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Scientometric study of Research productivity of ARIES, Nainital

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Abstract:

This paper describes scientometric study of research productivity of Scientists of Aryabhata Research Institute of Observational Sciences (ARIES), Nainital. The purpose of this study is to evaluate the research performance of ARIES, Nainital. For this study, the data is collected from Web of Science (WoS) bibliographical database for the period of 15 years from 2001-2015 and analyzed. 574 research paper has been published over 15 years of time in which 510 research publications are in referred journals and 64 research publications are in conferences, symposiums, bulletins etc. This paper identifies the scientists of ARIES those are active; the areas in which they are active, the journals in which they publish their research work, their productivity in terms of publication, citations and H-Index etc. The paper reveals the collaborating institutions, countries and research funding agencies. Findings also indicate the publication pattern, degree of collaboration as well as the nature of the research activities.

Keywords: Astronomy, Astrophysics, Atmospheric, Solar Physics, Research Productivity, Scientometrics, Bibliometrics.

1. Introduction

Research plays a vital role in enhancing the knowledge of a researcher to promote the prosperity of a nation; the well-being of its society and ultimately to the humankind. R & D institutions through research make an important contribution to the growth and development of industries and government businesses, thereby promoting national and global development. Some of the core scientific areas are directly not contributing in the upliftment of the society but are more concern about our existence in the universe and indirectly building the base for applied sciences. The Astronomy & Astrophysics is one of the subject which discovers our universe, Galaxies, solar system, birth of celestial objects and their life cycle. It gives millions of curiosity to the researcher like its million millions of stars. The scientists are actively involved in discovering the hidden facts of the universe and in result produce the research work in the form of research papers. The research papers are the base for further research. It would not be wrong to say that what is produce through research should be evaluated to know the trend as well as value of the research.

Evaluating scientific productivity and influence of different subject areas, countries, authors, institutions, etc. is one of the goals of scientometric studies. This impact and influence has been assessed through various indicators including number of citations, h-index, and so on. Evaluation and assessment plays an important role in decision and policy making about each area of science and provide useful information about the situation of that area and its strengths and weaknesses. Using quantitative techniques like bibliometrics, different studies have investigated

library and information science productivity and impact from various aspects during different periods of time¹.

Scientometrics is a discipline which analyses scientific publications to explore the trend and growth of science. The scientometric techniques are used to analyze various quantitative or qualitative aspects of a publication. It is a scientific field that studies the evolution of science through some quantitative measures of scientific information, as the number of scientific articles published in a given period of time, their citation impact, etc. The history of science and technology, philosophy of science and sociology of scientific knowledge are the related fields of Scientometrics.

2. Review of Literatures

Hasbrouck et al. (2003) examined the scientific literature by analyzing the citation pattern of specific journal articles to and by the American Journal of Epidemiology (AJE)- 1,78,396 journal citations to and 1, 26,478 citations by AJE were made during 1983-1999. They sorted citations based on the subject category of the referencing or referenced journal. Clinical medical journals accounted for 50.6% of all citations combined (both referenced to and referenced by AJE). General and internal medicine (17.9%), cancer (10.4%), and cardiovascular (4.9%) journals had the highest number of citations. Not many citations to and by AJE were found in publications specializing in dermatology, gastroenterology, orthopedics, allergy, anesthesiology, surgery, rheumatology, and other areas². Singh, Mittal and Ahmad (2006) conducted a bibliometric study of literature on digital libraries. The important findings are that most articles (61%) are single authored; author productivity is not in agreement with Lotka's Law, except in one case where the number of articles is three; the maximum number of articles were published in 2003 with English being the most productive language; maximum articles were published in the journal D-lib Magazine; distribution of articles nearly follows Bradford's Law; and USA ranked first for maximum number of journals³. Tiew (2000) found that 53% of articles contained journal self-citations, and a tendency is noticed for authors affiliated to the institution publishing the journal to cite the journal⁴. Patra, Bhattacharya and Verma (2006) analyzed the growth pattern, core journals and authors' distribution in the field of bibliometric using data from Library and Information Science Abstract (LISA) and found that the growth of literature does not show any definite pattern⁵. Bakri and Willet (2008) for the period 2001-2006 compared the results with the previous study and found that the number of publications was increased statistically and the significant changes occurred in types of articles, number of references per article and length of the articles. The study also revealed that the two-authored articles were greater in number⁶. Karpagam (2014) carried out scientometric analysis to evaluate nano-biotechnology research during 2003-2012 and studied the growth, global publications share and citation impact, share of international collaborative papers and contributions of major collaborative partner countries⁷. Gopikuttan and Awasthy (2014) measured research productivity of Kerala University and results of the study indicate that Chemistry, Physics, Astronomy & Astrophysics are the prime areas of research. The maximum numbers of international collaborations are with scientists from USA⁸. Mishra and Sarangi (2015) conducted bibliometrics studies of IITs & NITs during 2012-14 and ranked these technology institutes as per the citations received for their research papers and faculty h-index⁹.

