

Summer 6-13-2019

# Citation Analysis of Doctoral Theses of Physics: A Bibliometrics Study

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GAYAN, MITHU ANJALI and Singh, Sanjay Kumar, "Citation Analysis of Doctoral Theses of Physics: A Bibliometrics Study" (2019).  
*Library Philosophy and Practice (e-journal)*. 2903.  
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## *Citation Analysis of Doctoral Theses of Physics: A Bibliometrics Study*

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### **Abstract**

Citation analysis is one of the thrust areas of research in Library and Information Science. It provides very useful insights to librarians and policy makers in terms of which sources to be purchased and what to be replaced. The current study was carried out to understand different characteristics of Physics as a discipline by analysing the citations appended at the end of Doctoral theses of Physics, Tripura University. A total 5640 citations were analysed from 18 theses during the 10 years period of 2007 to 2016. Bradford's law of scattering of periodical was tested as it did not fit in the particular dataset. The appropriateness of Leimkuhler model was also evaluated with the dataset. Journal of Geophysical Research published from USA is found to be ranked one in the list of core journals. American Chemical Society, USA was found to be the top cited Publisher. The study also disclosed that electronic and subscription based journals receives more citations. The half life of Physics journals was found to be 15.9 years.

**Keywords:** Citation Analysis, Bibliometrics, Physics, Doctoral Theses, Tripura University, Bradford's law, Leimkuhler model, half life, Obsolescence.

### **1. Introduction**

Body of knowledge in a particular field of discipline either grows or declines over a given course of time. Knowledge in a particular area consists of different constituting bodies such as books, periodicals, proceedings, lectures, web information, etc and these are correlated to each other by the mechanism of referencing, citation or footnotes (Donald R. Baker, 1990). The citations / references/ footnotes appended at the end of each research article or chapters of book/ thesis/ dissertation provide enormous amount of critical information instrumental for understanding diverse characteristics of a particular subject. Systematic study of citations / references/footnotes to distinguish quantitative aspects such as authorship pattern, subject

relationships, impact, and research trends and to evaluate performance can be termed as Citation Analysis. Citations or references form part of the scholarly apparatus of primary communication. The spirit of the distinction is that citation in the primary literature specifically states an association between two documents, the citing and the cited, whereas citation in other listings does not usually entail any connection between documents other than that affected by the indexing technology (John Martyn, 1975). Citation analysis helps in identifying core journals and books in particular discipline which in turns helps the librarians to select resources for their libraries. As we all know that the cost of scholarly resources is increasing day by day and library's fund is shrinking so in this regard citation analysis provides a solution to tackle this issue.

Citation analysis is one of the most used methods in Bibliometrics which tries to ascertain relationships between authors or their work (Chikate, R.V. & Patil, S.K, 2008). In citation analysis "Citation" is the core around which the study revolves. Scholars for their theses and dissertations by default cite many documents for conducting their study. So, they are one of the best sources for collecting citation data. Thesis is essentially an example of primary sources as it presents first hand information in the form of primary research data. They are one of the most authentic and reliable constituents of universe of knowledge.

According to britannica.com, Physics deals with the structure of matter and the interactions between the fundamental constituents of the observable universe. In the broadest sense, physics (from the Greek *physikos*) is concerned with all aspects of nature on both the macroscopic and submicroscopic levels. For the current study citation analysis of doctoral theses of Physics from Tripura University is selected as in Web of Science highest number of articles from Tripura University is indexed from Physics. Tripura University is one of the central universities. It is located in Tripura which is one of the eight north eastern states of India.

## **Review of Literature**

(Kumar & Senthilkumar, 2018) assessed Bradford's law of scattering on research articles published in the field of Astronomy & Astrophysics by Indian scientist during 1988-2017 and Leimkuhler model was also tested to verify the data set. They failed to establish the consistency in scattering of literature due to high level concentration of articles in very few journals. (Kalita, 2017) examined the citations of the full research articles published in Nature journal from 2006 to 2015. Outgoing citations from Nature were circulated among

Science, Proceedings of National Academy of Science (PNAS), Cell, Journal of Biological Chemistry (JBC) and The Astrophysical journal (AstroPJ). USA and England were the top contributing countries. Japan and China are the only Asian countries to be featured in the top 15 countries list. (Tripathi & Sen, 2016) attempted to find out the applicability of Bradford law on crop science literature. The dataset comprised 10,100 papers indexed in Indian Science Abstracts and CAB Abstracts during the period 1965-2010 and this data set did not follow Bradford law even with Leimkuhler formulation. Indian Journal of Agricultural Sciences was found out to be the most cited journal. Leimkuhler model was employed and was found valid for the data set. (Gohain & Saikia, 2014) scrutinized 10983 citations, appended in the 30 PhD theses of chemical sciences submitted to Tezpur University. The Journal of American Chemical Society was found to be the most cited journal, they observed an average 366.10 citations were cited per theses, journal contributed the highest number of citations. (Singh & Bebi, 2014) studied 260 PhD Social Science theses submitted during 1995 to 2008 to Delhi University. They found out Economic and Political Weekly is the most cited journal. Their study satisfied the Bradford's law of scattering of journals. (Wardikar & Gudadhe, 2013) examined data of journals cited for doctoral research. Study included 798 periodical containing 5467 references collected from 138 theses during the period 1982-2010. Annals of Library Science and Documentation were found out to be most cited journals. The data set did not fit into the Bradford's distribution. (Jadhav Vandana Sheshrao & V. S. Khaparde 2011) performed citation analysis on 5726 citations from 30 Ph.D. theses of Physics submitted to Dr. Babasaheb Ambedkar Marathwada University Library. The ranked list of cited journals and books, to find out the language-wise distribution, geographical distribution of cited documents, the ranked list of cited web - sources and the cited authors were studied. (Sudhier, 2010) examined five-year data of journals (2004-2008) cited by the physicists at the Indian Institute of Science (IISc), Bangaluru to verify applicability of Bradford's Law of Scattering, which included 690 periodicals containing 11,319 references collected from 79 doctoral theses during the period 2004-08, Physical Review-B was found to be the top ranked journal. His study did not verify Bradford's law. (Kim, 2001) evaluated research productivity of Korean physicists, comparing Korean-authored papers versus internationally co-authored papers, indexed in SCI, 1994-1998, and using the number of citations received by internationally co-authored papers covered by the SCI CD-ROM. It was found out that Korean authored papers tended to be published in Korean, Japanese, and UK journals, while internationally co-authored papers were more likely to appear in German, Dutch, and Swiss journals. U.S. researchers had the

