IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES
ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed ( Group -I) Journal Volume 11, Iss 01, 2022

# Research Publications of Physics at the Indian Institute of Science, Bengaluru: A Scientometrics Study

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**Abstract**

This study aims to examine physics research articles from the Indian Institute of Science, Bengaluru from 2010 to 2019. The Web of Science (WoS) Core Collection database was the source of the bibliographic information for this investigation. The study examines research publications broken down by year, document formats, preferred journals for publication, prolific authors, h-index, most cooperating countries and institutions, etc. This study examines 2593 scientific publications that physicists from the Indian Institute of Science, Bengaluru, Department of Physics have published over the study period. The results show that the literature is growing in a linear fashion, with journal articles (2421) being the most popular format for researchers to share their work. Physical Review B is the most favored journal, and Ajay Kumar Sood is the most productive writer. Just one study and nineteen research papers with multiple authors were found in the most referenced publications. The two most important collaborating institutions were Jawaharlal Nehru Centre for Advanced Scientific Research and Indian Institute of Technology (195). The top five nations for collaboration were Sweden, the United States, Germany, France, and England.
Keywords: physics, research output, Indian Institute of Science, Scientometric, bibliometric.

## 1. Introduction

Reputation and prestige of an institution both at national or international level depend greatly on the research productivity and its impact. The higher academic ranking and the funding agencies give weight to research publications (Kumar & Senthikumar, 2019). It is, therefore, important to study, analysis and understand the research output of an institute and a discipline. The present study examines research publications of Physics discipline at the Indian Institute of Science, Bengaluru by using scientometric techniques. Bibliometrics, scientometrics, webometrics, and altmetrics are all aimed at analysing, quantifying, and measuring communication purposes. ALA Glossary of Library and Information defines bibliometrics as "the use of mathematical and statistical methods to study and identify patterns in the use of materials and services within a library". Hood and Wilson (2001) state that scientometrics includes "all quantitative aspects of the science of science, communication in science, and science policy". In general, bibliometric studies can be divided into two broad categories (Soos et al., 2013): evaluative bibliometric studies and structural bibliometric studies

Indian Institute of Science (IISc) was established in 1909. It is not only the leading institution in India but also in the world in the field of modern science and engineering. The Department of Physics at IISc was established in the year 1933 by the Nobel Laureate C.V. Raman. He was the first Indian to be appointed as IISc's Director in 1933.

Indian Institute of Science, Bengaluru was ranked 251-300 in the world by the *Times Higher*

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*Education* World University Rankings of 2019 (Times Higher Education, n.d.). The Ministry of Human Resource Development (MHRD), Government of India (MHRD, n.d.), released the National Institutional Ranking Framework (NIRF) rankings for higher educational institutions for the year 2019, where the Indian Institute of Science bagged the 1st position for the best university.

## 2. Related Literature

The study of matter and energy is regarded as Physics. It also enhances our knowledge in other subject areas such as engineering and chemical sciences. The department of physics of IISc is known internationally for research in condensed matter physics and physics of biomolecules (Department of Physics, n.d.). According to Gupta and Dhawan (2008), the most sought after research in the physics branch in the country is in condensed matter physics, which accounts for 20% share of India's total research productivity in physics.

