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Identification of Research Trends at Physical Research Laboratory (PRL), Ahmedabad, India

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1. Introduction

The ever increasing size and specialized nature of research today, makes it difficult for a small group of experts to evaluate fully, the complex landscape of research. At the same time the limited availability of funds has made it almost mandatory to measure the research outputs in all the subject fields. Since lot of money is being invested in this endeavor, most of the policy makers in the governments are asking for research output in quantitative terms. On the one hand science research is now such a large enterprise and so specialized and complex that personal knowledge and experience are no longer sufficient for understanding trends or for making decisions and on the other hand there is a need to highlight the promising areas of research and to manage better investments in science. Not only the government policymakers but scientists themselves are users of such kind of studies with which they assess their own research output.

The knowledge and processing of research results regarding any scientific area are a basic input to the evaluation of the research activities.

A study was carried out by Dhawan & Gupta (2007) which examined the broad characteristics of India's publication output in Physics, its subject areas of strength and also the extent to which the research pursuits have technological orientation. The study finds that India's physics related contribution is significantly high (86 per cent) in SCI covered journals of which 26.4 percent were in high impact journals (IF = 1.5).

As China and India are seen as emerging world leaders, a lot of curiosity exists as regards what happens in the area of S & T in these two countries. Madhan, Chandrasekar, & Arunachalam (2010) have analyzed research papers published by Chinese and Indian researchers during 1998-2007 which were cited at least 100 times by the end of 2009. The authors have identified prominent authors and institutions, journals used and fields of research. They found that Chinese authors have been able to place their papers in high impact journals such as *Nature* and *Science* far more often than Indian authors.

Such studies point to useful indicators of research such as scientific productivity, collaboration pattern and thrust areas of research. The quantifying methods employed in a bibliometric study yield a fairly good idea about an institute’s contribution in the national scientific output.

Bibliometrics measures inter-connected aspects of written communication. Though roots of Bibliometrics could be traced to 1920s, it took a quantum jump through the works of Eugene Garfield (1955) and Price (1963). The latter is considered to be the father of Scientometrics, which is science of measuring science. He was a historian of science and information scientist. A very important publication of Price is, "Little Science Big Science" (1963). The book describes the exponential growth of the scholarly literature and scientific manpower. It covers various aspects of the productivity of scientists. Eugene Garfield's "Essays of an Information Scientist" published in Current Contents, are world renowned. These contain dozens of bibliometric studies.

As no bibliometric study has been carried out so far for the institute – Physical Research Laboratory, the author undertook this study as a part of her doctoral research.

2 Literature Review

The survey of literature yielded many interesting studies, collected from various sources. A few of them were evaluating a subject field, a few were limited to journals' impact in a subject field and some of them studied the research output of countries. Sujit Bhattacharya, et al (1997) and (2000) carried out two studies which attempted to reveal active research themes within frontier area of physics during 1990 and 1995. The papers attempt to monitor the changes in research priorities in physics by analyzing the research profile of thirty-three countries in major fields of physics as classified under PACS (Physics & Astronomy Classification Scheme). The publication profile of a country can be visualized as an indicator of its research priorities. Tracking changes in the publication profile of a country can lead to identification of thrusts and areas of weakness in different macro-fields and micro-fields of research. Earlier study had identified the high activity areas (macro-fields), while actual research is conducted in micro-fields. Hence the study was undertaken again in 2000.

Subbiah Arunachalam and Jayshree Balaji (2001) carried out a study, wherein Fish & Aquaculture research in the People's Republic of China over the six years 1994-1999 was compared with that of India. The authors found that during this six year period, China published 2035 papers (roughly 4.5-5 % of the world output) and India published 2454 papers. More than 95% of China's papers are journal articles compared to 82.8% of Indian papers. About 78% of China's journal paper output has appeared in 143 domestic journals compared to 70% from India in 113 Indian journals. Less than a dozen papers from each of these countries have appeared in journals of impact factor greater than 3.0. Although China's research output and its citation impact are less than those of India, China's fish production and export earnings are far more than those of India. Probably China is better at bridging the gap between know-how (research) and do-how (technology).

Eva Isakson (2007) got interested to carry out a study when at the latest research assessment evaluation done at the University of Helsinki in 2005, the panel of experts asked for citation count data for the first time. She then decided to carry out a

bibliometric study of Astronomy in Finland. The author used both ADS and ISI databases in order to find out how they compare. The sample of the study consisted refereed papers of four institutes doing astronomical research in Finland for the period 1995-2004. The 910 papers had 1,998 authors out of which 162 were listed with affiliations from one of the four Finnish astronomy institutes. Of the most productive 50 authors (with more than 12 published papers) eight were identified as women. Other interesting finding was that majority of the papers were stand alone in the sense that only one of the four institutes was involved in its publishing. There was not even one paper with all of the institutes co-operating. All the collaborations are directed abroad instead of with other Finnish Astronomy institutes.

