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GLOBAL RESEARCH PRODUCTIVITY IN PHYSICAL COSMOLOGY: A SCIENTOMETRIC ANALYSIS

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ABSTRACT

Cosmology is the most preferred research area among global research and development for quite a time in terms of the total number of publications, authorship pattern, h-index, institution, journals, and countries. The present study deal with the assessment of Physical Cosmology research output as reflected in the Web of Science (WOS) database for the period 2011 to 2020 for identifying the research output in the field of Physical Cosmology. We measure global contribution to Physical Cosmology research. In the ten years, 2011 to 2020 researchers have published 1979 papers. India published 254 papers with a 12.83 percentage, the USA contributed 688 papers with a 34.77 percentage, UK published 341 papers with a 17.23 percentage, and Germany produced 399 papers with a 20.16 percentage. The 20 core journals are identified which contains 1452 of the total articles, the topmost productive journal Monthly Notices of the Royal Astronomical Society published 416 articles. The above-mentioned points are deeply analyzed.

Keywords: Physical Cosmology, Authorship pattern, h-index, Scientometric and Web of Science.

INTRODUCTION

Scientometrics is the science of measuring and analyzing science, in practice scientometric is often done using bibliometric which is a measurement of the impact of publication. They founded the institute of scientific information which is heavily used for scientometric analysis. The methods of research include qualitative, quantitative, and computational approaches. The most important point to be discussed in the paper is how Scientometric studies develop the sources of the writer and their citation of the discussed papers irrespectively. By keeping this view in mind, the researchers wish to analyze the research involvement of the Physical Cosmology research during 2011- 2020.

Physical Cosmology of branch of Cosmology concerned with the study of cosmological models, a cosmological model, or simply cosmology. Physical Cosmology is the study of the largest-scale structures and dynamics of the universe and is concerned with fundamentals about its origin, structure, evolution, and ultimate fate. The subject matter of this field is studied using the scholarly methodology, including the scientific method and reason. It is studied by scientists such as astronomers, theoretical physicists, and academic philosophers, such as metaphysicians, philosophers of physics, and philosophers of space and time. The present study is entitled “Global Research Productivity in Physical Cosmology: A Scientometric Analysis”. The present study is an attempt to Scientometric measures of the published research Performance of Physical Cosmology to use various statistical tools.

REVIEW OF LITERATURE

Vijaya Kumar, R., Palaniappan, M., and Thangamani, T. (2021) have analyzed Scientometric analysis on Astronomy research output during 2010-2020. The researcher downloads the required data from the web of science database, a total number of 6905 bibliography records. The main aim of this paper is to bring to light such as the year wise publications, authorship pattern, the degree of collaboration, relative growth rate, doubling time, annual ratio of growth, time serious analysis, ranking of countries, and productive institutions. The highest number of publication in the year 2018 which was 861(12.47%) articles. The highest number of 1956 articles was contributed by a single author. Katz U occupied the first position having 38 articles with 1645 citations and 20 h-index.

Satish Kumar and Senthilkumar, R. (2018) discussed the research output of Astronomy and Astrophysics research in India during the period from 2001 to 2015. The total number of 12144 bibliography data was harvested from the Web of Science database. The purpose of Astronomy and Astrophysics research in India is literature growth, authorship pattern, publication frequencies, open access publications, prolific institutions and authors, prolific research collaborating countries with India, and preferred journals. Major findings show Astronomy and Astrophysics research in India. The maximum numbers of 1220 publications were published in the year 2014. India holds the thirteenth position with 12144(3.63%) research publications.

Vijay Kumar Rai., Senger, K.P.S., and Rajesh K Lohiya (2018) have focused on Astronomy research publication in India with the period 1991-1995 and 2011-2015 ten years. The publication output has been analyzed with quantitative and qualitative indicators, such as progress in a research article published, change in authorship pattern, citation analysis, etc. The Indian researchers published a total number of 1987 articles. A total number of 4581 articles were published in peer-reviewed journals during 2011- 2015. Indian articles in international journals with the highest impact factors.