highest citation rate. (Uzun, 1996) studied the publication efforts in physics in Egypt, Iran, Iraq, Jordan, Saudi Arabia, Syria, and Turkey. Comparisons show that physicists from Egypt and Turkey combined, produced 75% of the total publication output. Condensed matter physics was found to be among the three most active subjects for the countries except Iran. Iranian authors tended to be more active in Astrosciences, and nuclear science and technology. A change in the publication patterns of the Middle Eastern physicists in the direction of decreasing isolation and increasing collaboration was noticed.

## **Objectives**

1. Identify the document type wise distribution of citations
2. To verify the application of Bradford's law of scattering and Leimkuhler Model.
3. Identify the leading Scimago categories and core journals
4. Identify most productive countries and Publishers of the journals
5. To identify the form and type of journal literature used for the study
6. To find out Rate of obsolescence hence half life of journals

## **4. Scope and Limitations**

The scope of the present study is to examine the application of Bradford's Law of scattering and Leimkuhler Model only in the field of Physics Journals. The present study is focused on citations scattered in journals and limited for the specific time period of 10 years from 2007 to 2016.

## **Methodology**

### **Identifying the data source:**

Initially, the researcher visited the central library for identifying the primary data. Tripura University has been converted to a Central University w.e.f 2nd July, 2007 under the Tripura University Act, 2006 as enacted by the Parliament. So, for this study the sample is selected for the time period of July, 2007 to July 2016. The proposed sample of the study is 1 department from School of Science, Tripura University for the time period of 10 years duration starting from July, 2007 to July 2017 counting to 18 theses available in the library.

**Data Collection:** Data were collected from Shodhganga by downloading theses chapter wise from Tripura University's collection. The theses which were not uploaded on Shodhganga were clicked and were converted to PDF from image files. Some of the theses contained the citation at the end of each chapter and in some others the citations were appended separately at the end of the theses in the form of bibliography. Data are collected from a total of 5640

citations coming from 18 theses for the detailed analytical study. The detail thus obtained has led to the study of subject, Country of publication, bibliographic forms, rate of Obsolescence, Language, Citation age, etc.

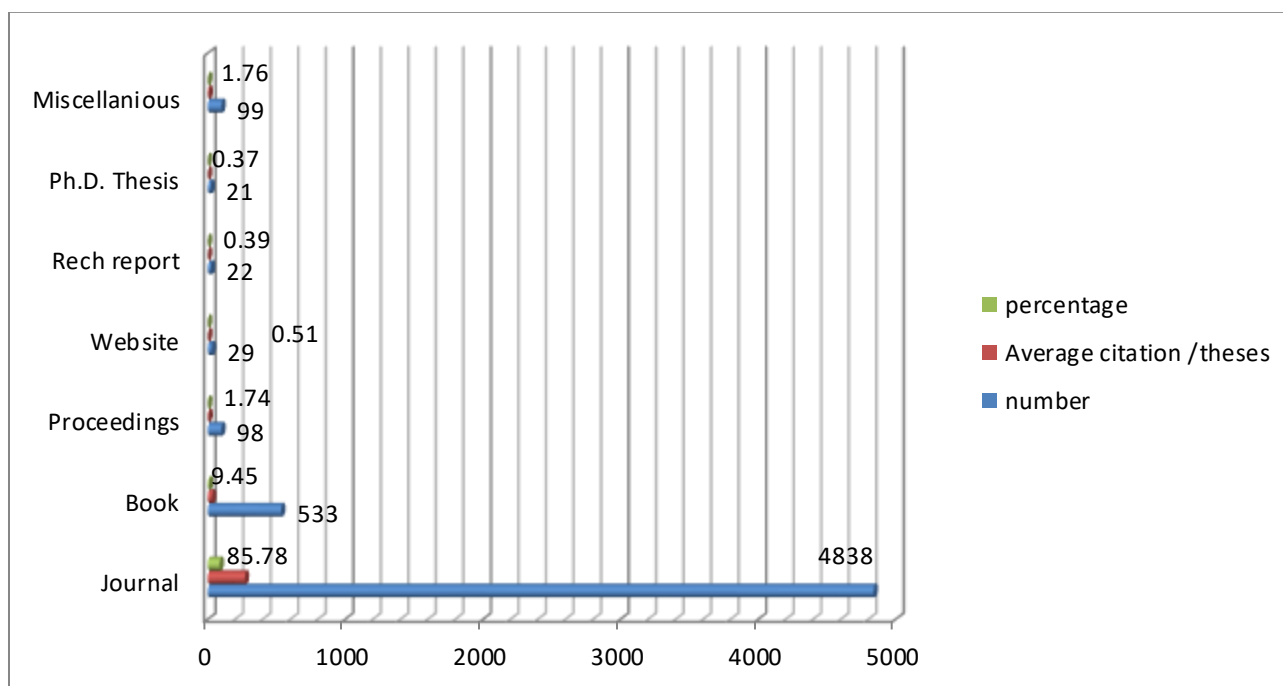
**Analysis:** The analysed data are categorised and interpreted in respect of different criteria like journals, years, countries, research areas.

