P: ISSN NO.: 2394-0344 RNI No.UPBIL/2016/67980 VOL-4* ISSUE-12* March- 2020
E: ISSN NO.: 2455-0817 *Remarking An Analisation*

Astronomy and Astrophysics in India during 1994 -2015: Analysis of Geographically Distribution of Publications from Astrophysical Data System

Paper Submission: 15/03/2020, Date of Acceptance: 23/03/2020, Date of Publication: 28/03/2020

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Abstract

The impact of scientific productivity of country is measured by different parameters. It is important to a country that its research output should be contributed from all corners. In digital era, the research productivity of different institutes is gaining importance in the field of Astronomy and Astrophysics. Indian Astronomy and Astrophysics research growth has been shown in publications. Though numbers of institutes have been increased but only few institutes are contributing significant numbers of publications. The study attempts to trace the origin of the research output from different parts of India in the field of Astronomy and Astrophysics during 1995 – 2015.

Keywords: Astronomy and Astrophysics; Growth of Research; Productivity of India; Origin of Research Output; Scientometric Study.

Introduction

Astronomy is one of the oldest subject of India. It was practiced in India in the religious, mythological, and astrological practices. Modern Astronomy and Astrophysics (AA) research has root in ancient astronomy. The astronomy is being studies since ancient time in India. Gradually astronomy research evolved itself like other subject and new inventions made subject more advanced. Invention of telescope changed the entire process of astronomy research. The beginning of telescope aided astronomy gave researchers many opportunities to scale the universe. However it was not possible without using physics formulas and astrophysics became an integral part of astronomy research. Malik[1] states about Indian astronomy that "The beginning of telescope aided astronomy can be ascribed to the commissioning of the Madras observatory by East India Company in 1792. Besides some noteworthy observations, a catalogue of positions of over 11,000 stars was completed using this observatory". There are numerous institutes in India which are doing frontline research in AA.

In the cutting edge, astrophysicists comprehend the utilization of material science equations in stargazing. They applied material science laws to examine vast items and universe in enormous which develop cosmology into stargazing and astronomy as a subject. The research trends and growth of knowledge in scientific field can be measured by using various quantitative methods and techniques but to locate source of publication need lots of analysis. Hausmann[2] et al. states that "the amount of knowledge embedded in a society, however, does not depend mainly on how much knowledge each individual holds. It can be combine this knowledge, and make use of it, through complex webs of interaction". Latest research facilities should reach to as many as researcher want to use and want to take part in new research of any subject. It is also important to analyse the reach of a subject to common student. This paper attempts to find the origin of research publications and find out the reason behind imbalance in distribution geographically in research output with the help of Astrophysics Data System.

The data of present study is retrieved from Astrophysics Data System (ADS)[3] database. ADS was developed by the National Aeronautics

and Space Administration (NASA), and is being operated by the Smithsonian Astrophysical Observatory. The online database contains over thirteen million (1.3 Crores) Astronomy and Physics papers from both peer reviewed and non-peer reviewed sources. The data base contains abstract of for almost all articles and full scanned older articles in gif and pdf format. The ADS consists of searchable bibliographic records of astronomical literature which can be browsed or searched via search interface. The ADS provides access and pointers to external resources, including electronic articles, data catalogues and archives.

Objectives of the Study

The main objectives of the present study are to analyse the geographically distribution of Indian Astronomy and Astrophysics research output during 1994 – 2015, using quantitative and qualitative indicators. The main objectives of study are as following

1. Year-wise distribution of publications and cumulative research output of Indian Astronomy and Astrophysics;
2. To identify institute/organization-wise research output distribution;
3. To identify most productive organizations;
4. To identify most prolific research institutes as per average citations;
5. Analysis of Research Contribution different organizations toward Indian Astronomy and Astrophysics;
6. Tracing the origin of research output geographically.

Methodology

The study is based on the publications data retrieved from NASA - Astrophysical Data System. The data retrieved by using Perl programming language. Data is retrieved 9 May 2018 and updated on 29 July 2019 in text file which is converted into excel file. The study is limited to the period of 1994 – 2015.During the study period several new academic institutes have been established and these institutes have undertaken AA research. To understand the shift in the research output of Indian Astronomy and Astrophysics encourage me to take the study for the periods 1994 – 2015. The data was analysed as per the objectives of the study after the validation.