Vijayakumar, R., and Palaniappan, M. (2016) carried out a Scientometric analysis based on the research output of Periyar University and Bharathiar University during the period of 2005-2014. The required data were obtained from the web of science database. The main aim of this paper is to bring into light such as the year-wise publications, authorship pattern and publication citation, degree of collaboration, geographical, institutions, and keywords. The highest number of articles is observed in the year 2014 which is accurate to 492 (19.44%). It was observed that Periyar University 680 articles with the highest citation 13585. N.Krishna Kumar has identified a prolific author at Periyar University with 111 papers.

Gireesh A Ganjihah and Keshava (2015) conducted a Scientometric study on India radio Astronomy literature during the study period 1999-2012. The researcher retrieved the required data from the web of science. India has produced 6840 papers during the year 1999-2012. The average activity index for Indian publications is 97.86. The Indian publications have grown steadily from 4.357% (298) in 1999 to 11.9% (814) publications in 2012. Among the top ten Indian Institutes is IUCAA ranks first with the highest h-index 67. The mean growth rate and doubling time for the world publication are 0.218 and 4.526 respectively.

OBJECTIVES OF THE STUDY

The major objectives are framed with the exclusive notion of the present study as mentioned below:

- To examine the year wise distribution of publications and citations
- To find out the Authorship pattern and collaboration factors
- To study the Authors based on h-index
- To determine the ranking of country wise distribution
- To find out the ranking of institutions and research performance
- To identify the ranking of journals with h-index

METHODOLOGY

The required data were collected from the Web of Science database maintained by Thomson Reuters for a period of ten years from 2011 to 2020. It can be seen that the total number of 1979 bibliographic records were retrieved from Physical Cosmology research. The details with observation that for each published article such as year-wise publication and citations, authorship pattern and collaboration factors, ranking of authors based on h-index, and ranking of countries. The retrieved data were analyzed by using Bibexcel, Histcite, and Excel. The study covered the following bibliometric indicators: the Degree of Collaboration, Collaborative Co-efficient, Collaborative Index, Modified Collaborative Co-efficient, Co-Authorship Index, etc.

ANALYSIS AND RESULTS

Table 1: Details of the Important Points of the Data Sample During 2011 to 2020

S. No	Details about Sample	Observed Values
1	Duration	2011-2020
2	Collection Span	10
3	Total Number of Records	1979
4	Total Number of Authors	5676
5	Frequently used Words	3202
6	Document Types	10
7	Contributing Countries	79
8	Contributing Institutions	1726
9	Cited References	72196

10	Local Citation Scores	1261
11	Global Citation Scores	58634
12	Sum of Times cited	58866
13	Average citation per item	29.76
14	Without self citations	55914
15	Citing Articles	34268

Table 2: Annual Distribution of Publications and Citations

S.No	Year of Publications	Records	%	Rank	TLCS	%	Rank	TGCS	%	Rank
1	2011	165	8.34	10	163	12.93	5	11542	19.68	2
2	2012	183	9.25	8	199	15.78	4	5791	9.88	5
3	2013	206	10.41	4	212	16.81	2	7159	12.21	3
4	2014	204	10.31	5	206	16.34	3	14726	25.12	1
5	2015	207	10.46	3	223	17.69	1	7310	12.47	4
6	2016	199	10.05	7	81	6.42	7	4475	7.63	6
7	2017	203	10.26	6	85	6.74	6	2999	5.11	7
8	2018	176	8.89	9	52	4.12	8	2283	3.89	8
9	2019	209	10.56	2	34	2.70	9	1788	3.05	9
10	2020	227	11.47	1	6	0.47	10	561	0.96	10
Total		1979	100		1261	100		58634	100	

**TLCS = Total Local Citation Score *TGCS = Total Global Citation Score*

Table 2 indicates that year wise distribution of publication of Physical Cosmology research, it is observed that the total numbers of 1979 publications were published from 2011 to 2020. The highest number of 227 (11.47%) articles were published in the year 2020 with 6 (0.47%) of local citation score and 561 (0.96%) of global citation score which is occupied the first position among the 10 year's research output, followed by 209 (10.56%) articles were published in the year 2019 with 34 (2.70%) of local citation score and 1788 (3.05%) of that global citation score which is occupied the second position and 207 (10.46%) articles were published in the year 2015 with 223 (17.69%) of local citation score and 7310 (12.47%) of global citation score values which are occupied the third position.

