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July 2021

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Koner, Souvik and Jalal, Samir Kumar Dr., "Research Collaboration by faculty members in Physics in the University of Calcutta during 2001-2019: Using Bibliometrix R" (2021). *Library Philosophy and Practice (e-journal)*. 5850.

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Research Collaboration by faculty members in Physics in the University of Calcutta during 2001-2019: Using Bibliometrix R

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Abstract

The paper analyses 775 publications by the faculty members in the Department of Physics, University of Calcutta, collected from Scopus database for the period of 19 years (2001-2019). A number of bibliometric indicators e.g. total publications, citations, journal cites score, h-index, year-wise productivity, national and international collaborations, the most preferred and cited journal are employed for analysing the nature of publications. Bibliometric technique and open source software like Publish or Perish and Bibliometrix R Package are used for data analysis. The findings of the study revealed that 775 papers published in 173 journals with 9090 citations. The average citations per paper is 11.73 with departmental h-index (40) and g-index (62). It is also found that Debnarayan Jana (n=92) and Aritra Banerjee (n=82) are the most productive authors in the department of physics in Calcutta University.

Keywords: Bibliometrics; Bibliometrix R; Citation Analysis; Growth; Collaboration; Physics; University of Calcutta.

1. Introduction

Research collaboration is increasing day-by-day due to its great potential power to solve complex scientific problems through sharing and exchanging of ideas and thoughts among researchers working in similar fields. Bibliometricians have contributed a lot towards visualizing the research collaboration in various fields, not only in popularizing science, social science, sustainable development, social issues, nursing research, trend of subjects¹. Research collaboration happens either at individual, institutional or country level. Individual level collaboration takes place due to strong personal relationship maintained by group members. Various factors such as knowledge enhancement, exchange of skills and government supports are responsible for international collaboration. Co-authorship network is the best way to visualize the research collaboration and in fact, the degree of collaboration indicates the visibility of knowledge.

Physics is one of the fundamental areas of research in basic sciences and taught in almost all the Universities, IISERS, NITs, and IITs. The trends of physics during the last five centuries have changed tremendously². In the mid-19th century, more emphasis was given to the study of thermodynamics whereas during 1865 to the end of the century, more and more studies were conducted on electromagnetic phenomena when Maxwell formulated electromagnetic equations and Hertz established the existence of electromagnetic radiation. During 1900 to 1915, physicists had given attention to study the properties of matter from the point of view of the atomic and electronic constitution of matter. Department of Science and Technology

(DST), Govt. of India; Council of Scientific and Industrial Research (CSIR), Indian Space Research Organization (ISRO), Physical Research Laboratory (PRL), BARC Mumbai, Indian Institute of Astrophysics Bangalore, TIFR Mumbai, IISC Bangalore, Premier IITs, NITS, IISERs, IUCAA, Pune are some of the premier institutes working in research and development in the field of physics. The University of Calcutta, a collegiate public state university located in Kolkata, West Bengal, India established on 24 January 1857. National Assessment and Accreditation Council (NAAC) recognized this as "five-star university" and accredited "A" Grade. The department of physics conducts MSc and PhD courses since 1916. Many eminent professors in physics like D. M. Bose, C.V. Raman, Satyendranath Bose, Meghnad Saha were associated in the department. The thrust areas of the research of this department are theoretical high energy and nuclear physics, statistical physics, mathematical physics, condensed matter physics, materials physics and electronics, laser physics.

Research activities and sharing of the research outcome through publication in quality journal is one of the key role of faculty members and research scholars of the universities and institutions. Conventionally, a university's academic position in the competitive market is determined through publications. Besides, the relative strength of a department within the university is judged by volume of publications. Numbers of bibliometrics parameters i.e. citation count, h-index, impact factor of the journal, h-index, g-index, i-10 index, total citations, country collaboration and authors productivity were used to measure the research productivity of authors, institutions, countries, and understanding the research trends in specific subjects.