3. The Institute : Profile

Aryabhata Research Institute of Observational Sciences (ARIES) is one of the premier institute under the Department of Science and Technology, Government of India engaged in carrying out frontline research in the fields of Astronomy & Astrophysics, Solar Physics and Atmospheric Sciences. The institute is also developing state-of-the-art backend instruments for the national and international facilities. ARIES has installed a 3.6-m aperture new technology optical telescope at Devasthal campus which is Asia's largest optical telescope. The institute has also setup a ST Radar system at Nainital which is one of the unique radar systems in its kind.

The institute was started on 20 April 1954 as Uttar Pradesh State Observatory (UPSO). With the creation of the State of Uttarakhand on 9 Nov 2000, and because of its geographical location within the boundaries of Uttarakhand, UPSO came under the administrative control of the new government and was renamed as the State Observatory (SO). Later, it was re-christen as Aryabhata Research Institute of Observational Sciences (ARIES) under the DST, Govt. of India as an autonomous body on 22 March 2004. The institute is actively engaged in the core areas of research in its domain.

4. Objectives of the Study

In every scientific research, there should be some specific objectives for which the study is to be conducted. Without definite objectives, the research has no meaning. In the present study "Scientometric study of Research productivity of ARIES, Nainital" has following objectives as enumerated bellow:

- Evaluation of the research productivity of scientists at ARIES, Nainital.
- Year wise publications and productivity.
- Authorship pattern in research publication.
- Most popular journals in term of publications.
- Most collaborating institutions and countries.
- Institutional total productivity, citations and h-Index.
- Project funded research and project funding agencies and countries.
- Highly productive authors, their no. of publications, citations and h-Index.

5. Statement of the Problem

The statement of the problem describes the background of the study, its theoretical basis and underlying assumptions and the problem in concrete, specific and workable questions.

The problems involved in the present research can be represented through the following questions:

- What is the productivity level of the ARIES faculties in respect of referred research publications?
- What is the trend in research publications with regard to the sources, authorship pattern, frequency of publication, areas of research, collaborating institutions and countries etc?

6. Scope and Limitations

- The Scope of the present study is to evaluate the research outcomes of ARIES, Nainital.
- The study is limited up to the analysis of the referred research publication of ARIES, Nainital published during 2001-2015.

7. Data Source

Thomson Reuters's (now Clarivate Analytics) Web of Science¹¹ (WoS) bibliographic database was used to harvest the bibliographical details of referred research publications of ARIES, Nainital. The 'Advance search' was used with the field tag 'OG' (Organization-Enhanced) i.e. OG= (ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES OR ARIES OR UTTAR PRADESH STATE OBSERV OR STATE OBSERV). The Time Span was used from 2001 to 2015. Total 574 research papers were retrieved with this search syntax for research analysis. Bibexcel and Pajek software were used for data analysis, processing and visualization.

8. Data Analysis and Interpretation

8.1 Publications over the years:

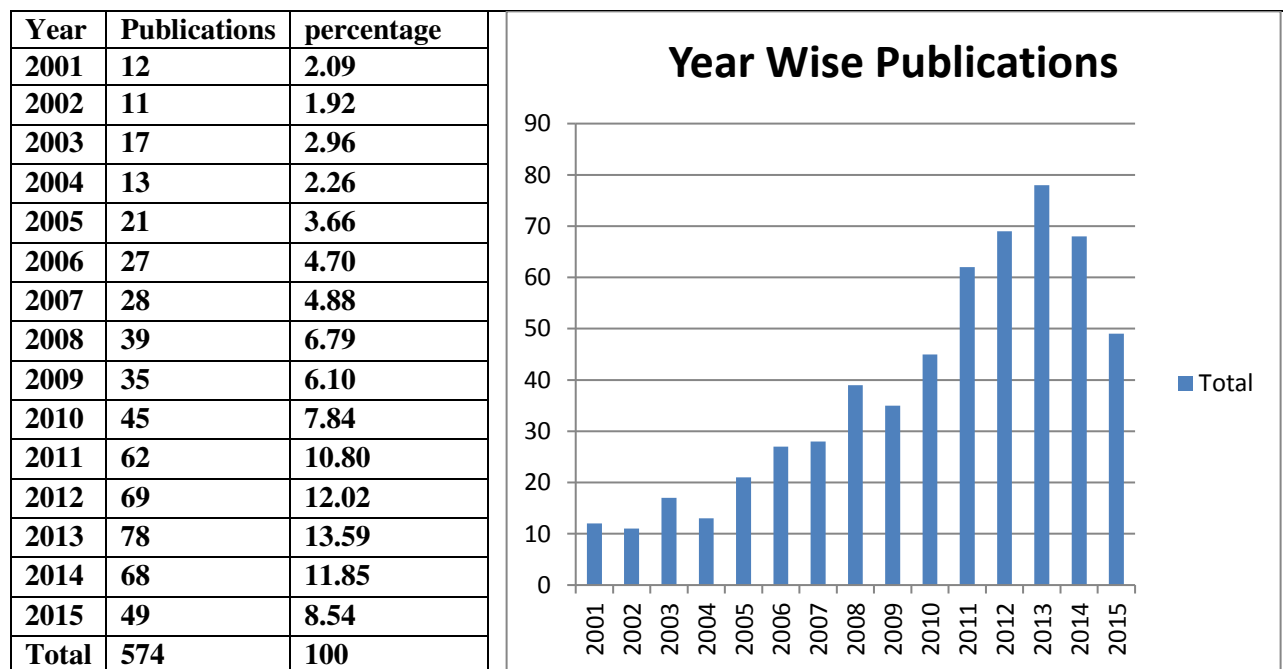


Table -01 & Graph-01

Publication of ARIES, Nainital has progressively increased over the years. 2002 was that less productivity year (1.92%) and 2013 was the highest productive year (13.59%). It shows that the institute is putting more effort to increase its no. of publications.