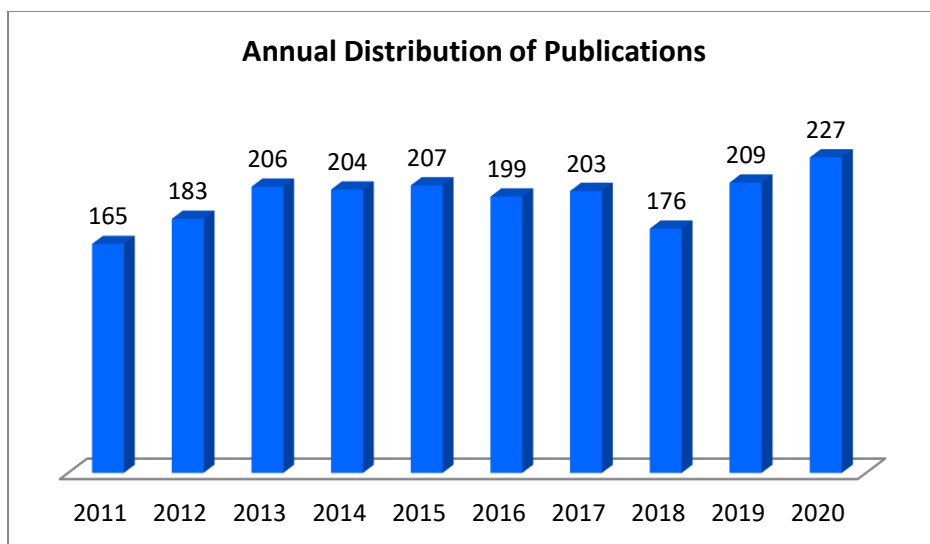


Figure 1: showing annual distribution of publications

Table 3: Year wise distributions of Authorship pattern and Collaboration factors

Numbers of Authors	Year										Total
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
1	37	41	42	56	36	42	42	35	48	38	417
2	38	52	48	43	54	41	36	56	43	46	457
3	35	31	40	37	44	48	37	32	40	42	386
4	23	19	21	21	22	21	33	19	29	44	252
5	6	12	15	7	12	7	12	12	13	12	108
6	4	7	4	8	6	4	8	3	9	8	61
7	9	3	6	6	4	4	4	5	0	4	45
8	1	1	3	3	7	4	3	5	6	1	34
9	1	3	1	6	3	2	9	0	5	3	33
10 & above	11	14	26	17	19	26	19	9	16	29	186
Total	165	183	206	204	207	199	203	176	209	227	1979
DC	0.78	0.78	0.80	0.73	0.83	0.79	0.79	0.81	0.76	0.83	0.79
CC	0.53	0.47	0.44	0.39	0.45	0.46	0.47	0.49	0.41	0.43	0.42
CI	1.29	1.29	1.26	1.38	1.21	1.27	1.26	1.23	1.31	1.20	1.27
MCC	1.91	1.94	1.82	2.00	1.78	1.83	1.78	1.92	1.87	1.71	1.86

Table 3 explain different collaboration factor for the period of ten years 2011-2020. The table includes Authorship pattern, Degree of Collaboration, Collaborative Co-efficient, Collaborative Index, and Modified Collaborative Co-efficient. It is found that the Degree of Collaboration was increasing and decreasing trend 0.73 to 0.83. Collaborative Co-efficient at the highest rate of 0.53 in the year 2011 it is the lowest rate of 0.34 in the year 2014. Collaborative Index at the highest in the year 2014 (1.38) and the lowest range in the year 2020 (1.20) and the mean Modified Collaborative Co-efficient during the period of study was 1.86.

Table 4: Pattern of Co-Authorship Index (CAI)

Year	Single Author		Two Author		Three Author		>Three Author		Total
	Articles	CAI	Articles	CAI	Articles	CAI	Articles	CAI	
2011	37	106.42	38	99.73	35	108.75	55	97.75	165
2012	41	106.33	52	123.05	31	86.85	59	88.74	183
2013	42	96.76	48	100.9	40	99.55	76	101.55	206
2014	56	130.28	43	91.28	37	92.99	68	97.75	204
2015	36	82.54	54	112.97	44	108.98	73	97.07	207
2016	42	100.16	41	89.22	48	123.66	68	94.05	199
2017	42	98.19	36	76.8	37	93.44	88	119.32	203
2018	35	93.31	56	136.24	32	92.17	55	85.05	178
2019	48	110.05	43	89.96	40	99.07	76	101.06	207
2020	38	79.45	46	87.75	42	94.86	101	122.47	227
Total	417	100	457	100	386	100	719	100	1979