In one such similar study Chu Keong Lee (2003) thought of measuring the research output of Institute of Molecular and Cellular Biology (IMCB) as lot of funds had gone into building up this institute. It was set up in 1987 at the National University of Singapore (NUS).

The study found that the number of research scientists and engineers (RSEs) increased from 116 in 1991 to 179 in 1996 and the recurrent budget increased from S$19.38 million to S$ 36.37 million in the same period. In its first 10 years, the IMCB produced 395 research papers, 33 book chapters, 24 conference papers and 4 monographs. The research papers were published in journals of increasing impact factor, resulting in increased visibility for the IMCB. The articles received 25 to 35 citations per article. Four of its articles received more than 200 citations. IMCB contributed 46 PhDs and 14 MScs to the research force in Singapore.

As no bibliometric study had been carried out to measure the research output of Physical Research Laboratory (PRL), Ahmedabad, India, to discern the research trends at the institute, author undertook the study of the research publications of PRL scientists for a ten year period.

3. Objectives and Scope of the study

Several investigators have conducted bibliometric analysis of research productivity of different countries in the world. Comparisons between research outputs in different subject fields are limited because of the different methodologies used and the impact of geographic and population characteristics on the research output. A few studies have also been carried out to assess the productivity and impact of a single institute. As no bibliometric study on PRL has been done before, the researcher thought it appropriate to carry out the study for her doctoral research with the following objectives:

a. To study the division wise output of research
b. To identify the thrust areas of research at PRL

The present bibliometric study aims to measure the research output of Physical Research Laboratory (PRL) during a 10 year period (1997-2006) using the data of papers published in journals. Thrust areas of research at PRL during this period have

been found using content analysis of articles published in journals and allotting keywords to each of them.

3.1 Physical Research Laboratory (PRL)

Known as the *cradle* of Space Sciences in India, the Physical Research Laboratory, Ahmedabad owes its existence to Dr Vikram A Sarabhai due to his deep interest in scientific research, his initiative and his outstanding powers of organization and management. It was founded in November 1947.

As a unit of the Department of Space, Government of India, PRL carries out fundamental research in select areas of Experimental and Theoretical Physics, Space and Atmospheric Sciences, Astronomy & Astrophysics and Planetary & Geosciences.

Human Resource Development in several areas of above mentioned subject areas is one of the priorities for PRL. There are about 140 scientists (60 are academic faculty and remaining are technical faculty and Post doctoral fellows) carrying out research in PRL. It has been offering the doctoral programme in various physics related fields since its inception. Accrediting universities with which it has signed the Memorandum of Understanding are Gujarat University, Nirma University, M. S. University of Baroda and Mohanlal Sukhadia University, Udaipur. Up till now 320 doctoral theses have been submitted by the PRL students. Every year about 15 students join for the Ph. D. program.

3.2 Period: 1997-2006

The period of study has been taken from 1997-2006. The landscape of scholarly communication witnessed a sea change during this period from print to electronic medium due to the Internet. Developed countries like USA, UK, Japan, and Germany were the first to adopt this change. The internet made it possible to disseminate the latest information to the scientists and students very quickly. The electronic delivery of journals resulted in elimination of paper, storage and transportation costs and the ability to handle complex data, tables, moving pictures, sound, images and video clips. In addition, unlike sequential design of printed papers, web technology made it possible for the publishers to give interactive hyperlinks to related sources. The growth of the Internet witnessed emergence of several e-journals that were launched only for Internet without a printed counterpart. However, as the technology and popularity of Internet grew, several mainstream journals primarily available for print subscription also started appearing on the web. By 2001-02, the Indian publishers too had started providing the e-access to the print journals.

Keeping in mind this paradigm shift in scholarly communication, the scope of the present study is limited to the period 1997 to 2006.

4. Research Method used

To arrive at an appropriate method for the present study, the researcher made a detailed study of the research methods/strategies commonly used.

This study is a bibliometric study of one organization. According to Lancaster (1991) the tools used in bibliometric studies are : i) citation and reference analysis ii) document and content analysis iii) user studies and iv) circulation statistics. This study has carried out content analysis of articles published by PRL authors.

4.1 Content Analysis

Content analysis is a method for summarizing any form of content by counting various aspects of the content. This enables a more objective evaluation than comparing content based on the impressions. The results of content analysis are numbers and percentages. Though it may seem crude and simplistic, the counting serves two purposes: to remove much of the subjectivity from summaries and to simplify the detection of trends. Thus content analysis requires extreme thoroughness. The content that is analysed can be in any form to begin with, but is often converted into written words before it is analysed. The original source can be printed publications, broadcast programs, other recordings, the Internet, or live situations.

The researcher has carried out the document and content analysis of the research articles published in journals by providing the keywords to each article. The keywords were then used, to allot a PACS number (Physics and Astronomy Classification Scheme) to each article.