8.2 Document Type

Document Type	Numbers	Percentage
Journal Articles	502	87.46 %
Reviews	08	1.4 %
Conference Proceeding papers	64	11.15 %
Total	574	100 %

Table-02

ARIES, Nainital has produce 87.46 % of its research publications during 2001-2015 in referred journals that is a good attribute of a research institution.

8.3 Publication growth over the Blocks of Five years

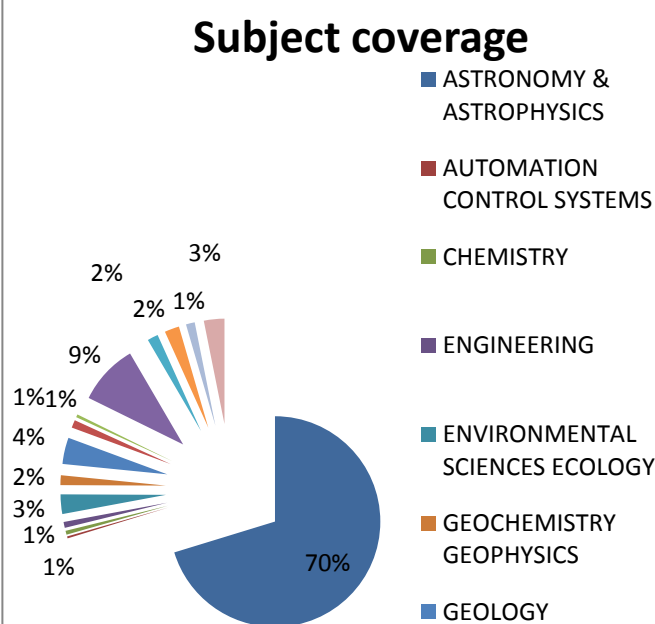
Document Types	Five Years Blocks			Growth in 2 nd block over 1 st block	Growth in 3 rd block over 2 nd block
	2001-05	2006-10	2011-2015		
Journal Articles	70	156	282	122.86 %	80.77 %
Reviews	02	04	02	100 %	-50 %
Conference Proceeding papers	02	14	42	700 %	300 %
Total	74	174	326	135.14 %	87.36 %

Table-03

The growth in second block has accelerated of 122.86 % for journal articles, 100 % for Reviews and 700 % i.e. seven times for conference proceedings in the second block over first block. The growth of journal articles were 80.77 % , reviews -50 % and conference proceeding 300 % for the third block over second block. The gross growth in second block and third block were 135.14 % and 87.36 % respectively.

