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Citation profiles of some Indian scientists: J.C. Bose, S.N. Bose and K.C. Kar

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Abstract

This article gives a clear panorama of citation profiles of the research publications of three Indian scientists namely J.C. Bose, S.N. Bose and K.C. Kar. The present study approaches more than one or two scientists taken together and their scientific research contributions (in terms of measurable outputs) as statistical populations. Citations to the scientific research papers by them were collected on checking through Science Citation Index (SCI) and online database of SCI i.e. Web-of-Science (WOS). This paper presents a temporal distribution and the geographical distribution of citations made to the publications of the scientists under study. It has been found that J.C. Bose was the most productive author but K.C. Kar even with much more collaborators was not the same. It has been further noted that S.N. Bose ranked first and was followed by the two other scientists J.C. Bose and K.C. Kar as per the number of total citations received by their scientific papers.

Keywords Scientometrics, Scientific Productivity, Citations, Web-of-Science

Abbreviations Science Citation Index (SCI), Web-of-Science (WOS)

1 Introduction

The significance of individual scientists in the progress of science and technology has been acclaimed over the years. Respective contributions and roles of them in the S & T activities have been the subject of much investigation and many debates. In the recent past, social scientists especially biographers, bio-bibliographers and librarians have been taking the help of quantitative and/or semi-quantitative approach that attempts a spectral view relating to the individual personality. This can be achieved with the help of a tool of scientometrics or a citation analytical study. A careful enquiry into the citation profile of the individual scientist provides clear panorama

and significant insights in diverse ways. The citation received by the publication of the respective scientist is the best available indicator of the use of that publication.

2 Objective

The main objectives of this study are:

1. To depict the citation profiles of the research publications of two theoretical physicists Satyendra (S) Nath (N) Bose or Basu (1894-1974) and Kulesh (K) Chandra (C) Kar (1899-1975), and a unique pluridisciplinary scientist Jagadish (J) Chandra (C) Bose or Basu (1858-1937);
2. To ascertain the temporal distribution of citations made to the publications of the scientists under study;
3. To present geographical distribution of the citations received by the scientists and
4. To present a citation analytical comparison among the citations received by their scientific research contributions.

3 Tools of the work

Information about the scientists under study are varied and scattered in many different places.

Some of the more important sources about them are:

i) Biographical memoirs of the fellows of the different societies and academies,
ii) Websites including citation databases,
iii) Books written by the scientists,
iv) Collected works of the scientists, if any,
v) Obituaries published in different sources after their death,
vi) Unpublished writings as may be found out.

Different potential source materials or tools such as Science Citation Index (SCI: five yearly cumulated hardcopy volumes) from 1945 onwards in the National Library of India in Calcutta, Biographical Memoirs of the Fellows of INSA in hardcopy, Google Scholar, Wikipedia, online documents, etc. have been consulted to find citations to their writings as far as possible. Almost of all publications were further searched for citations as per Web of Science (1900─January, 2013) ─ SCI online Database. The data collected was scientometrically analysed. Results were produced in tabular form only.

4 Why these scientists were clubbed as a group for the present study?

J.C. Bose as a first rate biophysicist, internationally accredited for the all round progress of country, prospecting quite a number of important plant electro-physiological features over an immense experiments on plant response, as an instrumentationist (Sen, 1983) enriching laboratories of microwave physics or radio physics and experimental biophysics. S.N. Bose's work on Planck's formula

derivation and light quantum hypothesis brought him instant international recognition. But it was not so for K.C. Kar. Kar went on publishing his papers on acoustical physics, wave mechanics and particle physics during the period when S.N. Bose was conducting his full-fledged works on quantum physics, statistics and mathematical physics. There was hardly anyone in India who obtained distinction over such a wide range of subjects in theoretical physics as Kar. Notably, Kar has more than hundred research papers in theoretical physics covering a wide spectrum of subjects from wave statistics to a new theory of gravitation. Moreover, he strongly realised that writing more scientific papers would not foster the scientific progress in its true sense among the student community in India. For this purpose, he felt urge to write appropriate text-books on related subjects. Accordingly, he wrote five text books on Physics for the students of higher classes. He continued his research works in his Institute of Theoretical Physics (Bijnan Kutir) until the end of his days with a serious handicap of near sightlessness during the fag end of his life. There are hardly a few who remember him and recognize his scientific works and activities. Such a talented scientist in India woefully sunk into oblivion. Perhaps there has been the question of inquisitiveness which culminates in building up a quantitative or semi-quantitative device of science mapping of the research productivity of the scientists clubbed as a group for the present study.

5 Short life sketch of the Scientists

J. C. Bose

J.C. Bose was one of the pioneers of modern science in India whose major contributions and discoveries affected the advanced scientific research in India in multiple fields like micro-wave physics, plant physiology and biophysics. Jagadish Chandra was a unique pluridisciplinary scientist whose early researches on invisible rays, wireless telegraphy and microwaves brought him quick recognition all over the world. After qualifying B.Sc. from the St. Xavier's College in Calcutta (now Kolkata), Bose went to England for higher studies. He appeared for the Tripos Examination from the Cambridge University in 1884. He obtained a B.Sc. degree from the London University in the same year. Prof. Bose returned to India and joined Presidency College (now University) as Professor Emeritus. In 1917, he founded the Bose Institute (Basu Bijnan Mandir) in Calcutta for higher research. Prof. Bose was the director of the Institute till his death on 23th November, 1937. He commenced researches in small radio waves which is now called micro-wave physics. In fact Bose was one of the earliest microwave physicists. He shifted his research interests to plant physiology and plant biophysics in 1902. He invented a number of high precision instruments for the sake of his researches. Bose is envisaged as a forerunner of modern biophysics. He was honoured by Fellowship of the Royal Society of London (FRS) in 1920.