Analysis and Interpretation

Astronomy and Astrophysics Research Output

Total 14715 publications are published within a span of twenty-two years and publications vary every year. The highest numbers of publications are published in the year 2014 with the count of 1261 followed by year 2013 and 2015 with count of 1239 and 1205 respectively. The lowest numbers of publications are published in the year 1995 with count of 184. It is observed that out of 22 years, 8 years 1995, 1999, 2002, 2003, 2004, 2007, 2009, and 2015 have negative growth in term of number of publications. Over all research output of Indian AA increased but no definite pattern of literature growth can be ascertained.

Table 1: Year-wise Distribution of Indian Astronomy and Astrophysics Research Output

Year	Indian Research Output	Share (%) in Total Output	Cumulative Research Output	Cumulative % of Research Output
1994	268	1.82	268	1.82
1995	184	1.25	452	3.07
1996	202	1.37	654	4.44
1997	291	1.98	945	6.42
1998	379	2.58	1324	9.00
1999	364	2.47	1688	11.47
2000	537	3.65	2225	15.12
2001	545	3.70	2770	18.82
2002	508	3.45	3278	22.28
2003	484	3.29	3762	25.57
2004	442	3.00	4204	28.57
2005	563	3.83	4767	32.40
2006	867	5.89	5634	38.29
2007	704	4.78	6338	43.07
2008	852	5.79	7190	48.86
2009	788	5.36	7978	54.22
2010	941	6.39	8919	60.61
2011	1045	7.10	9964	67.71
2012	1046	7.11	11010	74.82
2013	1239	8.42	12249	83.24
2014	1261	8.57	13510	91.81
2015	1205	8.19	14715	100.00
Total	**14715**	**100.00**		

Indian cumulative research output is represented in the fig 1. From the figure, it can be visualise easily that until year 2005, graph has increased steadily. Between 2005 and 2010, research output growth increased consistently but after year 2010 research output growth has increased rapidly. It is found that output toward end of the study period is much higher compare to initial years and last three years of study is found highest hike in research output in AA.

