

Research Productivity of Indian Institute of Astrophysics (IIAP) during 2005-2014: A Scientometric Study

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Abstract - *The study has been conducted to explore the scholarly communications of faculties and researchers of Indian Institute of Astrophysics (IIAP), Bangalore. The data were retrieved from the world most preferable database Web of Science. The study analyzed 1005 articles published by IIAP during the period 2005-2014. The highest number of articles 125(12.44%) were published in the year 2011 followed by 113 (11.24%) in the year 2009 & 2010. Three author contributions have predominant with 220(21.89%) articles followed by two author 179(17.81%) and four author 153(15.22%) articles. The 1005 articles have received 10183 citations during the year. The degree of collaboration is 0.88. R.K.Chaudhuri, G.C.Anupama and B.P.Das are top three authors contributed 64, 59, and 56 articles during the period. Astrophysical Journal topped the rank list to publish the papers by authors with 153 (15.22%) followed by Monthly Notices of the Royal Astronomical Society 129 (12.84%) and Astronomy and Astrophysics 122 (12.14%).*

Keywords: Astronomy and Astrophysics, Scientometrics, Authorship Pattern, Citations, Lotka's Law

Introduction

The publication profile of an institution is a vital indicator to the individual institution as well as to the country. Evaluation of research output of an institution's highlights the research performance of individual Faculties, Scientist and Engineers as well as contribution of the institution. The study will benefit policy makers and decision makers of the individual institutions to increase the research productivity. The scientific productivity can be measured through the techniques of scientometrics. In 1969, Vassily V. Nalimov & Z. M. Mulchenko coined the Russian equivalent of the term 'scientometrics' ('naukometriya'). It is a quantitative and qualitative study of publication productivity in various types namely, publication pattern, authorship pattern, degree of collaboration, citation analysis, impact factors, h-index, and networks of scholarly communications etc.,

Indian Institute of Astrophysics (IIAP), Bangalore

The Indian Institute of Astrophysics (www.iiap.res.in) is a premier institute devoted to research in astronomy, astrophysics and related physics. It traces its origin back to an observatory set up in 1786 at Madras Observatory. William Petrie first started as his own private observatory set up for the navigational purpose to East India Company. In 1899, the observatory moved to Kodaikanal. In 1971, the Kodaikanal Observatory was converted to an autonomous research institute, wholly financed by Government of India and henceforth as the Indian Institute of Astrophysics. The headquarters were shifted to Bangalore into its present campus in Koramangala in 1975. The main campus of the Institute is in Koramangala, Bangalore, whereas the Hosakote campus, near Bangalore houses the Centre for Research and Education in Science and Technology (CREST). The main observing facilities of the Institute are located at Gauribidanur, Hanle, Kavalur and Kodaikanal.

Review of Literature

Chaurasia, N.K. & Chavan, S.B. (2014) studied the research output of IIT (Delhi) during 2001-2010 using Web of Science database. The study explored that, the total number of 6109 publications has been registered by IIT (Delhi) for 10 years. In that "Journal Article" was found most favored document type with 5731(93.812%) followed by "Proceedings Paper" with 461(7.546%) and "Review" with 192(3.143%). The year wise growth shows that its publications steadily increasing year by year and the annual average growth rate was 10.37%. The authorship pattern shows that the multi-authored contributions were predominant where as the single author contributions are 4.41%. The degree of collaboration of IIT Delhi is 0.96. The IIT faculties are most preferred foreign journals to publish their research work. Finally, the author concluded that there is urgent need for bibliographic control of IIT Delhi publications by creating a comprehensive database of publications.

Aswathy, S. & Gopikuttan, A. (2013) analyzed the publication of faculty members of three universities in Kerala viz., University of Kerala, Mahatma Gandhi University and University of Calicut during 2005-2009. The study focused on journal articles only. The data were collected by consulting the annual reports and websites of the concern universities. The study shows that there is a growth in the year wise publication. It is found that multi-authored contributions are more and Lotka's inverse square law was not suitable for the data.