S. N. Bose

S.N. Bose, an Indian theoretical physicist started his academic life at the University of Calcutta where he obtained a degree in Mixed Mathematics in 1915 and became a

lecturer in Physics and Applied Mathematics in 1917. He obtained B.Sc. Honours and M.Sc. degrees in Mathematics and stood first in the first class in both examinations. S.N. Bose later joined the University of Dacca and it was there in 1924 that he wrote his most popular paper "*Planck's law and the light-quantum hypothesis*", which he sent to Albert Einstein for comments. Being highly impressed with his paper Einstein translated it into German. Later it was published in the prestigious journal "*Zeitschrift fur Physikalische*". Einstein later applied Bose's derivation and technique to a collection of particles and the treatment came to be known as "Bose-Einstein Statistics". Prof. Bose's interests were varied and embraced the diverse fields as chemistry, mineralogy, history, social science, philosophy, literature, languages, fine arts and music. His interests later were predominantly concentrated to unified field theory and the theory of numbers. But he dedicated himself to take up the role of a devout teacher. In 1945, he went back to the University of Calcutta and in 1958 he became Fellow of the Royal Society of London for his contributions to the modern physics. He died on 4th February, 1974 at the age of 80.

K. C. Kar

K.C. Kar was one of the leading theoretical physicists in India. He was highly meritorious from his early life. He passed the Entrance Examination from Hare School, Calcutta, in 1916 and stood first in Mathematics and rewarded the gold medal. He passed Intermediate Examination in 1918 and B.Sc. (Honours in Physics) in 1920 with Jubilee Scholarship from Presidency College, Calcutta. He stood first class first in the M.Sc. Examination in Physics from the University of Calcutta in 1922. Prof. Kar was very much interested in research work. He came in contact with the Nobel Laureate Sir C.V. Raman from whom he received encouragement to carryout research on Indian musical instruments. In his student life, he wrote an article "*the action of the bow in stringed instruments*" which was published in *Physical Review*, Vol. 20, 1922. Of his own, he learnt French and German languages. Many of his papers were published in the German Journal '*Physikalische Zeitschrift*' and '*Philosophical Magazine*' of London. For his outstanding research work, he obtained D.Sc. degree from the University of Calcutta in 1925. He was appointed as a Professor in Physics in Presidency College, Calcutta and then lifelong Emeritus Professor of Physics at the College. He established the Institute of Theoretical Physics, Calcutta and started the *Indian Journal of Theoretical Physics* (Chatterjee, 1975).

6 Citations received by the Scientists

Citations are references made by later author. Citations to scientific research papers and documents are considered as indicators of usage, utility and influence of the research work or information contained in those documents. There are several types of citation profiles. Firstly, rare or no citations at any point of time, short lived citations immediately after publication, prolonged citations and delayed citations. Much of the time delayed citations are not traceable as they occur highly scattered or

via intermediary citations, which means citing a secondary source that in turn cites the original.

Citations to J. C. Bose, S. N. Bose and K. C. Kar's scientific papers ranging from the year of publication up to and including 2000 counted from hardcopy versions of SCI, Web of Science ranging from the year 1900 up to and including January, 2013 and other online citations to prepare database of their citation histories (SCI, 1945-2000 and WOS, 1900-2013). Some of J. C. Bose and S. N. Bose's citations may be considered as prolonged and some as delayed. Mainly, the citations those were received in other research papers or journal-articles (except e-publications) were mainly taken into consideration. Self-citations were not considered for the present study.

Table – 4: Citation Profile of J.C. Bose

1	2	3	4	5	6	7	8
Rank	**Ranked List of Short Titles (Ref. to Bibliography)**	**Subject**	**No. Cited**	**Date of First Citation**	**Date of Last Citation**	**Median Age of Citations**	**Modal Concentration of Citations**
1	Proc. Roy. Soc. 1898, 63, p.146-52.	Microwave	45	1952	2013	58	7
2	Nature. 1925, 115, p.457.	Biophysics	13	2000	2009	5	2
3	Proc. Roy. Soc. 1899, 65, A, p.166-72.	Microwave	11	1958	2005	41	8
4	Proc. Roy. Soc. 1897, 60, A, p.433-36.	Microwave	9	1958	2007	41	7
5	Phil. Trans. Roy. Soc. 1913, 204, B, p. 63-79.	Biophysics	6	1915	2007	80	2
6	Proc. Roy. Soc. 1895, 59, A, p.160-67.	Microwave	4	1962	1998	3	1
7	Proc. Roy. Soc. 1896, 60, A, p.167-78.	Microwave	4	1964	1998	6	2
8	Proc. Roy. Soc. 1897, 62, A, p.293-300.	Microwave	4	1986	1998	7	1
9	Nature. 1923, 112, p. 95-96.	Biophysics	3	1934	2003	16	1