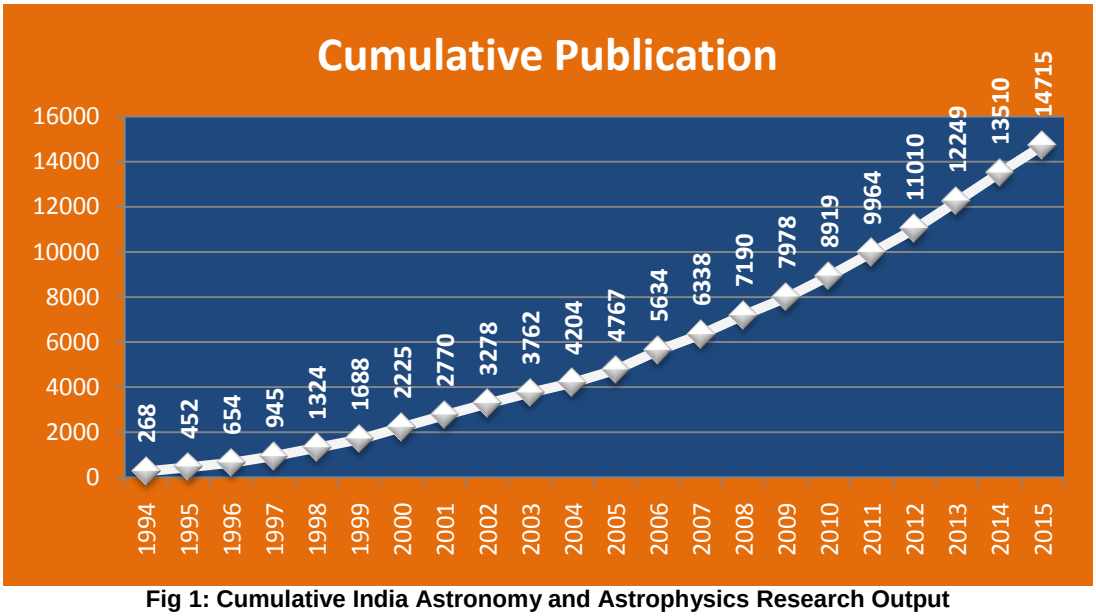


Fig 1: Cumulative India Astronomy and Astrophysics Research Output

Types of Documents

Indian research output in the field of AA mostly published in the form of articles. It has wide range of publications. Indian research output is published in 11 different categories as per ADS. These categories are journals' articles, proceeding articles, abstracts, proposals, Book chapters, Ph. D Thesis, Erratum, Books, Technical reports, Book reviews and miscellaneous categories.The research articles contribution toward India's output is 95.6 %. Out of total research output, 12,312 (83.67%) research articles are published in journals and 1,756 (11.93%) articles published in proceedings. The contribution of rest of the categories is less than one percent (<1%). Table 2 depicts the type of documents published by Indian researchers in the field of Astronomy and Astrophysics.

Table 2: Type of Documents

S. No.	Documents Type	Number of Publications
1.	Article	12312
2.	Proceedings	1756
3.	Abstract	456
4.	Proposal	50
5.	Book Chapter	42
6.	PhD Thesis	39
7.	Erratum	34
8.	Book	21
9.	Tech Report	2
10.	Misc	2
11.	Book Review	1
	Total	**14715**

As shown in above table, most part of the contribution comes from articles. Apart from articles (journals + proceedings), abstract 456 (3.10%), proposals 50 (.0.34%), book chapters 42 (0.29%), PhD thesis 39 (0.27%), erratum 34 (0.23%), books 21(0.14), technical reports 2 (0.01%), miscellaneous (0.01%) and 1 book review have been published.

Institutes wise Research Output Distribution

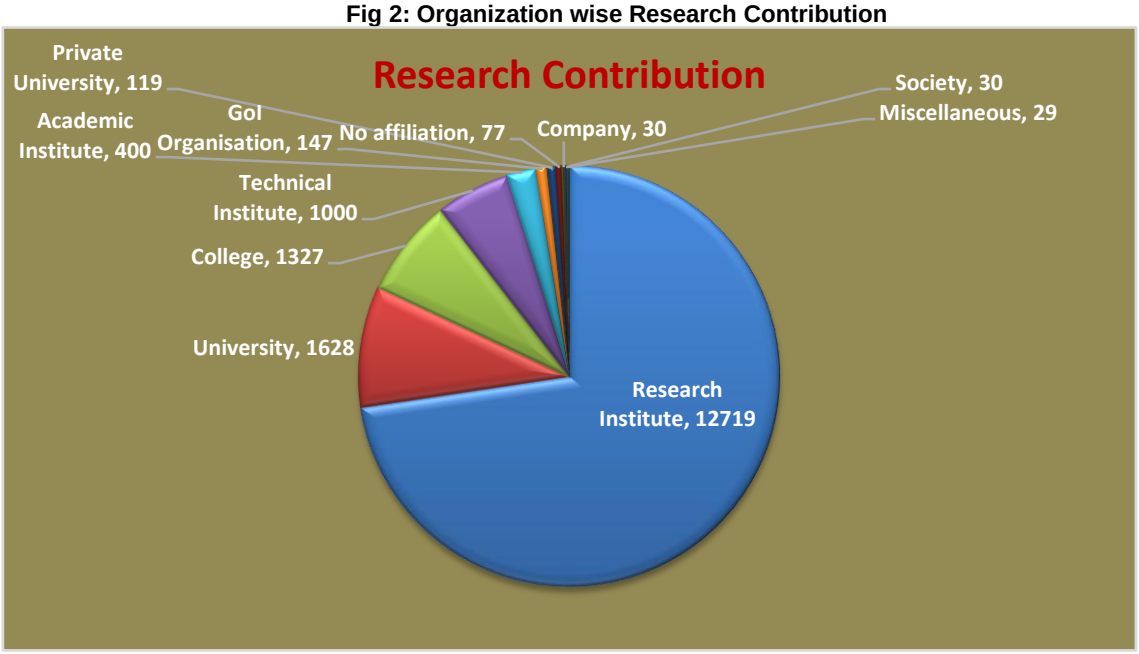
There is several evidences support existence of Astronomy in ancient India and Astronomical instruments were used during ancient era. Astronomy as a subject evolved after the invention of telescope. Indian share to the world AA research output is around 2%. AA in India is flourishing in the mostly in research institutes. Contribution of other organizations are less, so they have long way to go. Indian universities do not have AA as an independent subject. Although some of the universities have introduced AA as one of the papers in masters' degree. In comparison to universities, colleges do not have much presence of AA in their curriculum. New academic institutes have started AA research and their contribution to the Indian research output is increasing every year. Total 981 organizations have contributed in total 14715 publications of AA during 1994 - 2015. Efforts from all corners resulted on increasing the number of researchers and publications over the period of time. These organizations belong to different categories and these categories are being represented in tabular form in table 3.