Pillai Sudhier, K.G. & Priyalakshmi, V. (2013) in their study explored the publications of Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram during 2001-2010. The data were collected from annual reports of the centre. They studied about year wise

distribution, year wise breakup of the article in Indian and Foreign journals, authorship pattern, collaboration, most productive journal and applicability of Bradford's Law of Scattering. It was found that the average number of publications per year was 97.82. Multi-authored contribution was more than the single author. The degree of collaboration was 0.87. The CTCRI scientist does not fit the Bradford's distribution pattern.

Meera and Sahu, Surendra Kumar. (2014) carried out the study of research output of University College of Medical Science, University of Delhi. The data were collected from SCOPUS database. The results shows that collaborative works has got more number of publications i.e. contribution of 25.6 percent of total publications is made by three author. The degree of collaboration is 0.92. The researchers are most preferred Indian journals to publish their research papers. USA is the most preferred country by the researchers for research collaboration.

Radhakrishnan, Natarajan and Velmurugan, Chandran. (2015) studied the Scholarly publications by the Faculty members of Periyar University, Salem, India. The data were retrieved from Web of Science (WOS) database during the year 1998-2014. The study focused on authorship pattern, type of documents, TLCS (Total Local Citation Score), TGCS (Total Global Citation Score), TLCR (Total Local Citation References), TLCSb (Total Global Citation Score in the beginning), and TLCSe (Total Local Citation Score at the end). The study found that, multi-authors publications are higher than single author. The degree of collaboration is 0.99. The study observed that collaborative research among the institutions, South Korea is well associated with Periyar University.

Velmurugan, C., and Radhakrishnan, N. (2015) studied collaborative research and authorship pattern of Journal of Intellectual Property Rights during 2007-2014. The study analyzed authorship pattern, length of articles, multi-authored papers, degree of collaboration and state wise distribution. The single author contribution was very high with 248(63.92%) out of 388 articles during the year. The degree of collaboration of this journal is 0.36. Indian author's contribution was high compare to foreign authors.

Objectives of the Study

- To portrait the research productivity of IIAP
- To assess the year-wise distribution of publications
- To exhibit the authorship pattern
- To explore the most productive author
- To provide year-wise citations to the articles published
- To find out the authors most preferred journals to publish their research work
- To test the Lotka's Law of Scientific Productivity

Methodology

The present study aims to evaluate the research productivity of IIAP during the period 2005-2014. The data were retrieved from the world most preferable database ISI, Web of Science (WoS), Science Citation Index (SCI). We used the advance search field to retrieve data and the query entered like this, "AD=Indian Inst Astrophys AND PY=2005-2014". The data was taken from the database as on 25th Nov. 2016. The data were taken into MS-Excel to analyze further.

Analysis of Data

Table.1 represents the year-wise distribution of publications of IIAP during the period 2005-2014. The result shows that the highest number of papers published in the year of 2011 with 125 (12.44%) followed by the year 2009 and 2010 with 113 (11.24%) and lowest number of papers published in the year 2006 with 77 (7.66%) followed by the year 2005 with 89 (8.86%) and the year 2008 with 90 (8.96%). The average number of papers published per year is 100.5.

Table.1 Year-wise Distribution of Publications

Year	Total Publications	%
2005	89	8.86
2006	77	7.66
2007	94	9.35
2008	90	8.96
2009	113	11.24
2010	113	11.24
2011	125	12.44
2012	104	10.35
2013	104	10.35
2014	96	9.55
Total	1005	100%

Authorship Pattern

Table 2 depicts that out of 1005 papers, the three author contributions 220 (21.89%) followed by two author contributions 179 (17.81%), four author contributions 153 (15.22%), single author contributions 111 (11.04%), five author contributions 104 (10.35%) and >100 & >200 author contributions 2 (0.2%) is the least number. It shows that the multi-authored collaboration is predominant than single author and it also proves the earlier studies. Hence, the team work gets more publications for IIAP.

