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An Evaluation of India's Research output in Condensed Matter Physics for the years 2014-2022

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Abstract: From the SCIE database, in this analysis, 27018 research publications from 2014-2016, 2017-2019, and 2020-2022 in the field of condensed matter physics are analyzed. According to the study,twenty percent of India's physics output may be attributed to the program's focus on condensed matterphysics. The fields of academia and research and development provide the most funding for condensedmatter physics. When compared to the 17.4 growth in total physics over the same time period (2014-2016 to 2020-2022), the six-yearly growth in this discipline has been negative (-1). Institutionalspecialization, research cooperation, and production are all mapped for the field of condensed matterphysics. It looks at the most-cited publications and identifies the most-active researchers in this area. Inaddition, it offers recommendations for boosting India's condensed matter research efforts.

Keywords: India, condensed matter, physics, science citation index

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INTRODUCTION

Condensed matter physics, the study of the characteristics and behavior of materials in their solid and liquid phases, has seen significant participation from India. The success and significance of scientific efforts can't be properly gauged without first evaluating the results of relevant research. This assessment is useful for examining the breadth, depth, and trajectory of a country's scientific output in terms of publications, collaborations, and citations.[1-2]

Between 2014 and 2022, condensed matter physics research in India advanced significantly. A large number of high-quality research articles were published during this period by Indian scientists and academic organizations. The successes, failures, and new areas of interest in Indian condensed matter physics may be shown by analyzing the research produced during this time period.[3-5]

In order to gain insight into the research output and effect of a certain subject, a scientometric analysis may be conducted. This comprises the quantitative assessment of scientific publications, citations, and cooperation patterns. [7-8]

Using scientometric methods, academics have examined India's condensed matter physics research output, providing insight into topics including publishing patterns, cooperation dynamics, citation influence, and the international profile of Indian scientists.[9-10]

The purpose of this study is to present a holistic perspective of India's contributions to the field of

condensed matter physics between the years of 2014 and 2022. It provides insights into the development, productivity, and influence of Indian scholars in this subject by evaluating publication data, cooperation networks, citation patterns, among other important variables.

MATERIAL METHODS

Web of SCIE-Extended Version provided the foundational publication data for this analysis. In February of 2022, we scraped the Web of Science for the raw publication data and citations. The downloaded data was then imported into a DBMS for additional processing, including but not limited to data cleansing, coding, and table construction. During data cleaning, we got rid of everything that was a duplicate or related to a year of publication that was beyond the scope of our research. "To compare research performance between sectors, regions, and institutions as well as across different domains of Indian S&T output, the whole database was modified to compute publication and citation data on a massive scale."

"Absolute variables like as (i) average IF per publication, (ii) average citations per publication, and (iii) proportion of collaborative paper and international collaborative articles were used to evaluate the institutions' performance in the field of condensed matter physics." Furthermore, the strength, number of researchers hired, and number of papers produced by HPIs from the three distinct institutional financing models in India are very different from one another. We employed relative measures such as (iv) the relative effect factor, (v) the relative reference impact, (vi) the partnership index, (vii) the global collaboration index, or (viii) the relative specialized index (SI) to make reliable cross-institutional comparisons. The term "relative indicators" is used to describe measurements of success in relation to the whole sample. For instance, if an institution has an impact factor of 1.5 a article, it is half again as important as the mean of the group (1.0). The Specialization Index (SI) evaluates a school's performance relative to the national average in a certain subject of research publication production. Additionally, SI values above 0.5 indicate a substantial degree of specialization, where as values between 0.2 and 0.5 or -0.2 reflect a moderate level of specialization.

RESULTS

Web of Science publication data shows that between 2014 and 2022, Indian physicists produced a total of 27018 scholarly articles; yearly production increased from 2768 in 2014 to 3336 in 2022, or a growth rate of 2.5% per year. "The country publications output and market share at sub-field level was the largest in condensed matter physics (20.3%), followed by atomic, molecular & chemical physics (9.87%), applied physics (8.63%), crystallography (7.43%), astronomy & astrophysics (6.88%), nuclear physics (6.69%), optics (4.88%), fluids and plasmas physics (4.43%), particles & fields physics (3.49%), spectroscopy (2.57%), thermodynamics (2.48%) and acoustics (2.10%)."

Improved research output and increased productivity

In the field of condensed matter physics, scholars from across India's 449 academic institutions published 5,492 works between 2014 and 2022. When compared to the national average growth of 17.4% for physics production over that time period, the field of condensed matter physics had its triennial research output fall from 2014-2016 levels (1795 articles) to 2020-22 levels (1778 papers), a decrease of -1%.

Table lists the top 10 national and international journals that published articles in the field of condensed

matter physics in the country between 2014 and 2022.