According to Roy (2019), 75% are single-authored papers and the women researchers' productivity contributed to a share of 0.62% publication in the field of biological science research from 1901-1945. Seel & Zierer (2019) investigated the educational researchers' productivity of bibliometric data on Germany in comparison with the data of several European scientific communities, such as Spain, Netherlands, and Scandinavian countries (Denmark, Finland, Norway, Sweden). Khanna, *et al*. (2017) analysed the research publications of Guru Nanak Dev University (GNDU), Amritsar for the period 2006-2015 using the Scopus database. They examined 652 papers published in the field of physics and astronomy. The study reveals that the research publications is increasing, papers getting good citations and thereby journals have a good impact factor. Out of the top 25 most prolific Indian universities in physics and astronomy, GNDU stood at 23rd rank in term of research contributions. Bebi & Kumar (2017) presented an analysis of publication contributions, most prolific authors, authorship pattern, areas of research interest, collaborative co-efficient, preferred journals of 44 women faculties in select institutions of Delhi in physics discipline during 2011-2015. The study which analysed 463 journal articles, found that the most prolific author was Ratnamala Chatterjee from IIT Delhi with 54 (11.7%) publications, and the topmost preferred journal was "*Journal of Applied Physics"* with 36 (7.8%) research articles. The study reveals that in joint authorships, women authors preferred to be the 2nd author. Chakravarty & Sharma (2016) analysed the research output in the field of Library & Information Science of the two universities i.e Panjab University (PU), Chandigarh and the Guru Nanak Dev University (GNDU), Amritsar. Moradi-Motlagh, Jubb, & Houghton (2016) in their study finds that with changes in university funding and sector competition, there was significant productivity improvement of 15.2% for 37 Australian universities from 2007 to 2013. Noruzi & Abdekhoda (2014) carried out a study of 459 papers published by Iraqi-Kurdistan universities' index in the Scopus database. The scientometric study by Sife & Lwoga (2014) highlights the research productivity and scholarly impact of Tanzania academic librarians during 30 years. The analysis includes the publication of 434 research papers, collaboration patterns, journal preference and citations. In the studies (Hassan & Loebbecke, 2017; Kim, 2001; Pradhan & Ramesh 2017; Tan, Ujum, & Ratnavelu, 2014)

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similar metrics related findings were done. Traditional scientometric studies mainly focused on evaluating research efforts and measuring scholarly influence like ranking on authors, best papers, journals, countries, and institutions.

## 3. Objectives

The study tries to analyse the various research objectives as follows:

- To examine the growth of literature from 2010 to 2019 at the Physics department of IISc, Bengaluru
- To find out the document types and core journals in Physics, used for publication by scientists of IISc, Bengaluru
- To identify the most productive authors and most cited publications during the period of the study
- To identify the top collaborative institutions/affiliation and countries.

## 4. Methodology

The research publication data of the Department of Physics at the Indian Institute of Science, Bengaluru was retrieved and downloaded from the Web of Science (WoS) Core Collection citation database. The Web of Science Core Collection database is an organised database that collects and indexes over 21,000 peer-reviewed, high-quality scholarly journals including Open Access journals published worldwide in over 250 disciplines such as science, social sciences, and humanities (Web of Science Group, n.d.). The data was searched using the search string phases "OE=Indian Institute of Science" AND "AD=Department of Physics." The search was limited for ten years from the publication year 2010 to 2019. A total number of 2,593 research publications retrieved from WoS was considered in the study. All the bibliographic data was exported using MS-Excel software and analysed as per the objectives of the study.

## 5. Data Analysis and Interpretation

### 5.1 Literature Growth

Figure-1 shows the year-wise growth of literature pattern during the period of 2010-2019. From 2010 to 2019, a total of 2,593 research publications were published by the Department of Physics, IISc scientists. The literature growth pattern shows that the scholarly publication by physicists is growing in a linear pattern. Out of the 2593 published articles, 192 (7.40%) were published in 2010, increases to 323 (12.46%) articles published in 2019. The highest number of publications was in 2019 with 323 (12.46%) articles and the least number of publications were in 2010 and 2011 with only 192 (7.4%) articles each as shown in Figure-1.

