

**OUTSTANDINGLY CITED AND MOST SIGNIFICANT PUBLICATIONS
OF R. CHIDAMBARAM, A NUCLEAR PHYSICIST**

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ABSTRACT

Analyses 164 papers by R. Chidambaram, a nuclear physicist from India, published during 1958-93, and identifies highly cited papers as per Science Citation Index. His self evaluated 'most significant publications' were also considered and it is found that the self assessment by a scientist about the significance of his papers may not always tally with the world's opinion. The citation data were subjected to domain-wise and category-wise classification, and used to study time lag for receiving first citation to each paper, synchronous and diachronous self-citations, core journals in which his publications were published, publication density, publication concentration, journals in which his publications were cited, and influence of channels of communications and authorships on citedness.

Keywords: Nuclear Magnetic Resonance, Citation analysis, Synchronous self-citation, Diachronous self-citations, Scientometrics, Bibliometrics, Research productivity, Impact factor, Immediacy index, Nuclear scientist, R. Chidambaram.

INTRODUCTION

The individual investigator has been the subject of quite a number of bibliometric studies in the recent past (Mulchenko et al., 1979; Ruff, 1979; Sinha and Bhatnagar, 1980; Gupta, 1983; Gupta and Gupta, 1983; Mahapatra, 1992; Sinha and Ullah, 1993; Kalyane and Devarai, 1994; Kalyane and Kalyane, 1994a, 1994b; Kalyane and Samanta, 1994). By and large, citation analysis has been found to be a suitable technique to evaluate the contributors in any field (Mahapatra, 1992). However, it is to be noted that citation pattern varies from one field to another. The number of times a paper is cited depends strongly on the number of workers in the field. Someone working in a well-populated

field is likely to receive a lot of citations whether or not his work is significant (Johnson and Davies, 1975; Geller, de Cani and Davies, 1978). Citation analysis hence, cannot replace peer judgement, but can make it objective and astute (Garfield, 1978).

The present study deals with the highly cited and most significant publications of one of the well-known Indian nuclear physicists, R. Chidambaram, who started his research career as a Ph.D. student at the Indian Institute of Science, Bangalore, India during the late fifties, where he used the Nuclear Magnetic Resonance (NMR) technique. He joined Bhabha Atomic Research Centre (the then Atomic Energy Establishment, Trombay), in

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1962, to head a section working in the field of neutron crystallography and initiated neutron crystallography research in India. He is internationally known for his work on non-linear hydrogen bonds in crystals and on high pressure induced phase transformations in metals. He and his co-workers have proposed a new equation of state in the 'intermediate' – high pressure (5-100 Megabar) region. The positron annihilation studies were also carried out during late seventies and early eighties. His recent research on quasicrystals has given fresh insights. He has made significant contribution to the peaceful uses of nuclear energy in the Indian Atomic Energy programme (INSA, 1984 ; INSA, 1986).

Studies on hydrogen bonding interactions have been his major field of research in which he has made lasting contributions. He is an internationally known crystallographer and is currently a member of the executive committee of the International Union of Crystallography. Many awards were bestowed on him including the Padmashri in 1975, and the Second Jawaharlal Nehru Birth Centenary International Visiting Fellowship by the Indian National Science Academy in 1992 to visit Germany and Japan. Since January 31, 1993 he is the Chairman, Atomic Energy Commission, India.

OBJECTIVES

The objectives of the present study are:

- to classify publications of Chidambaram domainwise;
- to identify outstandingly cited papers based on citations received till 1992 ;

- to project citation pattern of outstandingly cited papers ;
- to highlight outstandingly cited papers, and the most significant papers identified by the scientist himself ;
- to compare total citations received by all papers published with total citations received by outstandingly cited papers ;
- to enquire into different bibliographic forms of publications;
- to identify core citing journals and their impact factor, immediacy indexes to investigate coverage in abstracting and indexing journals, and the countries of their origin ;
- to find channels of communications most used by this scientist.