### **Objective 1: Document type wise distribution of citations**

Table 1 and figure 1 exhibit an outline of the various types of documents used for citations. Out of total citations, it is found out that most number of citations 4838 (85.78%) are concentrated in journals which clearly specify that all other sources together comprise of only 14.22% citations. Books being the second highest in the list received 533 (9.45%) citations followed by Proceedings received 98 (1.74%) citations.

**Table 1: Document type wise distribution of citations**

<b>Sl. No.</b>	<b>Type</b>	<b>Number</b>	<b>Percentage</b>	<b>Average citation /theses</b>
1	Journal	4838	85.78	269
2	Books	533	9.45	30
3	Proceedings	98	1.74	5
4	website	29	0.51	2
5	tech report	22	0.39	1
6	Ph.D. Thesis	21	0.37	1
7	unknown	15	0.27	1
8	tech notes	10	0.18	1
9	tech doc	9	0.16	1
10	Magazine	7	0.12	0
11	Ph.D. dissertation	5	0.09	0
12	Interviews with Leading Thinkers and Writers	3	0.05	0
13	master thesis	3	0.05	0
14	memo	3	0.05	0
15	annual rep	2	0.04	0
16	Encycl	2	0.04	0
17	Symp	2	0.04	0
18	abstract	1	0.02	0
19	image	1	0.02	0
20	NASA special pub	1	0.02	0
21	workshop	1	0.02	0
22	blank	34	0.60	2
<b>Total</b>		<b>5640</b>	<b>100.00</b>	<b>313</b>



**Figure 1: Document type wise distribution of citations**

It is also found that journals receive 269 average citations per theses followed by books receiving 39 citations per theses and Proceedings receiving 5 citations per theses. A total of 313 average citations per theses are observed from the data set.

### **Objective 2: Application of Bradford's law of scattering and Leimkuhler Model**

The verbal and graphical theory of the Bradford's Law of Scattering is applied to the citations appended in Physics theses. Citations are arranged in the decreasing order of its frequency in table number 2. For the study, 26 unidentified sources are not included as they are inconsequential. The data in table number 2 reports that a total of 4812 citations come from 544 journals.

**Table 2: Decreasing Frequency of Journal Citations**

Sl. No.	Rank	No. of periodicals	Cumulative No. of journals	No. of citations	Total of citation	Cumulative total	log of cum. no of journal
1	1	1	1	270	270	270	0.00
2	2	1	2	256	256	526	0.301
3	3	1	3	232	232	758	0.477
4	4	1	4	214	214	972	0.602

5	5	1	5	182	182	1154	0.699
6	6	1	6	137	137	1291	0.778
7	7	1	7	133	133	1424	0.845
8	8	2	9	87	174	1598	0.954
9	9	1	10	84	84	1682	1.000
10	10	1	11	83	83	1765	1.041
11	11	1	12	81	81	1846	1.079
12	12	2	14	80	160	2006	1.146
13	13	1	15	79	79	2085	1.176
14	14	1	16	72	72	2157	1.204
15	15	2	18	60	120	2277	1.255
16	16	2	20	56	112	2389	1.301
17	17	1	21	48	48	2437	1.322
18	18	1	22	45	45	2482	1.342
19	19	1	23	43	43	2525	1.362
20	20	1	24	39	39	2564	1.380
21	21	2	26	33	66	2630	1.415
22	22	1	27	31	31	2661	1.431
23	23	2	29	29	58	2719	1.462
24	24	2	31	28	56	2775	1.491
25	25	3	34	27	81	2856	1.531
26	26	1	35	26	26	2882	1.544
27	27	1	36	25	25	2907	1.556
28	28	2	38	24	48	2955	1.580
29	29	5	43	22	110	3065	1.633
30	30	1	44	21	21	3086	1.643
31	31	3	47	20	60	3146	1.672
32	32	3	50	19	57	3203	1.699
33	33	5	55	18	90	3293	1.740
34	34	6	61	17	102	3395	1.785
35	35	1	62	16	16	3411	1.792
36	36	1	63	15	15	3426	1.799
37	37	7	70	14	98	3524	1.845
38	38	3	73	13	39	3563	1.863
39	39	4	77	12	48	3611	1.886
40	40	5	82	11	55	3666	1.914
41	41	1	83	10	10	3676	1.919
42	42	7	90	9	63	3739	1.954
43	43	11	101	8	88	3827	2.004
44	44	13	114	7	91	3918	2.057
45	45	20	134	6	120	4038	2.127



46	46	20	154	5	100	4138	2.188
47	47	27	181	4	108	4246	2.258
48	48	44	225	3	132	4378	2.352
49	49	115	340	2	230	4608	2.531
50	50	204	<b>544</b>	1	204	<b>4812</b>	2.736

The top ranked journal consists of 270 citations followed by the second journal having received 256 citations and the third ranked journal received 232 citations. It is also revealed that 204 unique journals received 1 citation each. The table provides evidence that only a few journals received huge number of citations and a large chunk of journals receive a few citations each.