PACS is a hierarchical subject classification scheme designed to classify and categorize the literature of physics and astronomy. PACS provides an essential tool for classification and efficient retrieval of literature in physics and related fields. PACS contains 10 broad subject categories subdivided into narrower categories. PACS also includes detailed schedule for acoustics, geophysics, nanoscale science and technology supplement and an alphabetical topical index with corresponding PACS codes (AIP, 2006).

5. Data Collection

Data for the study (papers published in journals) was collected from the Annual Reports of PRL from 1997-98 to 2006-07.

For papers in journals, the record consisted of names of the authors, name of the division, name of the journal, and the year of publication. Keywords were given to each article after reading the abstract and introduction of the paper. Based on these keywords, PACS number was allotted to each article. This part of the study took almost three years, as 1318 articles published in journals had to be searched, downloaded, indexed and then PACS number were allotted to each article.

Excel software was used to enter the records of each year. The data was sorted to find out how many articles are published under each relevant PACS number in descending order. Each year's data was then merged and computed in similar manner.

6. Data Analysis for the study

The research output of PRL scientists during the period of 1997-2006 was 2518 units out of which 1318 were papers published in journals, 436 papers in conference proceedings and 764 were the invited talks delivered. For identification of active research topics, content analysis of 1318 papers published in journals during this period was done. The PACS codes of all the articles were grouped under main subject headings and then added up for each year. This data was then merged for all years to arrive at top 15 areas of research (thrust areas of research) carried out in PRL.

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6.1. Division wise break up of research output of PRL scientists

According to research carried out in six broad subjects, there are six divisions in PRL. These are Astronomy and Astrophysics (AAD), Geosciences (GSDN), Planetary Sciences (PSDN), Space and Atmospheric Sciences (SPA-SC), Theoretical Physics (THE-PH) and Solar Physics (SO-PH). Earlier SO-PH was part of Astronomy Division. PSDN, which was formed by merging PLANEX and SOXS projects is included as part of GSDN. The researcher thought it appropriate to find out the division wise break up of productivity of PRL scientists. Tables and figures 1.1 to 1.6 give the division wise research output of PRL scientists – papers published in journals, papers published in conference proceedings and number of invited talks delivered.

Table 1 gives an indication of the division wise publication output in journals from 1997-2006. The data for SO-PH and PSDN is from 2002. Amongst all divisions, productivity of Theoretical Physics - THE-PH (38.77%) and Geosciences - GSDN (28.45%) divisions is more than other divisions during 1997-2006.

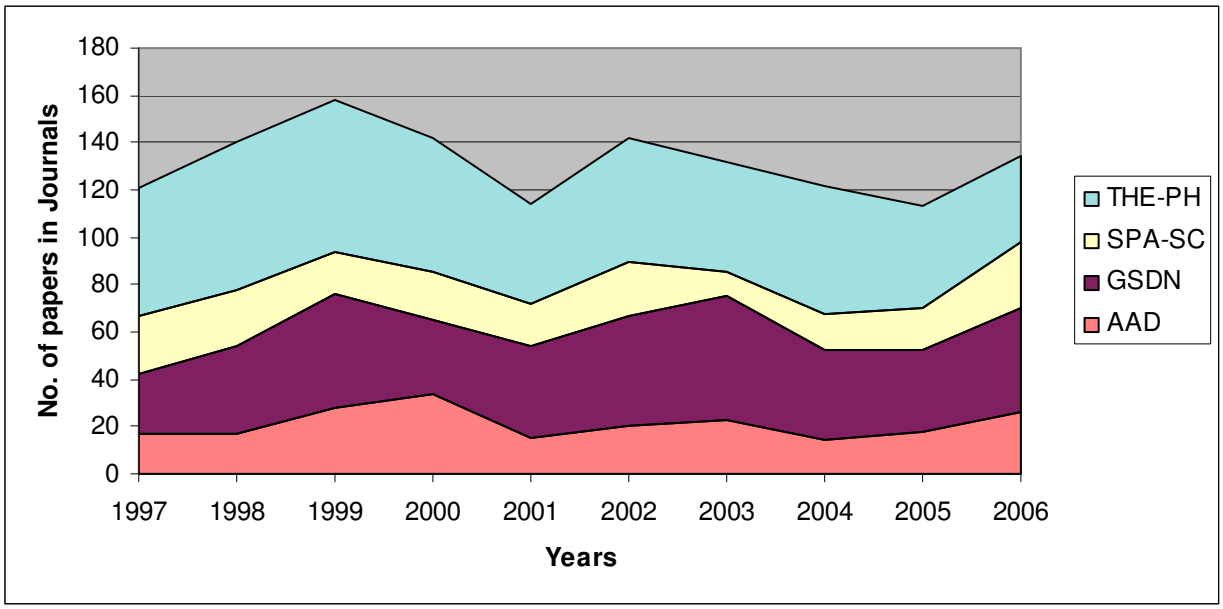
Table 1: Division wise break up of Papers Published in Journals during 1997-2006

Division	No. of Papers
AAD	180
GSDN	375
PSDN	20
SO-PH	32
SPA-SC	200
THE-PH	511
Total	1318

Figure 1 gives the research output pattern of four major divisions from 1997 through 2006. For broader picture, Solar Physics is included in Astronomy Division and PSDN is included in Geosciences division. AAD produced maximum (34) number of papers in the year 2000, Geosciences Division (GSDN) produced maximum number of papers (52)

in 2003, Space Sciences Division (SPA-SC) produced maximum (28) papers in 2006 and Theoretical Physics Division (THE-PH) produced maximum (64) papers in 1999.