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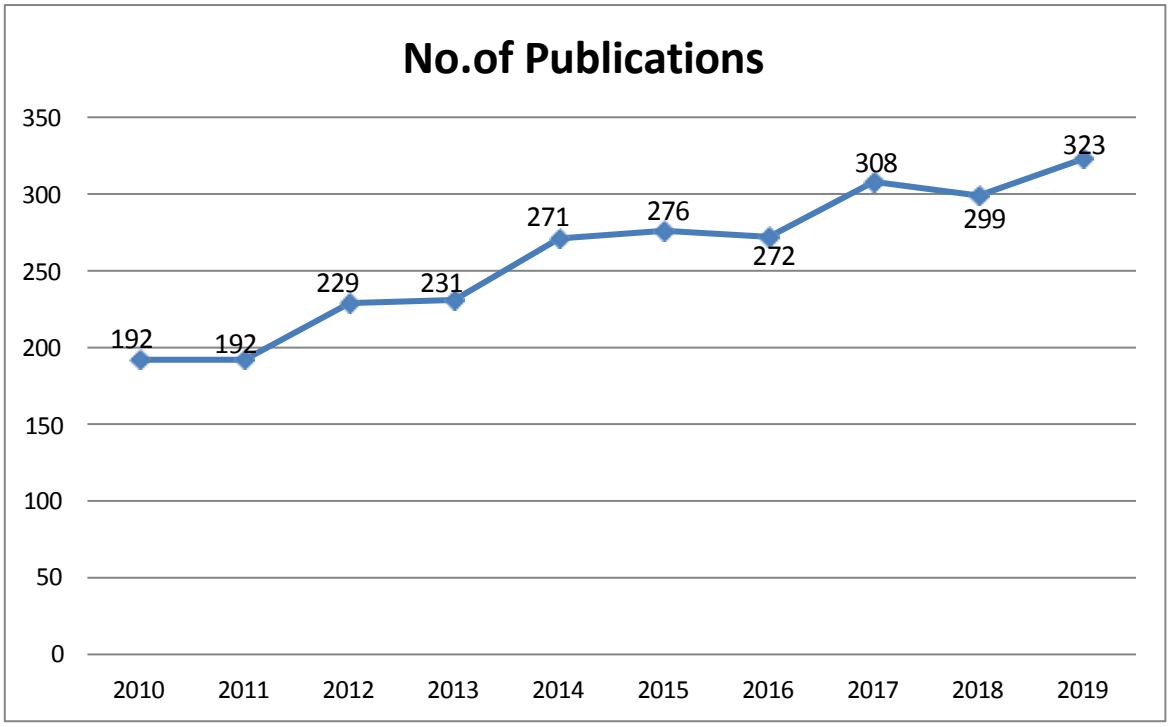
**Figure-1. Literature Growth of Publications**




## 5.2 Document Types

Web of Science records includes various document types such as article, early access, proceedings paper, editorial material, review, book chapter, letter, etc. Out of the 2593 collected bibliographical records, Figure-2 shows that 2421 (93.37%) of the total research output was published as a journal article, followed by proceedings paper with 68 (2.62%) and review with 35 (1.35%) respectively. The document type 'Early Access' is "an article that has been electronically published by a journal before it has been assigned to a specific volume and issue." (Web of Science Core Collection Help, n.d.). The least preferred document choice for publication among the scientists of IISc was 'Letter' with only 2 (0.08%) publications (Table-1).

**Table-1. Types of Document**

| Sl.No | Types | Number of Publications | Percentage % |
|---|---|---|---|
| 1 | Article | 2421 | 93.37 |
| 2 | Article; Early Access | 3 | 0.12 |
| 3 | Article; Proceedings paper | 68 | 2.62 |
| 4 | Biographical-Item | 3 | 0.12 |
| 5 | Correction | 14 | 0.54 |
| 6 | Editorial material | 14 | 0.54 |
| 7 | Letter | 2 | 0.08 |
| 8 | Meeting Abstract | 22 | 0.85 |
| 9 | News item | 3 | 0.12 |
| 10 | Review | 35 | 1.35 |
| 11 | Review; Book Chapter | 8 | 0.31 |
| **Total** | | **2593** | **100** |