### **Bradford's zone for Physics**

Based on table 2, three Bradford zones (Bradford, 1948) of journals having equal number of citations are presented in table number 3 by. In this case, each zone accounts for about 1604 citations. Table 3 depicts the data in three Bradford zones. The difference in the value of the multiplier is too high, more than two times. Hence, it is concluded that the dataset does not fit into Bradford's law.

**Table 3: Bradford's zone for Physics**

<b>Zone</b>	<b>No. of Periodicals</b>	<b>number of citations</b>	<b>Cumulative number of citations</b>	<b>Bradford multiplier</b>
Zone 1	9	1598	1598	1
Zone 2	41	1605	3203	4.55
Zone 3	494	1609	3812	54.88
Total	544	4812		

In this case, each zone accounts for about 1604 citations. Table 3 depicts the data in three Bradford zones. The difference in the value of the multiplier is too high. Hence, it is concluded that the dataset does not fit into Bradford's law.

The relationship of the each zone in the present table is explained with the following equations,

‘F’ denotes Finding, ‘R’ denotes Result and ‘E’ denotes Excepted result

$$F = 1:n:n^2$$

$$R = 1:4.55: 54.88$$

$$E = 1: 4.55:20.70$$

i.e.  $R \neq E$

$$1: 4.55:20.70 \neq 1: n: n^2$$

Thus, it does not fit well into the law. Hence, to examine the verification of Bradford’s Law of Scattering, Leimkuhler Model (Leimkuhler, 1967) of distribution is employed. Leimkuhler model has been used many times in previous studies such as (Wardikar & Gudadhe, 2013) (Kalita, 2016) (Tripathi & Sen, 2016) to study its applicability for calculating non cumulative rank frequency calculation.

Leimkuhler model of Bradford’s distribution is a size frequency measure and in this model at first the core journals with specific citations in the first zone is determined and then Bradford Multiplier is found out. Accordingly with its multiples the journals in the following zones are counted. Bradford’s multiplier (K) for Leimkuhler distribution is counted with Egghe’s formula (Egghe, 1986).

Leimkuhler’s model based on Bradford’s verbal formulation is,

$$R_0 = T (K-1)/(K^p-1),$$

To apply this formula, first we have to find out value of “K” with the following formula,

$$K = (e^y Y_m)^{1/p} \text{ where, } \{e^y = 1.781 \text{ (Euler's No)}\}$$

$Y_m$  = no of citations in the most productive journal i.e.  $Y_m = 270$  (From table 2)

$$K = (e^y Y_m)^{1/p} \text{ where, } e^y = 1.781 \text{ (Eular's No)}$$

$P$  =Bradford’s group of no of zones of distribution i.e.  $P =3$

By applying our data,

$$K = (1.781 * 270)^{1/3}$$

$$= (480.87)^{1/3}$$

$$= 7.83$$

Now, let's find out number of journals in the Nucleus of each zone by using Leimkuhler developed model,

$$R_0 = T(K-1) / (K^p - 1), [T = \text{Total no of journals} = 544 \text{ (from table 56)}]$$

$$R_0 = 544 * (7.83-1) / \{(7.83)^3 - 1\}$$

$$= 3715.52/479.048 = 7.756$$

That means in the Leimkuhler model of Bradford's distribution the core group contains 7.8 ( $\approx 8$ ) journals.

Hence, the modified Bradford's distribution from Leimkuhler model can be written down as