Table 4 represents the pattern of the Co-Authorship Index (CAI). The data has been separated into a single author, two authors, three authors, and more than three authored articles for ten years (2011-2020). It is observed that the above table single authors publications CAI values are higher than the average in the year 2014, the remaining years CAI values are less than the average, followed by two authors publications CAI values are higher than average in the year 2018 and remaining years CAI values are less than average, three authors, CAI values are higher than average in the year 2016, the remaining year's CAI values are less than the average and more than three authors CAI values are higher than average in the year 2020, the remaining years CAI values are less than the average.

Table 5: Ranking of authors based on h-index

Rank	Authors Name	Records	H-Index	Citations	Citation sum with in h-core
1	Schaye J	26	21	1404	1331
2	Springel V	22	17	3026	2980
3	Bond JR	21	16	9690	9640
4	Hernquist L	21	16	2604	2567
5	Scott D	21	15	9356	9311
6	Vogelsberger M	19	15	2510	2477
7	Dave R	16	14	1541	1535
8	Ferrara A	16	13	777	755
9	Pointecouteau E	13	12	9059	9055
10	Chluba J	13	12	606	603
11	Danese L	14	12	9000	8991
12	Noterdaeme P	16	12	740	718
13	Petitjean P	17	11	622	605
14	Banday AJ	11	11	9050	9050
15	Pradhan A	24	11	285	225
16	Hivon E	11	11	9082	9082
17	Rubino-Martin JA	12	11	9208	9206
18	Oppenheimer BD	12	11	1034	1024
19	Ledoux C	14	11	395	381
20	Delabrouille J	12	11	9054	9050