10	Proc. Roy. Soc. 1900, 66 (433), A, p.452-74.	Biophysics	2	1998	1998	-	2
11	T.B.R.I. 1919, 2, p. 255-67.	Biophysics	2	1998	2012	-	-
12	Phil. Mag. 1897, 43, p.55-68.	Biophysics	1	1998	1998	-	-
13	Proc. Roy. Soc. 1897, 62, A, p.301-10.	Microwave	1	1998	1998	-	-
14	Proc. Roy. Soc. 1900, 66, A, p.450-51.	Biophysics	1	1958	1958	-	-
15	Proc. Roy. Soc. 1901, 70 (461), A, p. 185-93.	Biophysics	1	1903	1903	-	-
16	Brit. Asso. Glasg. 1901.	Biophysics	1	1998	1998	-	-
17	Journal of Linnean Society (Bot.). 1902, 35, p. 275-304	Biophysics	1	1998	1998	-	-
18	Proc. Roy. Soc. 1902, 70 (463), A, p. 273-94.	Biophysics	1	1928	1928	-	-
19	T.B.R.I. 1918, 1, p. 151-72.	Biophysics	1	1985	1985	-	-
20	T.B.R.I. 1918, 1, p. 195-204.	Biophysics	1	1989	1989	-	-
21	Proc. Roy. Soc. B, 1918, 90 (631), p. 364-400.	Biophysics	1	1933	1933	-	-
22	Proc. Roy. Soc. B, 1925, 98 (690), p. 290-312.	Biophysics	1	1988	1988	-	-

(JC Bose's 112 papers were not included in the Citation Profile as these were not cited at all. In case of all those non-cited papers, Rank is '0'.)

Table 4 represents the citation profile of J.C. Bose for his scientific papers publication dates of which range from 1895 to 1934. The citations have been enumerated by

extracting them searching on the citation-databases viz. SCI (hardcopies), Web of Science (online) and Google Scholar (internet/online). SCI was scanned up to 2000 volumes starting from 1945; whereas Web of Science was last accessed in January 2013. J.C. Bose's fourth physical paper entitled "*on the determination of the indices of refraction of various substances for the electric ray, I-Index of refraction of sulphur*" of 1895 received only 4 citations and that has been citing from 1962 and last cited year 1998. A long gap of 36 years was there in between the first and last cited year. After then no more cited. His most cited paper was recorded in the *Collected Physical Papers* in 1898. Overall 45 citations received by the paper in 62 years. One of his papers in *Nature,* 1925 received 13 citations in 10 years. His two papers (came out in *Proceedings of Royal Society, London*) received 11 citations in 48 years and 9 citations in 50 years respectively. Another paper which was published in *Philosophical Transactions of Royal Society,* 1913 received 6 citations in 93 years. The three papers received only 4 citations each. First six/seven papers in the ranked list still receiving citations in different journals. Therefore, these are the more potential papers than the others. A paper in *Nature,* 1923 received 3 citations. His two papers ─ one in *Proceedings of the Royal Society, London,* 1900 and the other in *Transactions of the Bose Research Institute,* 1919 received only 2 citations.

Eleven research papers (including ten biophysical) of J.C. Bose received only 1 citation each. Most of his papers (112) including his first physical paper which was published in Asiatic Society of Bengal lack citations.

Table ─ 5: Citation Profile of S.N. Bose

1	2	3	4	5	6	7	8
Rank	**Ranked List of Short Titles (Ref. to Bibliography)**	**Subject**	**No. Cited**	**Date of First Citation**	**Date of Last Citation**	**Median Age of Citations**	**Modal Concentration of Citations**
1	Zeits. fur Physik. 1924, 26, p. 178-81.	Quantum Physics	505	1924	2013	81	37
2	Zeits. fur Physik. 1924, 27, p. 384-93.	Quantum Physics	28	1924	2013	51	4
3	Ann. Math. 1954, 59 (1), p. 171-76.	Unified Field Theory	6	1955	2007	20	1
4	C.R. Acad. Des Sci. 1953, 236 (13), p. 1333-335.	Unified Field Theory	5	1956	1974	10	1
5	L.J. Phys. Rad. 1953, 14 (12), p. 641-44.	Unified Field Theory	3	1955	1995	20	1

6	Sankhya, 1936, 2, pt. 4, p. 385-96.	D^2-Statistic	2	1974	1995	-	-
7	Sankhya, 1937, 3, pt. 2, p. 105-24.	D^2-Statistic	2	1974	1995	-	-
8	L.J. Phys. Rad. 1953, 14 (12), p. 645-47.	Unified Field Theory	2	1958	1958	-	-
9	T.B.R.I. 1955, 20, p. 177-80.	Thermolumi-nescence	2	1965	1968	-	-
10	Phil. Mag. 1918, Ser 6, 36, p. 199-203.	Equation of State of Real Gas	1	1972	1972	-	-
11	Phil. Mag. 1920, Ser 6, 39, p. 456.	Equation of State of Real Gas	1	1972	1972	-	-
12	Phil. Mag. 1920, 40, p. 619-27.	Quantum Physics	1	1972	1972	-	-
13	Proc. Nat. Inst. Sci. Ind. 1941, 7, pt. 1, p. 93-102.	Mathematical Physics	1	1948	1948	-	-
14	Bull. Cal. Math. Soc. 1945, 37, p. 51-61.	Mathematical Physics	1	1972	1972	-	-
15	Bull. de Soc. Math.de France 1955, 83, p. 81-8.	Unified Field Theory	1	1974	1974	-	-
16	Bull. Cal. Math. Soc. 1919, 10, p. 117-21	Classical Mechanics	0	-	-	-	-
17	Bull. Cal. Math. Soc. 1919, 11, p. 21-22.	Classical Mechanics	0	-	-	-	-
18	Zeits. fur Physik. Chem. 1927, 125, p. 442-51.	Chemistry	0	-	-	-	-

