

Research Output of University of Delhi In The Field Of Physics: A Scientometric Analysis

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Abstract: current study is based on a scientometric examination of the physics research trend. The data for this study was extracted from the Scopus Database covering the study period 1942 to 2023. The current study examined 14462 articles in the field of physics and also the recent research trends between them. The analysis mainly covers the chronological distribution of documents, forms of publications, top-ranked journals, top-cited articles, and the authorship pattern has been examined during the study. The result of the study found that Most of the articles was published in the year 2022, with 1079 (7.46%), Chaudhary B.C. has contributed the maximum number of articles i.e., 1785 (2.23%); The degree of collaboration (DC) decreases from 1.00 to 0.97 and the average value of DC is 0.80. The journal articles form of documents constitutes the maximum number of publications i.e., 12536 (86.68%) publications. The research paper "CMS physics technical design report, volume II: Physics performance" has the highest number of citations 751. The top most journal name 'Journal of High Energy Physics' is having the maximum number of publications i.e., 409 (2.82%).

Keywords: Degree of Collaboration, Physics, Scientometrics, Research Output, University of Delhi

1. INTRODUCTION

The research output of a university encompasses a diverse array of scholarly and creative products generated from its research activities. These outputs include peer-reviewed journal articles, conference papers, books, and technical reports that contribute to the academic community's knowledge base. Additionally, universities produce theses and dissertations, patents, and innovative software,

reflecting the cutting-edge research conducted by faculty, researchers, and students. Creative works, such as artistic performances and exhibitions, also form a significant part of a university's research output. These outputs not only advance academic and scientific understanding but also drive innovation, inform public policy, and enhance the institution's reputation globally.

Research is an important phenomenon that has been the part of the society from beginning and now, in the recent times, it has become the criteria to measure the productivity of an institute, society or country, because it plays a multifaceted and indispensable role in advancing society, driving innovation, and improving our quality of life. It is a cornerstone of progress in various fields and catalyst for positive change. Today huge amount of money has been spent on different research and development work by various organizations/Institutions and Research Centre to promote the development of new ideas, technologies, and solutions to existing problems, fostering innovation and progress.

University of Delhi has a rich history in terms of research in science. Over the years, it has made significant contributions to various scientific disciplines. Therefore, it is necessary to study the research output of university of Delhi in the field of physics.

The Russian statistician Nalimov in 1966 suggested the term 'Scientometrics' as a method of quantification to study the growth and development of research output. Scientometrics helps to quantify the literature to evaluate emerging concepts and determine trends in research and publications in specific fields for policymaking and future. Hence, scientometrics is one of the best tools available for science evaluators, policymakers, science administrators, and librarians to identify the core areas of research in any field of knowledge.

ABOUT UNIVERSITY OF DELHI

The University of Delhi is India's premier higher education institution with a rich tradition. It was established in 1922 by the Act of the Central Legislative Assembly, located in New Delhi, India. It has a rich history in terms of research in science. Over the years, it has made significant contributions to various

scientific disciplines. After India gained independence in 1947, there was a significant push for the development of scientific research and higher education. Delhi University expanded its science departments and research programs during this period.

The Department of Physics at Delhi University played a crucial role in nuclear research. The establishment of the Nuclear Physics Laboratory in 1952 marked a significant milestone in this regard. It is internationally renowned for its outstanding collaborations to teaching and research, the highest academic level and advanced infrastructure. Leading scientists have worked in the Department of Science, such as Prof. D.S. Kothari in Physics.

Delhi University gradually expanded its scientific departments, including physics, chemistry, mathematics, botany, zoology, and others. These departments conducted research in various fields, including theoretical and experimental physics, organic and inorganic chemistry, genetics, and ecology. In recent decades, there has been a growing emphasis on interdisciplinary research. Delhi University has encouraged collaboration between different scientific disciplines to address complex problems. This approach has led to advancements in areas such as biotechnology, environmental science, and material science.

Delhi University's science research has benefited from grants and funding provided by government agencies such as the Department of Science and Technology (DST), Department of Biotechnology (DBT), and the University Grants Commission (UGC).

1.1 ABOUT SCOPUS

Scopus is basically a bibliographic database containing abstracts and citations for peer reviewed academic journals produced by Elsevier (Netherlands) in 2004. It is also called as the largest abstracting and citation database of peer-reviewed literature which includes scientific journals, books and conference proceedings etc., Scopus covers nearly 36,377 titles from more than 11,678 publishers,

including 34,346 peers reviewed journals, 390 trade publications, 370 book series, and 5.5 million international conference/ seminar papers in top-level subject fields: life sciences, social sciences, physical sciences and health sciences.

2. LITERATURE REVIEW

Mahala and Singh (2021) examined the research output pattern of University of Delhi for the period of five years i.e. (2005-2019). They investigate the most productive institutes, countries, authors the impact of their output in terms of Relative Citation Impact (RCI) and Citation per Paper (CPP). Total 6500 papers were retrieved from Web of Science and findings of study shows that the consistent growth with increasing multi-authorship is the general trend of research. Multi-authored papers have more research impact (CPP, RCI) compared to others because they have international collaboration. In science research USA, Germany, Korea topped in the list of collaborating countries. In terms of domestic Collaboration University of Delhi has a major collaboration with BHU, JNU, IIT, and CSIR.

Singh and kumar (2019) examined the research output of University of Delhi and found that the year wise distribution of publication indicates that there is a growth in the number of publications and also found that most of the literature published in the form of articles. Collaboration pattern with other countries shows that USA has collaborated the most with University of Delhi. Chemistry and Physics is most preferred subject area having 26% of total publications.

Bharti (2017) presented the comparative study on the publication trends and analysis the research productivity of University of Delhi and Jawaharlal Nehru University in the area of arts and humanities. The methodology of this article reveals that data have been collected from Web of Science citation database for the period of 2004-2016 in selected field. Result of the study found that JNU has contributed 195 articles with 3778 citations which is highest from DU contributed 161 articles with 3504 citations. Maximum articles are written on History with 74 research papers in the both universities JNU and DU in this

period. There were 132 total source titles in which 22 source titles used by both universities JNU and DU like Indian Economic and Social History Review, Indian Historical review etc. The most productive authors in the area of arts and humanities during the period of study were Romila Thapar from JNU, Bindu Puri and Charu Gupta from DU.

Yadav, Verma and Singh (2020) sought to trace the publication trends of Mizoram University based on Journal Indexed in Indian Citation Index for the period of fourteen years from 2004-2017. Their study endeavours to measure the year-wise distribution of publication output, co-authorship index, and collaborative index, degree of collaboration, collaboration coefficient, modified collaboration coefficient, most productive author, top-ranked subjects and top-ranked publications based on the collected data. The result of the study indicates that the average research output is 18.93 articles per year. The most productive author was U. K. Sahoo department of Forestry with 25 publications. Current Science has the highest rank publication i.e., 16 publications. Maximum publications were from Biological Science subject which is 54 and research article 230 was a preferred document by the scientists of Mizoram University during 2004-2017.