METHODOLOGY

The bibliography of publications of Chidambaram was compiled first, as the *Science Citation Index (SCI)* links only the first author with the publication, a practice that requires compilation of a complete bibliography of the author's work before using the index to ascertain the author's "impact" (Coleman, 1992). Each item was subjected to manual scores for citations received as per *SCI* 1958 -1992 published by Institute for Scientific Information, Philadelphia, PA. Chidambaram's papers are classified into four domains within which citation patterns are studied. The mean citation of the papers in each domain is calculated. The data obtained are arranged in categories (Schubert, Glanzel and Braun, 1987) of citedness: uncited papers, sparingly cited (papers cited lower than the mean

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citation of papers), fairly cited (papers with the scores equal to mean citation of the paper, \bar{x}), remarkably cited (papers receiving citations above \bar{x} but below five times of \bar{x}), and outstandingly cited (papers cited more than five times of \bar{x}).

The statistical analysis of variance has been carried out using NCSS (Number Crunching Statistical System) software, and Scheffe's Test was used to find the significant differences.

RESULTS AND DISCUSSION

The four domains in which the papers have been classified are: Nuclear Magnetic Resonance, Neutron Diffraction and Hydrogen Bonding, High Pressure and Shock Wave Physics and Quasi-crystals. The results and discussions follow the same order here.

1. Nuclear Magnetic Resonance.

The mean citation of the papers for this domain was 7 for the 17 papers published during 1958-64 and standard deviation was found to be 16. Eight papers remained uncited, six papers were sparingly cited, and one paper was remarkably cited. Two papers (P1, P2; vide Appendix) which were published in 1961 and 1962 were outstandingly cited receiving 37 and 59 citations respectively, out of which self citations were two (5.4%) and five (8.7%) respectively.

2. Neutron Diffraction and Hydrogen Bonding.

There were 64 publications during 1963-93. The mean citation of the papers was

16 with standard deviation of 29. Twenty-four papers remained uncited. Sparingly cited papers were 23, and remarkably cited papers were 14. Three papers (P3, P4, P5; vide Appendix) were outstandingly cited having 152, 112, and 113 citations respectively, out of which self-citations were nineteen (12.5%), four (3.5%), and only one (0.88%) respectively.

The first of the three outstanding papers, (Chidambaram, Sequeira and Sikka, 1964) was the first attempt towards classification of a variety of interesting lone-pair coordinations exhibited by hydrogen bonded water molecules in crystal hydrates.

The other two papers are excellent examples of accurate neutron study.

3. High Pressure and Shock Wave Physics.

In this domain there are 46 papers published during 1975-93. The mean citation of the papers was 3 with standard deviation of 5.

Nineteen papers remained uncited, 17 papers were sparingly cited, one paper was fairly cited, and seven papers were remarkably cited. Two papers (P6, P7; vide Appendix) published in 1983 and 1988 were outstandingly cited receiving 27 and 21 citations respectively, out of which self citations were three (11.11%) and three (14.29%) respectively.

In the first paper, Chidambaram and co-workers delve on the equation of state model which traverses thermodynamic

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states from condensed matter region to screened Coulomb limit, and makes right contact with statistical (Thomas,1927; Fermi,1927; Dirac,1930) theories in high density limit, when Paulies Exclusion principle forces electrons to occupy high momentum states giving dominant kinetic energy turn in the total energy being treated as perturbation. The predictions made by Chidambaram and co-workers have already been verified by recent experimental data.

The most interesting feature of the second paper was the vanishing of diffraction peaks above 12 GPa in this compound.

4. Quasicrystals

The recent domain "Quasicrystals" has ten papers during 1988-93. The mean citation of the papers was two and standard deviation was one.

Three papers remained uncited, three papers were sparingly cited, and one paper was fairly cited. Since this is the youngest domain, it is too early to find out outstandingly cited papers.

Discussions

Graphic representation of the number of publications for each domain, as per categories of citedness, categorywise mean citations per paper, and year of publication are depicted in Figure 1.

[Figure 1: Citation Scores for Publications of Chidambaram is available in hardcopy]

The average citation of the outstandingly cited seven papers is 74. Whereas the average citation of all 164 papers is only eight.

The sparingly cited papers in the domain of High Pressure and Shock Wave Physics are significantly different from those of Neutron Diffraction and Hydrogen Bonding and Nuclear Magnetic Resonance, at $p < 0.05$ level. Remarkably cited papers of Nuclear Magnetic Resonance and High Pressure and Shock Wave Physics have significantly different citedness from Neutron Diffraction and Hydrogen Bonding papers at $p < 0.05$ level.

