

Publications Trends in Atomic Physics: A Global Perspective

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Abstract

The present study involves analysing the worldwide publication scenarios on Atomic Physics using Web of Science database for a period of 10 years from 2004-2013. The database contains 29402 publications in the field of atomic physics. The publications have reached the highest number in the year 2008 with maximum of 6099 publications and the average paper per year is 2940.2. The compound annual growth rates (CAGR) of these publications have decreased from 0.58 in the year 2005 to 0.33 in the year 2012. The average value of collaboration coefficient on atomic physics paper publication is 0.63. 94.40% of papers have the multi authorship whereas 5.60% of contributions have come from single authors. USA has contributed maximum number of publications and India stands 12th in terms of paper publications on this topic in this period. The most prolific author is Ye, P D who has contributed 39 articles whereas Fanciulli, M and Kobayashi, K, contributed 37 articles each. University of Tokyo, Japan is on top of the list of most contributed institutions with 470 publications followed by Japan Science and Technology Agency, Japan with 376 publications and Osaka University, which is also from Japan with 354 publications.

Keywords: Atomic Physics, Scientometrics, Annual Growth Rate, Authorship Pattern, Co Authorship Index and Collaboration Coefficient

Introduction

Atomic physics is the field of physics concerned with the structure of the atoms as an isolated system of electrons and atomic nucleus. Atomic energy is the source of power for both nuclear reactors and nuclear weapons. Atomic energy comes from the fission or fusion of atoms. The applications of atomic physics to the needs of society and to our nation's goal are extensive. Atomic physics play a conspicuous role in precision measurements, fusions, national security, materials processing, and manufacturing

with lasers, database services and medicine. The power and precision of lasers have revolutionised the field of atomic physics. Emerging applications of atomic energy show great potential for addressing the future needs of the world. There is a lot of research being carried out all over the world in the field of atomic physics and their applications in various fields. This study was done to get the information on the latest developments of publications in the area of atomic physics research as indexed in web of science database.

Scientometric analysis is the quantitative study of a subject growth by using bibliometric indicators and statistical tools and techniques. Scientometric is an academic discipline and number of research is being carried out for a quantitative study of the various aspects of literature of a particular subject. During the last few years scientometric analysis has been increasingly used to evaluate the research performance of researchers and the growth of various disciplines of sciences. The analysis has also been used to evaluate the research output of many researchers around the world. Scientometric analysis is an extensive application in the field of information science to identify the research trends in a particular discipline. Scientometric is also facilitating to identify the trends in pattern of publication, authorship, contributing of a particular author or institutions, countrywide contribution, collaboration in research, author productivity, core journals and scattering of literature over the period of time. This paper highlights the growth pattern of literature on atomic physics to testify the current development in the subject and focuses on its literature.

Objectives for the Study

The objective of the study was to perform a scientometric analysis of all atomic physics publications in the world.

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The parameters studied include:

1. Forms of publications
2. Identification trend in the growth with least square methods
3. Authorship pattern of publications
4. Relative citation impact of highly productive countries
5. Highly productive institutes
6. Highly preferred source titles for publication
7. High productivity subject areas of atomic physics research output

Methodology

The Web of Science database was used for retrieving data on atomic physics during 2004-2013, using search terms namely 'atomic physics' in topic filed. A total of 29402 publications were downloaded and analysed by using the spreadsheet application as per the objectives of the study. The bibliographic fields were analysed by normal count procedures for countries, authorships, and journals.