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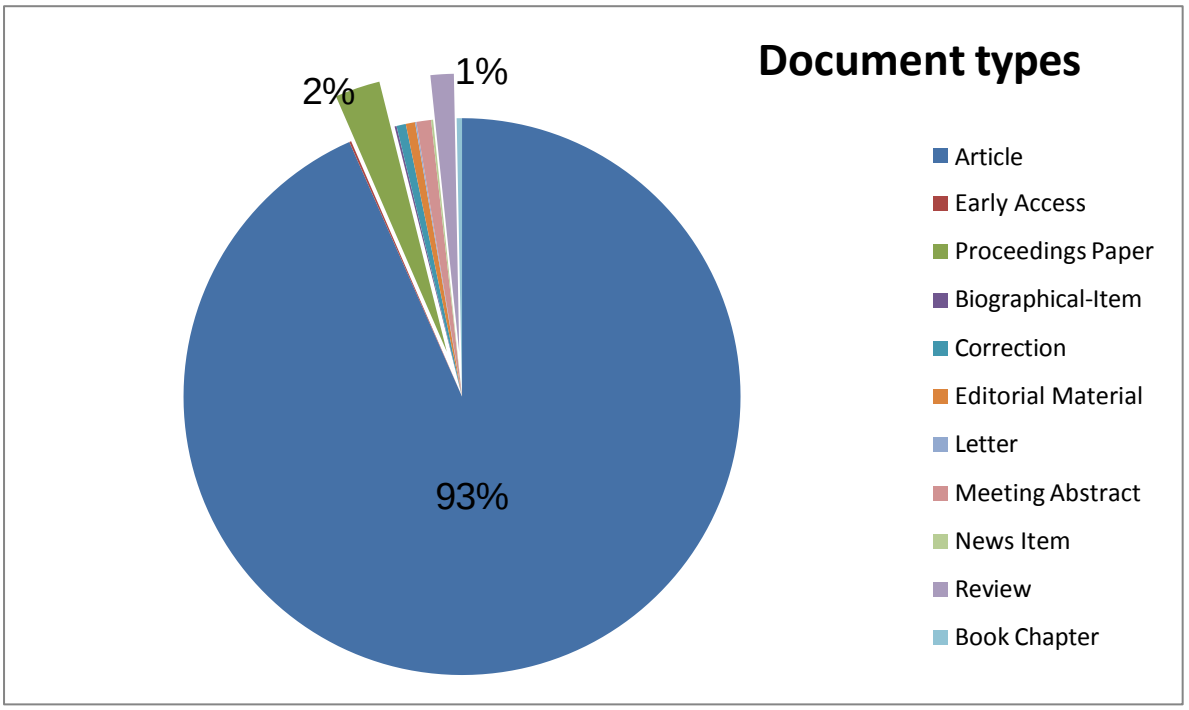
**Figure-2. Types of Document**




### 5.3 Core Journal

The topmost productive journals are shown in Table-2. It has been seen that the topmost productive journals are "*Physical Review B"* with 175 (6.75%, IF 3.736) number of published articles at the first rank, followed by "*Journal of Applied Physics*" and "*Monthly Notices of the Royal Astronomical Society*" with 86 (3.32%, IF 2.323) and 75 (2.89%, IF 5.231) respectively. The least preferred choice was "*Journal of Physics-Condensed Matter*" with 38 (1.47%, IF 2.907) publications. As observed from Table-2, the Indian Institute of Science scientists published their research publications in high impact factor journals. It is evident from the table below that the IISc scientists preferred international journals more in comparison to Indian journals for communicating their research work. The USA top the list of countries originate publishing journals with 6 journals, followed by England with 3 journals and lastly Switzerland with one journal.

**Table-2. Top 10 Productive Journals During 2010 -2019**

| Rank | Source | Total Publications | Impact Factor (2018) | Journal Publishing Country |
|---|---|---|---|---|
| 1 | *Physical Review B* | 175 | 3.736 | USA |
| 2 | *Journal of Applied Physics* | 86 | 2.323 | USA |
| 3 | *Monthly Notices of the Royal Astronomical Society* | 75 | 5.231 | England |
| 4 | *Physical Review Letters* | 66 | 9.227 | USA |
| 5 | *Applied Physics Letters* | 53 | 3.521 | USA |
| 5 | *Physical Review E* | 53 | 2.353 | USA |
| 7 | *Physical Review D* | 52 | 4.368 | USA |
| 8 | *Journal of Alloys and Compounds* | 51 | 2.931 | Switzerland |
| 9 | *Spectrochimica Acta Part A-Molecular and Biomolecular Spectroscopy* | 39 | 2.711 | England |
| 10 | *Journal of Physics-Condensed Matter* | 38 | 2.907 | England |

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### 5.4 Most Prolific Authors

Table-3 shows the number of publications and it's corresponding rank of the top 10 most prolific authors. Out of the total 2593 IISc physicists publications, Ajay Kumar Sood with 152 (5.86%) research papers topped the rank, followed by A Ghosh and Anil Kumar, P.S contributing 117 (4.51%) and 110 (4.24%) publications hold 2nd and 3rd rank respectively.