2. Literature Review

Gupta and Dhawan³ elaborately studied the status of physics research in India during 1993 to 2001 dealing with institutional productivity and nature of institutional collaboration. Gupta, Sharma and Kumar⁴ made a study on the world and Indian physics literature using the three popular growth models and the findings of the study revealed that the growth of Indian physics literature follows a logistic model, while the growth of world physics literature explained by a combination of logistic and power models. Uzun⁵ studied 2368 papers published in international journals in physics from in Egypt, Iran, Iraq, Jordan, Saudi Arabia, Syria, and Turkey and found that 75% of total papers were from Egypt and Turkey and there was a high concentration of publication in national journals in Egypt. Another finding of Uzen' study showed that condensed matter physics was active and highly studied in these countries except Iran and there was an increasing collaboration found among the middle-east countries. Another study⁶ on research performance of Korean physicists was made by Kim using 4,665 papers published by physics-associated laboratories at Korean universities and found that there was no correlation between the average number of citations per paper and the total number of citations. Kumar et al⁷ analyzed the research publications of Kurukshetra University during 2006 to 2015 based on Scopus data covering 2361 publications and found an annual average growth rate of 13.25 per cent with the largest share (22.60%) of publications in astronomy and physics. The analysis of 760 publications of Gujrat University by Kumar et al⁸ using Scopus database for the period between 2004 to 2013 revealed that around 10% of papers are having international collaboration. Maharana and Das⁹ analysed 447 papers using bibliometrics characteristics annual growth of university publication, author pattern, author productivity, degree of collaboration, length of paper published, geographical distribution of Utkal University's research papers during 2008 to 2012 and found 8.77% average growth of publications. Bapte and Gedam¹⁰ have conducted a Scientometric study of Sant Gadge Baba Amravati University (SGBAU), Amravati during 1996-2017 using 1130

research output with 10.65 per cent average citation per paper. Kumbar et al¹¹ showed the research contribution of University of Mysore during the time period of 1996 to 2006 using 1518 research papers in different disciplines of science and technology from Scopus and found the annual growth rate at 23.9%. Siwach and Kumar[10] studied 1247 papers from Scopus during 2000-2013 of Maharshi Dayanand University, Rohtak and found average citations per paper is 5.58 and highest international collaborating country was South Korea with 56 papers, followed by USA with 26 papers. Dhawan and Gupta¹³ thoroughly studied the physics research in India based on publications output and found that 26.4 percent of articles are published in high impact (IF=1.5) journals by Indian researchers.

3. Objectives

The main objectives of this paper are as follows:

- To find out year-wise publication growth and citation pattern in the Dept. of Physics, University of Calcutta;
- To analyze the authorship pattern from the point of view of publications, citation and dominance factor of the authors of the department of physics, University of Calcutta.
- To explore the departmental, state, national and international collaborations by the concerned faculty members;
- To know the impact of physics research, the most preferred and cited journals of the researchers of the university; and
- To visualize the keyword growth pattern in Physics through research publication of the dept. of physics, University of Calcutta.

4. Methodology:

The publication data are collected from Scopus for faculty members of the department of physics University of Calcutta during 2004–2019. This university has been chosen for this study because it is one of the oldest and highly prestigious university in the world. The university received 5th position (top within the state) to the NIRF ranking 2019. There are nineteen (19) faculty members in the department of physics. The list of faculty members are collected from the university's website and Scopus ID are collected from Scopus database. The advanced query was formulated and submitted to Scopus on dated 6th April 2020 to retrieve data as: AU-ID("Bandyopadhyay, Sudipta" 35242084200) OR AU-ID ("Banerjee, Aritra" 57201471802) OR AU-ID ("Banerjee, Sourish" 57212204856) OR AU-ID ("Bhattacharyya, Abhijit" 57201085534) OR AU-ID ("Biswas, Salilkumar" 55312690100) OR AU-ID ("Dasgupta, Subinay" 7202153971) OR AU-ID("Datta, Anindya" 13403408100) OR AU-ID("Gangopadhyay, Gautam" 7003321520) OR AU-ID("Jana, Debnarayan C." 57206538136) OR AU-ID("Kundu, Anirban" 7101958826) OR AU-ID("Mitra, Indrajit" 56253531200) OR AU-ID("Ray, Biswajit" 57200800503) OR AU-ID("Saha, Jayashree" 7005777117) OR AU-ID("Sen, Parongama" 57210528886) OR AU-ID("Shamanna, Jaya" 6602748774) OR AU-ID("Dasgupta, Raka" 35223081700) OR AU-ID("Das, Dipankar" 55574400400) OR AU-ID("Ghosh, Sharmistha N." 55478977400) OR AU-ID("Ray, Shamayita" 55451753700) AND PUBYEAR > 2000 AND PUBYEAR < 2020 =775