Sahoo et al (2021) conducted research to investigate the trends of basic science research in India for the period of five year i.e., 2015-2019. They examined the publication patterns and impact of research productivity of five science institutions i.e., Indian Institutes of Science Education And Research (IISER), namely IISER Kolkata, IISER Pune , IISER Mohali, IISER Bhopal IISER Thiruvananthapuram. The findings of this study reveals that these five institutions had accountable for important research outcomes, such as a high number of citations, preferences towards open access publications and high impact in the terms of scientometrics indicators.

Gopikuttan and Aswathy (2014) evaluated a scientometric study on the publication output of the University of Kerala based on the records collected from the Web of Science database during 2000-2012. It was found that at the

early stage of publication was less but it was increasing gradually but there are very ups and down in few years and the year 2011 was the highest publication year which was 126 (11.80 %) articles out of 1068 articles during the study period. Maximum articles were published in Indian journals, USA and Netherlands. The highest collaboration coefficient was found in the subject Chemistry i.e., (0.37) and the lowest collaboration coefficient was found in the subject Mathematics i.e., (0.22).

Nafukho, Wekullo and Muyia (2019) examine the research productivity of faculty in selected two leading public universities in Kenya and showed that the research growth varied by gender, institution, terminal degree, work experience, rank, etc. It was found that experienced faculties were not productive but research students were more productive in comparison to experienced faculty members in the study. Currently the status of Kenyan public universities enhances research productivity to achieve their vision, mission, and goals.

Kappi, Biradar and M Sab (2020) investigate the research productivity of physics scientist Dr R. G. Sonkawade, Department of Physics Shivaji University, Kolhapur. Authors had found that Dr R. G. Sonkawade in his 20 years of research publishing career, He had 191 publications during 1998 – 2019 in various domains, Data for the study collected from SCOPUS database and present study was analysed 90 research publications. This study mainly covers characteristic features, pattern and citation impact of the well-known Indian scientist and his scientific research works. Result of the study found that he authored maximum papers in collaboration, except 3 paper as a single author. The study found a strong correlation between quantity, quality and the awards and honors won by R G Sonkawade. The high value of citations per paper (14.41) indicates that the research output is well connected to the main stream.

Roy (2019) conducted their research to find out the scientific production in the area of biological science for the period of 1901- 1947. The researcher have applied scientometric tool to discover the authorship pattern, collaborative research work, most productive author, growth rate of the literature in biological science. The result of the study found that the relative growth rate was 0.615

and exponential plot is greater than liner plot. Maximum contribution was done by single authors with 75%. Degree of collaboration was 0.249. The collaborative author index present decreasing trend for single author and increasing trend for two author or more than two.

G. Ulaganathan (2017) Investigates research output in the subject area of Astrophysics in India. It is a sub area of space science which consist the planets, galaxies etc. The methodology of this research article showed that data had been collected from Web of Science database during 1989-2016 year. The total number of publication found 17046 during this period. The most productive year was 2016 year with 1179 research publications. Minimum research papers were written in 1995 year. The highest exponential growth was achieved in 1995 year with 341(1.18%) publications. The average exponential growth was 0.961 during this period. In India there are total 20 institution of subdivision of astrophysics, in which Indian institute of astrophysics Bangalore had contributed 1189 papers followed by Tata institute fundamental research, Mumbai. This article is more useful to researchers of astrophysics subject area to identify the core publications in that area of knowledge.

Majhi and Maharana (2012) Investigates a scientometric study on the research productivity of Physical Science disciplines at Sambalpur University Orissa during 1971. This study is has collected data from the Scopus database. A total of 417 articles were published with 3.48 per capita productivity. It found that the highest 92.35 per cent publication was the multi-authored articles and only 7.65 per cent of articles were single-authored articles which very low in comparison to multi-authored articles during the study period. It was found that the most productive subjects were Chemistry and Physics, over the other subjects in Physical Science disciplines. B. K. Mishra from Chemistry was the most productivity author in Physical Science and the most preferred journal was Journal of the Indian Chemical Society with 34 articles from the Physical Science disciplines of Sambalpur University during 1971-2010.

Wang, Xie & Yang (2023) Suggested a unique methodology that combines a regression discontinuity design with the notion of "Value of a Statistical Life" to estimate the monetary value of research output using data regarding promotions from a medium-ranked Chinese university between 2011 and 2019. The result of the study found that an associate professor promotion is worth \$467 and a full professor promotion is worth \$515 per unit of research score. Calculated economic values for a publishing in a regular journal, a renowned journal, and a top journal are approximately \$1,538, \$5,154, and \$20,615, respectively, based on the rate for full professors. Furthermore, a book publication has an approximate economic value of \$7,723. These research outputs are severely undervalued as compared to the faculty's total income, the income of peers in similar industries, or the income of peers from other nations' higher education. Their analysis provides not just insights for incentive system reform in Chinese higher education, but also a methodology that can be used worldwide to every higher education institution that employs a scoring system or sets implicit research standards in the promotion and merit processes.

Hilary (2018) explains the ranking, status and impact of universities in the world. Researcher well emphasized the qualitative research analysis for universities of technologies in Nigeria. For this study, 27 subject areas had been selected. Top ten universities of Nigeria with 27 subject's area have been accessed for Scopus database. Finding of this study reveal that universities had less than two hundred papers which were not included. To analysis the data ranking and statistical methods had been used. The analysis of data had been cleared that research outputs of universities of technology in Nigeria were poor with the comparison of other African countries such as Morocco, Ghana, Egypt etc. There were 27 subjects area in which maximum research output had been retrieved from Agricultural & Biological sciences, Engineering, Environmental Sciences & Medicine. This study showed that universities have not good research papers and output in the area of science which is chemistry, physics & mathematics.

3. STATEMENT OF THE PROBLEM

University of Delhi is one of the prominent university of Indian terms of scientific research output and its Department of Physics played a crucial role in nuclear research. The establishment of the Nuclear Physics Laboratory in 1952 marked a significant milestone in this regard. It is internationally renowned for its outstanding collaborations to teaching and research, the highest academic level and advanced infrastructure. Many Leading scientists have worked in the Department of Physics, by doing research on this topic give us a clear picture on their research productivity as well as their growth and development with the passage of time as the period of study covers the data since the inception of scopus database i.e., 1942 to August 2023.

The present study composed under the title “Research output of University of Delhi in the field of Physics: A Scientometric Analysis” to explore, analyze the Research productivity and to know recent research trends of publications in the field of physics in University of Delhi.

The main focus of this study is to examine the research output of physics department university of Delhi in terms of their research productivity and their work as collaboration among researchers as well as with institute at national and international level.

4. OBJECTIVES OF THE STUDY

The study focuses on the publication output of the University of Delhi in Sciences with the following objectives:-

- 1) To find out the Chronological distribution of publications output of the University of Delhi during the period 1942-2023;
- 2) To find out the most prolific authors and the effect in their output;
- 3) To analyse year wise authorship patterns and find out degree of collaboration;
- 4) To find out the different forms of literature published in the field of physics.