8.4 Subject wise Research coverage

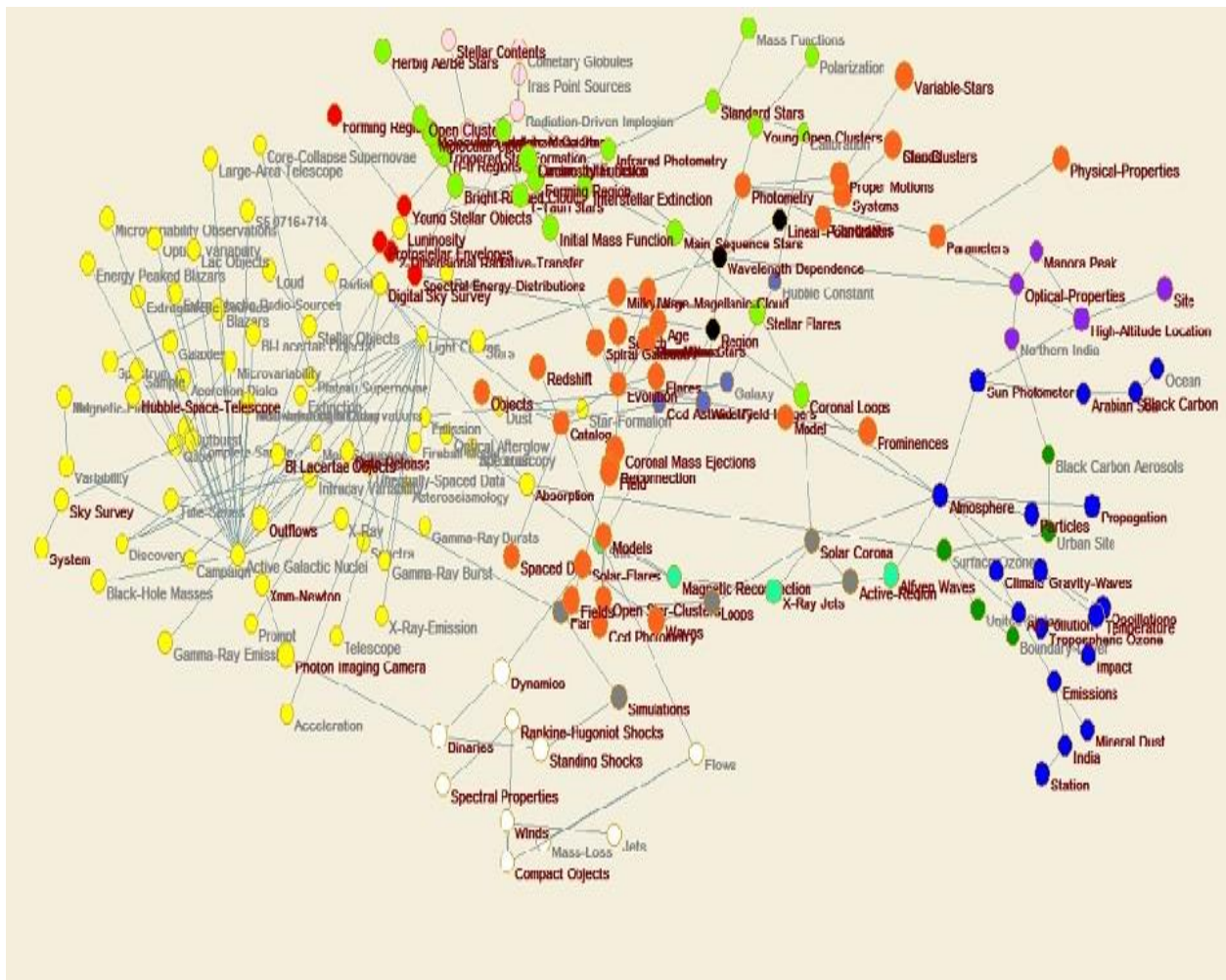
Subject	No. of Publications
ASTRONOMY & ASTROPHYSICS	468
METEOROLOGY ATMOSPHERIC SCIENCES	62
GEOLOGY	27
SCIENCE TECHNOLOGY OTHER TOPICS	21
ENVIRONMENTAL SCIENCES ECOLOGY	20
PHYSICS	15
OPTICS	11
GEOCHEMISTRY GEOPHYSICS	10
REMOTE SENSING	9
IMAGING SCIENCE PHOTOGRAPHIC	8



TECHNOLOGY		
ENGINEERING	6	
CHEMISTRY	4	
INSTRUMENTS INSTRUMENTATION	3	
AUTOMATION CONTROL SYSTEMS	2	

Table-04 & Graph-02

The Above table and chart shows clearly that ARIES, Nainital main focus area of research is Astronomy & Astrophysics and Atmospheric Sciences. Apart from its core area of research, scientists are also engaged in the sub-domain of research and/or doing interdisciplinary research. The key word clustering graph is given below which also shows the area of interest and how research terms are interrelated that denotes the overlapping of research fields.



Graph-03- Key words clustering Graph

8.5 Top 10 collaborating countries

Country	Collaborative Publications	Percentage
USA	166	28.92 %
GERMANY	74	12.89 %
FRANCE	71	12.37 %
ENGLAND	62	10.80 %
JAPAN	55	09.58 %
RUSSIA	54	09.41 %
SPAIN	52	09.06 %
ITALY	51	08.89 %
SOUTH KOREA	44	07.67 %
TAIWAN	43	07.49%

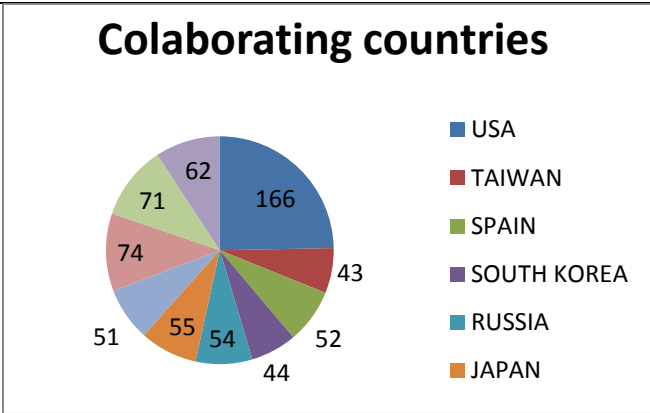
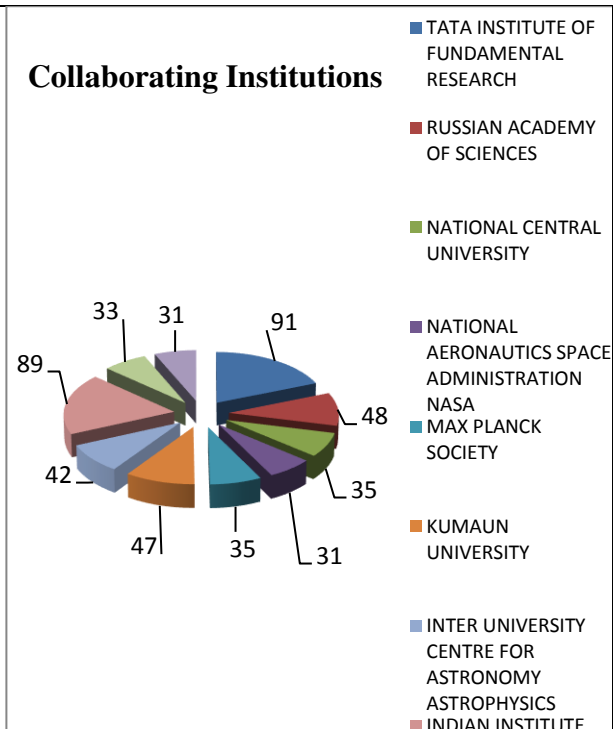