5. Analysis and Results

Total 775 publications are analyzed through bibliometrix R tool and found that there are no single-authored documents and 3468 authors are multi-authored. Collaboration index value is 4.74, which is the ratio of total authors of multi-authored articles and total multi-authored articles. Average citation per document is 11.73 and co-authors per document is 9.8 appeared in 173 sources including journals, conferences, editorials and book chapters.

5.1 Growth of physics literature reported by University of Calcutta

Table 1 depicts the year-wise article growth of publications of physics in University of Calcutta during 2001-2019. From the tabulation, average citations per paper is 11.73, which is quite satisfactory and the highest citation (837) is in the year 2003.

Table 1— Growth of publications by dept. of physics in university of Calcutta

Year	No. of Papers	Cumm. total	% of Publications	Citations	% of Citations
2001	39	39	5.03	614	6.75
2002	27	66	3.48	638	7.02
2003	47	113	6.06	837	9.21
2004	37	150	4.77	419	4.61
2005	34	184	4.39	543	5.97
2006	23	207	2.97	327	3.60
2007	37	244	4.77	513	5.64
2008	21	265	2.71	252	2.77
2009	38	303	4.90	673	7.40
2010	38	341	4.90	644	7.08
2011	49	390	6.32	475	5.23
2012	43	433	5.55	406	4.47
2013	47	480	6.06	652	7.17
2014	43	523	5.55	527	5.80
2015	64	587	8.26	577	6.35
2016	58	645	7.48	453	4.98
2017	54	699	6.97	361	3.97
2018	40	739	5.16	118	1.30
2019	36	775	4.65	61	0.67
Total	775		100.00	9090	100.00

Figure 1 shows the constant growth of publication since the last 20 years, except the little highest publications (8.26%) in 2015. The relationship between publications with respect to time shows a strong positive relationship through the equation: $y = 0.994x + 30.84$.

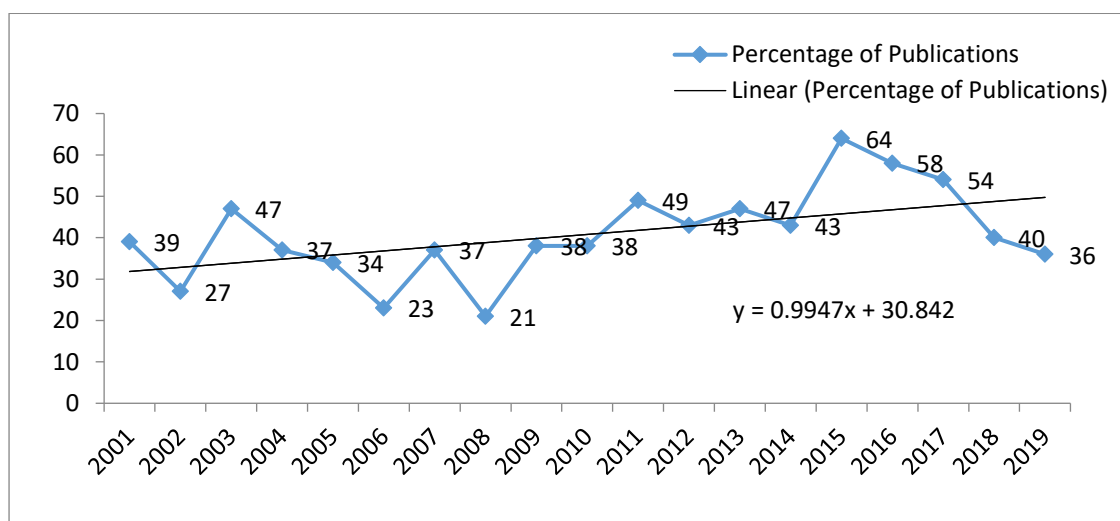


Figure 1: Trends in publication growth during 2001-2019

5.2 Status of faculty publications

Table 2 shows 19 faculty members currently working in the Department of Physics. The publications and citations as retrieved from Scopus are mentioned here. There are two major publications counting methods— whole count and fractional counting system. For normalized comparisons across countries or institutions, whole count system is somewhat inappropriate whereas fractionalized methods are more justified and valid.