Data analysis and Interpretations

Forms of Publications

Table 1: Forms of Publications

S. No.	Forms of publications	No. of publications	Percentage
1	Journal articles	22271	75.75
2	Conference papers	5587	19.00
3	Review	696	2.37
4	Erratum	407	1.38
5	Short survey	118	0.40
6	Conference review	89	0.30
7	Book	79	0.27
8	Book chapter	72	0.24
9	Note	40	0.14
10	Editorial	32	0.11
11	Letter	11	0.04
Total		29402	100.00

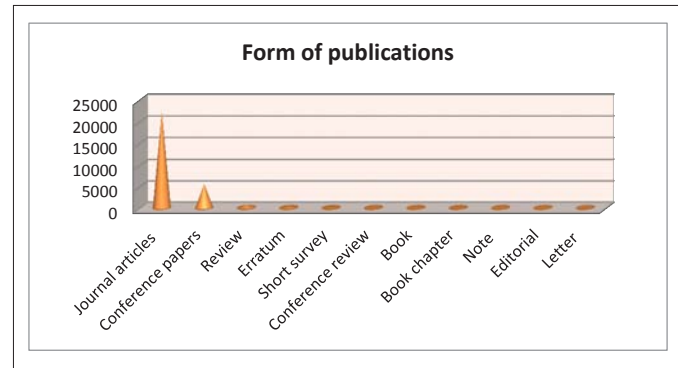


Fig. 1: Form of Publications

The major source of publications covered by Web of Science databases on atomic physics research is journal articles with 22,271 publications (75.75%) followed by conference papers with 5,587 publications (19%). Review ranks the third position with 696 publications (2.37%), erratum with 407 publications (1.38%), and remaining forms are less than one percentage as seen in Table 1.

Annual Growth Rate and Compound Annual Growth Rate of Publications

Table 2 provides the AGR and CAGR of the documents for the study period (2004 to 2013).

$$\text{AGR} = \frac{\text{End Value} - \text{First Value}}{\text{First Value}} \times 100$$

Table 2: AGR and CAGR of Publications

Year	No. of publications	Cumulative total	Annual growth rate (AGR)	CAGR
2004	1657	1657	-	-
2005	2840	4497	71.39	0.58
2006	3387	7884	19.26	0.53
2007	3272	11156	-3.40	0.50
2008	6099	17255	85.40	0.30
2009	3105	20360	-49.09	0.46
2010	1902	22262	-38.74	0.52
2011	2258	24520	18.72	0.40
2012	2794	27314	23.74	0.33
2013	2088	29402	-25.27	0.34

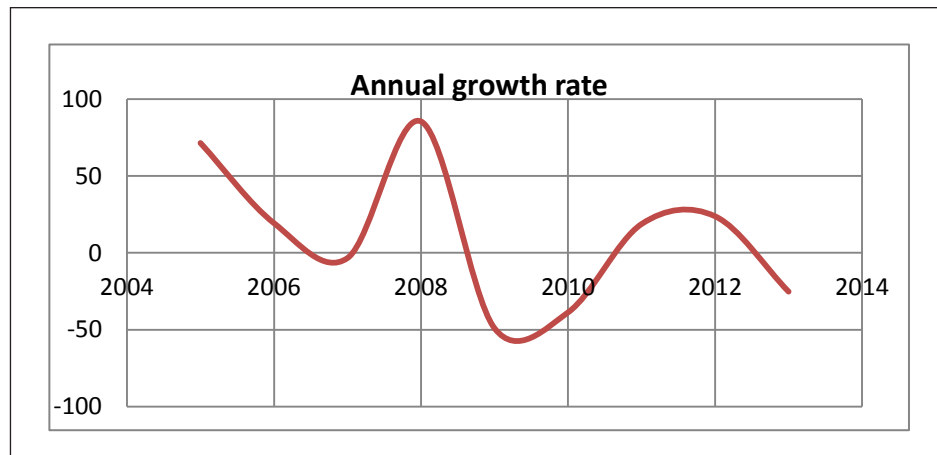


Fig. 2: Annual Growth Rate of Publications

During the period of 2004 to 2013, a total of 29,402 publications were published on atomic physics research. The highest number of publications is 6,099 articles in 2008. The lowest number of publication is 1,657 in 2004. The average number of publications published per year was 2940.2.

Table 2 and Fig. 2 reveal the fluctuation in annual growth rate in the study period. In the year 2007, there is a drop with -3.40 along with in year 2009 and 2010 are -49.09 and -38.74. Again, there is a drop in 2013. This fluctuation in the annual growth rate indicates that there is no constant upward growth in the atomic physics literature.