Table-05 & Graph-04

The above table shows that ARIES’s scientists are highly collaborating with USA. Out of 10 collaborating countries 07 are from western countries and 03 countries are from Asia; and which are too leading researcher’s countries among Asian countries are. The analysis shows ARIES, Nainital scientists are doing leading research work in their field of research in collaboration with leading researcher’s countries.

8.6 Top 10 collaborating Institutions

Institutions	Collaborative Publications	Percentage
TIFR MUMBAI	91	15.85 %
IIAP BANGALORE	89	15.51 %
RUSSIAN ACADEMY OF SCIENCES	48	8.36 %
KUMAUN UNIVERSITY NAINITAL	47	8.19 %
IUCAA PUNE	42	7.32 %
MAX PLANCK SOCIETY GERMANI	35	6.10 %
NATIONAL CENTRAL UNIVERSITY TAIWAN	35	6.10 %



CSIC SPAIN	33	5.75 %	
CNRS FRANCE	31	5.40 %	
NASA USA	31	5.40 %	

Table-06 & Graph-05

Tata Institute of Fundamental Research (TIFR) is the top most collaborating Institutions with 15.85 % followed by IAP Bangalore (15.51%), Russian Academy of Sciences (8.36 %), KU, Nainital (8.19 %), IUCAA, Pune (7.32 %), Max Planck (6.10%), NCU, Taiwan (6.10%), CSIC Spain (5.75 %), CNRS France (5.4 %) and NASA, USA (5.4 %) during 2001-2015. ARIES, Nainital's 6 top most collaborating institutions are from western countries and popularly known worldwide for research and 04 institutions are from India, they are too doing high quality of research.

8.7 Top 10 Research Journals

Journal	No. of Publications	Percentage (out of 574)	Impact Factor of the journal *	Total citation received	Average citation per paper	Citing Articles	H-Index
MNRAS	146	25.44%	4.952	2072	14.19	1403	24
ASTRONOMY & ASTROPHYSICS	75	13.10%	5.185	1709	22.79	1403	25
ASTROPHYSICAL JOURNAL	54	9.41 %	5.909	1024	1896	848	19
JOURNAL OF ASTROPHYSICS AND ASTRONOMY	31	5.4 %	0.394	170	5.48	157	7
NEW ASTRONOMY	22	3.83 %	1.085	183	8.32	173	7
SOLAR PHYSICS	20	3.48 %	2.862	340	17	277	10
JGR-ATMOSPHERES	16	2.79 %	3.454	515	32.19	356	11
CURRENT SCIENCE	13	2.27 %	0.967	63	4.85	62	5
ATMOSPHERIC ENVIRONMENT	12	2.10 %	3.459	288	24	257	9
ASTRONOMICAL JOURNAL	10	1.74 %	4.617	177	17.7	167	6
Average of above 10 Journal's Publication	399	69.51	3.289	6,541	16.39	5,103	25

Table-07

(*JCR-IF-2017)

Monthly Notices of the Royal Astronomical Society (MNRAS) is the highly preferred research journal at ARIES, Nainital. It has published 146 (25.44 %) articles. The articles have received 2072 citations. The average citation received is 14.19 with H-Index of 24. The Astronomy & Astrophysics and Astrophysical Journal are in second and third rank for publications. Both of the journals are high quality journals and citations received by the publications are 1709 and 1025

respectively. The H- Index is 25 and 19 respectively. All the above shown journals are well reputed in the field of Astronomy & Astrophysics and Atmospheric Sciences. The above top 10 journals cover 399 (69.51 %) articles of total publications during 2001-2015. Total citations received by these publications are 6,541 with average Impact factor 3.289. It is also clearly indicated that the citing articles are less than the citations. It shows the wider recognition of the publications than its citing articles. It indicates the progressive science done by the Institutions. During 2001-15, ARIES, Nainital has produce two Research papers in highly respected research journal- NATURE in the year 2008. Overall it can be said that ARIES, Nainital is doing good research in its domain of research.