Table 3: Organisation / Institute wise Contribution

S. No.	Organisation	Number of Institute	Total Output	Contribution in % of 14715
1.	Research Institute	129	12719	86.44
2.	University	158	3945	26.81
3.	College	434	1341	9.11
4.	Technical Institute	66	1000	6.80
5.	Academic Institute	26	398	2.70
6.	GoIOrganisation	44	147	1.00
7.	Private University	35	119	0.81
8.	No affiliation	44	77	0.52
9.	Company	22	30	0.20
10.	Society	9	30	0.20
11.	Miscellaneous	14	29	0.20

Total 981 institutes are categorized in 11 different categories. Research institutes have contributed highest 12719 (86.44%) articles. This 86.44 percent contribution of research institutes are contributed by 129 institutes. India has 799 Universities, 39071 colleges as per "All India Survey of Higher Education 2015 -15"[4] and 193 universities (public and private) universities have contributed second highest 4064 articles during 1994 – 2015.The colleges also contributed 1341 publications however average publications of colleges are 3 publications per college. Lack of infrastructure and research facilities is the reason behind less contribution from universities and colleges.Although technical institutes like IITs, NITs are technical education and research oriented still 66 technical institutes have contributed 100 research publications. Some of old academic institutes like Indian Association for the Cultivation of Science, Kolkata contributed more than 100 articles and new academic institutes like IISERs also showing their presence in AA. Contribution of government organisations, private companies, and society is small in number in AA. 44 individuals have contributed independently 77 articled during the study period. Fig 2 represents the organization-wise research output.

Fig 2: Organization wise Research Contribution



Most Productive Institutes

As explained above most of the research output is contributed by research institutes still there is significant contribution from other organizations as well specially university sector in the field of AA during 1994-2015. Table 4 depicts the most productive institutes which have contributed more than 200 publications during study period.

Table 4: Most Productive Institutes

Sr. No.	Institute	Place	Organization	Count	Cumulative Citations	H-Index
1.	TIFR with its Centres	Mumbai	Research Institute	2236	59747	95
2.	IUCAA	Pune	Research Institute	1600	79595	117
3.	IIA	Bangalore	Research Institute	1541	26596	64
4.	PRL	Ahmadabad	Research Institute	1192	16515	55
5.	RRI	Bangalore	Research Institute	714	18707	65
6.	ARIES (Formally UPSO)	Nainital	Research Institute	666	10474	47
7.	IISc.	Bangalore	Research Institute	478	10330	52
8.	VSSC	Thiruvananthapuram	Research Institute	393	4431	29
9.	IIG	Mumbai	Research Institute	393	4420	33
10.	Jadavpur University	Kolkata	University	362	5291	34
11.	SIN P	Kolkata	Research Institute	345	7003	44
12.	SNBNCBS	Kolkata	Research Institute	336	7099	45
13.	HRI	Allahabad	Research Institute	291	9853	53
14.	BHU	Varanasi	University	290	3105	26
15.	University of Delhi	Delhi	University	275	5578	37
16.	CSIR-NGRI	Hyderabad	Research Institute	264	3950	33
17.	BARC	Mumbai	Research Institute	233	2155	21
18.	University of Calcutta	Kolkata	University	207	2031	23
19.	IIT Kanpur	Kanpur	Technical Institute	201	4159	32
20.	University of North Bengal	Siliguri	University	110	2084	26
21.	IACS	Kolkata	Academic Institute	106	1831	23
22.	ISRO	Bangalore	Research Institute	101	1445	17