The CAGR for publications has decreasing trend from 0.58 in 2005 to 0.30 in 2008. Again the CAGR has increased 0.46 in 2009 to 0.52 in 2010 and it was reduced to 0.40 in 2011. Since then there is fluctuations in the study period. The reason for the fluctuations is that the number of publications in every year is no constantly growth.

Relative Growth Rate (RGR) and Doubling Time

The Relative Growth Rate (RGR) is the increase in number of articles or pages per unit of time. This definition derived from the definition of relative growth rates in the study of growth analysis in the field of mobile technology. The mean relative growth rate (R) over the specific period of interval can be calculated from the following equation.

Relative Growth Rate (RGR)

$$1 - 2R = \frac{\log W_2 - \log W_1}{T_2 - T_1}$$

whereas

1-2 R- mean relative growth rate over the specific period of interval

$\log_e W_1$ - log of initial number of articles

$\log_e W_2$ - log of final number of articles after a specific period of interval

$T_2 - T_1$ - the unit difference between the initial time and the final time

The year can be taken here as the unit of time.

$$\text{Doubling Time (DT)} = 0.693/R$$

Table 3: Relative Growth Rate (RGR) and Doubling Time (DT) of Publications

Year	No. of Publications	Cumulative Total	W1	W2	RGR	DT
2004	1657	1657	-	7.41	-	-
2005	2840	4497	7.41	8.41	1.00	0.69
2006	3387	7884	8.41	8.97	0.56	1.24
2007	3272	11156	8.97	9.32	0.35	2.66
2008	6099	17255	9.32	9.76	0.44	1.58
2009	3105	20360	9.76	9.92	0.16	4.33
2010	1902	22262	9.92	10.01	0.09	7.70
2011	2258	24520	10.01	10.11	0.10	6.93
2012	2794	27314	10.11	10.22	0.11	6.30
2013	2088	29402	10.22	10.29	0.07	9.90

The year wise RGR is found to be in the range of 1 to 0.07. Year wise calculation of RGR reveals that it has

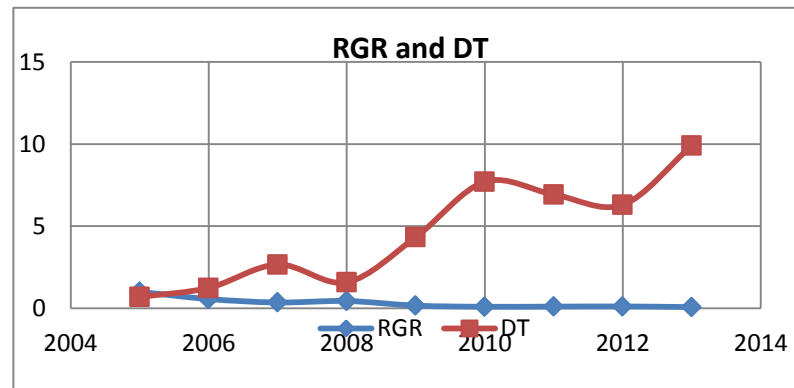


Fig. 3: Relative Growth Rate and Doubling Time

decreased from 2005 to 2007 and slight increase in 2008 and thereafter the trend is seen to be decreasing (Fig. 3). The highest value corresponds to 2005, whereas the lowest value for the year 2013.

The Doubling time for publications has shown an increasing trend from 0.69 in 2005 to 2.66 in 2007. In 2008 it was reduced in to 1.58. Again there is increasing trend from 4.33 in 2009 to 7.70 in 2010. Since then there is for a few years but throughout the study period the doubling time is in fluctuations.

Trend Analysis – Method of Least Squares

The least square method is the best method for obtaining the trend values which is often used to analyse the counting trends, population growth etc. Line of the best fit is a line from which the sum of the deviations of various points on its either side is zero. Further the sum of the squares of these deviations would be the least as compared to the sum of squares of the deviations obtained by using other lines.

The straight line trend has an equation of the type: $Y = a + bX$,

where,

Y represents the estimated values of the trend, X represents the deviations in time period; 'a' and 'b' are constants.