8.8 Top 10 Research funding Agencies for Project handled research

Research Project Funding Agency	Country	No. of project handled articles	Percentage (out of 574)
NATIONAL SCIENCE FOUNDATION	USA	72	12.54
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION	USA	30	5.23
DST, GOVERNMENT OF INDIA	INDIA	21	3.66
RUSSIAN FOUNDATION FOR BASIC RESEARCH	RUSSIA	13	2.26
BULGARIAN MINISTRY OF EDUCATION AND SCIENCES	BULGARIA	10	1.74
NATIONAL NATURAL SCIENCE FOUNDATION OF CHINA	CHINA	9	1.57
SCIENCE AND TECHNOLOGY FACILITY COUNCIL	UK	9	1.57
ALFRED P SLOAN FOUNDATION	USA	8	1.39
INSU CNRS FRANCE	FRANCE	8	1.39
DFG GERMANI	GERMANI	8	1.39
TOTAL		168	29.27

Table-08

The above table shows the rank of top 10 research funding agencies / institutions and its country. The NSF and NASA, USA are the top contributing research project funding agencies which result 102 (17.77 %) research publication during the year 2001-2015. 168 (29 .27%) research papers were published through the project funded research. ARIES, Nainital is involved in research project based publications with world's leading research agencies that indicate the level of research quality of the institute.

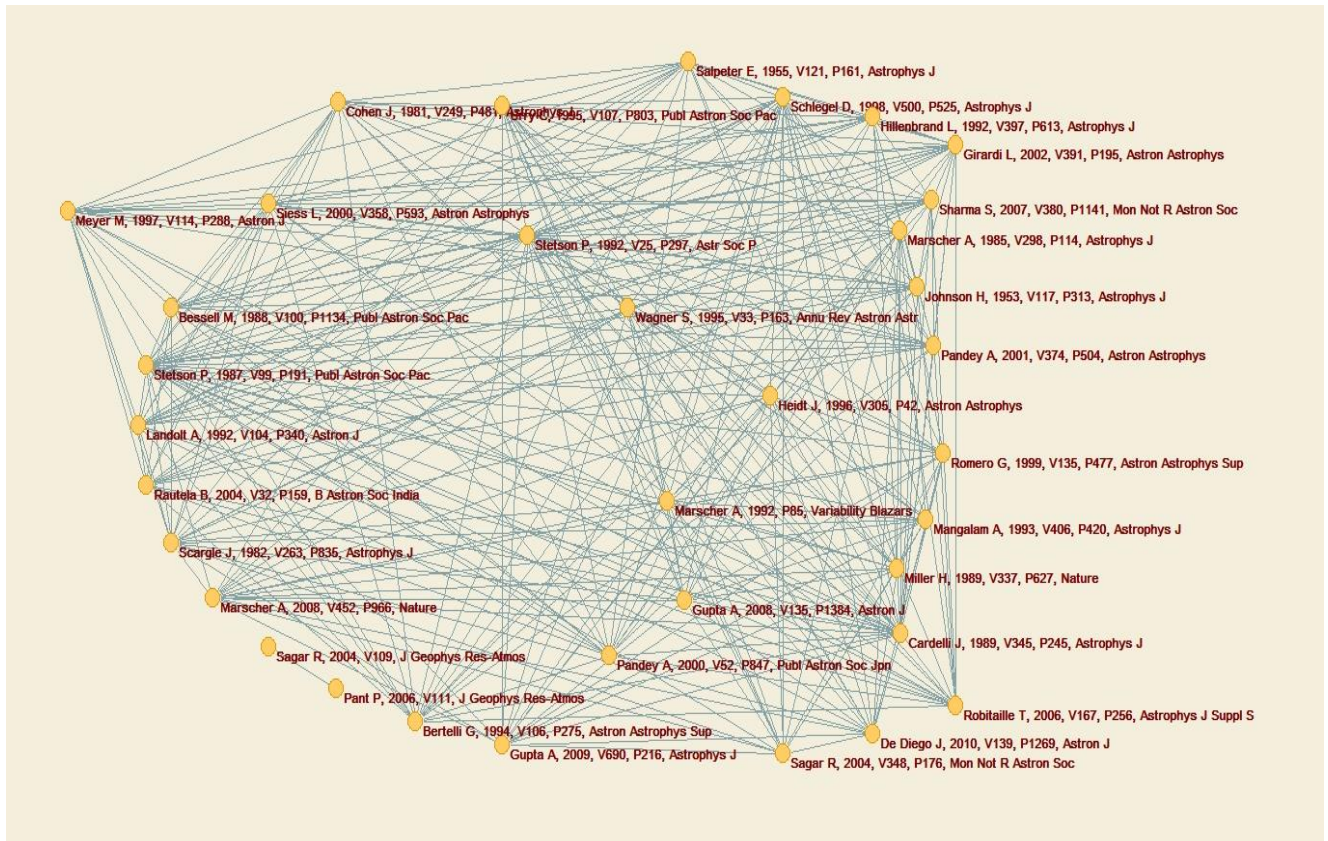
8.9 Top 10 Highly productive Authors and Institutional gross productivity during 2001-15