Table 2—Most productive authors from Scopus

S.N	Name	Publications	Citations	Citations Per paper	h-index
1	Debnarayan Jana	92	1572	17.09	19
2	Aritra Banerjee	82	1252	15.27	19
3	Anirban Kundu	70	949	13.56	21
4	Parongama Sen	70	1552	22.17	11
5	Sudipta Bandyopadhyay	69	540	7.83	13
6	Gautam Gangopadhyay	67	663	9.90	14
7	Abhijit Bhattacharyya	60	653	10.88	14
8	Anindya Datta	59	685	11.61	15
9	Sourish Banerjee	51	536	10.51	12
10	Biswajit Ray	45	294	6.53	11
11	Sharmistha Ghosh	38	444	11.68	10
12	Subinay Dasgupta	26	567	21.81	10
13	Dipankar Das	25	331	13.24	11
14	Salil Kumar Biswas	22	216	9.82	8
15	Shamayita Ray	19	201	10.58	9
16	Indrajit Mitra	18	70	3.89	5
17	Jayalakshmi Shamanna	16	55	3.44	5
18	Jayashree Saha	11	45	4.09	4
19	Raka Dasgupta	5	16	3.20	3
	Total	845	10641		

Although Debnarayana Jana having the highest publications (n=92), Abhijit Bhattacharyya (n = 60) is the top ranked author based on dominance factor (0.4286). The Dominance Factor is a ratio indicating the fraction of multi-authored articles in which a scholar appears as the first author. The function *dominance* in ‘R’ calculates the authors’ dominance ranking as proposed by Kumar & Kumar¹⁴. Using the function arguments i.e. *results* (object of class *bibliometrix*) obtained by *biblioAnalysis*; and *k* (the number of authors to consider in the analysis), value of DF has been calculated and is shown in table 6. `DF <-dominance (results, k =15)` and `DF` (for Print the output).

Table 3— Rank of authors by dominance factor

S.N	Author	Dominance Factor	Multi Authored	First Authored	Rank by DF
1	Abhijit Bhattacharyya	0.4286	63	27	1
2	Anindya Datta	0.4250	80	34	2
3	Dipankar Das	0.3016	63	19	3
4	Aritra Banerjee	0.2000	85	17	4
5	Sudipta Bandyopadhyay	0.1915	62	9	5

6	Parongama Sen	0.1571	70	11	6
7	Sourish Banerjee	0.1452	62	9	7
8	Anirban Kundu	0.1286	70	9	8
9	Debnarayan Jana	0.0909	88	8	9
10	Gautam Gangopadhyay	0.0448	67	3	10

Jalal¹⁵ conducted a co-authorship and co-occurrence study between India and Bangladesh using 1156 papers retrieved from WoS for the period of 1991 to 2017 and has shown an inverse relation between DF and multi-authored papers graphically.

5.3 Authorship Study

Authorship study is an important aspect in bibliometric study with respect to assigning the appropriate authorship for a study and its order of placement (for the case of multi-authored papers) is an ethical issue. The first survey on actual (rather than hypothetical) authorship practice was performed by Ross Vasta¹⁶. Tarnow¹⁷ made a detailed survey by members of the American Physical Society (APS) on the ethics of scientific co-authorship and pointed out that ‘forty-six percent of respondents report that the most important contributor cannot be identified from the authorship list’.

In the study, single authorship occurred is 43 (5.5%) of the manuscripts. Three-authored articles was the highest in numbers, 173 (22.32%) followed by two authored publications 146 (18.84%).