Fig 1 : Year wise pattern of Papers in Journals from 1997-2006



Note : AAD – Astronomy, GSDN – Geosciences, SPA-SC – Space & Atmospheric Sciences, THE-PH – Theoretical Physics

The figure above shows that over the years, productivity of SPA-SC has remained more or less same while it has improved for AAD and almost doubled for GSDN. Most likely reason for this seems to be that more number of faculty joined PRL in Geosciences division during this period. THE-PH has seen a decrease in its research output in journals especially from 2004 onwards.

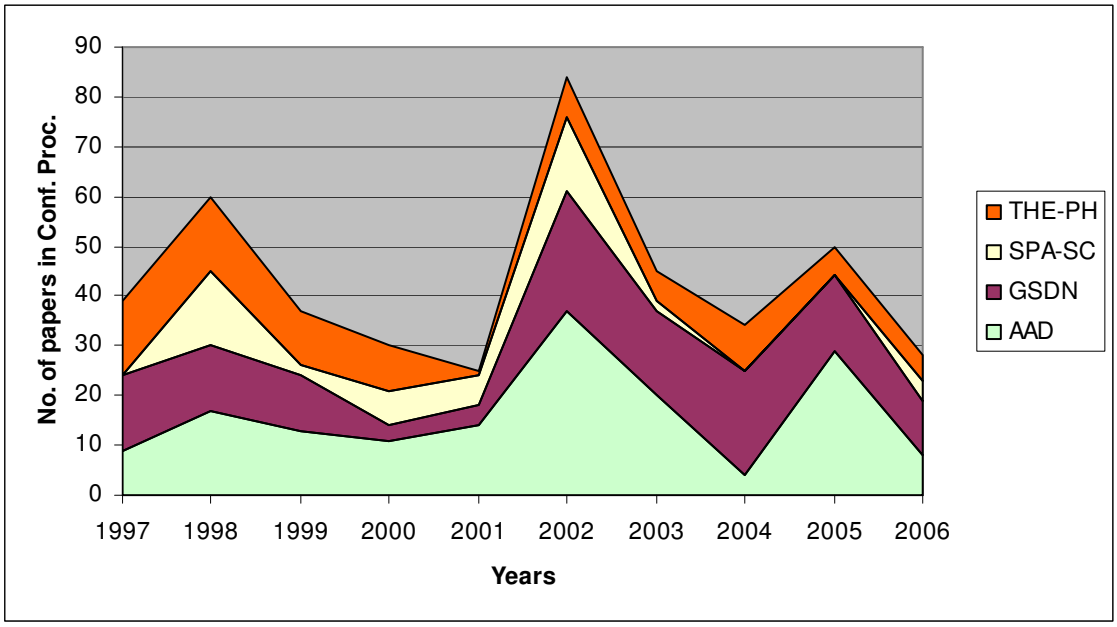
Table 3 and Figure 2 below give the division wise break up of papers published in conference proceedings. Out of 436 papers in conference proceedings, maximum of 129 papers (29.59%) are published by Astronomy division followed by GSDN with 116 papers (26.61%) and THE-PH with 85 papers (19.50%). Space Science Division published only 51 papers (11.70 %) in conference proceedings during the 10 year study period. Amongst the Facilities of the institute, 3 papers were published by Library & Information Services and one paper by Electronics Lab. There is no paper from Computer Centre and Workshop published in the conference proceedings during the period 1997-2006.

Table 3 : Division wise break up of Papers in Conference Proceedings during 1997-2006

Division	No of Papers
AAD	129
GSDN	116
PSDN	18
SO-PH	33
SPA-SC	51
THE-PH	85
ELEC.LAB	1
LIB-SR	3
Total	436

Figure 2 below give the year wise pattern of research output in conference proceedings in four major divisions of PRL (by bringing SO-PH under the fold of Astronomy and PSDN under the fold of GSDN as these were formed in the middle of the study period) . The table shows that Geosciences and Theoretical Physics division saw a decrease in number of papers published in conference proceedings, while Space Science division saw an increase in number of papers in conference proceedings from 1997 to 2006. There is an increase in Astronomy division's contribution in conference proceedings till 2005 with a sharp dip in 2006.