19	Phil. Mag. 1929, Ser 7, 7, p. 197-200.	Spectroscopy	0	-	-	-	-
20	Proc. Ind. Sci. Cong. 1929, 16, p. 55-62.	Modern Theoretical Physics	0	-	-	-	-
21	Sci. & Cult. 1937, 2, p. 473-79.	Nuclear Physics	0	-	-	-	-
22	Sci. & Cult. 1937, 3, p. 335-37.	Ionosphere	0	-	-	-	-
23	Ind. J. Phys. Sci. & Cult. 1938, 12, p. 121-44.	Ionosphere	0	-	-	-	-
24	Bull. Cal. Math. Soc. 1939, 31, p. 137-47.	Mathematical Physics	0	-	-	-	-
25	Sci. & Cult. 1943, 9, p. 48-49.	Chemistry	0	-	-	-	-
26	Ind. J. Phys. Sci. & Cult. 1943, 17, p. 301-08.	Quantum Physics	0	-	-	-	-
27	Proc. Ind. Sci. Cong. 1944, 31, p. 1-6.	Quantum Physics	0	-	-	-	-
28	Jour. Sci. Ind. Res 1950, 9B, p. 52-53.	Chemistry	0	-	-	-	-
29	Jour. Sci. Ind. Res 1950, Pt. I, 9B, p. 251-52.	Chemistry	0	-	-	-	-
30	Jour. Sci. Ind. Res 1950, Pt. II, 9B, p. 271-72.	Chemistry	0	-	-	-	-

Table 5 represents the citation profile of S.N. Bose for his scientific papers publication dates of which range from 1918 to 1955. It is interesting to note that the

first paper of S. N. Bose received only one citation after 54 years of its publication. S.N. Bose's most cited paper "*Planck's law and the light-quantum hypothesis*", 1924 received 505 citations which has been citing from its publication year i.e. 1924 and it was last cited in 2013 (till the date of last accessed SCI and WOS). The paper in *Zeitschrift fur Physikalische,* 1924 received 28 citations in 90 years. The paper in *Annals of Mathematics,* 1954 received 6 citations in 53 years. His two papers of 1953 received 5 and 3 citations in 19 and 41 years respectively. First two/three papers in the ranked list still receiving citations in different journals. Therefore, these are the more potential papers than the others. His other four papers — two papers brought out in *Sankhya* and other two were in *Le Jour de Phys et le Radium* and *Transactions of the Bose Research Institute* received only 2 citations each.

His other six research papers received only 1 citation each. Half of S.N. Bose's papers (15) lack citations. It is also seen that the Indian research workers who rarely cited his papers in their respective contributions on the related field of study.

Table – 6: Citation Profile of K.C. Kar

1	2	3	4	5	6	7	8
Rank	**Ranked List of Short Titles (Ref. to Bibliography)**	**Subject**	**No. Cited**	**Date of First Citation**	**Date of Last Citation**	**Median Age of Citations**	**Modal Concentration of Citations**
1	Phys. Rev. 1923, 21(6), p. 672-79.	Wave Statistics	6	1925	2012	29	2
2	Ind. Jour. Th. Phys. 1970, 18 (1), p. 1-11.	Acoustical Physics	5	1972	1979	7	2
3	Phil. Mag. 1931, Pt. III, 12 (78), p. 676-85.	Acoustical Physics	4	1934	1987	-	2
4	Ind. Jour. Phys. 1945, 18, p. 223-42.	Nuclear and Particle Physics	4	1950	1953	2	1
5	Ind. Jour. Th. Phys. 1964, 12 (2), p. 39.	Nuclear Physics	4	1979	1981	2	2
6	Physik. Zeits. . 1923, 24, p. 429-34.	Acoustical Physics	3	1924	1953	12	1
7	Phil. Mag. 1928, 6 (35), p. 276-80.	Acoustical Physics	3	1939	1987	34	1