$$= R_0 : R_0 * K : R_0 * K^2$$

$$= 7.756 : 7.756 * 7.83 : 7.756 * (7.83)^2$$

$$= 7.756 : 60.7294 : 475.511 = 543.9964$$

$$\% \text{ Error} = \{(544 - 543.9964) / 544\} * 100$$

$$= 0.00011$$

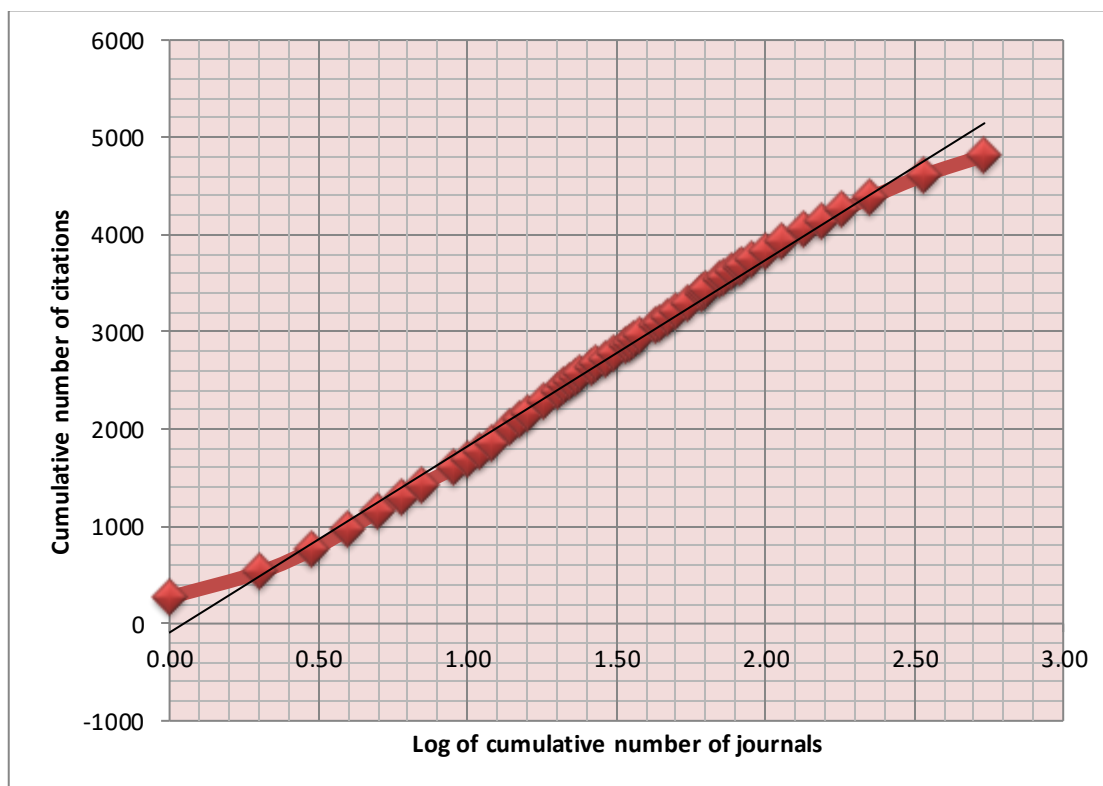
So, from the above equation % of error is found out to be 0.00011% which is a very slight deviation. So researcher can acknowledge the acceptability of new modified Bradford's distribution given by the Leimkuhler model.

After application of Leimkuhler model we got three zones which are illustrated in table 4, the core zone which is Zone 1 containing 8 journals with 31.40 % share of citations, Zone 2 containing 61 journals with 41.54 % and Zone 3 containing 475 journals with 27.06 % share of citations.

**Table 4: Bradford's Distribution based on Leimkuhler's model in 3 zones**

Zone	No of Journals	cumulative no of journals	Total Citations share	cumulative no of citations	% Share to total citations
1	8	8	1511	1511	31.40

2	61	69	1999	3510	41.54
3	475	544	1302	4812	27.06
	544		4812		100.00



**Figure 2: Graphical formulation of Bradford's distribution**

Figure 2 gives a graphical formulation of the Bradford's law, when we put the log of cumulative no of journals in the X axis and cumulative no of citations in Y axis. In the graph, we see there is a step rise initially which contains the core group of journals then it becomes linear and sloping part of the graph starts towards the end. So, the graph in figure 5 satisfies the criteria of Bradford's distribution graph given by Brookes (Brookes, 1969).

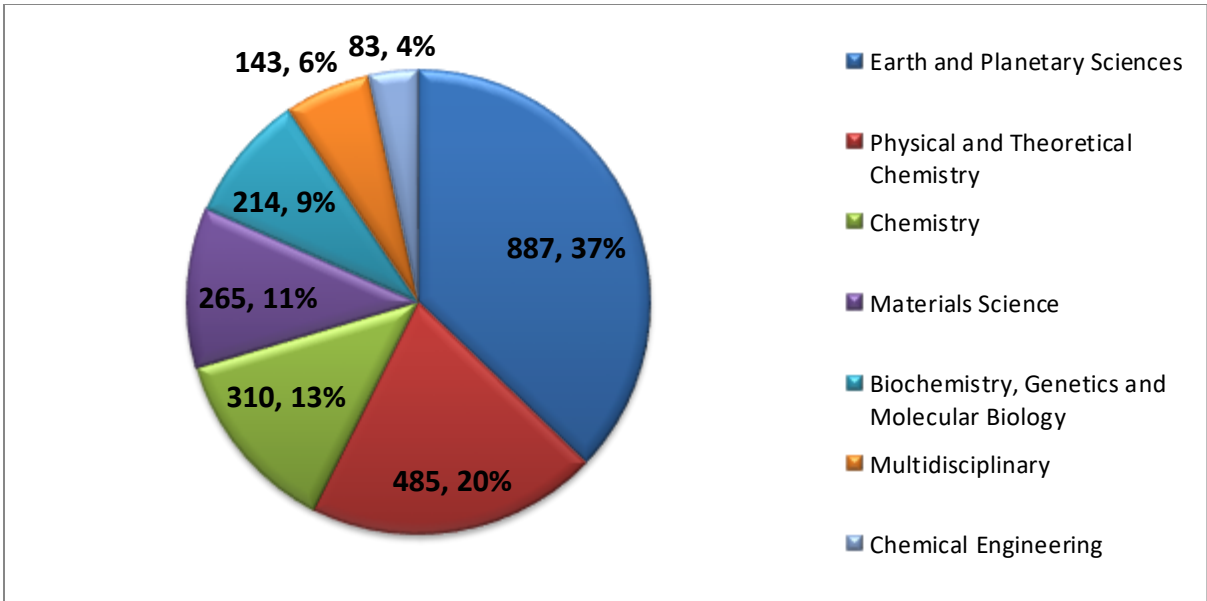
**Objective 3: Identify the core journals and leading Scimago categories**

