | Total Papers | Number of Journals | % of Total Papers | Country        | Total Papers | Number of Journals | % of Total Papers |
|-----------------------|--------------|--------------------|-------------------|----------------|--------------|--------------------|-------------------|
| USA                   | 3188         | 53                 | 36.77             | Kazakhstan     | 9            | 6                  | 0.10              |
| The Netherlands       | 1610         | 23                 | 18.57             | Pakistan       | 9            | 6                  | 0.10              |
| England               | 1426         | 38                 | 16.45             | Syrian-Arab-Republic | 8          | 3                  | 0.09              |
| Switzerland           | 655          | 10                 | 7.56              | Australia      | 7            | 4                  | 0.08              |
| Russian Federation    | 458          | 48                 | 5.28              | Canada         | 6            | 5                  | 0.07              |
| Germany               | 303          | 27                 | 3.50              | Italy          | 5            | 2                  | 0.06              |
| Japan                 | 280          | 55                 | 3.23              | Armenia        | 4            | 2                  | 0.05              |
| Peoples R China       | 230          | 23                 | 2.65              | Belarus        | 4            | 3                  | 0.05              |
| Ukraine               | 100          | 12                 | 1.15              | Egypt          | 3            | 2                  | 0.03              |
| Poland                | 72           | 7                  | 0.83              | Ireland        | 3            | 1                  | 0.03              |
| Austria               | 51           | 4                  | 0.59              | Uzbekistan     | 3            | 1                  | 0.03              |
| India                 | 41           | 10                 | 0.47              | Bangladesh     | 2            | 1                  | 0.02              |
| Hungary               | 40           | 4                  | 0.46              | Indonesia      | 2            | 2                  | 0.02              |
| France                | 26           | 17                 | 0.30              | Malaysia       | 2            | 1                  | 0.02              |
| Republic of Korea     | 22           | 7                  | 0.25              | Viet-Nam       | 2            | 2                  | 0.02              |
| Sweden                | 22           | 6                  | 0.25              | Bulgaria       | 1            | 1                  | 0.01              |
| Brazil                | 14           | 2                  | 0.16              | Norway         | 1            | 1                  | 0.01              |
| Czech Republic        | 12           | 1                  | 0.14              | Peru           | 1            | 1                  | 0.01              |
| Romania               | 12           | 5                  | 0.14              | Serbia-and-Montenegro | 1          | 1                  | 0.01              |
| Slovakia              | 12           | 1                  | 0.14              | Spain          | 1            | 1                  | 0.01              |
| Mexico                | 10           | 1                  | 0.12              | Thailand       | 1            | 1                  | 0.01              |
| Iran                  | 9            | 6                  | 0.10              | Turkey         | 1            | 1                  | 0.01              |
4.11 Quality of Research Output
Around 81.72 percent if the total publications in vacuum research in nuclear science and technology during 2002-2006 were published in the journals with impact factors (IF) ranging from 0.01 to 30.25, and around 18.72 per cent published in journals having zero IF. A significantly large number of publications (35.59 per cent) appeared in journals having impact factors from 1.01 to 2.00 followed by 11.14 percent of publications appeared in journals having impact factors from 3.01 to 4.00. (Figure 3).

![Figure 3. Impact Factor-wise Distribution of Journals and Publications](image)

4.12 Analysis of Keywords
Keywords are one of the best scientometric indicators to understand and grasp instantaneously the thought content of the papers and to find out the growth of the subject field. Analysis of the keywords appeared either on the title or assigned by the indexer or the author himself will help in knowing in which direction the knowledge grows. The high frequency keywords will enable us to understand the various aspects of vacuum research in nuclear science and technology under study. The keywords appeared in the Indexer–Assigned-Descriptors (DEI) field in INIS were analysed for the purpose. The high frequency keywords were: Thin-films (1322), Vacuum-states (1259), Plasma (1092), Electrons (817), Quantum-field-theory (783), Surfaces (716), X-ray-diffraction (682), annealing (632), supersymmetry (609) and Magnetic-fields (600). Table 8 gives a list of high frequency keywords appeared more than 299 times.

| Article II. | Keyword         | Article III. | Frequency | Article IV. | Keyword          | Article V. | Frequency |
|------------|----------------|--------------|-----------|-------------|------------------|------------|-----------|
| thin-films |                |              | 1322      | potentials  |                  | 427        |           |
| vacuum-states |              |              | 1259      | symmetry-breaking |              | 420        |           |
| plasma     |                |              | 1092      | cosmology   |                  | 402        |           |
| electrons  |                |              | 817       | excitation  |                  | 398        |           |

Table 8. Keywords ≥ 299 frequencies appeared in Indexer–Assigned Descriptors (DEI) field in INIS database (2002-2006)
5. Conclusion

In this study, an attempt has been made to find out quantitatively an overall view of the literature published on vacuum science and technology and its applications in nuclear science and technology as reflected in INIS database during 2002-2006. During 2002-2006 a total of 12027 papers were published in forty-four different subject categories. The highest number of publications were in ‘Physics of Elementary Particles and Fields’ with 2644 (21.98%) publications followed by ‘Condensed Matter Physics, Superconductivity and Super fluidity’ with 1985 (16.50%) publications, ‘Materials Science with 1705 (14.18%), Plasma Physics and Fusion Technology’ with 1637 (13.61%) publications, ‘Particle Accelerators’ with 915 (7.61%) and Atomic and Molecular Physics’ with 914 (7.60%) publications. The highest number of papers (3276) were published in 2004. The average number of publications published per year was 2405.4. The highest growth rate 37.18 was observed in 2004 and the lowest growth rate –48.88 was observed in 2006. The domains ‘Materials Science’; ‘Plasma Physics and fusion Technology’; ‘Classical and Quantum Mechanics, General Physics’ witnessed rise in their activity during 2002-2006.United States topped the list with 1936 publications followed by Japan with 1770 publications and Germany with 1147 publications. Authorship and collaboration trend was towards multi-authored papers as 80.3 percent of the papers were collaborative is indicative of the multidisciplinary nature of research activity. The highly productive institutions were: Japan Atomic Energy Research Institute (Japan) with 366 publications, University of Tokyo (Japan) with 274 publications, Hiroshima University (Japan) with 245 publications, Osaka University Japan (Japan) with 224 publications and Chinese Academy of Science (P-R-China) with 123 publications.
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