- 5) To find out the Language of documents in which it published during the period of study;
- 6) To determine the highly cited physics research papers throughout the period under consideration;
- 7) To examine the most common journals used for communicating by the research scholars;
- 8) To identify and prepare the rank-wise list of most frequently used keywords in the field of physics;
- 9) To find out the most contributed Funding agency in the field of physics during the period of study.

5. SCOPE OF THE STUDY

The present study entitled “Research output of University of Delhi in the field of Physics: A Scientometric Analysis” is carried out through Scopus database of Elsevier Publishing group. The study is confined only to University of Delhi in the field of Physics & Astrophysics. The scope of study covers the data from 1942-2023 (August). There are total 14462 data included in this study. The data were extracted on 02/09/2023 in CSV format from Scopus and analyzed using MS Excel software.

6. RESEARCH METHODOLOGY

This study is conducted to analyze the research output of University of Delhi in the field of Physics & Astrophysics. The data source for the research publication was taken from the core collection of Scopus database for collecting and evaluating the research output of University of Delhi. The Data have been obtained working on the “Advanced search” window of SCOPUS, using the “AFFILIATION” search code and the term “University of Delhi” used to retrieve the record and further applying subject filter for physics & Astrophysics then applying country filter which includes India which gave 14462 results. The data was downloaded on 02/09/2023 which includes different research records such as reviews, research articles, books chapters, proceeding papers, editorial corrections with the name of authors and affiliation, year of

publication, source name, and number of citations of each article. To achieve the previously defined goals, the downloaded information was analyzed by using Excel Software.

INDICATORS

Various indicators have been used to examine the growth and collaboration pattern in the area of Physics throughout the period of study.

- i. **Annual Growth Rate (AGR):** It is used to compute the rate of increase in the number of publications every year. The yearly growth rate of publications or the annual growth rate is derived using “Kumar and Kaliyaperumal’s (2015)” methodology, which is listed below:

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

- ii. **Relative Growth Rate (RGR):** $(\text{RGR}) = \frac{W2 - W1}{T2 - T1}$

RGR signifies the rate of growth throughout the span;

W1 signifies the natural log (Loge) of the initial number of publications;

W2 signifies the natural log (Loge) of the final number of publications;

T1 signifies the initial time unit;

T2 signifies the final time unit “Shilpa and Padmamma, (2020)”.

- iii. **Doubling Time (DT):** is a measure of the time it takes for a quantity or population/sample to double in size. This formula was developed by Mahapatra in 1985. “Mahapatra (1985)”.

The formula for calculating doubling time (Dt) is:

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

DT denotes the doubling time;

R denotes the relative growth rate of the publications

- iv. Degree of Collaboration (DoC):** is a measure of research collaboration that quantifies the number and extent of collaborations among authors of a published scientific paper. DoC is used to assess the degree of teamwork, interdisciplinary research, and knowledge exchange among authors.

The Degree of Collaboration (DoC) is calculated using the following formula given by “K Subramanyam(1983)”:

$$\text{DoC} = (N_c / N_a)$$

Where N_c is the total number of co-authors on the paper, and N_a is the total number of authors on the paper. The DoC ranges from 0 to 1, with a higher value indicating a greater degree of collaboration among authors. A DoC of 1 indicates that all authors collaborated equally on the paper, while a DoC of 0 indicates that there was no collaboration among the authors.

DATA ANALYSIS AND INTERPRETATION

TABLE 1: CHRONOLOGICAL DISTRIBUTION OF PUBLICATIONS

Year	No. of Articles	Percentage	Cumulative no. Publications	AGR	W1	W2	RGR=	DT= (0.693/R)
					(ln of initial value)	(ln of final value)	(W2-W1)	
1942	1	0.00%	1		0.00	0.00		
1943	1	0.00%	2	0	0.00	0.69	0.69	1.00
1944	2	0.01%	4	100	0.69	1.39	0.69	1.00
1945	1	0.00%	5	0	0.00	1.61	1.61	0.43
1946	1	0.00%	6	0	0.00	1.79	1.79	0.39
1947	1	0.00%	7	0	0.00	1.95	1.95	0.36
1948	1	0.00%	8	0	0.00	2.08	2.08	0.33
1949	3	0.02%	11	200	1.10	2.40	1.30	0.53
1950	2	0.01%	13	-33.33	0.69	2.56	1.87	0.37
1951	1	0.00%	14	-50	0.00	2.64	2.64	0.26
1952	2	0.01%	16	100	0.69	2.77	2.08	0.33
1953	6	0.04%	22	200	1.79	3.09	1.30	0.53
1954	7	0.05%	29	16.66	1.95	3.37	1.42	0.49
1955	7	0.05%	36	0	1.95	3.58	1.64	0.42
1956	7	0.05%	43	0	1.95	3.76	1.82	0.38

1957	2	0.01%	45	-71.42	0.69	3.81	3.11	0.22
1958	2	0.01%	47	0	0.69	3.85	3.16	0.22
1959	5	0.03%	52	150	1.61	3.95	2.34	0.30
1960	3	0.02%	55	-40	1.10	4.01	2.91	0.24
1961	9	0.06%	64	200	2.20	4.16	1.96	0.35
1962	12	0.08%	76	33.33	2.48	4.33	1.85	0.38
1963	20	0.13%	96	66.66	3.00	4.56	1.57	0.44
1964	20	0.13%	116	0	3.00	4.75	1.76	0.39
1965	52	0.35%	168	160	3.95	5.12	1.17	0.59
1966	51	0.33%	219	-1.92	3.93	5.39	1.46	0.48
1967	50	0.34%	269	-1.96	3.91	5.59	1.68	0.41
1968	58	0.40%	327	16	4.06	5.79	1.73	0.40
1969	35	0.24%	362	-39.65	3.56	5.89	2.34	0.30
1970	44	0.30%	406	25.71	3.78	6.01	2.22	0.31
1971	44	0.30%	450	0	3.78	6.11	2.33	0.30
1972	45	0.31%	495	2.27	3.81	6.20	2.40	0.29
1973	66	0.45%	561	46.66	4.19	6.33	2.14	0.32
1974	82	0.56%	643	24.24	4.41	6.47	2.06	0.34
1975	65	0.44%	708	-20.73	4.17	6.56	2.39	0.29
1976	61	0.42%	769	-6.15	4.11	6.65	2.53	0.27
1977	80	0.55%	849	31.14	4.38	6.74	2.36	0.29
1978	77	0.53%	926	-3.75	4.34	6.83	2.49	0.28
1979	76	0.52%	1002	-1.29	4.33	6.91	2.58	0.27
1980	77	0.53%	1079	1.31	4.34	6.98	2.64	0.26
1981	71	0.55%	1150	-7.79	4.26	7.05	2.78	0.25
1982	72	0.49%	1222	1.4	4.28	7.11	2.83	0.24
1983	61	0.42%	1283	-15.27	4.11	7.16	3.05	0.23
1984	60	0.41%	1343	-1.63	4.09	7.20	3.11	0.22
1985	56	0.38%	1399	-6.66	4.03	7.24	3.22	0.22
1986	62	0.42%	1461	10.71	4.13	7.29	3.16	0.22
1987	52	0.35%	1513	-16.12	3.95	7.32	3.37	0.21
1988	56	0.38%	1569	7.69	4.03	7.36	3.33	0.21
1989	68	0.47%	1637	21.42	4.22	7.40	3.18	0.22
1990	67	0.46%	1704	-1.47	4.20	7.44	3.24	0.21
1991	83	0.57%	1787	23.88	4.42	7.49	3.07	0.23
1992	72	0.49%	1859	-13.25	4.28	7.53	3.25	0.21
1993	85	0.58%	1944	18.05	4.44	7.57	3.13	0.22