Table 2. Authorship Pattern

Number of Authors and Publications																			
Year	1	2	3	4	5	6	7	8	9	10	>10	>20	>30	>40	>50	>100	>150	>200	Total
2005	11	23	18	15	11	2	1	2			3	1			1			1	89
2006	8	15	16	19	8	5	1	1			2	1			1				77
2007	8	17	19	15	12	10	3	4			4	2							94
2008	16	16	18	13	14	3	4		1	1	1	1	1		1				90
2009	19	20	22	13	11	8	6	1	2	1	4	5				1			113
2010	20	18	32	13	9	3	2	1	2	2	5	1	1		3	1			113
2011	10	24	38	21	6	2	1	3	7	2	2		1		4		3	1	125
2012	7	23	17	17	7	7	5	4	1	2	8	2	1	1	2				104
2013	9	12	20	13	11	11	2	1	3	3	11	2	2	2	2				104
2014	3	11	20	14	15	10	5	4	2	1	8			1	2				96
Total	111	179	220	153	104	61	30	21	18	12	48	15	6	4	16	2	3	2	1005
%	11.04	17.81	21.89	15.22	10.35	6.07	2.99	2.09	1.79	1.19	4.78	1.49	0.6	0.4	1.59	0.2	0.3	0.2	100%

Year-wise Citations

Table 3 shows that the 1,005 papers (published) have received 10,183 citations during the period. The highest number of citations i.e. 2124 (20.86%) was received in 2011, followed by 1284(12.61%) citations in 2005. Lowest citations i.e. 183(1.80%) was received in 2014. The average number of citations per paper is 10.

Table.3 Year-wise appearance of citations		
Year	No. of Citations	%
2005	1284	12.61
2006	1216	11.94
2007	898	8.82
2008	940	9.23
2009	1264	12.41
2010	1210	11.88
2011	2124	20.86
2012	669	6.57
2013	395	3.88
2014	183	1.80
Total	10183	100.00

Degree of Collaboration

Degree of collaboration is useful to find out the publication pattern of single and multi-author. This can be achieved by the formula given by Subramanyam, K. (1983). The formula can be mathematically expressed as follows,

$$C = \frac{Nm}{Nm + Ns}$$

Where C=Degree of Collaboration,

Nm= Number of Multi-authored publication

Ns= Number of Single authored publication

Hence, $C = \frac{894}{894 + 111}$

$$C = 0.88$$

Table 4. Determines that the degree of collaboration ranges from 0.82 to 0.96 and the average degree of collaboration is 0.88.

Table 4 Degree of Collaboration

Year	1	2	3	4	5	6	7	8	9	10	>10	>20	>30	>40	>50	>100	>150	>200	Total	DC
2005	11	23	18	15	11	2	1	2			3				1			1	89	0.86
2006	8	15	16	19	8	5	1	1			2	1			1				77	0.89
2007	8	17	19	15	12	10	3	4			4	2							94	0.91
2008	16	16	18	13	14	3	4		1	1	1	1	1		1				90	0.82
2009	19	20	22	13	11	8	6	1	2	1	4	5				1			113	0.83
2010	20	18	32	13	9	3	2	1	2	2	5	1	1		3	1			113	0.82
2011	10	24	38	21	6	2	1	3	7	2	2		1		4		3	1	125	0.92
2012	7	23	17	17	7	7	5	4	1	2	8	2	1	1	2				104	0.93
2013	9	12	20	13	11	11	2	1	3	3	11	2	2	2	2				104	0.91
2014	3	11	20	14	15	10	5	4	2	1	8			1	2				96	0.96