Fig 2 : Year wise pattern of Papers in Conference Proceedings from 1997-2006



Note : AAD – Astronomy, GSDN – Geosciences, SPA-SC – Space & Atmospheric Sciences, THE-PH – Theoretical Physics

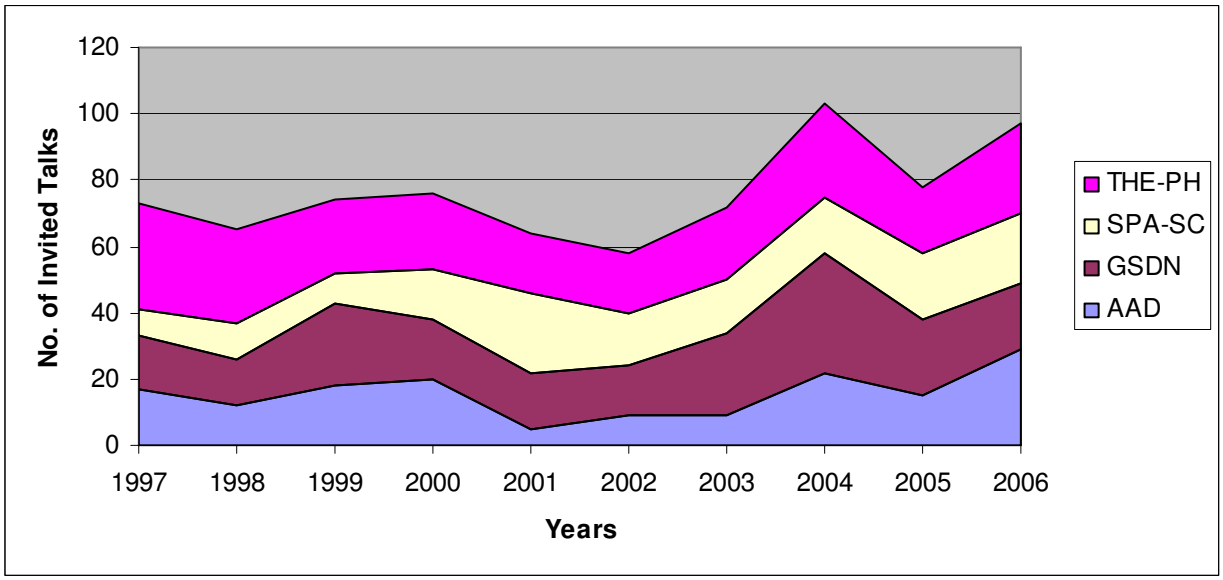
Table 4 gives the division wise break up of number of invited talks delivered by the scientists of PRL during 1997-2006. Out of the total of 764, THE-PH and GSDN top the list with 238 and 165 invited talks delivered respectively.

Table 4 : Division wise break up of Invited Talks delivered during 1997-2006

Division	No. of Invited Talks
AAD	116
GSDN	165
PSDN	44
SO-PH	40
SPA-SC	157
THE-PH	238
LIB-SR	1
COMP-SR	3
TOTAL	764

Figure 3 gives the year wise pattern of number of invited talks delivered by PRL scientists of four major divisions from 1997 to 2006. Here again the data of SO-PH is included in Astronomy and that of PSDN is included in GSDN. The table shows that number of invited talks over the years have decreased for Theoretical Physics division, increased for Astronomy and Space Science divisions and increased marginally for Geosciences division.

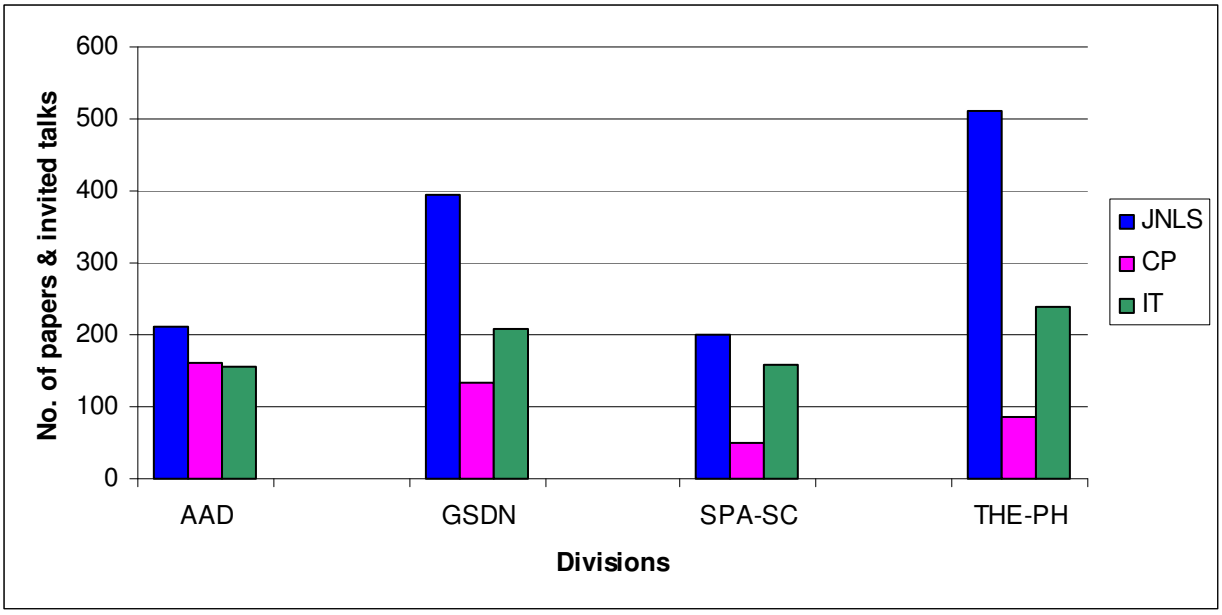
Fig 3 : Year wise pattern of Invited Talks delivered during 1997-2006