Outstandingly cited papers from High Pressure and Shock have Physics and Nuclear Magnetic Resonance have significantly different citedness from Neutron Diffraction and Hydrogen Bonding at $p < 0.05$ level.

Citograph for seven outstandingly cited papers of Chidambaram are shown in Figure 2. Rising trend was found for the citations to papers P3, P4 and P5 (vide Appendix) in Neutron Diffraction and Hydrogen Bonding, whereas declining trend was found for papers P1 and P2 in Nuclear Magnetic Resonance. The two papers (P6 and P7) identified in the domain High Pressure & Shock Wave Physics are expected to receive further citations as it is too early to find a trend.

[Figure 2: Citograph for Seven Outstanding Papers of R Chidambaram is available in hardcopy]

When we consider only the seven outstandingly cited papers, the papers P2, P3, P4 and P5 have received first citation in the same year of their publication. The papers P1, P7 and P6 received first citations after two, three

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and four years respectively. The 25 remarkably cited papers are expected to continue receiving further citations to attain the category of outstandingly cited papers.

SIGNIFICANT PUBLICATIONS : SELF ASSESSMENT BY THE SCIENTIST

It is interesting to note that Chidambaram himself listed 13 of his most significant publications (Chidambaram, 1991) in his D.Sc. thesis and four papers de-scribed in the present study P1, P3, P6, and P7 (vide Appendix) have appeared in the list. Four papers from his list of most significant publications have received the status of remarkably cited papers (P8, P9, P10 , P11; vide Appendix).

One of the papers (P12; vide Appendix) listed as his most significant contribution was identified in the present study as fairly cited paper having two citations only from the recent domain Quasicrystals, which was published in 1990.

One of the papers (P13; vide Appemdix) listed as his most significant publications in the domain High Pressure & Shock Wave Physics was identified as a sparingly cited paper having two citations only.

Two of the papers (P14 & P15; vide Appendix) figured in his list of most significant publications have not received any citation till 1992.

No citation analysis was done for the paper P16 (vide Appendix) as SCI

database was not readily available beyond 1992.

In present case, 57 percent of the highly cited papers are listed among the most significant papers identified by Chidambaram.

The papers P2, P4, and P5 which are identified as outstandingly cited papers were not found in his list of most significant publications. This study therefore helps to provide a proper perspective about self assessment by the scientist. Also, further study is required to know in what context these papers have received citations.

SELF CITATION

Self citations are either synchronous or diachronous:

$$\text{Synchro-} = \frac{\text{Self citation in an article}}{\text{Total no. of citations in an article}} \times 100$$

$$\text{Diachro-} = \frac{\text{Self citations to an article in SCI database}}{\text{Total no. of citations received by an article in SCI database}} \times 100$$

Synchronous and diachronous self citation rates for the highly cited and most significant publications of Chidambaram, R. are provided in Table 1.

On an average for the highly cited seven papers (P1 to P7) the synchronous rate was 9.08 whereas diachronous rate was 8.03. Mean synchronous rate for all the 16 papers discussed above was 12.20

Table 1: Synchronous and Diachronous Self-citation Rates for the Highly Cited and/or Most Significant Publications of Chidambaram

Paper	Synchronous rate(%)	Diachronous rate (%)
P1	8.00	8.47
P2	0.00	5.41
P3	17.24	12.50
P4	12.07	0.88
P5	16.07	3.57
P6	3.94	11.11
P7	6.25	14.29
P8	22.73	26.19
P9	21.74	19.44
P10	0.00	16.54
P11	6.90	40.00
P12	8.00	50.00
P13	13.33	50.00
P14	7.05	0.00
P15	24.61	0.00
P16	27.27	0.00

and diachronous rate was 16.15. Therefore publications of Chidambaram, have low synchronous rate associated with a low diachronous rate. This possibility was predicted by Lawani (1982). This has sociological implications indicating that the researcher concerned is a productive and key figure in his research speciality having no egotist nature.