Most Favored Journals for Publication

Table 5 represents the top 15 ranking of the journals of which the IIAP authors most preferred to publish their research work. The results shows that the Astrophysical Journal with 153 (15.22%) papers is highest in the 1st rank followed by Monthly Notices of the Royal Astronomical Society with 129 (12.84%) papers in the 2nd rank, Astronomy & Astrophysics with 122 (12.14%) papers in the 3rd rank. The remaining journals titles is of 2 digit value of publications in that the Indian Journals is also got interest of IIAP authors to publish their research work namely, Bulletin of the Astronomical Society of India with 40 (3.98%) papers in the 6th rank, Journal of Astrophysics and Astronomy with 21 (2.09%) papers in the 10th rank, Current Science with 17 (1.69%) papers in the 11th rank and Pramana-Journal of Physics with 11 (1.09%) papers in the 15th rank. Hence, the authors of IIAP mostly preferred foreign journals to publish their research work.

Table.5 Most Favored Journals

Sl. No.	Favored Journals	Total	%	Ranks
1	Astrophysical Journal	153	15.22	1
2	Monthly Notices of the Royal Astronomical Society	129	12.84	2
3	Astronomy & Astrophysics	122	12.14	3
4	Solar Physics	45	4.48	4
5	Physical Review A	44	4.38	5
6	Bulletin of the Astronomical Society of India	40	3.98	6
7	Astrophysics and Space Science	29	2.89	7
8	Astrophysical Journal Letters	27	2.69	8
9	Astronomical Journal	22	2.19	9
10	Journal of Astrophysics and Astronomy	21	2.09	10
11	Current Science	17	1.69	11
12	Journal of Chemical Physics	16	1.59	12
13	New Astronomy	15	1.49	13
14	Journal of Physics B	14	1.39	14
15	Pramana-Journal of Physics	11	1.09	15

Most Prolific Author

Table 6 indicates the list of top 15 prolific author's contribution during the period. During the period 1005 articles were published by 3023 authors. The study reveals that R.K.Chaudhuri is most prolific author contributed with 64 (0.93%) articles in the 1st positions followed by G.C.Anupama with 59 (0.86%) articles in the 2nd positions and B.P.Das with 56 (0.81%) articles in the 3rd positions.

Name	Number of Papers	Rank	%
Chaudhuri, R.K.	64	1	0.93
Anupama, G.C.	59	2	0.86
Das, B.P.	56	3	0.81
Sahu, D.K.	51	4	0.74
Nagendra, K.N.	48	5	0.70
Murthy, J	44	6	0.64
Bhatt, B.C.	37	7	0.54
Subramaniam, A	37	7	0.54
Banerjee, D	34	8	0.49
Prabhu, T.P.	33	9	0.48
Gaur, V.K.	28	10	0.41
Ravindra, B	29	11	0.42
Giridhar, S	27	12	0.39
Sampoorna, M	25	13	0.36
Rao, N.K.	25	13	0.36
Singh, J	17	14	0.25
Ramesh, R.	15	15	0.22

Highly Cited Articles

Table 7 shows that the list of top 25 highly cited articles during 2005-2014. It is found that the article title “SDSS-III: massive spectroscopic surveys of the distant universe, the milky way, and extra-solar planetary systems by Eisenstein, Daniel J...et al. in the year 2011 published in the journal “Astronomical Journal” has got highest number of citations as 733 citations in the 1st positions followed by the article titled “The eighth data release of the SLOAN digital sky survey: first data from SDSS-III” written by Aihara, Hiroaki...et al. in the year 2011 published in the journal “Astrophysical Journal Supplement Series” has got 725 citations in the 2nd positions and the article titled “Elemental abundance survey of the Galactic thick disc” by Reddy, BE; Lambert, DL; Prieto, CA in the year 2006 published in the journal Monthly Notices of the Royal Astronomical Society has got 393 citations in the 3rd positions.