Table 4—Authorship distribution in physics during 2001-2019

Year	Single author	Two Author	Three author	Four Authors	Five Authors	Six authors	More than Six Authors	No. of Papers
2001	8	6	15	7	3	0	0	39
2002	2	5	13	3	1	1	2	27
2003	4	9	13	3	2	11	5	47
2004	2	12	11	5	3	0	4	37
2005	1	9	4	9	0	3	8	34
2006	1	5	4	0	2	2	9	23
2007	1	10	10	6	6	1	3	37
2008	2	8	3	2	3	1	2	21
2009	4	3	7	8	4	3	9	38
2010	6	2	10	8	3	5	4	38
2011	4	4	11	7	3	12	8	49
2012	1	9	13	8	6	2	4	43
2013	0	6	9	10	8	4	10	47
2014	0	7	12	8	6	3	7	43
2015	1	13	10	16	12	3	9	64
2016	3	13	12	9	7	2	12	58
2017	0	10	5	12	7	6	14	54
2018	1	8	6	7	3	5	10	40
2019	2	7	5	4	5	2	11	36
Total	43	146	173	132	84	66	131	775

The degree of collaboration calculated dividing total number of co-authored papers (732) over total publications (775) and the value becomes. 0.94. The value of collaboration may vary discipline to discipline as is witnessed 0.55 in Library and Information science by Khan¹⁸. Large-scale collaborations, such as high-energy physics experiments involving

hundreds of people and listed the procedure whom will be included as author and in what order¹⁹.

5.4 Impact of physics research output

The impact of research output generally measured through the two popular indicators e.g. a) average impact factor per paper and b) average citation per paper. It would be wise to exclude self-citation while calculating average citation per paper.

Table 5— Impact of research papers during 2001-2019

Year	No. of Papers (A)	Citations (B)	Citation Period (C)	Average Citation per paper per year (D = A/ (B x C))
2001	39	614	19	0.83
2002	27	638	18	1.31
2003	47	837	17	1.05
2004	37	419	16	0.71
2005	34	543	15	1.06
2006	23	327	14	1.02
2007	37	513	13	1.07
2008	21	252	12	1.00
2009	38	673	11	1.61
2010	38	644	10	1.69
2011	49	475	9	1.08
2012	43	406	8	1.18
2013	47	652	7	1.98
2014	43	527	6	2.04
2015	64	577	5	1.80
2016	58	453	4	1.95
2017	54	361	3	2.23
2018	40	118	2	1.48
2019	36	61	1	1.69
Total	775	9090	-	-

Table 5 shows the calculation of ‘average citation per paper per year’. Total citation (614) recorded in year 2001 is the sum of all citations received during 2001-2019 i.e. during citation period of 19 years for the 39 papers published in 2001. Therefore, to calculate ‘Average Citation per paper per year’ is to divide total citation as mentioned against the years by number of papers followed by citation period.

5.5 International collaboration

Table 6 has been put forth to assess the geographical affiliation of authors in respect to corresponding authors. Out of 775 papers, Indian authors have contributed 671 articles (86.58%) as corresponding authors to 173 sources of journal, conferences proceedings etc across the globe with national and international collaboration.

Table 6– Most productive countries (of corresponding authors)

S.N	Country	Articles	% over total publications	SCP	MCP	Citations
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1	India	671	86.58	561	110	8130
2	Germany	13	1.68	0	13	263
3	Finland	10	1.29	3	7	185
4	Italy	8	1.03	1	7	84
5	USA	7	0.90	3	4	53
6	Bulgaria	5	0.65	0	5	16
7	Spain	4	0.52	3	1	75
8	Taiwan	3	0.39	1	2	31
9	France	2	0.26	0	2	38
10	Sweden	2	0.26	1	1	20
		726	93.68	-	-	-

Figure 2 depicts the data related to top 10 collaborating countries sharing of articles and citation impact. In the network graph, each node represented a country having collaboration with India. Indian authors have published 13 articles collaborating with Germany; 10 articles with Finland; 8 articles with Italy and so on. Mondal and Raychoudhury²⁰ made a collaboration study on the contribution of Indian authors on science communication and found that the authors from *Belgium* have contributed highest numbers of 9 articles closely followed by *Germany* with 8 articles and *USA* with 5 articles.