ANALYSIS FROM DIFFERENT ANGLES

1. Journal citographs

The journalwise citographs for all 164 papers including 'general and popular' publications compared with only seven outstanding papers is shown in Figure 3

The outstanding seven papers have received a total of 521 citations in 146 journals. Whereas the 164 papers in total have received 1293 citations in 231 journals and depict an extendend 'S' shaped curve. His papers were also cited in 9 books. Thus, total citations received by his papers till 1992 were 1302.

[Figure 3: Citograph for Publications of R. Chidambaram is available in hard copy]

The concave nucleus zone includes 8 journals. The linear zone extends up to 150 journals, and above that convex non-linear zone showing the formation of a Groos droop (Qui and Tague, 1990 ; Egghé and Rousseau, 1988).

2. Core Journals Which Published Chidambaram's Papers

The paper P1, P2, P3, P4, P5, P6, and P7 were cited in 32, 21, 64, 52, 17 and 15

journals respectively. The core journals in which Chidambaram has published 50 percent of his papers are provided in Table 2A. His maximum 14 papers were in *Acta Crystallographica-B* and eight papers in *Pramana*. The publication density was 2.34 and publication concentration (Vinkler, 1990) was 20.41.

3. The Citing Journals

The top ranking ten citing journals along with the following data: number of citations, percentage, cumulative percentage, impact factor, immediacy index, coverage in number of abstracting and indexing journals and country to which

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Table 2A : Core Journals in which Chidambaram has published his Papers

No.	Journal	No. of papers	Percentage	Cumulative percentage	Period of journal usage			Impact factor	Immediacy index	Coverage in no. of A & I
					FPY	LPY	Total			
1	Acta Crystallogr. B.	14	12.18	12.18	1968-1980	13	1.422	0.535	16	
2	Pramana	8	6.95	19.13	1973-1990	18	0.521	0.277	10	
3	Curr. Sci.	6	5.21	24.34	1984-1993	10	0.164	0.025	46	
4	Acta Crystallogr.	5	4.34	28.68	1961-1967	7	1.328	0.343	-	
5	J.Phys. Cond. Matt.	5	4.34	33.02	1989-1990	2	-	-	17	
6	Phys.Rev.B	5	4.34	37.36	1979-1993	15	3.820	0.940	19	
7	J.Chem. Phys.	4	3.48	40.84	1962-1968	7	3.588	0.776	28	
8	Physica-B	4	3.48	44.32	1991-1991	1	0.186	0.839	1	
9	Proc.Indian Acad.Sci.A	4	3.48	47.80	1971-1983	13	-	-	-	
10	Bull.Mater. Sci.	3	2.61	50.41	1981-1984	4	0.265	0.000	9	
11-49	Others	57	49.59	100.00	-	-	-	-	-	

FPY = First Publication Year LPY = Last Publication Year A&I = Abstracting & Indexing Periodicals

Table 2B : Citing Journals Wherein Publications of Chidambaram Received Citations

No.	Journals	No. of citations	Percentage	Cumulative percentage	Impact factor	Immediacy index	Coverage	Country of journal
1	Acta Crystallogr B	163	12.61	12.61	1.802	0.312	16	Denmark
2	J.Chem.Phys.	77	5.61	18.57	3.433	0.778	28	US
3	Int.J.Pept.Protein Res	32	2.47	21.04	1.894	0.259	19	Denmark
4	J.Am.Chem.Soc	32	2.47	23.51	3.593	0.649	-	US
5	Phys.Rev.B	32	2.47	25.98	3.259	0.577	19	US
6	Acta Crystallogr.C	31	2.40	28.38	0.479	0.200	7	Denmark
7	J.Mol.Struct.	31	2.40	30.78	0.943	0.132	13	Netherlands
8	Inorg.Chem.	30	2.32	33.10	2.721	0.466	18	US
9	Bull.Chem.Soc.Jpn	27	2.09	35.19	0.876	0.207	-	Japan
10	Curr.Sci	27	2.09	37.28	0.253	0.075	46	India
11-231	Others	811	52.72	100.0	-	-	-	-

Impact Factor & Immediacy Index as per 1992 SCI Journal Citation Reports, A&I = Abstracting & Indexing Journals

the journal belongs is provided in Table 2B. It is interesting to note that among the top ranking 10 citing journals, the journals published from Denmark (vide *Acta Crystallographica-B*, *International Journal of Peptide and Protein Research*, and *Acta Crystallographica-C*) have cited Chidambaram 163, 32 and 31 times respectively accounting for 226 citations. Among the top 10 citing journals, the journals published from United States, viz. *Journal of Chemical Physics*; *Journal of American Chemical Society*; *Physical Review B*, and *Inorganic Chemistry* have cited Chidambaram 77, 32, 32, and 30 times respectively, accounting for 171 citations.