1994	86	0.59%	2030	1.17	4.45	7.62	3.16	0.22
1995	80	0.55%	2110	-6.97	4.38	7.65	3.27	0.21
1996	122	0.84%	2232	52.5	4.80	7.71	2.91	0.24
1997	114	0.78%	2346	-6.55	4.74	7.76	3.02	0.23
1998	110	0.76%	2456	-3.5	4.70	7.81	3.11	0.22
1999	101	0.69%	2557	-8.18	4.62	7.85	3.23	0.21
2000	113	0.78%	2670	1.1	4.73	7.89	3.16	0.22
2001	161	1.11%	2831	42.47	5.08	7.95	2.87	0.24
2002	189	1.30%	3020	17.39	5.24	8.01	2.77	0.25
2003	211	1.45%	3231	11.64	5.35	8.08	2.73	0.25
2004	175	1.21%	3406	-17.06	5.16	8.13	2.97	0.23
2005	203	1.40%	3609	16	5.31	8.19	2.88	0.24
2006	201	1.38%	3810	-0.98	5.30	8.25	2.94	0.24
2007	235	1.62%	4045	16.91	5.46	8.31	2.85	0.24
2008	237	1.63%	4282	0.85	5.47	8.36	2.89	0.24
2009	278	1.92%	4560	17.29	5.63	8.43	2.80	0.25
2010	410	2.83%	4970	47.48	6.02	8.51	2.50	0.28
2011	472	3.26%	5442	15.12	6.16	8.60	2.44	0.28
2012	501	3.46%	5943	6.14	6.22	8.69	2.47	0.28
2013	531	3.67%	6474	5.98	6.27	8.78	2.50	0.28
2014	541	3.74%	7015	1.88	6.29	8.86	2.56	0.27
2015	526	3.63%	7541	-2.77	6.27	8.93	2.66	0.26
2016	657	4.54%	8198	24.9	6.49	9.01	2.52	0.27
2017	704	4.86%	8902	6.69	6.56	9.09	2.54	0.27
2018	858	5.93%	9760	21.87	6.75	9.19	2.43	0.29
2019	870	6.01%	10630	1.39	6.77	9.27	2.50	0.28
2020	1025	7.08%	11655	17.81	6.93	9.36	2.43	0.29
2021	1039	7.18%	12694	1.36	6.95	9.45	2.50	0.28
2022	1079	7.46%	13773	3.84	6.98	9.53	2.55	0.27
2023	689	4.76%	14462	-36.14	6.54	9.58	3.04	0.23
Total	14462	100%		17.20			2.43	0.30

AGR = (Annual Growth Rate); **RGR** = Relative Growth Rate; **DT**= (Doubling Time)

Table 1 shows the chronological distribution of publications in the field of Physics during the period 1942-2023. According to the data gathered from the Scopus Database, 14462 documents have been published. Most of the articles were published in the year 2022, with 1079 (7.46%), The values of AGR, RGR,

and DT are examined using MS-Excel, The average values of AGR, RGR, and DT are 3.84, 2.55, and 0.27, respectively and the lowest are published in 1942, 1943, 1945 and 1948, with only 1 (0.00%) publications each. Overall, the number of publications increased from the year 1961 (9 i.e., 0.06%) to the year 2023 (689 i.e., 4.76%). The complete table throughout the years shows a fluctuating growth trend during the period of study but the period 2020 -2023 indicates very less productivity in research publication due to COVID-19 pandemic, it brings various challenges for researchers in R&D Institutions.

TABLE 2: PROLIFIC AUTHORS

RANK	AUTHORS NAME	NUMBER OF PUBLICATIONS & %	H-INDEX	CITATIONS
1	Chaudhary, B.C.	1785 (2.23%)	131	1,04,525
2	Kumar, A.	1713(2.14%)	126	98,237
3	Ranjan, K.	1484 (1.85%)	121	87,422
4	Pant, L.M.	1261 (1.57%)	115	76,699
5	Sharma, R.	1205 (1.50%)	97	49,635
6	Mazumdar, K.	1086 (1.35%)	112	69,195
7	Sharma, V.	1130 (1.41%)	124	83,593
8	Banerjee, S.	1129 (1.41%)	110	62,813
9	Dutta, S.	1126 (1.40%)	114	74,845
10	Das ,S.	1126 (1.40%)	110	67,936
11	Narain, M.	1114(1.39%)	127	1,32,152
12	Malik ,S.	1112 (1.39%)	86	43,756
13	Dutta, D.	1089 (1.36%)	134	100925
14	Ahmad, M.	1085 (1.35%)	113	69,691
15	Beri , S.B.	1083 (1.35%)	126	1,00,495
16	Ahuja , S.	1077 (1.34%)	112	68,807
17	Tripathi, M.	1067 (1.33%)	118	80,344
18	Patel, R.	1067 (1.33%)	112	67,121
19	Dutta, V.	1059 (1.32%)	110	52,126
20	Bose, T.	573(0.00%)	123	90,448
Total		21608 (27.02%) 79941		