Tata Institute of Fundamental Research (TIFR)[5], Mumbai with its Centres is the most productive research institute among the all institutes with 2236 research publications. TIFR established in 1945 and it is involved in AA research since 1960s. Presently, TIFR has its six centres in different cities and couple of them are involved in AA research. Inter-University Centre for Astronomy and Astrophysics (IUCAA)[6], Pune has contributed second highest research output with count of 1600 articles during the study period. IUCAA has got maximum cumulative citations of 79595 for its publications during study period. IUCAA established as a resource centre for universities academicians in 1988 and manage to get highest h-index 117 among all organisations. Indian Institute of Astrophysics (IIA)[7] is stared with one of the oldest observatory but modern institute start functioning from 1971. IIA has its centres, located in Kodaikanal, Kavalur, Gauribidanur, Hanleand Hosakote. IIA contributed 1541 research publications. Physical Research Laboratory (PRL)[8] established in 1947 and is involved in astronomy and cosmic rays research in the initial years but now its areasof research are space and atmospheric science, solar physics, geoscience, theoretical physics, etc. PRL has contributed 1192 publications during study period. Other than research institutes only Javadpur University appeared in top 10 most productive institutes.There are 53 organizations which contributed more than 50 publications during study period in the field of AA. These 53 institutes involved highest 26 research institutes, 19 universities, 5 technical institutes and 3 academic institutes. Study of average citations of research institutes will help to identify most prolific institute.

Most Prolific Research Institutes as per Average Citations

Research Institutes have contributed maximum numbers of AA publications during 1994 – 2015. However, some of these institutes are not fully dedicated to AA research but have as a branch or group of researchers who are involved in AA research. It is important to identify the most prolific institutes in term of average citations per articles and their h-index[9]. There are 18 research institutes which have more than 10 average citations per paper. Table 5 represents the most prolific institutes as per average citations per paper and their h-index.

Table 5: Most Prolific Research Institutes

Sr. No.	Institute	Count	Cumulative Citations	Average Citation per paper	H-Index
1.	IIUCAA	1600	79595	50	117
2.	HRI	291	9853	34	53
3.	IMSc	149	4066	27	34
4.	TIFR with its Centres	2236	59747	27	95
5.	RRI	714	18707	26	65
6.	IISc	478	10330	22	52
7.	SNBNCBS	336	7099	21	45
8.	SINP	345	7003	20	44
9.	IIA	1541	26596	17	64
10.	ARIES	666	10474	16	47

It can be observed from table that higher number of publications do not mean to get more citations. TIFR has highest publications but stands fourth in term of average citations per paper. Among the top 10 research institutes IMSc has minimum publications but stands third. IUCAA is the top among these institutes in term of average citations per paper and h-index. It has highest 117 h-index. In term of h-index, six institutes namely IUCAA (117), TIFR (95), RRI (65), IIA (64), HRI (53), and IISc (52) have h-index more than 50. These institutes have impact on AA research in India.

Research Contribution of Universities and Colleges

Scientists get research attitude from their education institutes. Universities play important role to develop research attitude among students. Universities and colleges are nursery of researchers. Hence, research facilities and infrastructure of the universities should be upgraded from time to time. Indian universities and colleges contributions have been studied and it is found that some universities are contributing in all fields including AA research. Total 193 universities (158 public and 35 private) have contributed 4064 publications articles.Table 6 represents 10 top contributing universities.

Table 6: Contribution of Universities

Sr. No.	Name of University	Number of Publications	% of Universities Contribution (Total 4064)
1.	Jadavpur University	362	8.91
2.	Banaras Hindu University	290	7.14
3.	University of Delhi	275	6.77
4.	University of Calcutta	207	5.09
5.	Jamia Millia Islamia	141	3.47
6.	University of North Bengal	110	2.71
7.	Kumaun University	82	2.02
8.	Osmania University	75	1.85
9.	Andhra University	74	1.82
10.	Cochin University of Science and Technology	73	1.80

Out of 4064 publications, 158 public universities have contributed 1628 publications and 35 private universities have contributed 119 publications. 6 universities have contributed more than 100 publications and Jadavpur University has contributed highest 362 publications. Banaras Hindu University produced second highest 290 articles among universities followed by University of Delhi (275), University of Calcutta (207), Jamia Millia Islamia (141) and University of North Bengal (110). 40

universities contributed only single publications and 116 universities have contributed less than 10 publications. Among 35 private universities, four universities have contributed in 10 or more publications. Researcher affiliated to Christ University has contributed in 14 publications followed by Thapar University in 12 publications. Lovely Professional University and Sharda Group of Institutes have contributed in 10 publications each.