Note : AAD – Astronomy, GSDN – Geosciences, SPA-SC – Space & Atmospheric Sciences, THE-PH – Theoretical Physics

Thus the division wise break up of all the research output components (papers published in journals, papers in conference proceedings and invited talks) reveals that Theoretical division is most productive in terms of papers published in journals (511) and invited talks delivered (238). Geosciences division comes second in all the three categories of the research output with 375 papers in journals, 134 papers in conference proceedings and 209 invited talks delivered. Astronomy division produced maximum number of papers in conference proceedings (162) but delivered least number of invited talks (156). SPA-SC produced least number of papers in journals (200) and in conference proceedings (51). Graphical representation of the consolidated research output of four major divisions is given in Figure 4 below.

Fig 4 : Division wise consolidated research output of PRL during 1997-2006



Note : AAD – Astronomy, GSDN – Geosciences, SPA-SC – Space & Atmospheric Sciences, THE-PH – Theoretical Physics

7. Active Research Topics of PRL

After the broad division wise break up, it would be logical to take a look at the more specific subject headings under which the research was undertaken. The sample for identifying the research trends is papers published in journals (1318). The subject headings were arrived at by doing content analysis of the articles published in journals in each year and giving 2-3 keywords relevant to the main subject. Then each article was allotted a PACS number. PACS is Physics and Astronomy Classification Scheme, devised by American Institute of Physics.

This data was merged for all the years and sorted in descending order in order to determine the number of articles published in each micro topic. Thus a PACS number of

96.3 indicates the micro topic - Moon, where in 96 refers to the Solar System which is a topic under broad subject heading of 90 - *Geophysics, Astronomy and Astrophysics*. Then the number of articles published in all the micro topics under a topic were added up. These were further merged to arrive at a broad subject area. Tables 5 to 18 give the number of papers published in journals under different subject headings.

Table 5 gives the number of articles published in journals (1318) under 10 broad subject areas out of which first eight are under the Theoretical Physics, ninth is interdisciplinary and tenth includes Geoscience, Space Science and Astronomy. This is because the PACS covers the theoretical physics most extensively as it was the first field of physics for which PACS was developed. Gradually Astronomy, Geosciences and Space Science subjects were added by AIP for classification and retrieval of articles in these fields.

Table 5 : Number of papers under broad subjects of PACS

PACS No.	Broad Subjects	No. of Papers	%
0	***General Physics***	**136**	10.32
10	***Physics of Elementary Particles And Fields***	**118**	8.95
20	***Nuclear Physics***	**32**	2.43
30	***Atomic And Molecular Physics***	**31**	2.35
40	***Electromagnetism, Optics, Classical Mechanics***	**143**	10.85
50	***Physics of Gases, Plasmas, Electric Discharges***	**43**	3.26
60-70	***Condensed Matter***	**12**	0.91
80	***Interdisciplinary Physics And Related Areas***	**57**	4.32
90	***Geophysics, Astronomy And Space Sciences***	**746**	56.60
	Total	**1318**	100.00

The table above shows that Theoretical Physics subject field has been dealt with maximum depth (0-70) by PACS, as this scheme was devised to organise articles in Theoretical Physics. Five hundred and fifteen papers were published in this subject field. Fifty seven papers were published in interdisciplinary subject fields (corresponding to PACS number 80) and PACS number 90 (Geophysics, Astronomy and Astrophysics) accounts for more than half of the total share of articles published in journals (746) during the ten year period of 1997-2006.

Out of the seven broad PACS subject headings in Theoretical Physics, ***Electromagnetism, Optics and Classical Mechanics*** attracted 143 (10.85%) papers, followed by ***General Physics*** with 136 (10.32 %) papers and ***Physics of Elementary Particles And Fields*** with 118 papers (8.95%).

Tables 6-14 give the detailed picture of number of papers on various topics under each broad subject mentioned in Table 5.

Under the broad subject of ***General Physics***, 136 papers were published during 1997-2006 by PRL scientists. Out of these 136 papers, the top three topics which attracted maximum number of papers are *Quantum mechanics, field theories and special relativity* (66) followed by *Statistical physics, thermodynamics and nonlinear dynamics* (48) .