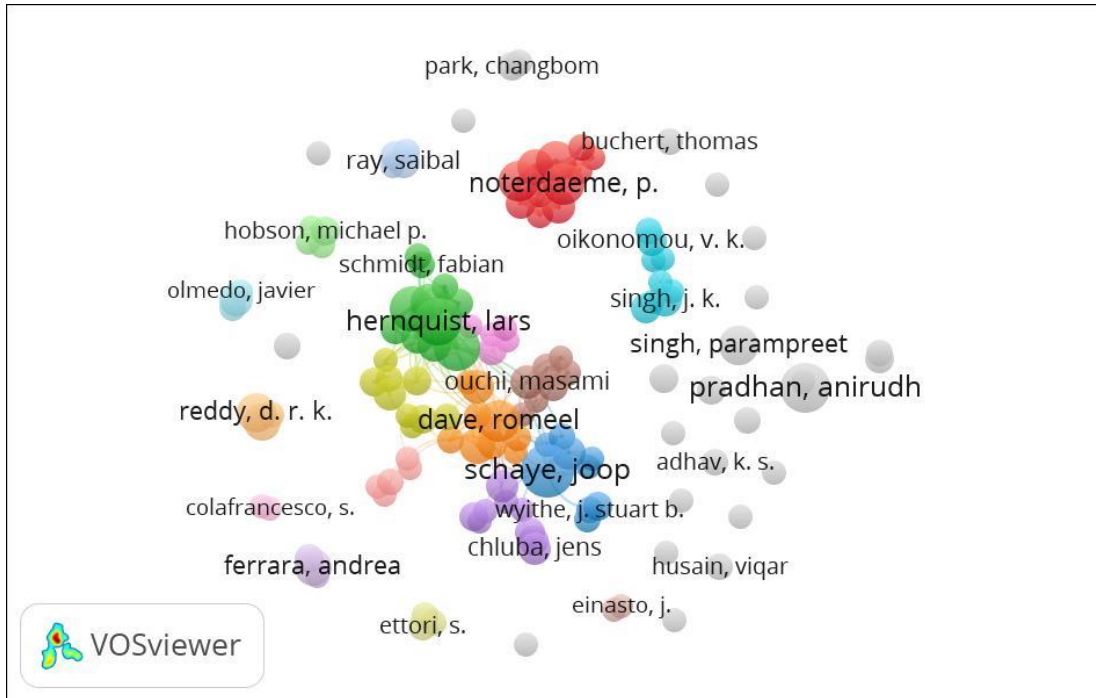


Figure 2: showing highly prolific authors

Table 5 and figure 2 shows that the ranking of authors of Physical Cosmology research. It was observed that there of 1979 records, the top 20 most productive authors, citations, and h-index during the period 2011-2020. Schaye J 26 papers with 1404 citations and 21 h-index, it is followed by Springel V 22 papers with 3026 citations and 17 h-index, Bond JR 21 papers with 9690 citations and 16 h-index, Hernquist L 21 papers with 2604 citations and 16 h-index, Scott D 15 papers with 9356 citations and 15 h-index and Vogelsberger M 19 papers with 2510 citations and 15 h-index. Other authors were h-index has 14 to 11 citations and publications different values.

Table 6: Ranking of Country and their Research Performance

S.No	Country	Records	%	TLCS	TGCS
1	USA	688	34.77	681	39606
2	UK	341	17.23	370	27588
3	Germany	399	20.16	459	22801
4	India	254	12.83	228	11009
5	Italy	245	12.38	126	15903
6	France	230	11.62	149	16539
7	Spain	168	8.49	89	13642
8	Japan	140	7.07	32	3115

9	Canada	137	6.92	65	19311
10	Netherlands	136	6.87	200	15006
11	Russia	117	5.91	60	10870
12	Peoples R China	116	5.86	42	2368
13	Switzerland	102	5.15	74	12695
14	Chile	90	4.55	67	10426
15	South Africa	87	4.4	66	12278
16	Australia	74	3.74	73	2508
17	Brazil	74	3.74	31	2134
18	Mexico	58	2.93	22	876
19	Poland	57	2.88	11	9614
20	Denmark	52	2.63	39	10452