Research Contribution of Colleges

Research activities are not priority in colleges yet it is pleasant to see 1341 research publications are contributed by 434 colleges in AA during 1994 - 2015. Out of 434 colleges, 238 colleges have produced one article each during 1994 – 2015. 71 colleges with 2 articles each, 39 colleges with 3 articles each, and 25 colleges with 4 articles also contributed. 39 colleges produced between 5 – 10 articles. 10 colleges produced more than 10 articles. Top 10 contributing colleges have been shown in table 7.

Table 7: Research Contribution of Colleges

Sr. No.	Colleges Name	Publications	Percentage of Colleges Contribution (Total 1341)
1.	Hindu Post Graduate College Zamania	46	3.43
2.	Presidency College, Kolkata	39	2.91
3.	VHNSN College, Virudhunagar	35	2.61
4.	Government College of Engineering & Ceramic Technology, Kolkata	28	2.09
5.	Cotton College , Guwahati	26	1.94
6.	GMR Institute of Technology, Rajam	25	1.86
7.	Pailan College of Management and Technology, Kolkata	22	1.64
8.	Arul Anadar College, Karumathur	21	1.57
9.	MaharajVijayaramGajapathi Raj Engineering College, Chintalavalasa	21	1.57
10.	Government Model Science College (Autonomous), Jabalpur	20	1.49

Out of 343 colleges, 18 colleges have contributed more than 1% of total college's publication. Hindu Post Graduate College (HPGC) Zamania, UP is contributed in highest 46 publications among all colleges. It is observed that HPGC faculties and their students are associated with research institutes like IUCAA. Presidency College, Kolkata and VHNSN College, Virudhunagar have contributed with 39 and 35 publications respectively. These three colleges contribute in more than 30 publications.

Research Output of Academic and Technical Institutes

One of the main objectives of academic institutes isto promote higher education and research attitude among students. These institutes have better research facilities therefore these institutes have produced significant research publications. Although main objective of technical institutes is to promote technical education among student but these institutes also have research facilities of allied sciences. 1000 publications have been contributed by 66 technical institutes and 27 academic institutes have contributed 398 research articles during the study period. Top 10 contributing institutes are shown in table 8.

Table 8: Research Contribution of Academic and Technical Institutes

Sr. No.	Name of Institute	Institute	Publications	% of 1398 Publications
1.	IIT Kanpur	Technical Institute	201	14.38
2.	IIT Kharagpur	Technical Institute	185	13.23
3.	IIT Roorkee	Technical Institute	116	8.30
4.	IACS Kolkata	Academic Institute	106	7.58
5.	IIT Bombay	Technical Institute	89	6.37
6.	IIT Delhi	Technical Institute	88	6.29
7.	IISER Pune	Academic Institute	51	3.65
8.	IISER, Trivandrum	Academic Institute	51	3.65
9.	IIT Gandhinagar	Technical Institute	46	3.29
10.	IISER, Kolkata	Academic Institute	42	3.00

Table 8 depicts the research contribution of academic and technical institutes. IIT Kanpur is highest contribution with count of 201 publications among all technical and academic institutes. Next two institutes IIT Kharagpur and IIT Roorkee are technical institutes. Indian Association for the Cultivation of

Science (IACS) Kolkata has contributed 106 publications. There are 6 Technical institutes and 4 academic institutes in top 10. Technical institutes include IITs, NITs and Engineering collegesand8 IITs have contributed 786 research publications. Among academic institutes 5 IISERs which are relatively new institutes have contributed in 174 publications. IISER Pune and Trivandrum have produced 51 articles each. IISER Kolkata (42), IIEST (37), IISST (37) have contributed more than 30 articles each.