The values of two constants 'a' and 'b' are estimated by solving the following two normal equations.

$$\sum Y = Na + b\sum X$$

$$\sum XY = a\sum X + b\sum X^2$$

where N represents number of years for which data is given.

The variable X can be measured from any point of time as origin. To make calculation simpler, it is better to take the mid-point of time as the origin because the negative values of first half of the time series will equalise the positive values in the second half of the series which symbolically gives $\sum X = 0$.

When $\sum X = 0$, the two normal equations for finding the constants 'a' and 'b' will be

$$\sum Y = Na \Rightarrow a = \frac{\sum Y}{N} = Y$$

$$\sum XY = b\sum X^2 \Rightarrow b = \frac{\sum XY}{\sum X^2}$$

This provides that the constant 'a' is simply equal to the mean of Y values and the constant 'b' gives the rate of change. The constant 'a' refers to the Y intercept, i.e. the difference between the point of origin and the point where the trend line touches the Y axis. The constant 'b' refers to the slope of the line which indicates the change in Y for each unit change in X .

Table 4: Computation of Straight Line Trend by the Least Squares Method

Year	No. of Publications Actual (Y)	Deviation	Multiply (X)	XY	X ²	Trend value
2004	1657	-4.5	-9	-14913	81	2394.17
2005	2840	-3.5	-7	-19880	49	2515.51

Year	No. of Publications Actual (Y)	Deviation	Multiply (X)	XY	X2	Trend value
2006	3387	-2.5	-5	-16935	25	2636.85
2007	3272	-1.5	-3	-9816	9	2758.19
2008	6099	-0.5	1	6099	1	3000.87
2009	3105	1.5	3	9315	9	3122.21
2010	1902	2.5	5	9510	25	3243.55
2011	2258	3.5	7	15806	49	3364.89
2012	2794	4.5	9	25146	81	3486.23
2013	2088	5.5	11	22968	121	3607.57
2014			13			3728.91
2015			15			3850.55
2016			17			3971.59
2017			19			4092.93
2018			21			4214.27
2019			23			4335.61
2020			25			4456.95
2021			27			4578.29
2022			29			4699.63
2023			31			4820.97
	29402			27300	450	72879.70

The equation of the straight line trend is $Y = a + bX$

Since $\sum X = 0$, therefore

$$a = \frac{\sum Y}{N} = \frac{29402}{10} = 2940.2$$

$$b = \frac{\sum XY}{\sum X^2} = \frac{27300}{450} = 60.67$$

Substituting the value of 'a' and 'b' in the straight line of the trend,

$$Y = a + bX \Rightarrow Y = 2940.2 + 60.67X$$

Estimate of 2023 will be calculated on the basis of $X = 31$

$$Y_{2023} = 2940.2 + 60.67 \times 31 = 4820.97$$

With the use of the trend analysis, the trend values are calculated up to 2023. The trend line and actual line are presented in the figure 4. And, it is seen from the table that the actual trend was standard in the year 2004 since then there is an upward trend up to the end of the year 2023. During the study period there is a fluctuation in the prediction line in the year. From this it can be interpreted that the fluctuations in the actual line reflects in the trend line also.

Authorship Pattern

Table 5 presents the distribution of output by single, two, multi and mega authored papers. Out of 29402 publications, maximum of 11,506 (39.13%) publications have been contributed by multi authors, followed by mega authors with 9,864 (33.55%) publications, two authors with 6,386 (21.72%) publications. Only 1,646 (5.6%) publications have been contributed by single authors. From this finding it can be interpreted that the multi authorship pattern is predominant in the output.