*TLCS = Total Local Citation Score *TGCS = Total Global Citation Score

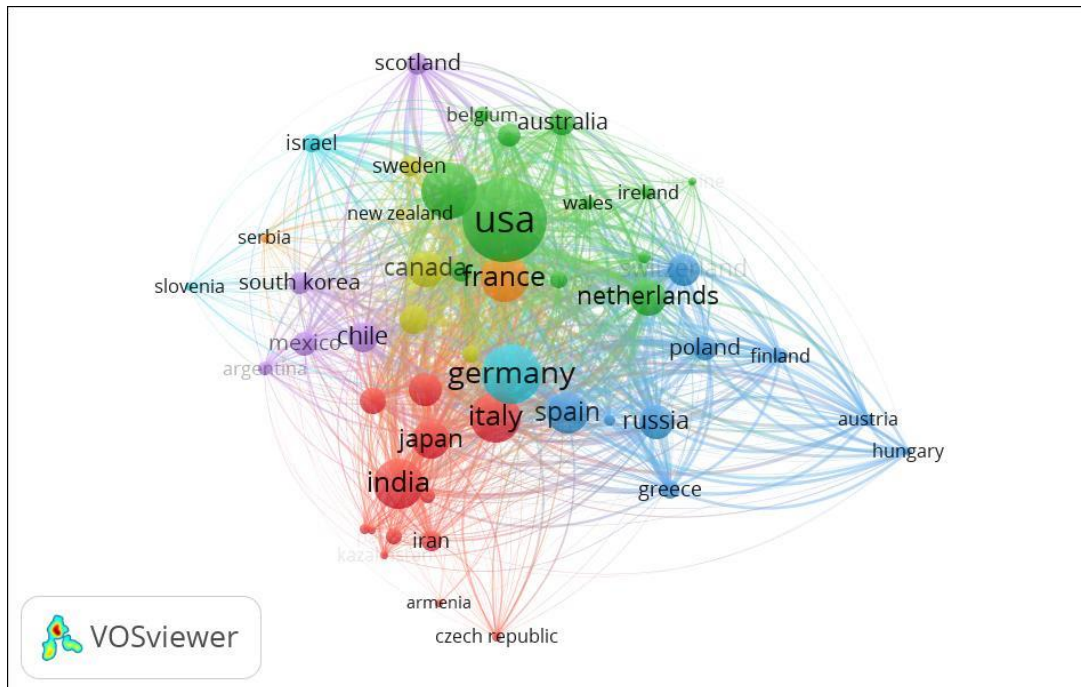


Figure 3: Showing ranking of country wise distribution

Table 6 and figure 3 show the ranking of countries wise papers of global level with top 20 countries during 2011-2020, in a total number of 79 countries participated in Physical Cosmology research. The largest number of publications of 688 physical cosmology was with the USA with a 34.77 percentage, 681 of local citation score and 39606 of global citation score. followed by the UK published 341 paper with a 17.23 percentage, 370 of local citation score and 27588 of global citation, Germany produced 399 papers with a 20.16 percentage, 459 of local

citation score and 22801 of global citation and India published 254 paper with a 12.83 percentage 228 of local citation score and 11009 of global citation score which is occupied the fourth position in Physical Cosmology research in the world.

Table 7: Ranking of Institutions and their Research Performance

S.No	Institution	Records	%	TLCS	TGCS	ACPP
1	California Institute of Technology	84	4.24	114	13098	155.92
2	Leiden University	81	4.09	163	4443	54.85
3	University California Berkeley	79	3.99	64	12544	158.78
4	Max Planck Institute Astrophysics	72	3.64	118	11837	164.4
5	University Tokyo	71	3.59	15	1787	25.17
6	University Cambridge	69	3.49	121	12388	179.54
7	Ist Nazl Fis Nuclear	66	3.34	14	10836	164.18
8	Harvard Smithsonian Center Astrophysics	64	3.23	211	4423	69.1094
9	University Durham	54	2.73	89	2292	42.44
10	Princeton University	53	2.68	27	17026	321.25
11	University Oxford	52	2.63	27	17059	328.058
12	CNRS	49	2.48	20	10254	209.27
13	University Chicago	49	2.48	63	8404	171.51
14	Johns Hopkins University	48	2.43	28	7986	166.38
15	Stanford University	48	2.43	39	9932	206.92
16	University Arizona	46	2.32	93	2528	54.96
17	Chinese Academy of Science	44	2.22	29	1287	29.25
18	University Edinburgh	44	2.22	61	1782	40.5
19	Heidelberg University	42	2.12	227	4399	104.74
20	University Paris	41	2.07	37	10354	252.54