4. Channels of Communication

The dynamics and internal structure of the system of scientific communication are greatly influenced by the varying quality of the primary journals in which scientific communications are published. The analysis of citations is among the means by which policy makers, scientists and librarians seek to achieve a greater understanding of the qualitative forces that affect formal communications in science. The publications with higher indices of "immediacy" tend to produce higher measures of "impact".

Given the distinct possibility that more immediate response to the contents of journals in the form of citations is governed to a significant extent by the frequency of issuance, volume of publication and size of readership, it may be unwarranted to speculate further that the rates with which journals are cited are influenced as much by the

circumstances and conditions of their publication as by the intellectual reception of their contents (Tomer, 1986).

The channels of communications used by Chidambaram for publishing his paper and the citations received are given in pie charts (Figure 4). The influence of channels of communications (Foreign and Indian) and categorywise citedness of the papers is provided in Table 3.

[Figure 4 and Table 3 are placed after the Appendix]

Chidambaram has published 12 papers in foreign journals and 4 papers in Indian journals belonging to the domain Nuclear Magnetic Resonance. The mean citation for foreign journal papers in this domain is 10.33, standard deviations 17.77, and standard error of mean 5.35. None of the four papers published in Indian journals received any citation.

He has published 33 papers in foreign journals and 10 papers in Indian journals, belonging to the domain Neutron Diffraction and Hydrogen Bonding. Papers published in foreign journals has 27.85 citations per paper, with standard deviation 36.32, and standard error of mean 6.33. The papers published in Indian journals received 6.3 citations per paper with standard deviation 8.39, and the standard error of mean 2.79.

He has published 21 papers in foreign journals and 10 papers in Indian journals belonging to the domain High Pressure and Shock Wave Physics. The papers published in foreign journals has a mean citation

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rate of 5.52, standard deviation of 7.12, and standard error of mean 1.55.

The papers published in Indian journals received mean citation per paper of 1.1 with standard deviation of 0.83, and standard error of mean 0.26.

He has published seven papers in foreign journals belonging to the domain Quasi-crystals. The mean of the citations received by these is two, standard deviation is 1.56, and standard error of mean 0.62. He has not published any paper in Indian journals in this domain.

Statistical calculation using Scheffe's test revealed that there is no statistically significant difference in the citations received by Indian or foreign journals. Hence the physics journals in which Chidambaram has published his papers have equal standing, quality and coverage in abstracting and indexing periodicals.

5. Mean Citations of Single and Multi-authored Papers

The domainwise mean citation for single authored papers and multi-authored papers is compared in Figure 5 {Available in hardcopy only}. Single author papers (11 nos.) in the domain Nuclear Magnetic Resonance has mean citation rate of 9.18 per paper, with standard deviation of 18.92. and standard error of mean 5.99. Multi-authored papers (6 nos.) received 4.17 citations per paper, with standard deviation of 4.14, and standard error of mean of 1.85.

There are 12 single authored papers and 52 multi-authored papers in the domain

Neutron Diffraction and Hydrogen Bonding. The mean of the citations for the single authored papers is 1.33, with standard deviation of 3.01, and standard error of mean 0.91. The mean of the citations for multi-authored papers is 19.11, with standard deviation of 30.89, and standard error of mean 4.33.

Three single author and forty-three multi-author papers figure in the domain High Pressure and Shock Wave Physics. One paper received only one citation among single authored papers.

The mean citation for multi-authored papers is 3.12, with standard deviation of 5.71 and standard error of mean 0.88. He has published one paper as single author which remained uncited, and 9 multi-authored papers having mean citation of 1.78 per paper, with standard deviation of 1.61, and standard error of mean 0.57.