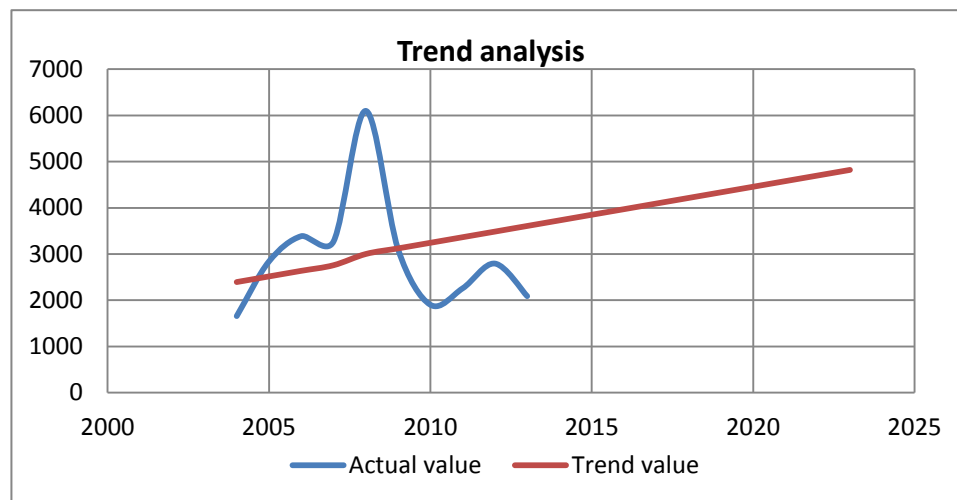
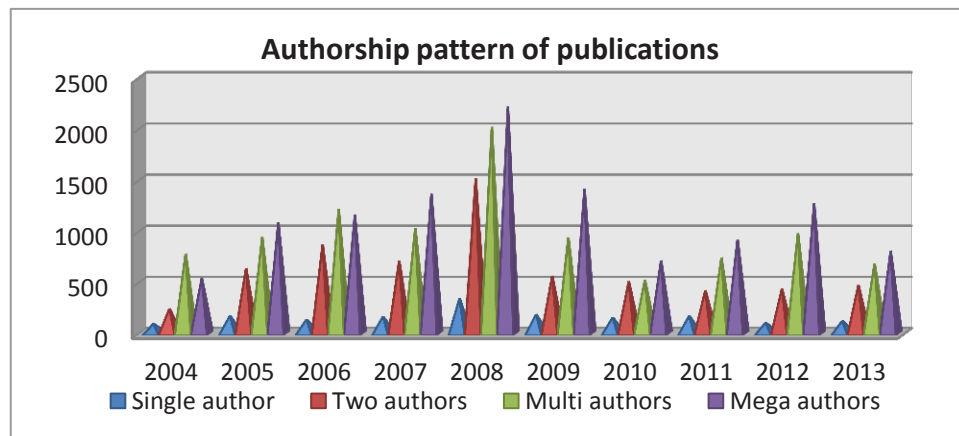


Fig. 4: Trend of the Atomic Physics Literature

Table 5: Authorship Pattern

Block	Year	Single	CAI	Two	CAI	Multi	CAI	Mega	CAI	Total	CC
1	2004	93	107	242	63	781	136	541	88	1657	0.63
	2005	172	115	637	92	945	96	1086	104	2840	0.62
	2006	136	76	872	112	1217	103	1162	93	3387	0.62
	2007	164	95	713	94	1028	90	1367	113	3272	0.64
	2008	343	107	1516	108	2021	95	2219	98	6099	0.62
Total		908		3980		5992		6375		17255	0.63
2	2009	186	99	564	92	940	95	1415	108	3105	0.64
	2010	155	134	510	135	523	86	714	89	1902	0.61
	2011	172	125	422	94	743	103	921	96	2258	0.62
	2012	104	61	437	79	981	110	1272	108	2794	0.65
	2013	121	93	473	114	685	103	809	92	2088	0.62
Total		738		2406		3872		5131		12147	0.63

CAI-Co -Authorship Index, CC-Collaboration Coefficient

**Fig. 5: Authorship Pattern**

Pattern of Co-Authorship

In order to assess the Pattern of Co-Authorship (CAI), the following formula suggested by Garg and Padhi has been employed.

$$N_{ij}/N_{i0}$$

$$CAI = \frac{N_{ij}/N_{i0}}{N_{0j}/N_{\infty}}$$

$$N_{0j}/N_{\infty}$$

where,

N_{ij} = Number of papers having authors in block i

N_{i0} = Total output of block i

N_{0j} = Number of papers having j authors for all blocks

N_{∞} = Total number of papers for all authors and all blocks

CAI = 100 implies that a country's co-authorship effort for a particular type of authorship corresponds to the world average, CAI > 100 reflects higher than average co-authorship effort, and CAI < 100 lower than average co-authorship effort by that country for a given type of authorship pattern.