Table 7. List of Top 25 Highly Cited Articles

S.N	Title	Authors	Year	Total Citations
1	SDSS-III: massive spectroscopic surveys of the distant universe, the milky way, and extra-solar planetary systems	Eisenstein, Daniel J...et al.	2011	733
2	The eighth data release of the SLOAN digital sky survey: first data from SDSS-III	Aihara, Hiroaki...et al.	2011	725
3	Elemental abundance survey of the Galactic thick disc	Reddy, BE; Lambert, DL; Prieto, CA	2006	393
4	Solar-like oscillations in low-luminosity red giants: first results from Kepler	Bedding, T. R...et al.	2010	153
5	Present and future observing trends in atmospheric magnetoseismology	Banerjee, D.; Erdelyi, R.; Oliver, R.; O'Shea, E.	2007	135
6	The metal-poor end of the Spite plateau I. Stellar parameters, metallicities, and lithium abundances	Sbordone, L... et al.	2010	135
7	Deep Impact: Observations from a worldwide Earth-based	Meech, KJ... et al.	2005	130

	campaign			
8	Crustal structure and earthquake focal depths beneath northeastern India and southern Tibet	Mitra, S; Priestley, K; Bhattacharyya, AK; Gaur, VK	2005	129
9	Magnetic activity in the photosphere of CoRoT-Exo-2a Active longitudes and short-term spot cycle in a young Sun-like star	Lanza, A. F... et al.	2009	99
10	The segue stellar parameter pipeline. IV. Validation with an extended sample of galactic globular and open clusters	Smolinski, Jason P... et al.	2011	96
11	The milky way tomography with SDSS: III. Stellar kinematics	Bond, Nicholas A... et al.	2010	94
12	The segue stellar parameter pipeline. V. estimation of alpha-element abundance ratios from low-resolution SDSS/SEGUE stellar spectra	Lee, Young Sun... et al.	2011	89
13	Photometric and spectroscopic evolution of the Type IIP supernova SN 2004et	Sahu, D. K.; Anupama, G. C.; Sridhya, S.; Muneer, S.	2006	86
14	The asteroseismic potential of Kepler: first results for solar-type stars	Chaplin, W. J... et al.	2010	83
15	Evolution of emission-line activity in intermediate-mass young stars	Manoj, P.; Bhatt, H. C.; Maheswar, G.; Muneer, S.	2006	77
16	Determining global parameters of the oscillations of solar-like stars	Mathur, S... et al.	2010	76
17	Seismic and spectroscopic characterization of the solar-like pulsating CoRoT target HD 49385	Deheuvels, S... et al.	2010	73
18	Configuration of the Indian Moho beneath the NW Himalaya and Ladakh	Rai, S. S.; Priestley, K.; Gaur, V. K.; Mitra, S.; Singh, M. P.; Searle, M.	2006	73
19	The case for the dual halo of the milky way	Beers, Timothy C... et al.	2012	73
20	A fresh look at the seismic spectrum of HD49933: analysis of 180 days of CoRoT photometry	Benomar, O... et al.	2009	68
21	Carbon-enhanced metal-poor stars in the inner and outer halo components of the milky way	Carollo, Daniela... et al.	2012	67
22	Solar-like oscillations in HD 181420: data analysis of 156 days of CoRoT data	Barban, C... et al.	2009	65
23	ESC observations of SN 2005cf - I. Photometric evolution of a normal Type Ia supernova	Pastorello, A... et al.	2007	63
24	Solar-like oscillations with low amplitude in the CoRoT target HD 181906	Garcia, R. A... et al.	2009	61
25	Dynamics of the solar magnetic network. II. Heating the magnetized chromosphere	Hasan, S. S.; van Ballegooijen, A. A.	2008	61

Testing Lotka's law of scientific productivity of IAP

Alfred J Lotka (1926) developed a law to study the author productivity pattern and it is commonly known as the "inverse square law". The law states that, the number of authors producing 'n' contributions is approximately equal to 1/n² of the number of authors that produce only one contribution. For example, in a given subject about 60% authors out of One Hundred will contribute one article each, 15% will contribute two articles each, and 7% will contribute 3 articles each and so on. Lotka's Law is mathematically expressed as:

$$Y_x = C/X^n$$

Where, Y is the number of authors credited with X (1, 2, 3, 4, 5, 6, 7, 8, 9.....) papers C is the number of authors contributing one paper and n is rate

$$X^n * Y_x = C \text{ (Where } X = 1)$$

i.e., 1 * 1813 = C (C = 1813, number of authors contributing one paper)