**Table-3. Top 10 Most Prolific Authors**

| Rank | Author's name | Number of Publications | Percentage | Total Citations these Publications Received | h-index* |
|---|---|---|---|---|---|
| 1 | Sood, A K | 152 | 5.86 | 2932 | 22 |
| 2 | Ghosh, A | 117 | 4.51 | 1622 | 23 |
| 3 | Kumar, P S Anil | 110 | 4.24 | 1357 | 22 |
| 4 | Maiti, Prabal. K | 84 | 3.24 | 1453 | 18 |
| 5 | Shivakumara, C | 81 | 3.12 | 1520 | 23 |
| 6 | Elizabeth, Suja | 70 | 2.70 | 1040 | 16 |
| 7 | Nagabhushana, H | 69 | 2.66 | 1155 | 21 |
| 8 | Sarma, D D | 60 | 2.31 | 752 | 18 |
| 9 | Nagabhushana, B M | 57 | 2.2 | 760 | 21 |
| 10 | Basu, J K | 56 | 2.16 | 811 | 16 |
| **Total** | | **856** | **33** | **13402** | - |

***h*-index***: The *h* was proposed by J.E. Hirsch in 2005. According to Hirsch, the *h* index is defined as "A scientist has *h* if *h* of his or her Np papers have at least *h* citations each and the other (Np – *h*) papers have ≤ *h* citations each."

### 5.5 Most Cited Publications

The analysis of the top 20 most cited publications details, along with the document types are shown in Table-4. All publications are multiple-authored except "The Mechanics and Statistics of Active Matter" by Sriram Ramaswamya which is a "Book Chapter". The review publication of Daniel J. Klionsky, et al. published in 2016, with the title "Guidelines for the Use and Interpretation of Assays for Monitoring Autophagy (3rd edition)" received highest with 2328 citations. The 2nd and 3rd ranked of most cited publications have received 1307 and 825 citations respectively. The 20th ranks of most cited publications are assigned to Girish S Kumar and Koteswara KSR Rao, published in 2015, title "Tungsten-based Nanomaterials (WO3 & Bi2WO6): Modifications Related to Charge Carrier Transfer Mechanisms and Photocatalytic Applications", and Prateek Sharma, et al, published in 2012, the title "Thermal Instability and the Feedback Regulation of Hot Haloes in Clusters, Groups and Galaxies" with 158 citations each. It is indicated that the top 20 most cited documents (Table-4) have received 158 citations and above.

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**Table-4. Top 20 Most Cited Publications (R-Rank; TC-Total Citations)**

| R | Title | Authors | Source | Year | TC | Doc.Type |
|---|---|---|---|---|---|---|
| 1 | Guidelines for the use and interpretation of assays for monitoring autophagy (3rd edition) | Klionsky, DJ; Abdelmohsen, K; Abe, A...et al. | *Autophagy* | 2016 | 2328 | Review Article |
| 2 | Hydrodynamics of soft active matter | Marchetti, MC; Joanny, JF; Ramaswamy, S ...et al. | *Reviews of Modern Physics* | 2013 | 1307 | Article |
| 3 | Definition of the hydrogen bond (IUPAC Recommendations 2011) | Arunan, E; Desiraju, GR; Klein, RA...et al. | *Pure and Applied Chemistry* | 2011 | 825 | Article; Proceedings Paper |
| 4 | Graphene-MoS2 hybrid structures for multifunctional photoresponsive memory devices | Arunan, E; Desiraju, GR; Klein, RA...et al. | *Nature Nanotechnology* | 2013 | 762 | Article |
| 5 | The Mechanics and Statistics of Active Matter | Ramaswamy, S | *Annual Review of Condensed Matter Physics, Vol 1* | 2010 | 683 | Review; Book Chapter |
| 6 | Defining the hydrogen bond: An account (IUPAC Technical Report) | Arunan, E; Desiraju, GR; Klein, RA...et al | *Pure and Applied Chemistry* | 2011 | 579 | Article; Proceedings Paper |
| 7 | Nature of Electronic States in Atomically Thin MoS2 Field-Effect Transistors | Ghatak, S; Pal, AN; Ghosh, A | *ACS Nano* | 2011 | 508 | Article |
| 8 | Symmetry-dependent phonon renormalization in monolayer MoS2 transistor | Chakraborty, B; Bera, A; Muthu, DVS...et al. | *Physical Review B* | 2012 | 487 | Article |
| 9 | Zinc oxide based photocatalysis: tailoring surface-bulk structure and related interfacial charge carrier dynamics for better environmental applications | Kumar, S.G., & Rao, K.S.R.K. | *RSC Advances* | 2015 | 401 | Review |
| 10 | Comparison of modification strategies towards enhanced charge carrier separation and photocatalytic degradation activity of metal oxide semiconductors (TiO2, WO3 and ZnO) | Kumar, S.G., & Rao, K.S.R.K. | *Applied Surface Science* | 2017 | 312 | Article; Proceedings Paper |
| 11 | Some Novel Attributes of Graphene | Rao, CNR; Sood, AK; Voggu, R ...et al. | *Journal of Physical Chemistry Letters* | 2010 | 278 | Article |
| 12 | Diketopyrrolopyrrole-Diketopyrrolopyrrole-Based Conjugated Copolymer for High-Mobility Organic Field-Effect Transistors | Kanimozhi, C; Yaacobi-Gross, N; Chou, KW...et al. | *Journal of the American Chemical Society* | 2012 | 262 | Article |
| 13 | Structural Chemistry of Peptides Containing Backbone Expanded Amino Acid Residues: Conformational Features of beta, gamma, and Hybrid Peptides | Vasudev, PG; Chatterjee, S; Shamala, N...et al. | *Chemical Reviews* | 2011 | 235 | Review Article |
| 14 | Near-Room-Temperature Colossal Magnetodielectricity and Multiglass Properties in Partially Disordered La2NiMnO6 | Choudhury, D; Mandal, P; Mathieu, R...et al. | *Physical Review Letters* | 2012 | 230 | Article |
| 15 | Graphene Oxide-MnFe2O4 Magnetic Nanohybrids for Efficient Removal of Lead and Arsenic from Water | Kumar, S; Nair, RR; Pillai, PB...et al. | *ACS Applied Materials & Interfaces* | 2014 | 212 | Article |
| 16 | Layer-dependent resonant Raman scattering of a few layer MoS2 | Chakraborty, B; Matte, HSSR; Sood, AK; ...et al. | *Journal of Raman Spectroscopy* | 2013 | 201 | Article |