Table 6 : Number of papers under ***General Physics.***

PACS No.	Topics	No. of Papers
0	***General Physics***	**136**
1	*Communication, education, history and philosophy*	0
2	*Mathematical methods in physics*	3
3	*Quantum mechanics, field theories and special relativity*	66
4	*General relativity and gravitation*	13
5	*Statistical physics, thermodynamics, nonlinear dynamics*	48
6	*Metrology, measurements and laboratory procedures*	0
7	*Instruments, apparatus and components*	6

Table 7 gives the number of papers in different topics under ***Physics of Elementary Particles and Fields.*** In this group, the topic *Properties of Specific Particles* attracted the maximum number of papers (56) out of 118 papers published.

Table 7 : Number of papers under ***Physics of Elementary Particles and Fields***

PACS No.	Topics	No. of Papers
10	***Physics of Elementary Particles and Fields***	**118**
11	*General theory of fields and particles*	22
12	*Specific theories and interaction models*	22
13	*Specific reactions and phenomenology*	18
14	*Properties of specific particles*	56

Table 8 shows that a total of thirty two papers were published in the broad subject of ***Nuclear Physics*** under which *Nuclear Structure* attracted 17 of papers in the ten year period of 1997-2006.

Table 8 : Number of papers under ***Nuclear Physics***

PACS No.	Topics	No. of Papers
20	***Nuclear Physics***	**32**
21	*Nuclear structure*	17
23	*Radioactive decay and in-beam spectroscopy*	1
24	*Nuclear reactions : general*	7
26	*Nuclear astrophysics*	3
28	*Nuclear engineering and nuclear power studies*	2
29	*Experimental methods and instrumentation*	2

Table 9 shows that ***Atomic and Molecular Physics*** attracted a total of 31 papers during 1997-2006 out of which 15 were published under the topic *Atomic Properties and interactions with photons* and 10 were published under *Atomic and molecular collision processes*.

Table 9 : Number of papers under ***Atomic and Molecular Physics***

PACS No.	Topics	No. of Papers
30	***Atomic and Molecular Physics***	**31**
31	*Electronic structure of atoms and molecules*	3
32	*Atomic properties and interactions with photons*	15
33	*Molecular properties and interactions with photons*	2
34	*Atomic and molecular collision processes*	10
37	*Mechanical control of atoms, molecules and ions*	1

Table 10 shows that 143 papers were published on the topic ***Electromagnetism, Optics, Acoustics and Fluid Dynamics***, out of which 134 were published on *Optics*. No papers were published on *Acoustics* and *Heat Transfer*.

Table 10 : Number of papers under ***Electromagnetism, Optics, Acoustics and Fluid Dynamics***

PACS No.	Topics	No. of Papers
40	***Electromagnetism, Optics, Acoustics & Fluid Dynamics***	**143**
41	*Electromagnetism, electron and ion optics*	8
42	*Optics*	134
43	*Acoustics*	0
44	*Heat Transfer*	0
47	*Fluid Dynamics*	1

Table 11 below shows that ***Physics of Gases & Plasmas*** attracted 43 papers during 1997-2006. It is interesting to note that the topic *Physics of Gases* did not attract a single paper during the study period.

Table 11 : Number of papers under ***Physics of Gases and Plasmas***

PACS NO.	Topics	No of Papers
50	***Physics of Gases and Plasmas***	**43**
51	*Physics of Gases*	0
52	*Physics of Plasmas and Electric Discharge*	43

Table 12 below shows that the broad subject of ***Condensed Matter*** attracted only 12 papers in the ten year period, clearly indicating that it is not an active area of research for PRL.

Table 12 : Number of papers under ***Condensed Matter***

PACS No.	Topics	No of Papers
60-70	***Condensed Matter***	**12**
61	*Structure of solids and liquids, crystallography*	2
62	*Mechanical and acoustical properties of condensed matter*	0
64	*Equations of state, phase equilibria and phase transitions*	2
65	*Thermal properties of condensed matter*	0
71	*Electronic structure of bulk materials*	1
74	*Superconductivity*	0
77	*Dielectrics, piezoelectrics and ferroelectrics*	1
78	*Optical properties, condensed matter*	6

Table 13 below shows that under the broad subject of ***Interdisciplinary Physics*** 57 papers were published during the 10 year period of 1997-2006 out of which 37 were published in *Physical Chemistry and* Ch*emical Physics*.