8	Phil. Mag. 1930, Pt. I, 9 (56), p. 305-20.	Acoustical Physics	3	1934	1987	6	1
9	Z. Physik. 1930, 61 (5-6), p. 411-15.	Wave Statistics	3	1930	1930	-	3
10	Ind. Jour. Phys. 1951, 25, p. 423-432.	Acoustical Physics	3	1952	1973	20	1
11	Phys. Rev. 1923, 21(6), p. 695-98.	Acoustical Physics	2	1930	1939	-	-
12	Physik. Zeits. . 1927, 28, p. 300-02.	Quantum Statistics	2	1930	1930	-	2
13	Phil. Mag. 1928, 5 (29); p. 547-59.	Acoustical Physics	2	1987	1987	-	2
14	Phil. Mag. 1928, 29, p. 143-44.	Wave Statistics	2	1929	1930	-	-
15	Phil. Mag. 1930, Pt. II, 9 (56), p. 321-24.	Acoustical Physics	2	1939	1987	-	-
16	Z. Physik. 1930, 62 (7-8), p. 510-17.	Wave Statistics	2	1930	1930	-	2
17	Z. Angew. Math. Mech. 1931, 11 (5), p. 361-72.	Acoustical Physics	2	1934	1987	-	-
18	Ind. Physico-Math. Jour. 1932, 3, p. 103-4.	Acoustical Physics	2	1972	1987	-	-
19	Phil. Mag. 1933, 16 (109), p. 1097-1109.	Wave Statistics	2	1938	1971	-	-
20	Ind. Jour. Phys. 1950, 24, p. 545-65.	Wave Statistics	2	1956	1971	-	-
21	Ind. Jour. Th. Phys. 1953, 1 (2), p. 87-120.	Nuclear and Particle Physics	2	1967	1971	-	-

22	Ind. Jour. Th. Phys. 1957, 5 (2), p. 31.	Acoustical Physics	2	1971	1973	-	-
23	Ind. Jour. Th. Phys. 1960, 8 (2-3), p. 47-83.	Nuclear and Particle Physics	2	1968	1971	-	-
24	Ind. Jour. Th. Phys. 1973, 21 (1), p. 1-14.	Theory of Relativity	2	1977	1979	-	-
25	Phys. Rev. 1922, 20 (2), p. 148-53.	Acoustical Physics	1	1932	1932	-	-
26	Physik .Zeits. 1925, 26, p. 465-67.	Wave Statistics	1	1929	1929	-	-
27	Z. Physik 1929, 53 (3-4), p. 308-11.	Nuclear and Particle Physics	1	1930	1930	-	-
28	Z. Physik 1930, 59 (7-8), p. 570-72.	Nuclear and Particle Physics	1	1930	1930	-	-
29	Z. Physik. 1930, 60 (3-4), p. 243-49.	Nuclear and Particle Physics	1	1931	1931	-	-
30	Zeit. f. Phys. 1930, 61 (7-8), p. 525-37.	Acoustical Physics	1	1987	1987	-	-
31	Z. Physik. 1930, 61 (9-10), p. 675-80.	Wave Statistics	1	1931	1931	-	-
32	Z. Physik. 1930, 64 (1-2), p. 75-80.	Wave Statistics	1	1931	1931	-	-
33	Zeit. f. Phys. 1930, 66 (5-6), p. 414-24.	Acoustical Physics	1	1987	1987	-	-
34	Phil. Mag. 1936, 21 (144), p. 1067-78.	Nuclear and Particle Physics	1	1938	1938	-	-

35	Phil. Mag. 1940, 29 (193), p. 169-84.	Nuclear and Particle Physics	1	1971	1971	-	-
36	Ind. Jour. Th. Phys. 1956, 4 (1), p. 21.	Nuclear Physics	1	1968	1968	-	-
37	Ind. Jour. Th. Phys. 1965, 13 (1), p. 1-20.	Nuclear Physics	1	1967	1967	-	-
38	Ind. Jour. Th. Phys. 1968, 16 (1), p. 1-6.	Theory of Relativity	1	1977	1977	-	-
39	Ind. Jour. Th. Phys. 1969, 17 (1), p. 1-11.	Theory of Relativity	1	1977	1977	-	-
40	Ind. Jour. Th. Phys. 1971, 19 (1), p. 1-14.	Theory of Relativity	1	1975	1975	-	-
41	Ind. Jour. Th. Phys. 1972, 20 (1), p. 1-8.	Theory of Relativity	1	1975	1975	-	-
42	Ind. Jour. Th. Phys. 1972, 20 (2), p. 33-38.	Nuclear and Particle Physics	1	1978	1978	-	-
43	Ind. Jour. Th. Phys. 1974, 22 (1), p. 35-9.	Theory of Relativity	1	1978	1978	-	-
44	Ind. Jour. Th. Phys. 1975, 23(1), p. 25-31.	Theory of Relativity	1	1979	1979	-	-

(Kar's 79 papers were not included in the Citation Profile as these were not cited at all. Rank for each of those non-cited papers is '0'.)

Table 6 represents the citation profile of K.C. Kar for his scientific papers the publication dates of which range from 1922 to 1975. Kar's most cited paper published in *Physical Review*, 1923 received only 6 citations. This paper of Kar has been citing from 1925 and last cited in 2012 (till the date of last accessed WOS). The three papers of Kar received 4 citations each. The five papers received only 3 citations each and the other fourteen papers of K.C. Kar received only 2 citations each. No papers were cited after 1987 except his most cited paper.

Other twenty papers (including first paper) of Kar received only 1 citation each. Most of his papers (79) lack citations.