Geographical Distribution of Publications

Indian AA research contribution of towardthe world publication is very less.It is important to know that why Indian is lacking behind. It is important to know the present status of research output distribution in India geographically in order to promote research and create new facilities in future. For better understanding of publication distribution geographically, India has been divided into 6 zones. Research output distribution is studied zone-wise. State-wise study helps to find out the most productive states then finally, cities-wise analysis is studied to find which cities are involvedin AA research most. India has been divided in following zones and states under these zones have been named. Contribution of each zone has been shown below in the table 9.

Table 9: Zone-wise Research Output

Geographical Zone	Name of States	Research Output	% of 14715
West Zone	Rajasthan, Gujarat, Goa and Maharashtra	7096	48.22%
South Zone	Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, Punducherry and Andaman and Nicobar	4731	32.15%
North Zone	Jammu and Kashmir, Himachal Pradesh, Punjab, Uttarakhand, Uttar Pradesh, Haryana, and Delhi.	4003	27.20%
East Zone	Bihar, Orissa, Jharkhand, and West Bengal	3213	21.83%
North-East Zone	Assam, Sikkim, Nagaland, Meghalaya, Manipur, Mizoram, Tripura and Arunachal Pradesh	417	2.83%
Central Zone	Madhya Pradesh and Chhattisgarh	375	2.55%

It is found from the above table that AA research is showing its presence in all zones but couple of zones i.e. Central and North-East have their share in less than 3% publications and reason behind of this no AA research institutes are located in these zones. Most of the research output from these zones is contributed by universities or colleges. Highly productive research institutes are located in West zone hence it has the highest numbers of publications with count of 7096. West zone contributes in almost half of the total publications. Three most productive institutes namely, TIFR, IUCAA and PRL are located in West zone. Some of prominent research institutes are located in South zone therefore; it has second highest contribution with count of 4731 publications. North zone with 4003 publications and East zone with 3213 publications have significant contribution. Research institutes and universities sectors have contributed for this zone.

State wise Contribution

States and union territories wise research output distribution in AA of India during 1994 – 2015is depicted in the table 10. State wise research contributionshave been studied on the present states and union territories (UT) by the end of year 2015. Chandigarh is considered as part of Punjab. It is found that research publications are contributed by all states and three union territories Delhi, Puducherry, and Andaman and Nicobar.

Table 10: State wise Contribution of Astronomy and Astrophysics

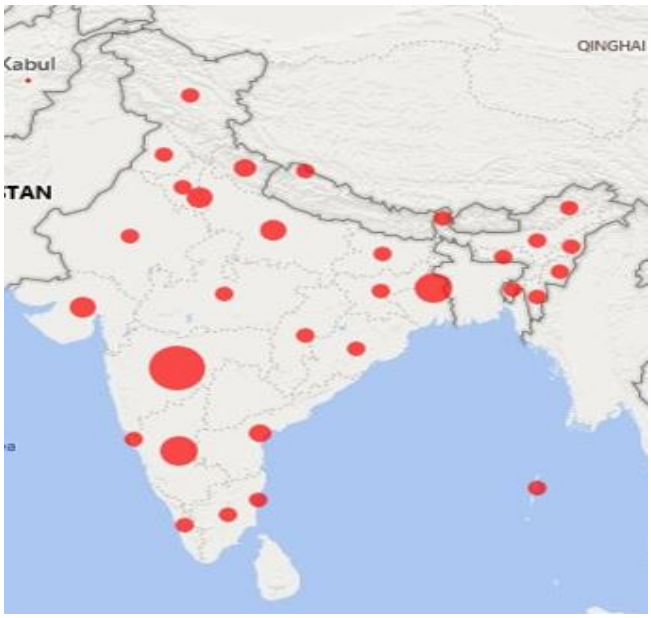
Sr. No.	State	Publications	Contribution in total output (14715)
1.	Maharashtra	5223	35.49
2.	Karnataka	2930	19.91
3.	West Bengal	2863	19.46
4.	Delhi (UT)	1525	10.36
5.	Gujarat	1485	10.09
6.	Uttar Pradesh	1228	8.35
7.	Uttarakhand	968	6.58
8.	Andhra Pradesh*	949	6.45
9.	Kerala	442	3.00
10.	Tamil Nadu	398	2.70
11.	Assam	316	2.15
12.	Rajasthan	287	1.95