**Table 5: Core journals and Scimago categories**

Rank	Name of Journal	Country	Number of citations received	Scimago Journal Category
1	Journal of Geophysical Research	USA	270	Earth and Planetary Sciences
2	Langmuir	USA	256	Chemistry
3	Journal of Atmospheric and Solar—Terrestrial Physics	UK	232	Earth and Planetary Sciences
4	Journal of the American Chemical	USA	214	Biochemistry, Genetics

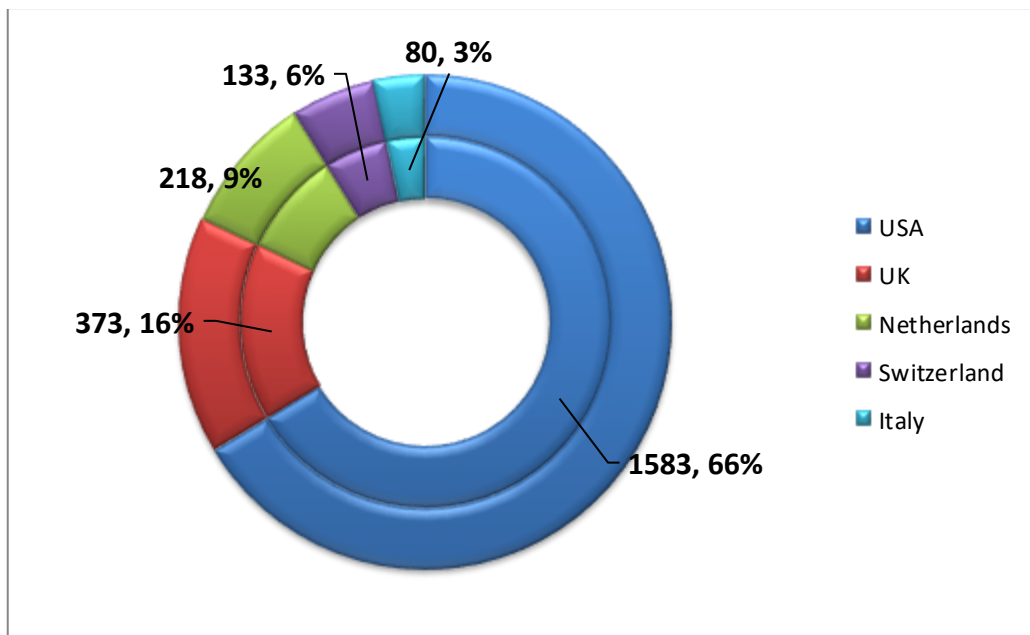
	Society			and Molecular Biology
5	Journal of Chemical Physics	USA	182	Physical and Theoretical Chemistry
6	Chemical Physics letter	Netherlands	137	Physical and Theoretical Chemistry
7	Thin Solid Films	Switzerland	133	Materials Science
8	Nature	UK	87	Multidisciplinary
8	Journal of Physical Chemistry	USA	87	Physical and Theoretical Chemistry
9	Radio Science	USA	84	Earth and Planetary Sciences
10	Journal of Colloid and Interface Science	USA	83	Chemical Engineering
11	Solar Physics	Netherlands	81	Earth and Planetary Sciences
12	Annals of Geophysics	Italy	80	Earth and Planetary Sciences
12	Geophysical Research Letter	USA	80	Earth and Planetary Sciences
13	Journal of Physical Chemistry B	USA	79	Physical and Theoretical Chemistry
14	Macromolecules	USA	72	Materials Science
15	Advanced Materials	USA	60	Materials Science
15	The Astrophysical Journal	USA	60	Earth and Planetary Sciences
16	Science	USA	56	Multidisciplinary
17	Spectro. Chim. Acta Part A	UK	54	Chemistry

Table 5 represents the list of core journals and their Scimago categories. It is found that no journals published from India belong to the list of journals having received more than 50 citations. Journal of Geophysical Research being published from USA is found to be ranked one in the list of core journals having cited 270 times and it belongs to the area of Earth and Planetary Sciences. Langmuir, USA belonging to subject area of Chemistry received second highest 256 number of citations followed by Journal of Atmospheric and Solar—Terrestrial Physics, UK belonging to area Earth and Planetary Sciences received 232 citations and is the 3<sup>rd</sup> most cited journal from the rank list. It is also observed that no journal published from India occur in the rank list of top 17 journals having received more than 50 citations each.



**Figure3: Subject areas of top cited journals based on Scimago journal category**

From figure 3, it is quite evident that most of the citations 887 (37%) belong to the category of “Earth and Planetary Sciences” followed by “Physical and theoretical Chemistry” 485 (20%) and Chemistry having received 310 (13%).



**Figure 4: Countries of top cited journals**

Figure 4 provides evidence that more than half of the top cited journal citations 1583 (66%) come from USA followed by UK receiving 373 (16%) and Netherlands receiving 218 (9%).