7 Geographical distribution of citations received by the Scientists

Table ─ 7: Geographical distribution of citations received by J.C. Bose

1	2	3	4	5
Ranks	**Geographical locations of the institutions where citing authors affiliated to**	**Citations received**	**Percentage of citations**	**Cumulative percentage**
1	USA	59	50.43	50.43
2	India	15	12.82	63.25
3	Canada	11	09.41	72.66
4	UK	9	07.70	80.36
5	France	7	05.99	86.35
6	China	3	02.57	88.92
7	Turkey	3	02.57	91.49
8	Brazil	2	01.71	93.20
9	Japan	1	00.85	94.05
10	South Africa	1	00.85	94.90
11	Finland	1	00.85	95.75
12	Greece	1	00.85	96.60
13	Germany	1	00.85	97.45
14	Australia	1	00.85	98.30
15	Poland	1	00.85	99.15
16	Korea	1	00.85	100.00
Total		**117**	100.00	

Table 7 presents the geographical distribution of citations received by J.C. Bose and the percentage of citations to the corresponding countries where first authors of the citing articles were affiliated to. Among the research workers citing J.C. Bose's papers were from USA with 59 (50.43%) citations followed by India with 15 (12.82%) citations, Canada with 11 (9.41%) citations, UK with 9 (7.70%) citations and France with 7 (5.99%) citations. It is very clear from the above table that the research workers from the then scientific communities of United States of America cited half of the total citations of J.C. Bose's papers. Notably, most of the citing research workers were from related fields of physics and biophysics i.e. electrical & electronic engineering, telecommunications, optics, materials science, plant physiology, biochemistry etc. except eight/nine of them cited J.C. Bose's papers in biographical works or works related to history of science & technology.

Table – 8: Geographical distribution of citations received by S.N. Bose

1	2	3	4	5
Ranks	**Geographical locations of the institutions where citing authors affiliated to**	**Citations received**	**Percentage of citations**	**Cumulative percentage**
1	USA	154	27.45	27.45
2	Germany	92	16.39	43.84
3	India	56	09.98	53.82
4	UK	28	04.99	58.81
5	France	26	04.63	63.44
6	Italy	25	04.46	67.90
7	China	20	03.56	71.46
8	Russia	14	02.50	73.96
9	Australia	13	02.32	76.28
10	Spain	11	01.96	78.24
11	Switzerland	9	01.60	79.84
12	Canada	8	01.43	81.27
13	Poland	8	01.43	82.70
14	Japan	8	01.43	84.13
15	Brazil	7	01.25	85.38
16	Netherlands	6	01.07	86.45
17	Hungary	6	01.07	87.52
18	New Zealand	6	01.07	88.59
19	Austria	5	00.89	89.48
20	Turkey	5	00.89	90.37
21	Mexico	4	00.71	91.08
22	Belgium	4	00.71	91.79
23	Portugal	4	00.71	92.50
24	Greece	4	00.71	93.21
25	Ukraine	4	00.71	93.92
26	Czech Republic	3	00.53	94.45
27	Ireland	3	00.53	94.98
28	Denmark	3	00.53	95.51
29	Sweden	3	00.53	96.04
30	Norway	2	00.36	96.40
31	Bangladesh	2	00.36	96.76
32	Israel	2	00.36	97.12
33	Singapore	2	00.36	97.48
34	Cameroon	2	00.36	97.84
35	Serbia	2	00.36	98.20
36	South Africa	1	00.18	98.38
37	Chile	1	00.18	98.56
38	Cuba	1	00.18	98.74

39	Algeria	1	00.18	98.92
40	Argentina	1	00.18	99.10
41	Uzbekistan	1	00.18	99.28
42	Iran	1	00.18	99.46
43	Luxembourg	1	00.18	99.64
44	Kenya	1	00.18	99.82
45	Taiwan	1	00.18	100.00
Total		**561**	100.00	

Table 8 gives the geographical distribution of citations received by S.N. Bose and the percentage of citations to the corresponding countries where first authors of the citing articles were affiliated to. Among the top research workers citing S.N. Bose's papers were from USA with 154 (27.45%) citations followed by Germany with 92 (16.39%) citations, India with 56 (9.98%) citations, UK with 28 (4.99%) citations and France with 26 (4.63%) citations. It is also seen that rhe most of the citing authors were from related fields of physics and only about twenty to twenty five researchers cited S.N. Bose's research publications in their biographical works or works related to history and philosophy of science.

Table ─ 9: Geographical distribution of citations received by K.C. Kar

1	**2**	**3**	**4**	**5**
Ranks	**Geographical locations of the institutions where citing authors affiliated to**	**Citations received**	**Percentage of citations**	**Cumulative percentage**
1	India	34	39.53	39.53
2	USA	24	27.91	67.44
3	Germany	7	08.13	75.57
4	UK	6	06.98	82.55
5	Poland	5	05.81	88.36
6	Czech Republic	2	02.33	90.69
7	Russia	2	02.33	93.02
8	Belgium	2	02.33	95.35
9	Italy	2	02.33	97.68
10	Romania	1	01.16	98.84
11	Jamaica	1	01.16	100.00
Total		**86**	100.00	

Table 9 shows the geographical distribution of citations received by K.C. Kar's papers and the percentage of citations. Among the research workers citing Kar's papers were from India with 34 (39.53%) citations followed by USA with 24 (27.91%) citations, Germany with 7 (8.13%) citations, UK with 6 (6.98%) citations and Poland with 5

(5.81%) citations. It can be noted that the researchers from Poland cited his most cited paper (Serial No. 2 in Table 3.a of App. III) with only 3 (50%) citations and India with only 2 (33.33%) citations.