Table 1: 2014-2022 Indian Contributions to the Top 20 Condensed Matter Physics Journals

Journal title	Revista Fisica B	Electrically-Isolated Signaling	The Condensed Matter Physics Journal	Physica B	Superthin Films	Physical Review Materials B: Foundational Studies	Magnetic Materials and Their Applications	Physics of Solids A: An Applied Journal	Applied Materials and Engineering B: Solid	Matrix States for Future Technology.	Solids: A Journal of Physics and Chemistry
14-22	1025	458	429	306	284	247	244	217		202	188
14-16	398	168	135	99	87	144	74	103		65	39
17-19	314	165	152	143	121	66	80	71		57	82
20-22	313	125	142	64	76	37	90	43		80	67

Institutional involvement was minimal throughout both research periods, with just 228 participating in 2014-2016 and 281 in 2020-22. "This is primarily due to the fact that a sizeable and significant portion of the participating institutions, including colleges, associations, foundations, or private bodies, do not publish as frequently as the rest of the participating institutions when it comes to condensed matter physics research."

Research product quality

From 2014–2016, 2017–2019, and 2020–2022, the nation's condensed matter physics production had an average effect per paper1 of 1.49, 1.30, and 1.38, respectively. The gradual reduction in India's average impact factor in condensed matter journals over time is suggestive of a change in the country's publication habits. Table empirical data supports this theory, showing that over time, the percentage of a country's articles published in journals with medium and low impacts has decreased, while the percentage published in journals with no impacts has increased.

Table 2: India's condensed matter physics publication output has an average IF and citation impact factor: 2014–2022

Year	2014–2016	2017–2019	2020–2022	2014 - 2022
Papers	1795	1919	1778	5492
IF per paper on average	1.49	1.3	1.38	1.39
Per-article citation frequency distribution	6.42	5.11	3.46	5

The majority of a country's condensed matter physics production (69%), for example, was published in journals with a low impact factor (IF 0.001), 12% in publications with no IF at all, and 19% in journals with an impact factor between 2.0 and 3.999. There were no published articles in significant journals.

Table 3: Share of total condensed matter physics journal articles published by India, 2014-2022, ordered by average IF per paperoutput

Average IF per paper within a certain range		0.000 – 0.000	0.001 – 1.999	2.000 – 3.999	More and 4	Total
% of papers	14 to 16	6	71	23	0	1795
	17 to19	14	68	18	0	1919
	20 to 22	15	68	18	0	1778
	14 to 22	12	69	19	0	5492

The average number of citations per paper published in the field of condensed matter physics during the years 2015–2016 and 2017–2018 was 6.42 and 5.11, respectively, which was slightly lower than the country's citations performance during the same period in overall physics. The country's physics production fared better in terms of citations than its condensed matter paper output.

In the field of condensed matter physics, the percentage of highly referenced articles is still quite small. Only 4% of its total production between 2014 and 2022 was released then. About 44% of its publications were cited just a few times, 28% were cited between 5 and 19 times, and 23% were never cited at all during the first decade after publication.

Table 4: National condensed matter physics publication output as measured by citations per manuscript, 2014–2022.

Citation frequency in a given work	14 to 16	% of papers 17 to 19	20 to 22	14 to 22
0	0.18	0.24	0.28	0.23
1 & 4	0.43	0.44	0.47	0.44
5 & 19	0.33	0.28	0.23	0.28
More and 20	0.06	0.05	0.02	0.04
Total	1795	1919	1778	5492

"In the field of condensed matter physics, the country's citation performance is quite uneven. In the field of condensed matter physics, almost 1% of the papers published between 2014 and 2022 obtained 80% of the total citations for the country's output, while the other 99% of the publications received just 20% of the citations." Even though 449 institutions were known to have engaged in condensed matter physics research between 2014 and 2022, this suggests that the pockets of brilliance are quite small and concentrated in a

select few universities.

Dissemination of Academic Work by Field

The nine-year period from 2014 to 2022 saw about equal contributions to national production in condensed matter physics from the Universities and Colleges sector (42,6%) and the Mission-oriented R&D sector (42,6%). The sector of Nationally Important Institutes came in second at 23.98%.

Table 5: India's condensed matter physics publication output by field, 2014–2022.

Sector	Production of Written Work				Production of Written Work			
	14–16	17–19	20–22	14–22	14–16	17–19	20–22	14–22
Higher Learning Institutions.	829	802	711	2342	46.18	41.79	39.99	42.64
Institutions Critical to the Nation's Security	365	491	461	1317	20.33	25.59	25.93	23.98
R&D with a clear purpose	666	814	837	2317	37.10	42.42	47.08	42.19
Industry	9	7	11	27	0.50	0.36	0.62	0.49
Others	6	5	6	17	0.33	0.26	0.34	0.31
Total	1795	1919	1778	5492	100.00	100.00	100.00	100.00

During the time period spanning 2014–1995, the universities and colleges sector's proportion of condensed matter physics publications decreased from 46.18 percent to 39.99 percent.

Examining the most-cited articles

There were 5492 condensed matter physics publications published by Indian researchers between 2014 and 2022. Of them, Table shows that 90 are highly referenced research publications . There were a total of 9883 citations to the most-cited works.