Sr. No.	State	Publications	Contribution in total output (14715)
13.	Madhya Pradesh	268	1.82
14.	Orissa	248	1.69
15.	Punjab	136	0.92
16.	Chhattisgarh	107	0.73
17.	Goa	101	0.69
18.	Bihar	92	0.63
19.	Haryana	68	0.46
20.	Manipur	51	0.35
21.	J&K** (UT)	46	0.31
22.	Himachal Pradesh	32	0.22
23.	Meghalaya	19	0.13
24.	Tripura	17	0.12
25.	Jharkhand	10	0.07
26.	Puducherry (UT)	9	0.06
27.	Sikkim	8	0.05
28.	Andaman and Nicobar (UT)	3	0.02
29.	Nagaland	3	0.02
30.	Arunachal Pradesh	2	0.01
31.	Mizoram	1	0.01

*Before Separation of Telangana ** Before bifurcation into Two UT

As shown in table 10 all states have produced at least one article. Five states and one UT have contributed in more than thousand publications. These six states have at least one research institutes which involve in AA research. Maharashtra's contribution is the highest with 5223 publications as most productive institutes are located in this state followed by Karnataka (2930) and West Bengal (2863). Delhi is only UT which contributed in 1525 publications. Delhi publications are combination of research institutes and universities publications. Gujarat and Uttar Pradesh have contributed in 1485 and 1228 publications respectively. With the use of research output data of table 10, A symbolically bubble map of India research output have been shown in figure 4. The size of bubble represents number of publications contributed.

Fig 4: Astronomy and Astrophysics Research on India's bubble map



City-wise Contribution

The study of city-wise distribution of research contribution is important to know the depth of research facilities of any country. Indian metro cities have research facilities in their research institutes or universities. Small cities,' universities and colleges always crave for research facilities. This city-wise study will help to identify the geographical areas to promote of AA research and education. Research and development activities in AA can be focused on these promising cities immediately. 982 different institutes have contributed in 14715 research output and these 982 different institutes are located in 344 cities. 111 cities have contributed in only one publication each and 244 cities have contributed in 10 or less than 10 publications. Four metropolitan cities namely Mumbai, Delhi, Kolkata and Bangalore have contributed in 9563 publications. Pune (1903 publications) and Ahmadabad (1192) two non metropolitan cities have contributed in more than 1000 articles however highly productive institutes are located in these cities. 25 cities have contributed in more than 100 publications and Mumbai has contributed in highest 3067 publications followed by Bangalore with count of 2894 and Kolkata 2072. It is found from table 11 that researcher from these cities are more attracted towards AA research than other cities and reason behind this is availability of research facilities in these cities. Highly productive top 10 cities are depicted in table 11.

Table 11: Most Productive Cities

Sr. No.	Name of City	Publications	% of 14715
1	Mumbai	3067	21
2	Bangalore	2894	20
3	Kolkata	2072	14
4	Pune	1903	13
5	Delhi	1530	10
6	Ahmadabad	1192	8
7	Naitital	748	5
8	Hyderabad	477	3
9	Allahabad	345	2
10	Varanasi	297	2

Conclusion

Modern Astronomy and Astrophysics research has root in ancient astronomy. The astronomy is being studied since ancient time in India. Still Indian contribution toward world AA research is less than 2 percent. India has highly productive institutes in term of publications and citations. These Indian research institutes are a part of big international consortium like LIGO, TMT, etc. and research publications of these projects have given new direction to research in this field. These institutes have collaboration with the world's top institutes as well. Still, many parts of India are not involved in quality research in many subjects especially in AA. It is found that AA is not part of even regular curriculum of graduate degree. Some of the universities have introduced astrophysics as a part of M. Sc. Degree. Indian research in AA during 1994 – 2015 is contributed by scientists form research institutes, faculties of universities and colleges and PhD scholars. There is no or less contribution from students. Indian metro cities are well equipped with research facilities whereas small cities education institutes are longing for facilities. Availability of research facilities resulted most of the research contributions from the metro cities in the field of Astronomy and Astrophysics during 1994 – 2015. However, many small cities also contributed significantly. This research may help to extend research facilities to various cities and as well many universities may be given research facilities.

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