8 Rank of the scientists as per their most cited papers

Table 10 represents the rank of the scientists under study as per their most cited papers. From the table below, it is interesting to note that S.N. Bose's paper entitled "*Planck's law and the light-quantum hypothesis*" (1924) received a greater number of citations than the citations received by the other two scientists J.C. Bose and K.C. Kar. S.N. Bose received 505 citations in 90 years (difference between the years of first and last citation) by his aforesaid paper which has been citing since its year of publication and was last cited in 2013.

Table – 10: Ranking of the scientists as per most cited papers

1	2	3	4	5	6	7	8	9
Rank	**Name of Scientist**	**Reference to Most Cited Paper**	**Year of Publication**	**No. of Citation**	**Year of first Citation**	**Year of last Citation**	**Median age of Citations**	**Modal Concentration of Citations**
1	S.N. Bose	*Zeitschrift fur Physikalische,* 26, p.178-81.	1924	505	1924	2013	81	37
2	J.C. Bose	*Proceedings of the Royal Society.* 63, p.146-52.	1898	45	1952	2013	58	7
3	K.C. Kar	*Physical Review.* 21, p. 672-79.	1923	6	1925	2012	29	2

Notably, S.N. Bose got at an average of 5/6 citations by this paper per year. Out of 505, 41 citations received by *Physical Review A,* 17 citations by *Zeitschrift fur Physikalische,* 17 citations by *Physics Letters A,* 17 citations by *Journal of Physics B,* 12 citations by *Physical Review B,* 11 citations by *Journal of Physics A,* 8 citations by the *American Journal of Physics,* 5 citations received by *Current Science* and the rest 377 citations by different journals. Less than forty Indian research workers had been

cited the aforesaid S.N. Bose's paper. Whereas, the physical paper "*on the rotation of plane of polarisation of electric waves by a twisted structure*", 1898 of J.C. Bose received only 45 citations 54 years after its publication. Out of 45, 4 citations by the *IEEE Transactions,* 3 citations received by the *Electro-magnetics,* 3 citations by the *Journal of Optics,* 3 citations by *Optics Express,* 2 citations by *Proceedings of IRE,* 2 citations by the *Physical Review- B* and the rest 28 citations by different foreign journals. Only four Indian research workers had been cited the aforesaid J.C. Bose's paper. K.C. Kar's paper "*the statistical theory of spontaneous fluctuations in energy, pressure and density*" of 1923 got only 6 citations after 2 years of its coming out. J.C. Bose received 45 citations in 62 years and Kar received only 6 citations in a long gap of 88 years. Hence, the average citation received by J.C. Bose and K.C. Kar's paper is less than one. As per the median age of citations, S.N. Bose's most cited paper received first half (253) of citations in 81 years and rest half (252 citations) received only in 9 years. Whereas J.C. Bose's most cited paper received first half (23) of citations in 58 years and rest half (22) in only 4 years. This would indicate that the most cited papers of both the scientists S.N. Bose and J.C. Bose received citations rapidly in last 4/5 years back from the year last accessed WOS i.e. 2013. But the rate of receiving citations by the most cited paper of S.N. Bose is much higher than that of J.C. Bose's most cited paper.

9 Analysis and Discussion

On checking through SCI for a period of more than half a century ranging from l945 to 2000 and Web-of-Science for a period extended over more than 100 years i.e. up to January 2013 from 1900, out of the total J.C. Bose's papers i.e. 134 (excluding unpublished works), only 22 papers were found to have been cited little more than 100 times. Very few of these citing papers (less than twenty) are by Indian research workers. It is interesting to note that his fourth paper of 1895 got only four citations within 103 years after its publication. Much could not be known regarding the pervasive influence of J.C. Bose in Indian research. It is clear from the fact that only a few (about two dozen) Indian Journals are included in SCI database. Notably, an unambiguous omission in this regard is the *Transactions of the Bose Research Institute*, Calcutta. However, almost none of these citations referred to any of his biophysical or plant physiological researches.

On checking through SCI and Web-of-Science, out of 30 papers of S.N. Bose, 15 were found to have been cited about 560 times in other research papers. Out of total 561 citations, only less than sixty citations were cited by Indian research workers. Rest fifteen of his very important papers of different fields of physics remained non-cited. It is to note that the paper of 1918 got only one citation within 54 years after publication. One should look further into the citing papers to understand this very belated renewed interest for the papers of J.C. Bose and S.N. Bose both.

It is notable from the list of citations received by K.C. Kar, that the first paper of 1922 got only one citation within 10 years after publication. Hence, Kar is not an exception. Out of 123, only 44 of Kar's papers were found to have been cited 86 times. Out of 86, only 34 citations made by Indian workers.