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| R | Title | Authors | Source | Year | TC | Doc.Type |
|---|---|---|---|---|---|---|
| 17 | Physics and chemistry of CdTe/CdS thin film heterojunction photovoltaic devices: fundamental and critical aspects | Kumar, S.G., & Rao, K.S.R.K. | *Energy & Environmental Science* | 2014 | 188 | Review Article |
| 18 | Cause and effect of feedback: multiphase gas in cluster cores heated by AGN jets | Gaspari, M; Ruszkowski, M; & Sharma, P | *Astrophysical Journal* | 2012 | 168 | Article |
| 18 | Structural, optical and EPR studies on ZnO:Cu nanopowders prepared via low temperature solution combustion synthesis | Reddy, AJ; Kokila, MK; Nagabhushana, H;...et al. | *Journal of Alloys and Compounds* | 2011 | 168 | Article |
| 20 | Tungsten-based nanomaterials (WO3 & Bi2WO6): Modifications related to charge carrier transfer mechanisms and photocatalytic applications | Kumar, SG; & Rao, KSRK | *Applied Surface Science* | 2015 | 158 | Article |
| 20 | Thermal instability and the feedback regulation of hot haloes in clusters, groups and galaxies | Sharma, P; McCourt, M; Quataert, E;...et al. | *Monthly Notices of the Royal Astronomical Society* | 2012 | 158 | Article |

### 5.6 Most Productive Institutions

The scientists of the Department of Physics involve research collaborations with other institutions both from India as well as foreign institutions (Table-5). The 1st rank was shared between "Indian Institute of Technology (IIT)" and "Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR)" with 194 (7.48%) publications each. The top 20 most collaborative institutions with the Indian Institute of Science has 1398 (53.91%) of the total number of the research publications. The top seven most productive collaboration institutions of IISc scientists were all from India (Table-5).