Table 13 : Number of Papers under Interdisciplinary Physics

PACS No.	Topics	No. of Papers
80	***Interdisciplinary Physics***	**57**
81	*Materials science*	1
82	*Physical chemistry and chemical physics*	37
83	*Rheology*	0
84	*Electronics, radiowave and microwa technology*	4
85	*Electronic and magnetic devices*	10
87	*Biological and medical physics*	2
89	*Other areas of applied and interdisciplina physics*	3

Since PACS has grouped ***Geophysics, Astronomy and Atmospheric Sciences*** under one broad subject, the researcher thought it appropriate to give the break up of micro topics as indicated by the specific PACS number under each topic. Table 14 gives the break up of topics under the broad subject group of ***Geophysics, Astronomy and Atmospheric Sciences.***

Table 14 : Number of papers under ***Geophysics, Astronomy and Astrophysics***

PACS No.	Topics	No. of Papers
90	***Geophysics, Astronomy And Astrophysics***	**746**
91	*Solid Earth Physics*	127
92	*Hydrospheric and Atmospheric Geophysics*	236
93	*Geophysical Observations, Instrumentation*	13
94	*Physics of The Ionosphere And Magnetosphere*	58
95	*Fundamental Astronomy And Astrophysics*	36
96	*Solar System, Planetology*	170
97	*Stars*	67
98	*Stellar Systems, Interstellar Medium, Universe*	39

As seen from the table above, *Hydrospheric and Atmospheric Geophysics* attracted the maximum number of papers (236) followed by *Solar System, Planetology* (170) and *Solid Earth Physics* (127) respectively.

Further narrowing of PACS 90 topic into micro topics gives a clearer picture about thrust areas of research under this broad subject.

Consolidating all the thrust areas of research which attracted most number of publications, a list was prepared by arranging all micro topics in a descending order of number of publications. Table 15 and Table 16 show the list of thrust areas (micro topics) on which more than 20 papers were published in Theoretical Physics and Geophysics, Astronomy & Space Science respectively during 1997-2006 by PRL authors.

Table 15 : Thrust areas of research in Theoretical Physics during 1997-2006

PACS No.	Micro Topics	No. of Papers
42.5	Quantum optics	80
14.6	Leptons	44
3.65	Quantum mechanics	41
5.45	Nonlinear dynamics and chaos	28
52.27	Basic studies of specific kinds of plasmas	21

Table 16 : Thrust areas of research in Geophysics, Astronomy & Space Sciences

PACS No.	Micro Topics	No. of Papers
92.6	Atmosphere dynamics & meteorology	114
96.6	Solar physics	82
92.4	Hydrology and glaciology	70
96.3	Solar system objects, Meteorites	63
94.2	Physics of the ionosphere	49
91.8	Geochronology	45
82.33	Reactions in various media	36
91.6	Physical properties of rocks and minerals	30
92.2	Chemical and biological oceanography	26
95.55	Astronomical, Space research instrumentation	25

8 Summary of results

1. The content analysis of the articles published in journals and the use of PACS to allot keywords helped to identify the thrust areas of research carried out in PRL. Thrust areas in **Geophysics, Astronomy & Space Sciences** are *Atmospheric Dynamics and Meteorology* (114), *Solar Physics (*82 papers)*, Hydrology and Glaciology (70 papers), Solar System Objects, Meteorites (63 papers), Ionosphere (49 papers), Geochronology (45 papers), Rocks & Minerals (30 papers), Oceanography (26 papers) and Astronomical Instrumentation (25 papers).* In **Theoretical Physic**s maximum number of papers were published on *Quantum Optics (*80 papers), *Leptons* (44 papers) and *Quantum Mechanics (*41 papers).

2. The broad subject of *Condensed Matter* attracted only 12 papers in the ten year period clearly indicating that it is not an active area of research for PRL. No research was done on the topics *Acoustics*, *Heat Transfer, Physics of Gases* and *Rheology*.

The researcher hopes that this information will be useful to the institute's decision makers for future research planning.

9 Conclusion

The aim of the present bibliometric study was to discover a better and complete understanding of what is actually taking place in research at PRL. It has fulfilled its objectives of discerning the research trends of PRL. The results of the study will help those charged with making difficult choices about allocating the resources. It will also help in taking human resource decisions as regards the induction of faculty members in different divisions.

10 Suggestions

a) The high productivity of Theoretical Physics division could be due to more number of faculty and students in the division. Induction of more faculty members and students in other divisions could help in increasing the number of papers published by PRL.

b) Also, higher publication output might have direct correlation with more number of journals subscribed. It is interesting to note that out of all the currently subscribed titles of journals, maximum number of journals pertain to Theoretical Physics.

c) The subjects that attracted very few papers in the ten year period clearly indicate that these are not an active area of research for PRL. The reasons for non-active research areas could be looked into.

11 Future Research

After arriving at the above conclusions and suggestions, the researcher feels appropriate to furnish a few pointers to the areas of future research. Going through the various studies during the literature survey, the researcher found that very few bibliometric studies have been carried out in the field of Geosciences and Space Sciences. These would be interesting subject fields to study. Comparative study may be undertaken of research institutes in similar research domain. Collaborating institutes can be identified so that non-collaborating institutes can be taken into the fold of collaboration which in turn may lead to increase in number of publications and number of citations for PRL.

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