Fig 1: Top prolific authors with their H-Index and Citations

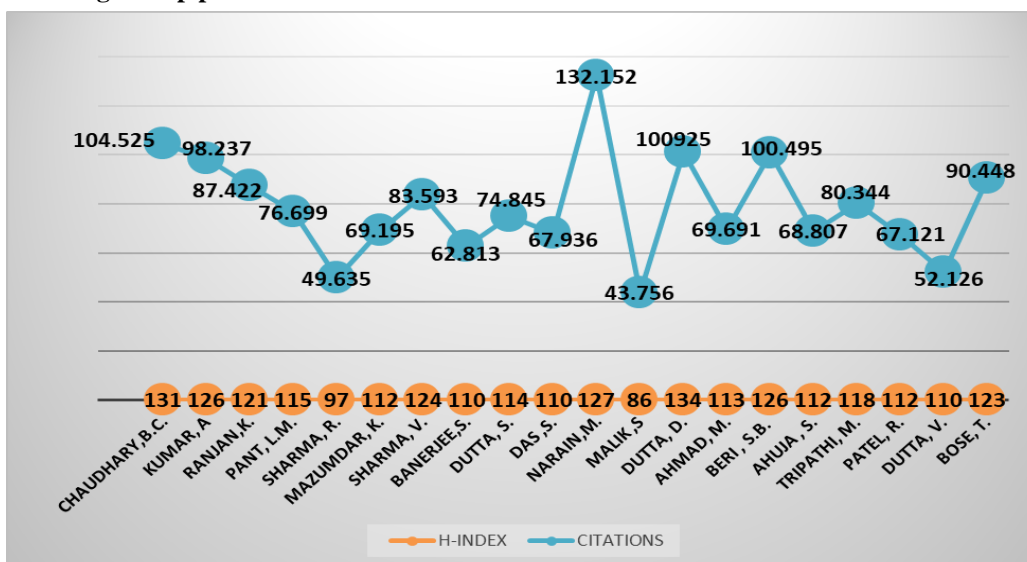


Table 2 shows the top prolific authors in the field of Physics during the period of study and their h-index value has been taken from Scopus. It is found that there are total 79941 authors in which B.C. Chaudhary had contributed the maximum number of publications i.e., 1785 (2.23%) having H-Index 131 and received 104,525 number of citations; followed by Kumar A had contributed having second highest number of publication i.e., 1713 (2.14%) having 126 H-Index and received 98,237 citation and occupies rank 2; followed by Ranjan, K having 1484 (1.85%) publication with having H-Index 121 and received 87,422 citations and occupies rank 3; Pant, L.M. having 1261 (1.57%) publication with having H-Index 115 and received 76,699 citations and occupies rank 4; Sharma, R. having 1205 (1.50%) publication with having H-Index 97 and received 49,635 citations and occupies rank 5.

The data further identified the highly cited authors which shows that Narain, Meenakshi is having highest number of citations i.e., 1,32,152 and having 127 H-Index with 1114 number of publications; followed by Chaudhary, B.C. with having 2nd highest number of citations 1,04,525; followed by Dutta, T with having 3rd highest number of citations 1,00,925.

TABLE 3: YEAR-WISE AUTHORSHIP PATTERN

Year	No. of Publications					Total Ns+Nm	DC
	SA (Ns)	DA	TA	More than three Author	Multiple author (Nm)		
1942	0	1	0	0	1	1	1.00
1943	0	1	0	0	1	1	1.00
1944	1	1	0	0	1	2	0.50
1945	1	0	0	0	0	1	0.00
1946	1	0	0	0	0	1	0.00
1947	1	0	0	0	0	1	0.00
1948	0	1	0	0	1	1	1.00
1949	0	3	0	0	3	3	1.00
1950	2	0	0	0	0	2	0.00
1951	0	0	1	0	1	1	1.00
1952	0	1	1	0	2	2	1.00
1953	1	3	2	0	5	6	0.83
1954	3	3	0	1	4	7	0.57
1955	3	2	1	1	4	7	0.57
1956	4	2	1	0	3	7	0.57
1957	0	2	0	0	2	2	1.00
1958	0	0	0	2	2	2	1.00
1959	0	3	2	0	5	5	1.00
1960	1	2	0	0	2	3	0.66
1961	6	2	1	0	3	9	0.33
1962	3	7	2	0	9	12	0.75

1963	8	12	0	0	12	20	0.60
1964	7	10	1	2	13	20	0.65
1965	21	22	6	3	31	52	0.59
1966	17	20	12	2	34	51	0.66
1967	12	24	12	2	38	50	0.76
1968	14	32	11	1	44	58	0.75
1969	12	20	3	0	23	35	0.65
1970	10	22	11	1	34	44	0.77
1971	9	20	13	2	35	44	0.77
1972	10	28	7	0	35	45	0.77
1973	15	33	11	7	51	66	0.77
1974	16	46	18	2	66	82	0.80
1975	13	34	10	8	52	65	0.80
1976	16	32	10	3	45	61	0.73
1977	12	42	16	10	68	80	0.85
1978	11	42	16	8	66	77	0.85
1979	12	26	25	13	64	76	0.84
1980	9	30	18	20	68	77	0.88
1981	4	35	12	20	67	71	0.94
1982	9	31	13	19	63	72	0.87
1983	9	30	11	11	52	61	0.85
1984	5	19	20	16	55	60	0.91
1985	5	19	18	14	51	56	0.91
1986	8	24	20	10	54	62	0.87
1987	7	21	13	11	45	52	0.86
1988	6	21	17	12	50	56	0.89
1989	14	31	21	2	54	68	0.79
1990	4	30	19	14	63	67	0.94
1991	13	31	19	20	70	83	0.84
1992	10	26	25	11	62	72	0.86
1993	11	35	22	17	74	85	0.87
1994	10	33	24	19	76	86	0.88
1995	9	28	19	24	71	80	0.88
1996	14	51	29	28	108	122	0.88
1997	14	33	39	28	100	114	0.87
1998	11	42	34	23	99	110	0.90
1999	14	28	28	31	87	101	0.86
2000	13	32	36	32	100	113	0.88
2001	12	54	57	38	149	161	0.92
2002	11	69	43	66	178	189	0.94
2003	12	56	61	82	199	211	0.94
2004	15	52	50	58	160	175	0.91
2005	10	57	57	79	193	203	0.95
2006	9	47	62	83	192	201	0.95
2007	23	43	46	123	212	235	0.90

2008	23	49	45	120	214	237	0.90
2009	18	51	48	161	260	278	0.93
2010	28	57	84	241	382	410	0.93
2011	19	87	114	252	453	472	0.95
2012	31	79	110	281	470	501	0.93
2013	22	93	124	292	509	531	0.95
2014	32	88	95	326	509	541	0.94
2015	14	102	114	296	512	526	0.97
2016	19	107	137	394	638	657	0.97
2017	13	132	149	410	691	704	0.98
2018	28	170	183	477	830	858	0.96
2019	13	151	181	525	857	870	0.98
2020	31	202	240	552	994	1025	0.96
2021	35	209	219	576	1004	1039	0.96
2022	37	226	231	585	1042	1079	0.96
2023	17	176	198	298	672	689	0.97
						Avg	0.81
Grand Total	913	3486	3298	6765	13549	14462	
%	6.31	24.27	22.80	46.77	93.68	100	

SA=single Author, DA= Double Author, TA=Triple Author, DC=Degree of Collaboration

The formula used for calculating Degree of collaboration was proposed by Subramanayam, K in 1983 "Subramanayam, K. (1983)". During the years 1942 to 2023, there were more multi-authored articles than single-authored publications. The degree of collaboration (DC) decreases from 1.00 to 0.97.

The average value of DC is 0.81 from the above table, it is concluded that multiple authorship dominates thereby indicating the increasing trend of collaborative research among Physics during the given period of study. Also in various other bibliometric studies, it is proved that the collaborative research work among the researchers is increasing nowadays in different fields for the enhancement of quality research in less and limited time.