**Table-5. Top 20 Most Productive Institutions**

| Rank | Institution | Country | Total Publications |
|---|---|---|---|
| 1 | Indian Institute of Technology | India | 194 |
| 1 | Jawaharlal Nehru Centre for Advanced Scientific Research | India | 194 |
| 3 | Council of Scientific & Industrial Research | India | 110 |
| 4 | Tata Institute of Fundamental Research | India | 98 |
| 5 | Indian Institutes of Science Education & Research | India | 82 |
| 6 | M.S Ramaiah Institute of Technology | India | 71 |
| 7 | Tumkur University | India | 62 |
| 8 | Max Planck Institutes | Germany | 61 |
| 9 | BMS Institute of Technology and Management | India | 59 |
| 10 | Rice University | USA | 58 |
| 11 | Uppsala University | Sweden | 55 |
| 12 | Bangalore University | India | 54 |

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| Rank | Institution | Country | Total Publications |
|---|---|---|---|
| 13 | Banaras Hindu University | India | 44 |
| 14 | National Institute of Technology | India | 40 |
| 15 | National University of Singapore | Singapore | 35 |
| 15 | University of California, Berkeley | USA | 35 |
| 17 | Vellore Institute of Technology University | India | 31 |
| 18 | Indian Association for the Cultivation of Science | India | 30 |
| 19 | Raman Research Institute | India | 29 |
| 20 | Indian Institute of Astrophysics | India | 28 |
| 20 | Sri Venkateswara University | India | 28 |

### 5.7 Most Collaborative Countries

The top 20 most collaborating countries with Indian Institute of Science during 2010 – 2019 is shown in Table-6. In collaborative research with IISc, out of total 65 countries, the USA tops the rank with a total of 670 (25.84%) publications, followed by Germany and France with 270 (10.41%) and 196 (7.59%) publications respectively. These top 20 most collaborative countries with IISc physicists has published 2401 (92.60%) of the total number of publications.

**Table-6. Top 20 Most Collaborative Countries**

| Rank | Country | Total Publications |
|---|---|---|
| 1 | USA | 670 |
| 2 | Germany | 270 |
| 3 | France | 196 |
| 4 | England | 160 |
| 5 | Sweden | 113 |
| 6 | Italy | 94 |
| 6 | Japan | 94 |
| 8 | Austria | 79 |
| 8 | South Korea | 79 |
| 10 | China | 78 |
| 11 | Taiwan | 65 |
| 12 | Belgium | 51 |
| 13 | Canada | 50 |
| 14 | Singapore | 48 |
| 15 | Switzerland | 44 |
| 16 | Netherlands | 42 |
| 17 | Israel | 37 |
| 18 | Russia | 33 |
| 19 | Turkey | 31 |
| 20 | Australia | 29 |

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## 6.Findings

Key inference of the study are:

i. The research output of the Department of Physics at the Indian Institute of Science, Bengaluru published 2593 publications during the period of the study i.e 2010-2019. The maximum publications were in 2019 with 323 (12.46%) research papers and the minimum in 2010 and 2011 with only 192 (7.4%) publications each.

ii. The majority of the contributions are in article form i.e 2421 research papers. The following document types such as 'Early Access'; 'News item'; and 'Biographical-Item' has only 3 (0.11%) publications each. 'Letter' is the least preferred choice with only 2 (0.08%) publications.

iii. The most productive journal is "*Physical Review B*" with 175 publications.

iv. IISc scientists published their research work in high impact journals.

v. The 1st and 2nd most prolific authors during the period 2010-2019 are Ajay Kumar Sood and A. Ghosh with 152 (5.86%) and 117 (4.51%) publications respectively.

vi. Cited 2328 times, the review article titled "Guidelines for the Use and Interpretation of Assays for Monitoring Autophagy" is the most cited publication.

vii. All the top 20 most cited publications were multiple-authored except for one "Book Chapter" which is a single-authored.

viii. The Indian Institute of Science, Bengaluru has the largest number of institutions collaboration publications with Indian Institute of Technology (IIT) and Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR) with 194 each published scholarly papers.

ix. 65 countries were identified as collaborators with IISc. The top 5 most collaborative countries are the USA, Germany, France, England, and Sweden.

## 6. Conclusion

The most popular medium for research communication was investigated, together with the research productivity of the Indian Institute of Science's Physics Department. The output of IISc physicists' research is steadily rising. The calibre and uniqueness of the research conducted by the IISc experts is demonstrated by the publications they have made in highly impact factor journals like Nature (IF 43.070), Nature Nanotechnology (IF 43.341), and Nature Physics (IF 21.797). A deeper comprehension of research publications, literature growth patterns, and the significance of citations received for scholarly communication has resulted from the scientometric study conducted at the Physics Department at IISc. Scholars, administrators, professional associations, funding organizations, and up-and-coming scientists can all benefit from these kinds of bibliometric and scientometric research.

 

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