Table 6: Indian condensed matter physics publications with the highest citation counts

Yearrange	Sum of highly cited works	A Varied Number of Publications Citing the Following		
		50 to 99 citations	100 to 199 citations	200 and more
14–16	34	24	6	4
17–19	31	18	8	5
20–22	25	16	9	–
14–22	90	58	23	9

"None of the 90 most-cited publications appeared only in high-impact journals. Table shows that 20% (18) were published in low impact journals (IF 2.0), 45.55 (51) were published in medium impact journals (IF > 3.999), and 34.45 (51) were published in high impact journals."

Table 7: High-impact journals versus frequently-cited publications in physics

IFrange	A Variable Number of Papers Referencing the Following			
	50–99 citations	100–199 citations	200 or more	Totalpapers
1.00–1.99	14	7	–	21
2.0–3.99	29	8	5	42
4andmore	18	8	4	30
Total	59	24	8	92
Totalpapers%)	64.55	24.55	10.00	100.0

Moreover, 13 low-impact journal articles received 50-99 citations each article, and 5 articles received 100-199 citations per article. This proves that article publication in high impact journals is not a prerequisite for receiving many citations. whether the material is novel and creative, it doesn't matter whether the journal has a low impact factor; the work will still have a strong probability of being cited. In Table, we can see that articles published in high-impact journals get a larger average number of citations than those published in lower-impact journals.

Consistently influential researchers in the field of condensed matter physics

On the basis of their publication output and citation output, 241 scientists from 21 institutions were recognized as productive and prominent in the field of condensed matter physics. There were 148 researchers who had published 10-19 publications and 93 researchers who had produced 20-79 papers.

The vast majority of researchers produced works that were cited just a modest number of times. Table shows that only a small percentage of papers obtained above-average to high levels of citations. This demonstrates the level of excellence that India has reached so far in the field of condensed matter physics.

Table 8: Organizing researchers in the field of condensed matter physics according to their publication rate and citations per article

Sorting papers by the number of citations each article has gotten		Scientists who have published at least one paper	
		20-79papers	10 -19papers
low-impact articles	0 - 4.89	42	78
Common number of references	5.00 - 9.89	38	54
articles with a higher than usual number of citations	10.00 - 14.89	6	8
Numerous citations	15.00 - 19.89	4	5
Extremely Popular Papers	20.0 and above	3	3

There are, however, many more who have made equally important contributions to the discipline in terms of publications output and citations per article but who have not yet been honored for their efforts. "The Tata Institute of Fundamental Research in Mumbai (30), the Indian Institute of Science in Bangalore (26), the Bhabha Atomic Research Centre in Mumbai (17), the Indian Institute of Chemical Sciences in Kolkata (14), the Hyderbad University of Science and Technology in Hyderabad (10), the Indian Institute of Technology in Kharagpur (10), the Indian Institute of Science in Bhubaneshwar (8), the Indian Institute of Nuclear Physics in Kolkata (8), the National Physical Laboratory in New Delhi (7), the Indian Institute of Technology in Chennai (5)"

Table 9: Highest-cited researchers in the field of condensed matter physics

Scientists	Publ. count	Inst. affiliat.	Average citations/page
RAYCHAUDHURI, AK	40	IIS-BANG	26.18
MAHENDIRAN, R	15	IIS-BANG	49.47
RANDERIA, M	22	TIFR	20.55
MAHESH, R	15	IIS-BANG	40.73
AYYUB, P	12	TIFR	22.25
RAO, CNR	70	IIS-BANG	18.69
RAMASESHA, S	27	IIS-BANG	20.48
HOSSAIN, Z	31	TIFR	16.97
PATI, SK	12	IIS-BANG	19.42
SHANTHI, N	11	IIS-BANG	16.64
GODART, C	30	TIFR	17.77
BARMAN, SR	14	IIS-BANG	15.14
KRISHNAMURTHY, HR	19	IIS-BANG	16.74
SARMA, DD	57	IIS-BANG	16.09

CONCLUSION

As many as 449 institutions in India specialize in condensed matter physics, making it the most popular and biggest subfield in physics there. Publication data from 2014-22 shows that it is responsible for as much as 20% of the country's physics research output. Nonetheless, despite this professed interest, the discipline of condensed matter physics has not been expanding. Its growth rate has slowed from 1793 papers in 2014–2016 to 1778 papers in 2020–2022. Several causes come to mind, one of which is the

sector of universities and colleges that has underperformed.

It is necessary to (i) create large-scale, nationally significant network initiatives in which high- and medium-productivity institutions actively participate in order to advance the field of condensed matter physics in the country. "To develop quality manpower in condensed matter physics in the country, these programs should (i) produce results with societal and industrial applications; and (ii) establish more centers of excellence in academic institutions modeled after institutes of national importance or on the model of centers of advanced research. (iii) provide grants to medium-productivity institutions so that they can purchase instruments; (iv) develop specialized programs to expose workers from medium- and low-productivity institutions to cutting-edge resources at international centers; (v) establish a national monitoring committee to develop an action plan for bolstering the state of the field."

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