TABLE 4: LIST OF CATEGORY WISE TOTAL NUMBER OF AUTHORS

Sr.no.	Authors category	Number of articles	Number of Authors	Percentage of authors
1.	Single authors	913	913	1.14%
2.	Double authors	3486	6972	8.72%
3.	Triple authors	3298	9894	12.37%
4.	Four authors	2573	10292	12.87%
5.	Five authors	1462	7310	9.14%
6.	Six authors	669	4014	5.02%
7.	Seven authors	348	2436	3.04%
8.	Eight authors	194	1552	1.94%
9.	Nine authors	120	1080	1.35%
10.	Ten authors	56	560	0.70%
	Total	13119	45023	56.29%
	More than 10 authors	1343	34918	43.67%
	Total	14462	79941	100%

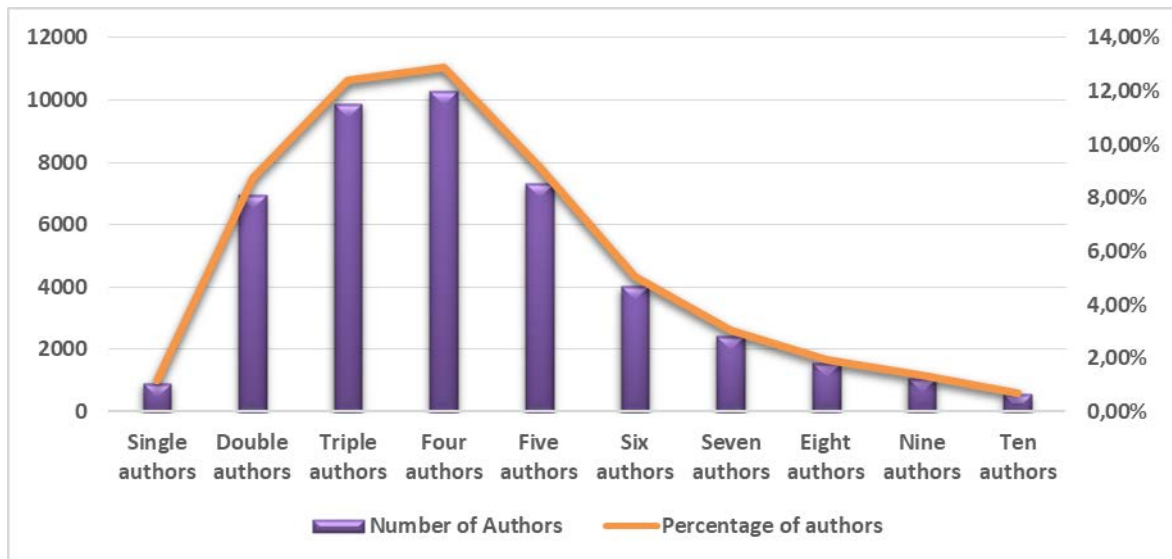


Fig 2: Category Wise Total Number of Authors

Table 4 shows the category wise distribution of authors along with the number of articles contributed by them. In total it is found that 79941 authors contributes a total of 14462 publications in the field of Physics research in India from 1942-2023. It can be seen from the table that researchers in the field of Physics prefer to work in collaboration as it can be seen that the proportion of single authors is only 1.15% of the total authors hence the rest prefers to work in collaboration with the other researchers.

TABLE 5: FORMS OF DOCUMENTS

S.NO.	TYPE OF DOCUMENT	NO. OF DOCUMENTS	TOTAL PERCENTAGE
1	Articles	12536	86.68%
2	Conference paper	1447	10.00%
3	Letter	169	1.16%
4	Review	144	0.99%
5	Erratum	87	0.60%
6	Note	25	0.17%
7	Book chapter	22	0.15%
8	Editorial	22	0.15%
9	Book	5	0.03%
10	Retracted	4	0.02%
11	Short survey	1	0.00%
Total		14462	100

Table 5 shows the classification of the documents published in different forms of availability there are total 14462 publications published during the period of study and found that journal articles are forming 86.68% of the total contributions i.e., 12536 followed by Conference paper 1447(10%), Letter 169(1.16%), Reviews 144(0.99%), Erratum 87 (0.60%), Notes 25(0.17%), Book chapter 22(0.15%) and later by Editorial 22(0.15%) Book 5(0.03%), Retracted 4(0.02%) and Short survey 1(0.00%).The majority of the publications in the field of Physics acquired by the dominance of journal article publications over the other forms of documents.

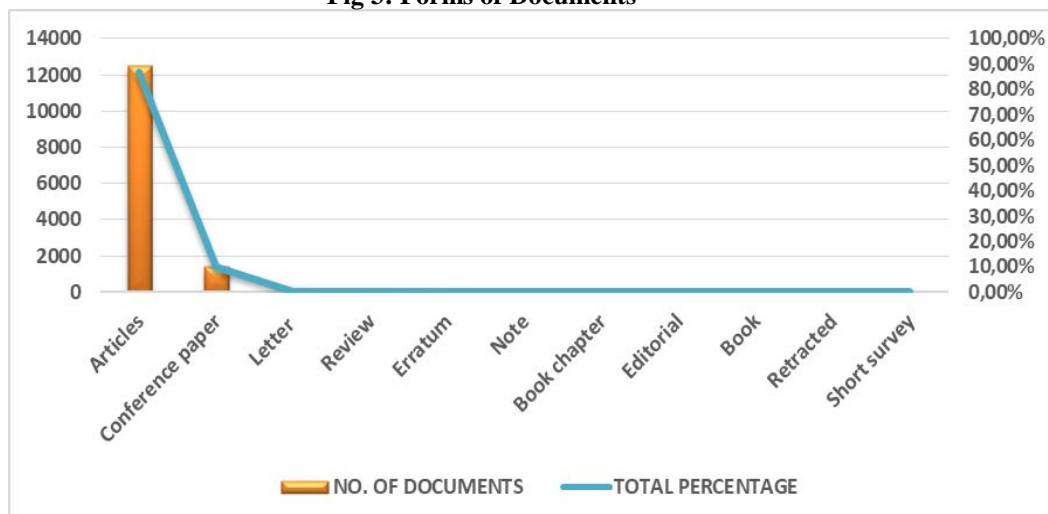
Fig 3: Forms of Documents

TABLE 6: LANGUAGE DISTRIBUTION OF THE LITERATURE

LANGUAGE	RECORD COUNT	PERCENTAGE
English	14454	99.95%
German	8	0.05%
Total	14462	100

The above table 6 shows that the maximum number of documents were published in English language during the period of study which constituted 14454 (99.95%) of documents, while rest was published in the German language i.e., 8 (0.04%).