**Objective 4: Most productive countries and Publishers of the journals**

**Table 6: Top ranked Publishers and Countries in the field of Physics, Journals**

Sl. No	Rank	Publisher	Country	Sources	Number of citations	Percentage
1	1	American Chemical Society	United States	37	995	20.57
2	2	Elsevier BV	Netherlands.	94	644	13.31
3	3	Wiley-Blackwell	United States	13	537	11.10
4	4	Elsevier Ltd.	United Kingdom	27	425	8.78
5	5	Elsevier Inc.	United States	11	165	3.41
6	6	Kluwer Academic Publishers	Netherlands	15	144	2.98
7	7	Royal Society of Chemistry	United Kingdom	17	110	2.27
8	8	American Physical Society	United States	7	86	1.78
9	9	Springer Verlag	Germany	10	54	1.12
10	10	John Wiley & Sons Inc.	United States	17	52	1.07
total of top ten journals					3212	66.39
remaining sources					1626	33.61
<b>Total</b>					<b>4838</b>	<b>100.00</b>

Table 6 represents the top ranked publishers and their respective countries. American Chemical Society, USA is ranked number 1 to which a total 37 sources were cited 995 (20.57 %) times. Elsevier BV, Netherlands ranked 2<sup>nd</sup> having 94 sources being 644 (13.31%) times cited and Wiley-Blackwell, United States ranked 3<sup>rd</sup> in the list consisting of 13 sources being 537 (11.10%) times cited.

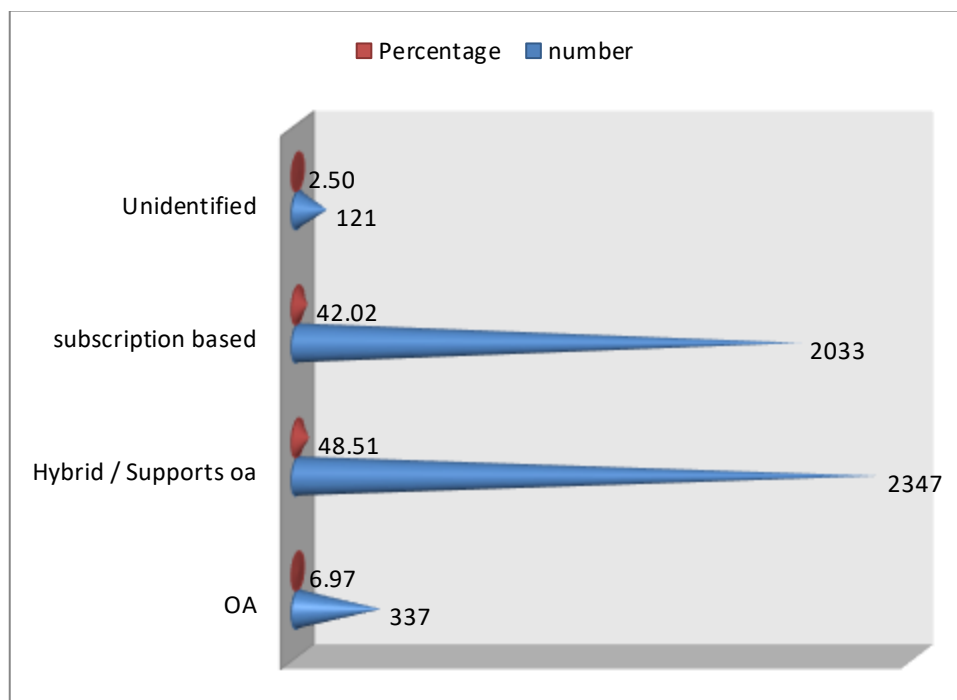
**Objective 5: form and type of journal literature used for the study**

**Table 7: Form of journals used in Physics**

Sl. No.	Format	Number	Percentage
1	Electronic	2451	50.66
2	Both electronic and printed	2250	46.51
3	only print	19	0.39
4	unidentified	118	2.44
<b>Total</b>		<b>4838</b>	<b>100.00</b>

Table 7 describes the format of journal used for citations by the scholars. There are 2 formats of journals. One being the traditional print format and the other one is the electronic format. There are journals who publish their content in both the formats. From table 4 it's clear that

most 2451 (50.66%) number of citations come from journals which get published in the electronic form. Journals which get published in both the form received 2250 (46.51%) citations. There are some scholars who cite only print 19 (0.39%) journals.



**Figure 5: Type of journals used for citing based on pricing policy**

There are two broader categories of journals namely subscription based and open access journals based on pricing policies. There is a 3<sup>rd</sup> category as well which is known as hybrid journals. They are basically subscription based journals but they also support open access publishing. Figure 5 depicts that Hybrid journals were cited highest 2347 (48.51%) number of times followed by subscription based journals 2033 (42.02%). Open access journals received 337 (6.97%) citations.

#### **Objective 6: Rate of obsolescence hence half life of journals**

Half life of journals in Physics is calculated by using the formula given by Sen, 1999. As per (Sen, 1999) the half-life period will be integral number consisting of whole years plus a fraction of a year.