For calculating the co-authorship index for authors, countries have been replaced by block. For this study, the authors have been classified into four blocks, viz. Single, Two, Three and More than three authors. The results of Co-authorship index as per the formula have been presented in the Table 5.

For calculating the co-authorship index and collaboration coefficient for authors, countries have been replaced by block. For this study, the authors have been classified into two blocks, viz. Single, Two, Multi and Mega authors. The results of co-authorship index and collaboration coefficient have been presented in the Table 5. It reveals that the result of co authorship index and it is observed that the value of CAI for increasing and decreasing trend in the two block year periods. This implies that the collaborative

pattern in atomic physics research is mainly characterised by co-authored papers not by single authored papers.

The average value of collaboration coefficient (CC) for atomic physics was 0.63. The highest value of collaboration coefficient is 0.65 in 2012 and lowest value 0.61 in 2010. However, the value of collaboration coefficient is showing increasing and decreasing trend in the two blocks year periods.

Comparative Study of Single Author Vs Multiple Authors

Table 6 presents the single and multiple authors productivity pattern on yearly basis. It is found that the productivity patterns on the atomic physics are much

Table 6: Single Author Vs Multiple Authors

Year	Single authors		Multiple authors		Quantum of research output	Degree of collaboration
	Quantum of output	Percentage	Quantum of output	Percentage		
2004	93	0.32	1564	5.32	1657	0.94
2005	172	0.58	2668	9.07	2840	0.94
2006	136	0.46	3251	11.06	3387	0.96
2007	164	0.56	3108	10.57	3272	0.95
2008	343	1.17	5756	19.58	6099	0.94
2009	186	0.63	2919	9.93	3105	0.94
2010	155	0.53	1747	5.94	1902	0.92
2011	172	0.58	2086	7.09	2258	0.92
2012	104	0.35	2690	9.15	2794	0.96
2013	121	0.41	1967	6.69	2088	0.94
Total	1646	5.60	27756	94.40	29402	0.94

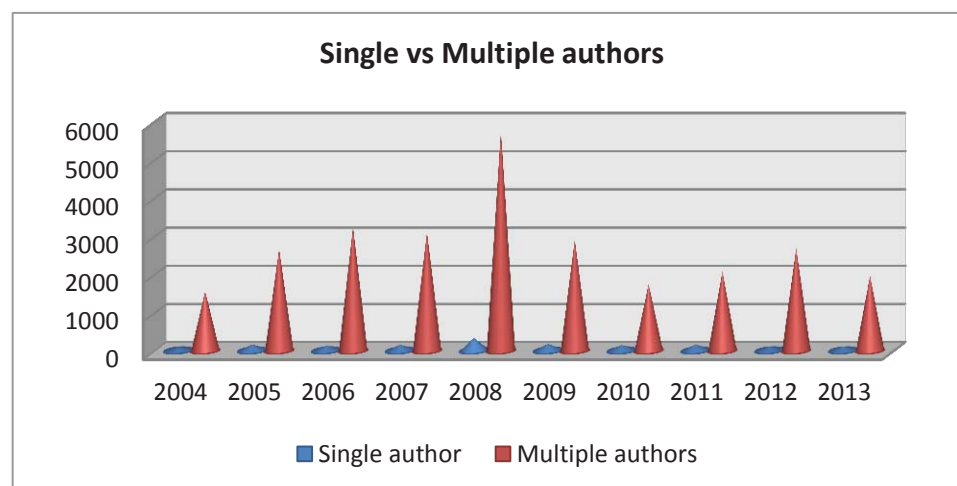


Fig. 6: Single Author Vs Multiple Authors

contributed by the multiple authors than the single author since 2004 to 2013. Thus, from this analysis it can be interpreted that basically the atomic physics research is much dominated by multiple researchers/authors.