S. N.	Author	No. of Publications	Percentage (out of 574)	Total citation received	Average citation per paper	Citing Articles	H-Index
1.	SAGAR R	115	20.10 %	2,174	18.90	1,498	26
2.	PANDEY AK	65	11.32 %	979	15.10	585	18
3.	PANDEY SB	49	8.54 %	1,160	23.67	889	20
4.	SRIVASTAVA AK	49	8.54 %	671	13.69	455	16
5.	KUMAR B	47	8.20 %	505	10.74	436	13
6.	GUPTA AC	46	8.01 %	852	18.52	468	19
7.	PANT P	38	6.62 %	868	22.84	521	19
8.	PANDEY JC	33	5.75 %	269	8.15	182	10
9.	NAJA M	32	5.57 %	472	14.75	279	13
10.	UDDIN W	32	5.57 %	459	14.34	330	12
ARIES, NAINITAL		574	100%	8,041	14.01	4,939	39

Table-09

The above analysis shows that Scientist Sagar, R. was the most productive author during the year 2001-2015. Sagar, R. published 115 (20.10%) articles. He received 2174 citations with an average of 18.19 citations. His citing articles were 1498. His H-Index is 26. Pandey, AK is on the second rank of most productive authors list. He has published 65 articles and his H-Index is 18. Pandey, SB has published 49 papers but got more citation than Pandey, AK and have H-Index of 20. Srivastava, AK has also published 49 articles but got less citation than Pandey, SB and have H-Index of 16. Kumar, B. has published 47 articles but have H-Index of 13 like Naja, M. who has published 32 papers. Pant, P and Gupta, AC has published 38 and 46 papers but hold same H-Index 19. Pandey, JC produced 33 articles and have least H-Index 10 in the list of top 10 most productive authors. Here, it is clear than citation is the key point in addition to the publication to get the proper recognition in the field of research. Citation defines a research work of a scientist and their value in the world of research. It is very affirmative to see that ARIES, Nainital Scientist's are getting good citations in their research publications.

ARIES, Nainital have produced 574 research papers during 2001-2015. The total citations received by these papers are 8,041 and the citing articles are 4,939. Co-citation analysis graph can be seen (given below) which shows the interest field of the researchers, trend of research, similarity of research and the areas of work at ARIES. It is remarkable to notice that citing articles are almost half of the citations were received; that shows the research work done at ARIES, Nainital have almost double impact on the researchers' community. The Institute had H-Index 39 during this period. It is very positive indicator. Overall, it can be said that the institute is performing well.



Graph-06: Co-Citation Analysis Graph

8.10 Authorship Pattern

Year	One Author	Two Author	Three Author	More than Three Author	Total
2001	2	2	2	6	12
2002	3	1	1	6	11
2003	-	-	2	15	17
2004	-	3	-	10	13
2005	2	7	1	11	21
2006	2	2	2	21	27
2007	2	3	3	20	28
2008	2	2	6	29	39
2009	-	4	5	26	35
2010	1	3	2	39	45
2011	2	4	9	47	62
2012	3	6	5	55	69
2013	5	13	13	47	78
2014	2	7	9	50	68
2015	1	8	3	37	49
Total	27	65	63	419	574

Authorship	No. of Publications	percentage
Single Author	27	4.70%
Two Authors	65	11.32%
Three Authors	63	10.98%
More than three Authors (Multi-Authors)	419	73%

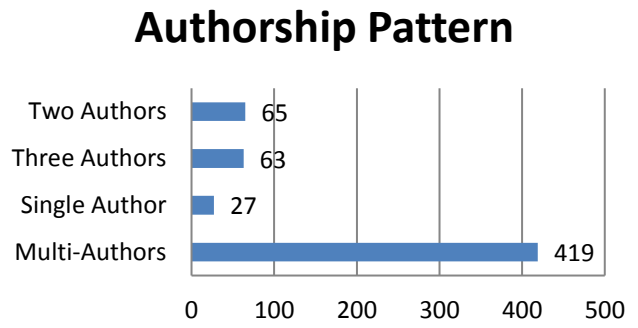
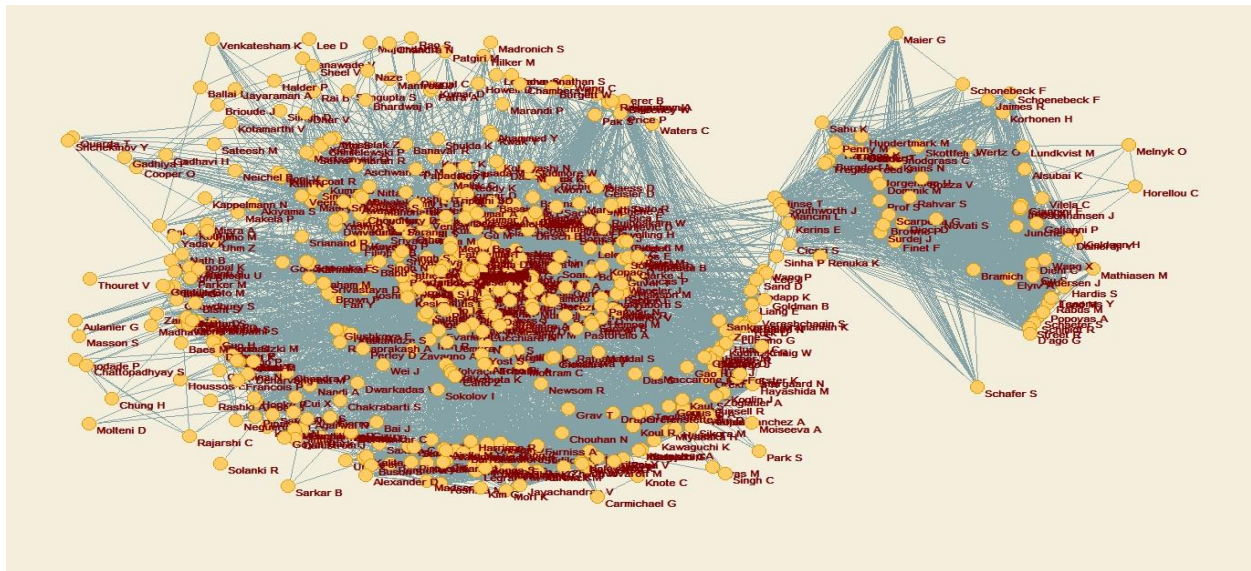