When X= 2

$$2^n * 519 = C \quad (C=1813)$$

$$2^n * 519 = 1813$$

$$2^n = 1813/519 = 3.49$$

$$n \log 2 = \log (3.49) \quad (\text{Applying log})$$

$$n = \log (3.49) / \log 2$$

$$n = 0.542/0.301$$

$$n = 1.80$$

Where, Y is the number of authors credited with X (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21, 22, 24, 25, 26, 30, 36, 37, 43, 49, 51, 56, & 64) papers, C are the number of authors contributing one paper.

Table 8: Lotka's Law of Scientific Productivity

No. of Articles X	No. of Authors (Observed) 3023	Observed%	No. of Authors (Expected) n=1.80 Exp3253	Expected %
1	1813	59.97	1813	55.73
2	519	17.16	521	16.01
3	285	9.42	251	7.71
4	124	4.1	150	4.61
5	91	3.01	100	3.07
6	44	1.45	72	2.21
7	38	1.25	55	1.69
8	26	0.86	43	1.32
9	10	0.33	35	1.07
10	11	0.36	29	0.89
11	7	0.23	24	0.73
12	6	0.001	21	0.64
13	4	0.13	18	0.55
14	5	0.16	16	0.49
15	4	0.13	14	0.43
16	4	0.13	12	0.36
17	5	0.16	11	0.33
18	3	0.099	10	0.30
19	2	0.066	9	0.27
21	4	0.13	8	0.24
22	3	0.099	7	0.21
24	1	0.033	6	0.18
25	2	0.066	5	0.15
26	1	0.033	5	0.15
30	4	0.13	4	0.12
36	1	0.033	3	0.09
37	1	0.033	3	0.09
43	1	0.033	2	0.06
49	1	0.033	2	0.06
51	1	0.033	2	0.06
56	1	0.033	1	0.03
64	1	0.033	1	0.03

The study covered 1,005 articles which were contributed by 3,023 authors during the period 2005-2014. In the present study, there are 1813 (59.97%) authors who contributed one article, 519 (17.16%) authors contributed two articles, 285 (9.42%) authors published three articles, and 124 (4.1%) authors contributed four articles. It has been proved that, the

expected number of authors vary, compared to the observed number of authors who contributed two, three and four etc. Hence the present study non-confirms the Lotka's Law of scientific productivity.

Findings & Conclusion

The study aimed to explore the research productivity of faculties and researchers of IIAP during the period 2005-2014 as per the data indexed in the Web of Science (Wos) database. The institute has published 1005 papers during the ten years. The result shows that the highest number of papers published in the year of 2011 with 125 (12.44%) followed by the year 2009 and 2010 with 113 (11.24%). Three author contributions have predominant with 220(21.89%) articles followed by two and four author. It is found that multi-authored publications are highest compare to single author publications and it is proved the earlier studies which mentioned in the literature review. Hence, team work gets more number of publications for the institutes. The study non-confirms the Lotka's Law of scientific productivity. The degree of collaboration of IIAP researchers is 0.88. The total number of 1005 papers has got 10183 citations during the period. R.K.Chaudhuri, G.C.Anupama and B.P.Das are top three authors contributed the papers. The IIAP authors most preferred to publish their research work in the journal "Astrophysical Journal" with 153 (15.22%) followed by Monthly Notices of the Royal Astronomical Society 129 (12.84%) and Astronomy and Astrophysics 122 (12.14%). Hence the authors mostly preferred the foreign journals to publish their work. As per the results the collaboration work has got highest citations.

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