The degree of collaboration is calculated with use of the formula and presented in the table 6. It is seen from Table 6 that every year high collaborative publications are made on the subject. The collaborative rate for the entire output during the period is 0.94. A high of 0.96 is found in the year 2006 and 2012. The remaining year collaborative rate is recorded more than 0.92. This one again proves the collaborative nature of research on the discipline is concerned.

Most Prolific Authors

Table 7 presents rank list of authors who have contributed more than 30 articles are taken into account to avoid a long list. It is observed that Ye, P D, Purdue University, USA is the most productive author contributing 39 articles followed by Fanciulli, M, Institute of Physics and astronomy, Denmark with 37 articles and Kobayashi, K, Ochanomizu University, Japan with 37 articles, Kitching, J, National Institute of Standards and Technology, USA with 37 articles, Yamada, H, Ochanomizu University, Japan with 36 articles, Hwang, C S, Seoul National University, South Korea and Wallace, R M, University of Texas, USA each with 34 articles respectively.

Table 7: Most Prolific Authors

Rank	Author	Institutions	No. of publications	Percentage
1	Ye, P D	Purdue University, USA	39	0.13
2	Fanciulli, M	Institute of Physics and astronomy, Denmark	37	0.13
3	Kobayashi, K	Ochanomizu University, Japan	37	0.13
4	Kitching, J	National Institute of Standards and Technology, USA	37	0.13
5	Yamada, H	Ochanomizu University, Japan	36	0.12
6	Hwang, C S	Seoul National University, South Korea	34	0.12
7	Wallace, R M	University of Texas, USA	34	0.12
8	Knappe, S	Institute of Clinical Psychology and Psychotherapy, Germany	33	0.11
8	Ritala, M	Laboratory of Inorganic Chemistry, Finland	33	0.11
10	Schneider, O	University of Lausanne, Switzerland	31	0.11
11	Eidelman, S	Budker Institute of Nuclear Physics, Russia	31	0.11
12	Bondar, A	Budker Institute of Nuclear Physics, Russia	30	0.10

Table 8: Highly Productive Institutes

Rank	Institutions	Country	No. of Publications	Percentage
1	University of Tokyo	Japan	470	1.60
2	Japan Science and Technology Agency	Japan	376	1.28
3	Osaka University	Japan	354	1.20
4	National Institute of Standards and Technology	USA	312	1.06
5	Kyoto University	Japan	292	0.99
6	Tohoku University	Japan	275	0.94
7	Los Alamos National Laboratory	USA	269	0.91
8	Oak Ridge National Laboratory	USA	250	0.85
9	Tsinghua University	China	248	0.84
10	Tokyo Institute of Technology	Japan	248	0.84

Highly Productive Institutes

Table 8 shows the institutes that have contributed 240 or more publications on atomic physics research during 2004-2013. University of Tokyo, Japan is the top producing institutions with 470 publications followed by Japan Science and Technology Agency, Japan with 376 publications, Osaka University, Japan with 354 publications, National Institute of Standards and Technology, USA with 312 publications and Kyoto University, Japan with 292 publications.

Highly Productive Countries

In all, there were 116 countries involved in research in atomic physics, which published at least one publication. The USA topped the list with highest share (29.57%) of publications. Japan ranked second with 12.22% share of publications followed by Germany 12.04% share of publications, China with 10.53% share of publications, France with 7.74% share of publications, UK with

6.44% share of publications, Russia with 5.37% share of publications, Italy with 4.72% share of publications, South Korea with 3.76% share of publications, Spain with 3.51% share of publications, Canada with 3.21% share of publications, India with 3.15% share of publications and the remaining seven countries are publishing less than 3% share of publications. The publication share of highly productive countries (≥ 500 publications) on atomic physics is given in Table 9.