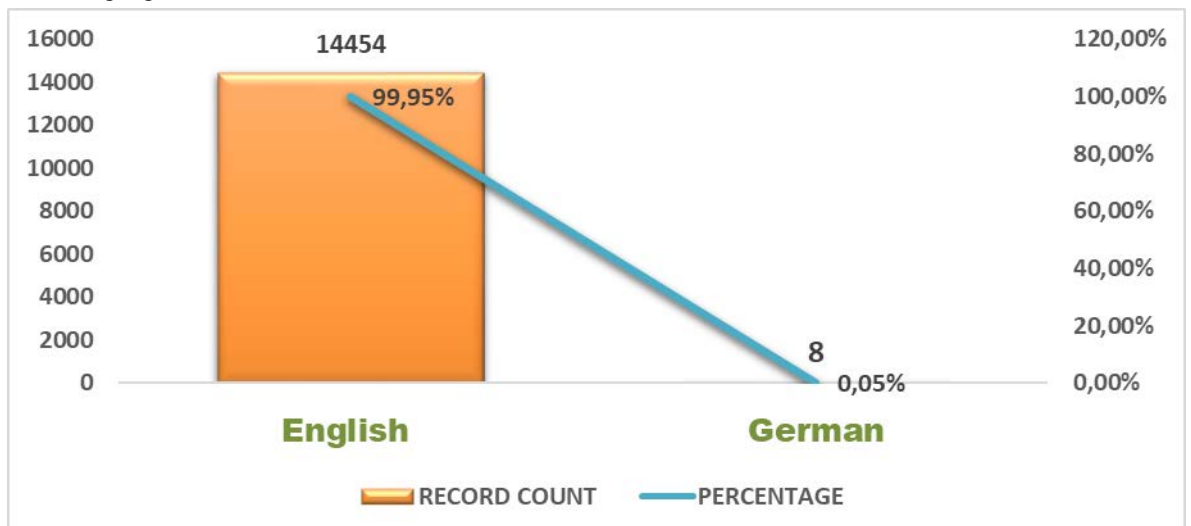


Fig 4: Language of Documents

TABLE 7: TOP CITED RESEARCH PAPERS IN THE FIELD OF PHYSICS

Sr.No	Title of the paper	Name of the Author	Year	No. of citation	Rank
1	CMS physics technical design report, volume II: Physics performance	B., Sproston, M.et al	2007	751	1
2	Solid polymer electrolytes: Materials designing and all-solid-state battery applications: An overview	Agrawal, R.C and Pandey, G.P.	2008	692	2
3	A gravitational wave observatory operating beyond the quantum shot-noise limit	J.A, Giampanis, S. et. al	2011	609	3
4	Nanoparticles for Bioimaging	Sharma, P et al..	2006	600	4
5	Precise determination of the mass of the Higgs boson and tests of compatibility of its couplings with the standard model predictions using proton collisions at 7 and 8 TeV	Khachatryan, V.	2015	592	5
6	Transport properties of semiconducting phosphate glasses	Sayer, M and Mansingh, A.	1972	590	6
7	Influence of postdeposition annealing on the structural and optical properties of sputtered zinc oxide film	Gupta, V and Mansingh, A.	1996	579	7
8	Observation and studies of jet quenching in PbPb collisions at $\sqrt{s_{NN}}=2.76$ TeV	Saoulidou, Net al.	2011	561	8
9	Measuring Quantum Coherence with Entanglement	Singh, U.et al.	2015	553	9
10	Observation of long-range, near-side angular correlations in pPb collisions at the LHC	Chatrchyan, S. et al.	2013	535	10
11	Observation of long-range, near-side angular correlations in proton-proton collisions at the LHC	D., Varelas, N et al.	2010	533	11
12	Combined results of searches for the standard model Higgs boson in pp collisions at $\sqrt{s}=7$ TeV	Henderson, C., et al	2012	518	12
13	Solution behaviour of Aerosol OT in non-polar solvents	De, T.K and Maitra, A.	1995	508	13
14	Observation of a new boson with mass near 125 GeV in pp collisions at $\sqrt{s}=7$ and 8 TeV	Schnitzer, S. et al.	2013	467	14
15	Transverse momentum and pseudorapidity distributions of charged hadrons in pp collisions at $\sqrt{s}=7$ TeV	R, Prokolyev O. et al	2010	456	15
16	A Review, Bibliography, and Tabulation of K, L, and Higher Atomic Shell X-Ray Fluorescence Yields	Hubbell, J.H et al.	1994	453	16
17	Recent progress in the development of nano-structured conducting polymers/nanocomposites for sensor applications	Rajesh et al.	2009	428	17
18	Event generator tunes obtained from underlying event and multiparton	Khachatryan, V. et al	2016	441	18

	scattering measurements				
19	Hidden attractors in dynamical systems	Dudkowski, D. et al.	2016	417	19
20	The Indo-US library of coudA© feed stellar spectra	Valdes, F et al.	2004	413	20

The most cited Physics research papers having maximum citations retrieved from Scopus database from 1942 to 2023 are shown in Table 7. The research paper “CMS physics technical design report, volume II: Physics performance” has the highest number of citations 751 followed by “Solid polymer electrolytes: Materials designing and all-solid-state battery applications: An overview” having 692 citations, followed by “A gravitational wave observatory operating beyond the quantum shot-noise limit” having 609 citations.

TABLE 8: TOP -RANKED JOURNALS IN PHYSICS

Sr.No.	Name of the Journal	Journal origin/country	No. of publications	H-INDEX
1	Journal of High Energy Physics	Germany	409	247
2	Physics Review D	U.S	319	378
3	Physics Letters Section B Nuclear Elementary Particle And High Energy Physics	Netherland	297	275
4	Journal of Applied Physics	U.S	227	341
5	AIP Conference Proceedings	U.S	224	80
6	Physics Review Letters	U.S	194	674
7	European Physical Journal C	Germany	187	188
8	SpectrochimicaActa Part A Molecular And Biomolecular Spectroscopy	Netherland	160	145
9	Physics Review	U.S	157	269
10	Physics Review D Particle Field Gravitation And Cosmology	U.S	141	363
11	Pramana Journal of Physics	India	132	58
12	Proceedings of SPIE The International Society For Optical Engineering	U.S	117	187
13	Physics Review C	U.S	94	229

14	Journal of Molecular Liquid	Netherland	92	150
15	Journal of Instrumentation	U.K	89	85
16	Physics Review C Nuclear Physics	U.S	88	229
17	Journal of materials science materials in electronics	U.S	83	88
18	Journal of Physics D Applied Physics	U.K	82	220
19	PhysicaScripta	U.K	79	91
20	Astrophysics and Space Science	Netherland	78	76

Table 8 shows the top-ranked journals in the subject of Physics throughout the study period, H-index value of these journals has been taken from Scimago journal & country rank according to the number of publications in the field. the topmost journal named 'journal of High Energy Physics' is having the maximum number of publications i.e., 409(2.82%) with having 238 H-Index of the journal, followed by 'Physics Review D' with 319 (2.20%) number of publications with having highest H-Index i.e., 363, followed by 'Physics Letters Section B Nuclear Elementary Particle and High Energy Physics' with 297(2.05%) number of publications and having 267 H-Index; followed by Journal of Applied Physics with 227(1.56%) number of publications with having second highest H-Index of the journal i.e., 331.

Table 9: KEYWORD DISTRIBUTION OF PUBLICATIONS

Sr. No.	Keywords	Frequency of occurrence	Percentage %
1	Article	617	2.66%
2	X Ray Diffraction	563	2.42%
3	Thin Films	528	2.27%
4	Scanning Electron Microscopy	444	1.91%
5	Nanoparticles	359	1.54%
6	Ions	324	1.39%
7	Optical Properties	323	1.39%

8	Synthesis (chemical)	309	1.33%
9	Chemistry	308	1.33%
10	Energy Gap	295	1.27%
11	Zinc Oxide	283	1.22%
12	Photoluminescence	279	1.20%
13	Physics	279	1.20%
14	Fourier Transform Infrared Spectroscopy	267	1.15%
15	CMS	260	1.12%
16	Temperature	251	1.08%
17	Refractive Index	233	1.00%
18	Substrates	221	0.95%
19	Hadron-Hadron Scattering (experiments)	214	0.92%
20	Electric Fields	206	0.88%
Total		6563(23,188)	(28.30%)

The above Table 9 shows TOP 20 keyword distribution of 14462 documents published during 1942- 2023. A total of 23,188 keywords have been found and arranged in order rank-wise according to their frequency of occurrence. The particular keyword 'Article' (617; 2.66%) has occurred most frequently, followed by 'Thin Films' (563; 2.42%), 'Scanning Electron Microscopy' (528; 2.27%), 'Nanoparticles' (359; 1.54%) and so on.