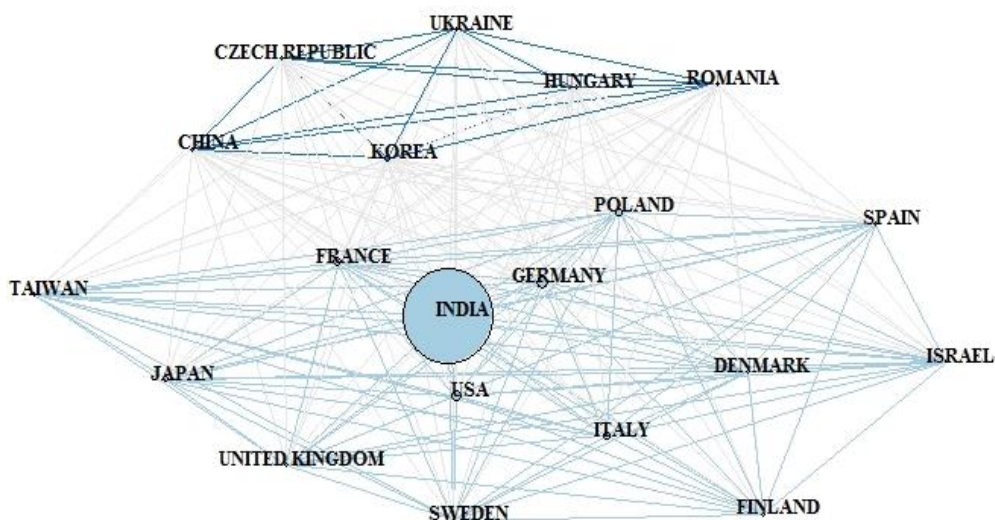


Figure 2: Country collaboration

Table 7 demonstrates that out of 775 papers 21.94% of publications are having international collaboration with various countries like Japan, UK, USA, Russia, and China etc by the faculty members in the department of physics, university of Calcutta. The analysis also reports that 56.53% of publications are having national collaboration with IITs, IISERs, top universities in India. The collaboration percentage with the institutes of West Bengal is 56.53% and rest 43.47% of national collaboration happened to be outside West Bengal spreader across all states of India.

Nature of Collaboration		Papers	Percentages
International Collaboration	<i>Total</i>	170	21.94%
	<i>Within the State of West Bengal</i>	342	56.53%
National Collaboration	<i>Outside the State of West Bengal</i>	263	43.47%

	Total	605	78.06%
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Table 7— Nature of Collaboration in Physics

It may worth to pointed out that there is a departmental collaboration but which is less and it is found that Aritra Banerjee and Sudipta Bandyopadhyay has the highest departmental collaboration (n=37) publication followed by Anirban Kundu and Anindya Datta (4), and two each for the case of Debnarayan Jana and Aritra Banerjee; Aritra Banerjee and Sourish Banerjee.

5.6 Top Cited Papers

The paper entitled ‘**Small-world properties of the Indian railway network**’ by Mukherjee, G., Sen, P., Dasgupta, S., Chatterjee, A., Manna, S.S., Sreeram, P.A published in Physical Review E, 2003 received 337 citations followed by the article ‘Role of defects in tailoring structural, electrical and optical properties of ZnO’ by Chattopadhyay, S., Jana, D., Sarkar, A., Dutta, S., Sanyal, D., Chakrabarti, M. published in Progress in Material Science, 2009 got 249 citations along with 8 more papers with more than 100 citation but less than 200.

5.7 Preferred Sources of Communications

Table 8 made it clear that authors under study preferred to communicate their research works in highly reputed journals and top ten journals listed here along with number of articles published in them. The faculty members of the university choose APS’s Physical Review D - Particles, Fields, Gravitation and Cosmology as the top (n-92) preferred journals to communicate their research.

Table 8— Authors preferred to publish their articles in Top 10 Journals

SN	Journals	No. of Articles	Percentage
1	Physical Review D - Particles, Fields, Gravitation and Cosmology	92	7.61
2	Physics Letters, Section B: Nuclear, Elementary Particle and High-Energy Physics	38	4.90
4	Physical Review C - Nuclear Physics	31	4.00
5	Physical Review E - Statistical, Nonlinear, and Soft Matter Physics	28	3.61
6	Journal of Applied Physics	25	3.23
7	Journal of Physics G: Nuclear and Particle Physics	16	2.06
8	Pramana - Journal of Physics	15	1.94
9	Journal of Magnetism and Magnetic Materials	14	1.81
10	Physica A: Statistical Mechanics and its Applications	13	1.68
	Total	272	35.1

It may be noted that authors published 30 articles in AIP conference proceedings during the last 19 years.