**Table 8: Rate of Obsolescence and Half life of journals, Physics**

Sl. No.	Year	Age of Citation	No. of citations	Cumulative no of Citations	percentage	Cumulative %
1	2016	0	1	1	0.02	0.02
2	2015	1	13	14	0.27	0.29
3	2014	2	50	64	1.04	1.33



4	2013	3	76	140	1.58	2.91
5	2012	4	87	227	1.81	4.72
6	2011	5	108	335	2.24	6.96
7	2010	6	206	541	4.28	11.25
8	2009	7	156	697	3.24	14.49
9	2008	8	159	856	3.30	17.79
10	2007	9	207	1063	4.30	22.10
11	2006	10	225	1288	4.68	26.77
12	2005	11	224	1512	4.66	31.43
13	2004	12	179	1691	3.72	35.15
14	2003	13	163	1854	3.39	38.54
15	2002	14	218	2072	4.53	43.07
<b>16</b>	<b>2001</b>	<b>Y=15</b>	<b>190</b>	<b>b=2262</b>	<b>3.95</b>	<b>47.02</b>
17	2000	16	174	<b>c=2436</b>	3.62	50.63
18	1999	17	167	2603	3.47	54.11
19	1998	18	174	2777	3.62	57.72
20	1997	19	188	2965	3.91	61.63
21	1996	20	121	3086	2.52	64.14
22	1995	21	144	3230	2.99	67.14
23	1994	22	112	3342	2.33	69.47
24	1993	23	96	3438	2.00	71.46
25	1992	24	76	3514	1.58	73.04
26	1991	25	79	3593	1.64	74.68
27	1990	26	42	3635	0.87	75.56
28	1989	27	53	3688	1.10	76.66
29	1988	28	60	3748	1.25	77.90
30	1987	29	50	3798	1.04	78.94
31	1986	30	58	3856	1.21	80.15
32	1985	31	61	3917	1.27	81.42
33	1984	32	39	3956	0.81	82.23
34	1983	33	39	3995	0.81	83.04
35	1982	34	53	4048	1.10	84.14
36	1981	35	35	4083	0.73	84.87
37	1980	36	46	4129	0.96	85.82
38	1979	37	38	4167	0.79	86.61
39	1978	38	33	4200	0.69	87.30
40	1977	39	24	4224	0.50	87.80
41	1976	40	18	4242	0.37	88.17
42	1975	41	28	4270	0.58	88.75
43	1974	42	26	4296	0.54	89.30
44	1973	43	25	4321	0.52	89.82
45	1972	44	36	4357	0.75	90.56
46	1971	45	27	4384	0.56	91.12
47	1970	46	10	4394	0.21	91.33
48	1969	47	32	4426	0.67	92.00

49	1968	48	20	4446	0.42	92.41
50	1967	49	20	4466	0.42	92.83
51	1966	50	22	4488	0.46	93.29
	<1966	More than 50	323	4811	6.71	100.00
		blank	27	4838	100.00	

Half life  $T = Y + y$

Here  $Y$  is the number of whole years and  $y$  is the fraction of a year which can be calculated by the formula,

$$y = (a-b)/(c-b)$$

Value of  $Y = 15$  (Table 8)

$$a = 4838/2 = 2419; \quad b = 2262; \quad c = 2436$$

$$y = (2419-2262) \div (2436-2262) = 157 \div 174 = 0.9022$$

$$\text{Half-life } T = Y + y = 15 + 0.902 = 15.902$$

The half-life period of Chemistry journals has been calculated as 15.9 years. Table 8 unveils that 6.96 % of the journal citations are 5 years old. More than 26.77% of the journal citations are 10 years old and 50.63% of the literature cited is 16 years old. Table also shows that researchers cite more than 50 years old documents the oldest citation dating back to 1774.

## Discussion and Conclusion

The current study provides insight on some very significant characteristics of Physics as a discipline and research field. Journals are the most preferred format in Physics research (Table1). Among journals those who publish in both the formats are cited more (Table 4). Researchers tend to cite more from those journals which follow Hybrid pricing policy (Figure 4). Journal of Geophysical Research published from USA is found to be ranked one in the list of core journals having cited 270 times and it belongs to the area of Earth and Planetary Sciences. (Sudhier, 2010) found Physics Review B to be the top ranked journal. Both the study found many common journals in the rank lists (Table 2). American Chemical Society stood 1<sup>st</sup> in the ranking of Publishers. Elsevier BV from Netherlands stood 2<sup>nd</sup>. Elsevier BV stood 1<sup>st</sup> in the rank list in a previous study done by (Tupe and Khaparde, 2016). Researchers in the field of Physics prefer to cite electronic journals. There are some scholars who still use

print journals. An affinity towards subscription based journals is observed from the study and only few citations go to exclusive open access journals which may imply that researchers finds subscription based journals more trustworthy or they may not be aware of open access literature in their field. In (Kalita, 2016) his study of citation analysis of the journal “Science” also Bradford’s law of scattering was not satisfied against the data set but Leimkuhler’s model was accepted. (Sudhier, 2010) tested the Physics theses citations for 690 periodicals containing 11,319 and it did not fit the Bradford’s distribution pattern. However, The Bradford multipliers were measured, and the law found to be applicable with the value of k as 1.2. The current data set was tested against Bradford’s law of scattering periodicals and further re-evaluated by Leimkuhler model. The data sent did not confirm the Bradford’s law of scattering but it satisfied modified Bradford’s distribution given by the Leimkuhler model. In this study Bradford’s multiplier was found to be 7.83. The half-life period of Chemistry journals has been calculated as 15.9 years.

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