Table – 11: Total & Average Year Publication and Distribution of Citations

1	2	3	4	5	6	7	8	9
Rank	**Name of the Scientists**	**Total Number of Papers**	**Productive Age (Years)**	**Average Paper per Year**	**Single Authored Papers**	**Citations received by Single Authored Papers**	**Joint Authored Papers**	**Citations received by Joint Authored Papers**
1.	J.C. Bose	134	40	3.35	77	112	57	3
2.	K.C. Kar	123	54	2.28	60	36	63	50
3.	S.N. Bose	30	38	0.79	18	556	12	5

Table 11 presents the total number of publications and the average publication per year of productive age. The table also shows the distribution of citations based on the authorship pattern. It can be noted that the more productive scientists usually have a longer productive period and a larger number of collaborators. J.C. Bose received 112 citations by his 77 single authored and only 3 citations by his 57 joint authored papers. K.C. Kar received 36 citations by his 60 single authored and only 50 citations by his 63 joint authored papers and S.N. Bose received 556 citations by his 18 single authored and only 5 citations by his 12 joint authored papers. It is clear from the table that J.C. Bose ranked first and followed by K.C. Kar and S.N. Bose as per total and average publication per productive year.

Table – 12: Ranking as per Total Citations received by the Papers

1	2	3	4	5
Rank	**Name of Scientists**	**Total No. of Papers**	**Number of Citations Received**	**Percentage with total citations**
1.	S.N. Bose	30	561	73.62
2.	J.C. Bose	134	115	15.09
3.	K.C. Kar	123	86	11.29
Total			762	

Table 12 is a ranked list of the scientists in order of the total citations received by their publications. This list shows the same ranking for the average publication per year of productive age. The ranked list shows S.N. Bose ranked first and followed by

J.C. Bose and K.C. Kar as per total citations received by the papers of the scientists under study.

It has been seen from the citation analysis that quite a number of papers of all the three scientists still remain non-cited. Notably, all the scientific endeavours taken by all the three scientists occurred in spite of a dominant British rule, while living with self-esteem and dignity. Probably, their works were not given due recognition and weight by their contemporary British research workers appointed in the higher graded post. At those days, those who were in the higher rank in their profession either suppressed the works of Indian research workers or wouldn't properly acknowledge their writings. Another reason usually arises that the related studies on the same fields have not been pursued in the later period and for this reason some of the earlier works of the three scientists still remain non-cited in the later works by the other researchers.

10 Findings

Single author contribution predominate which indicates degree of collaboration is less in the productivity of research works of the scientists. J.C. Bose was single author in 77 of his publications and the main author in 57 publications shows that he always preferred to work himself. But, K.C. Kar perhaps preferred to lead the team as 'mentor' as he was main author in 63 of his total number of publications (123). One can conclude that quantitative comparison of Kar's total scientific publications with that of the publications of J.C. Bose and S.N. Bose shows that Kar's disability with a serious handicap of near sightlessness did not influence his scientific productivity. Out of 134 papers of J.C. Bose, 112 (83.58%) papers remain non-cited. Out of 112 papers, 106 papers belonged to biophysical and plant physiological research. For the purpose of ascertaining the time-lag (the difference between the year of citing and year of cited paper), only most cited papers of the scientists were considered. Time-lag between publication of J. C. Bose's most cited paper and its receiving first citation is in the range of 0 to 54 years. Out of 30 papers of S. N. Bose, 15 (50%) papers remain non-cited. Time-lag between publication of S. N. Bose's most cited paper and its receiving first citation is nil i.e. zero. Out of 123 papers of K.C. Kar, 79 (64.23%) papers remain non-cited. Time-lag between publication of K.C. Kar's most cited paper and its receiving first citation is in the range of 0 to 2 years. Almost of all non-cited papers of Kar belonged to quantum or particle physics, wave statistics and statistical mechanics. Larger range of time-lag, suppose ten years, it normally implies that the paper or a series of papers pertains to an inactive or stagnating research field or is not much concerned with the main stream of research domain. Smaller time-lag reflects how contemporary the paper is or how far it is connected with the emerging research area. Usually "zero time-lag" shows the very active or rapidly unfolding areas. It is noteworthy that K.C. Kar who produced his first 50 percent of publications in the productive age of 20 has more productive period (54 years) than the other two scientists J.C. Bose and S.N. Bose who have been found to have comparatively shorter productive periods of 40 and 38 years respectively. The more productive scientists usually have a longer productive period and a larger number of collaborators. J.C. Bose worked with 11 collaborators and published 77 single and 57

multi-authored papers. S.N. Bose worked with 10 collaborators and published 18 single and 12 multi-authored papers whereas K.C. Kar worked with 28 collaborators but he published 60 single and only 63 multi-authored papers. Interestingly, J.C. Bose was the most productive author but K.C. Kar even with much more collaborators was not the same.

11 Conclusion

The citation profile of the scientists signifies the substantial growth in terms of quantifiable outputs with the clear perception about the work of them. Citation to the scientific contributions of the scientists highlights usage of the publications of each scientist and as such citation profile may act as an instrumental to the best available pointer to use of that publication. The present study approaches more than one or two scientists taken together and their scientific research activities (in terms of measurable outputs) as statistical populations. This study represents the relevancy, potentiality and permanence of the research publications of the scientists even in the contemporary period.

In the present study it has not been possible for us to work on their books and non-scientific publications (non-physical and/or non-biophysical) publications in minute detail for having a chance of diluted findings in lieu of a clear panoramic scientometric portrait. That work would be a more involved one and would probably review unexpected facts and features of literature study. This may be a topic of further research.

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