Most Preferred Source Titles

The scientific literature on atomic physics is spread over 2421 different source journals and conference publications. The leading journals preferred by the scientists are: Applied Physics letters with 3060 publications followed by Journal of applied physics with 2769 publications, Physical review A Atomic molecular and optical physics with 2231 publications and Physical review letters with 2034 publications. Table 10 gives the list of source titles with more than 500 publications.

Table 9: Highly Productive Countries

Rank	Country	Total Publications (%)	Rank	Country	Total Publications (%)
1	USA	8694 (29.57%)	11	Canada	945 (3.21%)
2	Japan	3592 (12.22%)	12	India	926 (3.15%)
3	Germany	3541 (12.04%)	13	Switzerland	695 (2.36%)
4	China	3095 (10.53%)	14	Australia	687 (2.34%)
5	France	2277 (7.74%)	15	Poland	686 (2.33%)
6	UK	1894 (6.44%)	16	Taiwan	646 (2.20%)
7	Russia	1578 (5.37%)	17	Netherlands	623 (2.12%)
8	Italy	1388 (4.72%)	18	Sweden	521 (1.77%)
9	South Korea	1106 (3.76%)	19	Brazil	505 (1.72%)
10	Spain	1033 (3.51%)			

Table 10: Source Title of Publications

Rank	Source title	No. of publications
1	Applied Physics Letters	3060 (10.41%)
2	Journal of Applied Physics	2769 (9.42%)
3	Physical Review A: Atomic molecular and optical physics	2231 (7.59%)
4	Physical review letters	2034 (6.92%)
5	Journal of Chemical Physics	1894 (6.44%)
6	AIPconference proceedings	1593 (5.42%)
7	Review of scientific instruments	718 (2.44%)
8	Japanese Journal of Applied Physics	718 (2.44%)
9	Journal of Physics B Atomic molecular and optical physics	573 (1.95%)
10	Japanese Journal of Applied Physics Part 1 Regular papers and short notes and review papers	516 (1.75%)

Table 11: High Productivity Subject Areas

Rank	Subject	No. of Articles	Percentage
1	Physics and Astronomy	24182	82.25
2	Chemistry	3719	12.65
3	Engineering	3649	12.41
4	Materials Science	3424	11.65
5	Mathematics	742	2.52
6	Medicine	720	2.45
7	Computer Science	682	2.32
8	Chemical Engineering	641	2.18
9	Biochemistry, Genetics and Molecular Biology	509	1.73
10	Energy	509	1.73

High Productivity Subject Areas

Table 11 shows high productivity subjects which are contributing more than 500 articles. It is observed that Physics and Astronomy has highest number of articles with 24182 followed by Chemistry contributing 3719 articles. Engineering occupy the third position with 3649 articles. The fourth highest articles belonged to the subject material science 3424 articles.

Conclusions

The present study explores the characteristics of global atomic physics output on Web of Science database during the period 2004 to 2013. A total of 29402 publications were published in the field and an average number of publications published per year was 2940.2. There was a fluctuation growth of publications during the period. The year wise RGR is found to be in the range of 1 to 0.07 and doubling time ranges is from 0.69 to 9.9. Out of 29402 publications, maximum of 11,506 (39.13%) publications have been contributed by multi authors, followed by mega authors with 9,864 (33.55%) publications. The degree of collaboration of publications of the Atomic Physics is 0.94 which is very high degree of collaboration. Among the top 19 most productive countries, USA registered the highest publication share of 29.57%, followed by Japan (12.22%), Germany (12.04%), China (10.53%), France (7.74%), UK (6.44%), and Russia (5.37%) etc. The largest publication share (82.25%) comes from Physics and Astronomy among subjects, followed by Chemistry (12.65%), Engineering (12.41%) and Material Science (11.65%) during 2004-2013. Applied Physics letter stops the list with 3060 (10.41%) publications followed

by Journal of Applied Physics with 2769 (9.42%) publications, Physical review A Atomic molecular and optical physics with 2231 (7.59%) publications and Physical review letters with 2034 (6.92%) publications.

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