5.8 Keywords analysis

Figure 3 shows the research interest of the faculty members of University of Calcutta as reflected through the keyword analysis conducted using R.

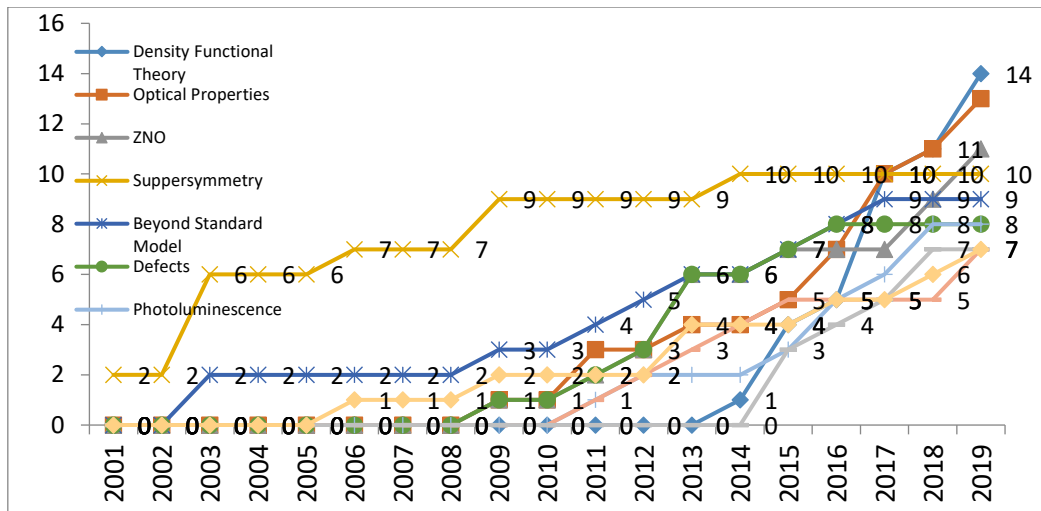


Figure 3: Trends in Top ten keywords

6. Findings of the study

Some of the key findings are:

- i) This is an unique observation that out of 775 publications, 84.52% of them deals with articles, conference papers (12%) and rest 3.48% papers deals with other types of documents like letter, editorials, note and erratum;
- ii) Debnarayan Jana (n=92) and Aritra Banerjee (n=82) are the most productive authors in the department of physics in Calcutta University.
- iii) *The Physical Review D* formerly known as '*The Physical Review D - Particles, Fields, Gravitation and Cosmology*' jointly published 92 articles followed by *Physics Letters, Section B: Nuclear, Elementary Particle and High-Energy Physics* with 38 publications;
- iv) Top collaborating countries with University of Calcutta, India are Germany, Finland, Italy and USA; with national and departmental collaboration as well;
- v) The highest departmental collaboration is witnessed by Aritra Banerjee and Sudipta Bandyopadhyay with 37 articles during the period of study;
- vi) The department of physics, University of Calcutta has collaborated 170 articles (21.94%) at the international level; 263 articles (33.94%) at national level, and 342 articles (44.13%) only state level (W.B).

7. Conclusion

The research contribution by the faculty members (19) in the department of physics, University of Calcutta shows a high degree of research productivity with average publication per year (40.79). Most of the publications brought out in reputed journals with high degree of international and national collaboration. The study also reflected that there is a departmental collaboration but it is limited to a few faculty members only. The limitation of the study is that data collected only from Scopus for the sake of time. Therefore, other articles which are not indexed in Scopus but indexed in other databases like Web of Science, Indian Citation Index (ICI), PubMed etc. are not considered in the study. In spite of such limitations, the study provides an overview of the research contribution in physics by the concerned faculty members of University of Calcutta.

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