Table 10: Top 20 Contributing Funding Agencies

Sr.no.	Funding Agency	Country name	No. of Contribution
1	Department of Science and Technology, Ministry of Science and Technology	India	1583
2	Council of Scientific and Industrial Research	India	1303
3	Science and Technology Facilities Council	UK	1111

4	National Science Foundation	USA	1058
5	University Grant Commission	India	774
6	U.S. Department of Energy	USA	679
7	Department of Atomic Energy, Government of India	India	651
8	Deutsche Forschungs geme in schaft	Germany	645
9	National Research Foundation of Korea	Korea	641
10	National Natural Science Foundation of China	China	626
11	Conselho Nacional de Desenvolvimento Cientificoe Technologico	Brazil	625
12	Bundesministerium fur Bildung und Forschung	Germany	621
13	InstitutoNazionale di FisicaNucleare	Italy	611
14	Russian Foundation for Basic Research	Russia	606
15	CERN	Switzerland	603
16	ConsejoNacional de Ciencia y Tecnologia	Mexico	601
17	Fundaco de Amparo a Pesquisa do Estado de Sao Paulo	Brazil	601
18	FondsDe La RechercheScientifique-FNRS	Brazil	600
19	Joint Institute for Nuclear Research	Russia	598
20	European Regional Development Fund	European Union	598
			15,135 (28.92%) Total (52,322)

The above table 10 shows the top 20 Funding agencies has contributed maximum number of time for providing Funds to carry out the research projects. The results has clearly shows that 'Department of Science and Technology, Ministry of Science and Technology, India' has contributed 1583 times from the period 1942-2023, followed by 'Council of Scientific and Industrial Research, India' (1303) ; 'Science and Technology Facilities Council' (1111) and 'National Science Foundation' (1058).

FINDINGS AND RESULTS

After analyzing the data of Physics from Scopus it is found:

1. A total of 14462 documents has been published during the period of study and found that Most of the articles are published in the year 2022, with 1079 (7.46%), The average values of AGR, RGR, and DT are 3.84, 2.55, and 0.27, respectively and the lowest are published in 1942, 1943, 1945 and 1948 with only one (0.00%) publications each. Overall, the number of publications increased from the year 1961 (9 i.e 0.06%) to the year 2023 (689 i.e 4.76%). The complete table throughout the years shows a fluctuating growth trend during the study period from 1942-2023.
2. The most productive authors during the study period are Chaudhary B.C had contributed the maximum number of publications i.e.,1785(2.2%) having H-Index 131 and received 104525 number of citations; followed by Kumar A had contributed having second highest number of publication i.e.,1713 (2.14%) having 126 H-Index and received 98,237 citation; followed by Ranjan, K having 1484 (1.85%) publication with having H-Index 121 and received 87,422 citations
The data further identified the highly cited authors which shows that Narain, Meenakshi is having highest number of citations i.e., 1,32,152 and having 127 H-Index with 1114 number of publications; followed by Chaudhary, B.C. with having 2nd highest number of citations 1,04,525; followed by Dutta, T with having 3rd highest number of citations 1,00,925.
3. The average value of DC is 0.81, it concluded that multiple authorship dominates thereby indicating the increasing trend of collaborative research among Physics field during the given period of study

4. The dominance of shared authorship of more than three author i.e., 257 (12.87%) is observed followed by single, double, and then triple authorships. The average value of DC is 0.81. From the above table, it is concluded that multiple authorship dominates thereby indicating the increasing trend of collaborative research among clinical psychologists during the given study period.
5. The majority of the publications in the field of Physics state the dominance of journal article publications (86.68%) over the other forms of documents.
6. Maximum number of documents was published in English language during the period of study which constituted 14454 (99.95%) number of documents.
7. The research paper “CMS physics technical design report, volume II: Physics performance” has the highest number of citations 751 followed by “Solid polymer electrolytes: Materials designing and all-solid-state battery applications: An overview” received 692 citations.
8. The topmost journal named ‘Journal of High Energy Physics’ is having the maximum number of publications i.e., 409 (3.13%) having 238H-Index followed by ‘Physics Review D’ with 319 (2.44%) number of publications having 363 H-Index.
9. The TOP-20 keyword distribution of 14462 documents published during 1942- 2023. Total of 23,188 keywords have been found and arranged in order rank-wise according to their frequency of occurrence. The particular keyword ‘Article’ (617; 2.66%) has occurred most frequently, followed by ‘Thin Films’ (563; 2.42%), ‘Scanning Electron Microscopy’ (528; 2.27%), ‘Nanoparticles’ (359; 1.54%) and so on.
10. Top-20 Contributing Funding agencies during the period of study that has contributed maximum number of times for providing funds to carry out the research without any hindrance. The ‘Department of Science and Technology, Ministry of Science and Technology, India’ has contributed highest number of times i.e., 1583 during the period of

study 1942-2023, followed by 'Council of Scientific and Industrial Research, India' contributed 2nd highest number of times i.e., 1303 ; 'Science and Technology Facilities Council' contributed 3rd highest number of times i.e., 1111.

CONCLUSION:

In the era of Information age, scientometric assessment becomes a key element to find out the research Productivity of an institution, with the help of scientometric indicators we can measure the quality and quantity of literature published from various disciplines within a particular geographical area. The current study attempted to examine the Research productivity of University of Delhi in the field of Physics based on the articles indexed in the Scopus database, covering the study period from 1942 to 2023. This study is limited to the data included in Scopus which means the journal articles which is not covered in this database does not come under the purview of this study. The study examined 14462 articles in the field of physics published by University of Delhi and also the recent research trends under physics domain. This study serves as a valuable reflection on how Physics as a discipline has evolved over eight decades. It underscores the increasing volume, collaboration, and influence of physics research globally. The presence of highly cited authors and articles suggests not only high research quantity but also quality and impact. Researchers like Meenakshi Narain and B.C. Chaudhary have played pivotal roles, contributing significantly to the field's development. Moreover, the high citation counts for certain papers reflect the field's relevance and the enduring value of foundational research contributions. The dominance of journals like the Journal of High Energy Physics and Physical Review D, along with popular keywords such as *Thin Films* and *Scanning Electron Microscopy*, reveals current hotspots of research. It reflects a shift toward applied and experimental areas, indicating how theoretical and practical components are evolving together in the discipline. This study will be beneficial to researchers, teachers, and

academicians working in the field of Physics in terms of understanding the current state of work within this field of study.

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