**TLCS = Total Local Citation Score *TGCS = Total Global Citation Score *ACPP = Average Citation per Paper*

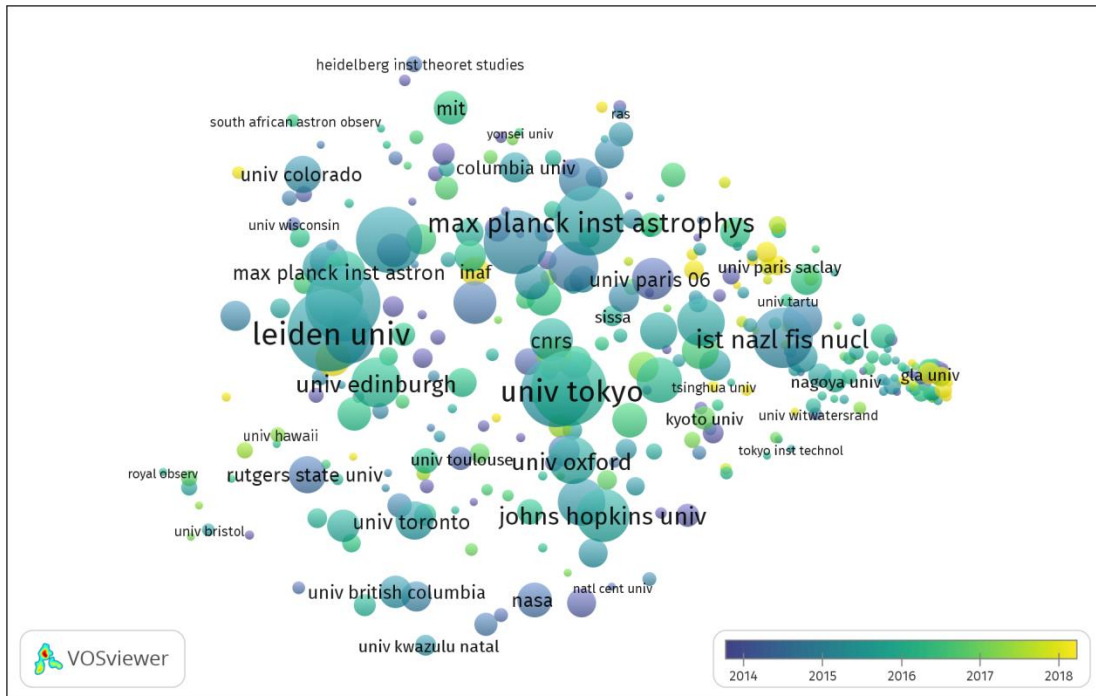


Figure 4: Collaboration of Institutions and their cluster

Table 7 and figure 4 the ranking list of the top highly productive research institutions in the global based on their highest publication, citations, and average citation per paper. According to the Web of Science database, it was found that output of 1979 research publication. California Institute of Technology contributed the highest publications in the field of physical cosmology, i.e. 84 (4.24%) research papers with 114 of local citation score, 13098 of global citation score, and 155.92 average citations per paper. It is followed by Leiden University published 81 (4.09%) research paper with 163 of local citation score, 4443 of global citation score, and 54.85 average citation per paper and University California Berkeley published 79 (3.99%) research paper with 64 of local citation score, 12544 of global citation score and 158.78 average citation per paper.

Table 8: Ranking of Journals with H-Index

Sl. No	Journal	Records	Citations	H-Index	Citation sum with in h-core	IF
1	Monthly Notices of the Royal Astronomical Society	416	13356	58	7160	5.356
2	Astrophysical Journal	175	5536	39	3789	5.745
3	Journal of Cosmology and Astroparticle Physics	126	3372	31	2388	5.210
4	Physical Review D	161	3315	31	2127	3.686

5	Astronomy & Astrophysics	100	10539	29	9901	5.636
6	Journal of High Energy Physics	63	1443	22	1156	5.875
7	Classical and Quantum Gravity	71	1271	20	968	3.487
8	International Journal of Modern Physics D	52	643	13	510	2.154
9	Astrophysical Journal Letters	17	680	13	649	5.745
10	European Physical Journal C	40	706	12	599	4.843
11	International Journal Of Theoretical Physics	39	322	11	237	1.347
12	General Relativity And Gravitation	39	310	11	223	2.030
13	Astrophysics And Space Science	48	358	10	240	1.885
14	Physics Letters B	21	586	10	534	2.087
15	European Physical Journal Plus	21	186	9	163	2.604
16	Canadian Journal Of Physics	20	141	8	112	1.032
17	Physics Reports-Review Section Of Physics Letters	7	1267	7	1267	28.295
18	Universe	19	86	6	65	2.165
19	Astrophysical Journal Supplement Series	7	6114	6	6109	5.745
20	Symmetry-Basel	10	92	6	82	2.645

**IF- Impact factor*

Table 8 shows the ranking of journals with h-index, the total number of 230 journals appeared in the list of 1979 physical cosmology publications during 2011-2020. This table reveals that Monthly Notices of the Royal Astronomical Society published 416 articles with 13356 citations, 58 h-index, 7160 h-core, and 5.356 impact factor, it is followed by Astrophysical Journal produced 175 articles with 3789 citations, 39 h-index, 3789 h-core, and 5.745 impact factor and Journal of Cosmology and Astroparticle Physics published 126 articles with 3372 citations, 31 h-index, 2388 h-core, and 5.210 impact factor. It is covered Physical Cosmology research from the web of science database journals; Monthly Notices of the Royal Astronomical Society get the first position and also the highest citations in this table.

FINDINGS AND CONCLUSION

The study quantitatively identified the research output in the field of Physical Cosmology at the global level over the study period of 2011-2020. The study identified the Degree of Collaboration was increasing and decreasing trend 0.73 to 0.83. Collaborative Co-efficient at the highest rate of 0.53 in the year 2011 and the mean Modified Collaborative Co-efficient during the period of study was 1.86, the modern trend towards research is one of the steps for the

updated current day by day. Physical Cosmology has become the most indispensable one in the field of research activity which leads the researcher to equip themselves and to bring new innovative ideas for the growth of Physical Cosmology.

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