Table-09 & Graph-07

ARIES, Nainital has published 27(4.70%) research papers in single authorship, 65(11.32%) papers in two authorship, 63(10.98%) papers in three authorship and remaining 419(73%) of the research publications in multi-authorship. The trends show that multi-authorship research or collaborative research work is focused at ARIES, Nainital. The single authorship is very less. The Co-authorship graph can also be viewed below that shows the multi-authorship pattern and trend of authorship at ARIES. The Scientists are more involved in collaborative research rather than individual research.



Graph-08: Co-Authorship occurrence Graph

Degree of Collaboration

In order to determine the strength of Collaboration (DC), the following formula given by Subramanyam K.¹⁰ has been applied-

$$DC = \frac{N_m}{N_m + N_s}$$

(Where, DC = Degree of Collaboration, N_m = Number of Multiple Authored Papers and N_s = Number of Single Authored Papers)

So, Degree of Collaboration (DC) = 547/547+27=0.953

The degree of collaboration during 2001-2015 at ARIES, Nainital is 0.953 and it brings out clearly that there is very high level of collaboration in research publications at ARIES, Nainital.

FINDINGS

As a result of systematic analysis and interpretation of the data obtained for the present study from WoS, the researcher observes the following specific points about the study of Research productivity of ARIES, Nainital

- ❖ ARIES, Nainital has published 574 research papers over a period of 15 years during 2001-15. The year 2013 was the most productive year and published 78(13.59%) research papers. It is also observed that ARIES, Nainital is increasing its productivity year by year.
- ❖ According to the type of publications by ARIES, the more numbers of articles are published in journals. ARIES has published 502 (86.46%) research articles in journals.
- ❖ The Institute main focus of research is Astronomy & Astrophysics and Atmospheric sciences. Institute has produce 486 (81.53%) research articles in Astronomy & Astrophysics and 82 (14.29%) in Atmospheric sciences.
- ❖ ARIES's scientists are highly collaborating with USA. Out of 10 collaborating countries 07 are from western developed countries and 03 countries are from Asia; and those are too leading researcher's countries among Asian countries.
- ❖ Tata Institute of Fundamental Research (TIFR) is the top most collaborating Institutions with 15.85 %. ARIES, Nainital is collaborating with high performing institutions from western developed countries and institutions from India, those are too doing high quality of research.
- ❖ ARIES, Nainital is publishing its research papers in high impact factor journals. The journal MNRAS is the most preferred journal by the scientists of ARIES, Nainital and having maximum number 146 (25.44%) of publications. The Average impact factor of its top 10 journal publications (69.51 %) is 3.289 with H-Index 25. ARIES has also published two research articles in the highly prestigious Journal '*NATURE*' in 2008.
- ❖ Project funded research are also very high in numbers (29.27%) at ARIES. Out of top 10 project funding agencies 8 are from western developed countries.
- ❖ Sagar, R. was the most productive researcher and has published 115 (20.10 %) articles. Top 10 most productive authors have published 506 (88.15%) of articles during 2001-15.
- ❖ The contributions of multi-authored publications have the highest number of articles i.e. 419 (73%) that shows collaborative research has been preferred in comparison to individual research.

Conclusion

This work explores the factors of productivity of scientists of ARIES in research, both in terms of the number of articles, the quality of the publication and trend of research. The picture that emerges the causes of productivity is complex. There are clearly many interacting factors

that contribute to research productivity. Research group size or access to resources is just one, which on the evidence available, may not be very important. Explanations of research performance must take into account personal (individual), motivational and structural (working environmental), and the interaction between them. However, it can be seen from the above quantitative analysis and its finding that ARIES scientist are working actively to increase the number of research articles, their publication in high impact factor journals, collaborating with leading institutions of India as well as from western countries to establish the institution in the high position in its domain of research.

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