India and quantum computing-related publications

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Introduction

We explore how India performs in the field of quantum computing. An Indian publication is defined as one in which at least one author has an Indian address. This investigation has the following purposes:

(1) To perform a bibliometric study of India as an upcoming country in the field of quantum computing.

(2) To perform a diachronous study of its yearly citations.

(3) To investigate the influence of collaborations with the USA on India in the field of quantum computing

Methodology

Using the Web of Science (WoS), we consider the period [2003, 2023] and focus on Indian publications as defined above. We used the following query: ALL = (qubit* OR (quantum AND (comput* OR algorithm* OR crypto* OR gate* OR superposition* OR complexit*))), Although we also considered (TS=)-queries, we prefer (All=)-queries for this investigation. In this way, we can include in the resulting set, institutes, conferences, and funding sources with e.g., the phrase "quantum computation" in their name. The difference between (TS=) and (ALL=) queries reflects the importance of "quantum computing" in the general scientific landscape in the country under consideration. For example, when a university has a department with quantum computing in its name, or when "quantum computing"- funds are available, this is a sign of the importance given to quantum computing in the country and its collaborating countries.

Results: publications

Total number of publications, (ALL=) versus (TS=) queries

In the whole database, we found 14,170 Indian articles (September 2024), where we have included here all publications (of article or review type) with at least one Indian co-author. Table 1 shows the number of publications. The resulting data are diachronous ones as they show how data change over time. The curves for (ALL=) and for (TS=) queries both show an exponential increase.

Table 1. Indian publications: results for (ALL=) and (TS=) queries, and their ratio.

Year	ALL	TS	%	Year	ALL	TS	%
2003	88	66	0.75	2014	448	321	0.72
2004	85	82	0.96	2015	518	374	0.72
2005	102	85	0.83	2016	565	389	0.69
2006	132	109	0.83	2017	628	412	0.66
2007	119	96	0.81	2018	769	542	0.71
2008	159	129	0.81	2019	847	581	0.69
2009	200	153	0.77	2020	1075	716	0.67
2010	222	181	0.82	2021	1449	920	0.64
2011	280	213	0.76	2022	1641	1071	0.65
2012	303	229	0.76	2023	1875	1187	0.63
2013	385	286	0.74				

The (TS/ALL)-ratio starts at about 0.81-0.86 in the early years and reaches a low of 0.63 in 2023.

Domestic production

In this section, we study the percentage of domestic production (all authors have an Indian address) in the total of the country. Results are shown in Table 2. The percentage of domestic production has a decreasing tendency. Note that all non-domestic publications are publications resulting from international collaboration. The increase of internationally collaborated publications by India in the field of quantum computing corresponds with the growth of international collaboration in general.

Table 2. Percentages of domestic production for India.

Year	Percentage	Year	Percentage
2003	0.75	2014	0.70
2004	0.81	2015	0.71
2005	0.73	2016	0.72
2006	0.78	2017	0.64
2007	0.74	2018	0.67
2008	0.75	2019	0.67
2009	0.76	2020	0.64
2010	0.72	2021	0.64
2011	0.68	2022	0.60
2012	0.73	2023	0.61
2013	0.72		

India-US collaborated publications

Next, we study the number of collaborated articles and their evolution between the USA and India. We chose the USA as this country was until recently (when China took over) the leading country in the field of quantum computing. By the term "collaborated article" we mean an article with addresses of two countries under study. Other countries may participate in such articles.

In absolute numbers the collaboration between the USA and India in quantum computing is increasing. This observation also holds relatively speaking (over the period [2003, 2023]): India participated in less than 1% of US quantum publications and increased its share to more than 6%, while the US had a share of almost 10% of India's publications, increasing to more than 16%. These numbers illustrate the unequal scientific relationship between India and the USA.

Results: Citations

We counted (in the WoS) the number of received citations for each publication year in the period 2003-2013. These citations were counted over a ten-year period (plus the publication year) if possible, i.e., for the publication years 2003-2013, and over 5-years (plus the publication year) for the period 2003-2018. For each publication year, we also determined the h-index again over a ten-year period, and over a 5-year period. Similarly, we determined the average number of citations and the median number of citations. We did this for all publications, domestic publications only, and for the collaboration with the USA.

Citations of all Indian publications

Table 3 shows the data for all Indian publications. The five columns refer respectively to the publication year (FPY), the sum of all citations received by all publications (of the year in the first column) over a ten-year period (plus the publication year) (CIT10), the h-index calculated over the ten-year period (h10), the average number of received citations over the ten-year period (AV10) and finally the median number of received citations over the ten-year (MED10).

Table 3. Citations received by all Indian publications.

FPY	CIT10	h10	AV10	MED10
2003	1,115	16	12.67	5
2004	1,380	21	16.24	8
2005	1,847	22	18.11	7
2006	1,724	21	13.06	7
2007	2,114	21	17.76	9
2008	3,830	32	24.09	10
2009	4,564	33	22.82	13
2010	4,241	31	19.1	11
2011	5,953	37	21.26	10
2012	6,804	43	22.46	13
2013	9,941	46	25.82	14

There is a clear linear increase for the h-indices, the average number of received citations and the median number of citations. As h-indices depend on the number of publications and the number of citations and as both are increasing, it is obvious that also the h-index should increase.

Citations of India-US collaborated papers

In this section we present citation data for the US-India collaborations, see Table 4. The numbers of India-American joint publications are relatively small and rather irregular. Data refer to a 5-year citation window.

Table 4. Citation data for US-India collaborated papers.

FPY	# PUB	CIT5	h5	AV5	MED5
2014	55	2,734	23	49.7	18
2015	55	1,880	23	34.2	17
2016	66	1,828	21	27.7	13
2017	89	4,236	22	47.6	14
2018	114	3,155	26	27.7	15

Conclusion

We have studied all quantum computing-related articles and reviews in the WoS with at least one Indian author in the period [2003, 2023]. We separately considered domestic publications and collaborations with the USA. Besides the number of publications we also considered yearly citations and the corresponding h-indices. There is a generally increasing trend for all indicators, but a relative decrease in domestic publications.

References

Fassin, Y., & Rousseau, R. (2022). On the difference between an (ALL=)- and a (TS=)-query in the Web of Science: the case of bibliometrics versus scientometrics. *ISSI Newsletter,* 18(2), #70, 30-33..