However, citations to single authorship and multi-authorship papers when tested for statistical significance by Scheffe's test revealed no statistically significant differences between various domains.

CONCLUSION

The important finding of the study is that out of thirteen papers considered by the scientist as most significant; four are outstandingly cited, four are remarkably cited, one is fairly cited and one which was published in 1990 received two citations till 1992 and two papers did not receive any citation. The citation analysis of papers published in 1993 was not carried out. The outstandingly cited

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papers of the scientist did not find any place in the aforementioned list of thirteen. This finding hints towards a possibility that self assessment by a scientist, about the significance of his papers may not always tally with the world opinion.

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APPENDIX

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P16 Chidambaram R., Sanyal M.K., Raghu-nathan V.S., Nambissan P.M. G., and Sen P. 1993. Positron annihilation studies on Al-Cu-Fe: their significance for the structural models of Icosahedral quasicrystals, *Phys. Rev.* 48(5): 3030-3036.

Figure 4: Channels of Communication and Citedness of the Papers of Chidambaram (

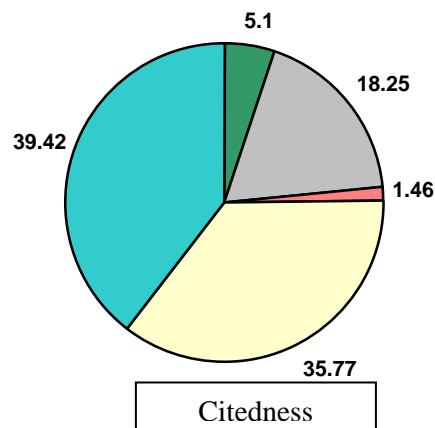
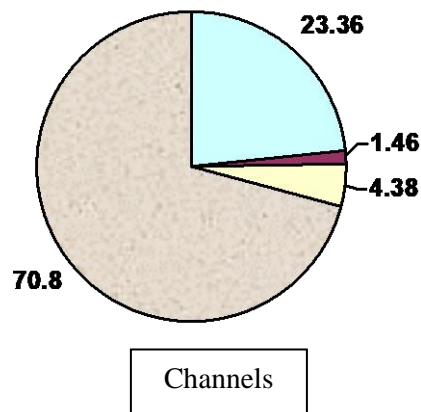


Table 3 : Influence of Channels of Communication on Citedness of the Paper of Chidambaram

Channels of communication /citedness	Uncited				Sparingly cited				Fairly cited				Remarkably cited				Outstandingly cited				Total papers	percentage	
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D			
X	-	-	-	-	3.00	5.65	1.70	1.00	-	-	3.00	2.00	12.00	36.21	7.85	3.66	48.00	125.66	24.00	-			
XI	-	-	-	-	2.08	4.71	0.37	-	-	-	-	-	-	13.46	3.48	0.46	11.00	18.62	3.00	-			
Journals	F	4	6	4	2	5	12	8	1	-	-	1	1	1	12	6	3	2	3	2	-	73	53.28
	I	4	3	3	-	-	5	7	-	-	-	-	-	-	2	-	-	-	-	-	-	24	17.52
Seminar & conference	F	-	4	9	-	-	1	-	1	-	-	-	-	-	-	1	-	-	-	-	-	16	11.68
	I	-	8	3	1	1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	16	11.68
Reports	F	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.73
	I	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.73
Chapter in books	F	-	2	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	3	2.19
	I	-	1	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2.19
Total	F	4	12	13	2	5	14	8	3	-	-	1	1	1	12	7	3	2	3	2	-	93	67.88
	I	4	12	6	1	1	9	9	-	-	-	-	-	2	-	-	-	-	-	-	-	44	32.12

A=Nuclear Magnetic Resonance, B=Neutron Diffraction & Hydrogen Bonding, C=High Pressure & Shock Wave Physics, D=Quasicrystals, F=Foreign publications, I=Indian Publications Uncited=Not cited at all, Sparingly cited=Lower than average, Fairly cited=Average citations only X, Remarkable cited=Above x, but below five times of X, Outstandingly cited=More than five times of X, XI = Mean citations in the domain as per citedness group of the papers