TRANSACTIONS ON ANTENNAS AND PROPAGATION: A 30-YEAR EVOLUTION

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ABSTRACT

The article presents the path of publications made between 1989 and 2019 by the journal Transactions on Antennas and Propagation. The analysis involved the creation of production and quoting metrics as well as co-occurrence maps for keyword and origin search of articles. The results show the advances in number and impact of the journal articles grouped into three relevant topics electromagnetic wave scattering, bandwidth and microwave antennas and two origin countries USA and China. An overview of the future is also defined in terms of microwave antennas and origin countries (USA, Canada and Singapore).

KEYWORDS: Bibliometrics, Publishing Activities & Scientific Publishing

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I. INTRODUCTION

The IEEE Transactions on Antennas and Propagation journal is present in the Scopus base since 1969, placed in the first quartile of SJR since 1999 in the Electrical and Electronic Engineering categories of the Engineering area and Condensed Matter Physics of the Physics and Astronomy area. The journal is known for publishing results of research projects regarding antennas that include design and propagation of electromagnetic waves ranging from a theoretical standpoint to empirical or experimental matters such as dispersion or diffraction under different scenarios and applications. Some of them pertain to remote detection, optics and techniques for sub-millimetric waves.

The impact metrics over the last 20 years exhibit a growth in the IF (quotes in 2 years) that went from 1.266 to 5.055 in 2018. The SJR was 1.055 in 2010 and 1.991 in 2005 (**Error! Reference source not found.**).

Hence, in recent years (2010-2014) it was concluded that: i) 44% of the journal publications were originated from USA (27%) and China (17%), ii) the topics with the highest recurrence were antennas, arrays and periodical structures, electromagnetics, numerical techniques, wave propagation and scattering, wireless and communication and iii) a degree of collaboration (Subramanian) of 0.94 which indicates a dominance of contributions from multiple authors [1].

Figure 1: Impact Factor (IF) and Scimago Journal Rank Indicator (SJR) 1999-2018. Source: Authors

This leads to think that the developments of telecommunications, changes in infrastructures for communication and the emergence of new economies with significant developments in communications and engineering have created new perspectives and sources for scientific literature published by the *IEEE Transactions on Antennas and Propagation*. In this sense, the present article goes through the articles published over the past thirty years by identifying the most recognized authors and origins, while also establishing the most significant changes in published article topics, their affiliations and the origin of the referenced literature.

This research starts by describing the most quoted articles and authors and then uses bibliometric tools often seen in network analyses in different journals [2] [3] and research topics within the scientific community [4] [5] [6] [7].

II. DATA AND METHODS

The analysis set was built using the research articles published between 1989 and October 2019 in the *IEEE Transactions on Antennas and Propagation* journal which represent 99.5% of the quotable documents (research articles, conference papers and reviews). This set of 14,149 texts was processed through a descriptive analysis of the number of publications and their citations using the metadata available in Scopus. Furthermore, the information regarding the citation and origin of articles was used to build bibliometric maps of keywords, author affiliation and origin in VosViewer[8] in order to identify trends and variation in the author groups that sign the articles.

III. RESULTS

The results show an increase in the number of articles published going from 230 in 1989 to over 800 at the end of the period. The number of annual quotes per article was maintained between 30 and 40 from 1989 to 2012, followed by a reduction of up to less than 20 quotes per article

Figure 2: Number of articles published and quotes per article. The citation for the articles published between 2017 and 2019 is still growing. Source: Authors

The chart shows that 93% (13.156) of the articles received at least one quote. This percentage, seen in every year of the studied period has varied from 30% in 2019 and 99% in 1999, 2004, 2005, 2006, 2007, 2008, 2010, 2011 and 2013. Prior to October 2019, three articles include more than 1.000 quotes, 27 articles between 500 and 1.000, 724 articles between 100 and 500, 4.256 articles between 1 and 10 and 657 articles only one quote.

The top 10 most quoted articles were published between 1994 and 2004, have 922 quotes in average and three of these articles have more than 1.000 quotes. Only 2 out of 10 were written by a single author. The most cited article was published in 2004 and 5 articles were written in the same decade. In this set of articles there is no text published after 2005 (Table 1).

Table 1: Most cited articles

Author	Title	Pub. Year	Cites
Robinson J., Rahmat-Samii Y.	Particle swarm optimization in electromagnetics	2004	1.566
Song J.	Multilevel fast multipole algorithm for electromagnetic scattering by large complex objects	1997	1.217
Gedney S.D.	An anisotropy perfectly matched layer-absorbing medium for the truncation of FDTD lattices	1996	1.075
Yang F., Rahmat-Samii Y.	Microstrip Antennas Integrated with Electromagnetic Band-Gap (EBG) Structures: A Low Mutual Coupling Design for Array Applications	2003	870
Pozar D.M., Targonski S.D., Syrigos H.D.	Design of millimeter wave microstrip reflect arrays	1997	804
Sacks Z.S., Kingsland D., Lee J.-F.	A Perfectly Matched Anisotropic Absorber for Use as an Absorbing Boundary Condition	1995	799
Liang J., Chiau C.C., Chen X., Parini C.G.	Study of a printed circular disc monopole antenna for UWB systems	2005	749
Haupt R.L.	Thinned Arrays Using Genetic Algorithms	1994	731
Yang F., Rahmat-Samii Y.	Reflection Phase Characterizations of the EBG Ground Plane for Low Profile Wire Antenna Applications	2003	706
Ziolkowski R.W.	Design, fabrication, and testing of double negative meta-materials	2003	703

Additionally, the selection based on number of quotes shows that six group of authors have obtained more than 1000 quotes in the period. In this set, five groups of authors have published between one and three articles and one author with 14 articles. In this list, the distinguished Professor from UCLA Yahya Rahmat-Samii stands out with the highest number of citations (8.624) as a product of his signature in 98 articles published year after year since 1990

Table 2: 1000 or more cited authors groups

Authors	Cites	N. Articles
Yang F., Rahmat-Samii Y.	1.667	3
Robinson J., Rahmat-Samii Y.	1.566	1
Haupt R.L.	1.527	14
Song J.	1.217	1
Gedney S.D.	1.166	2
Yang F., Rahmat-Samii Y.	1.667	3

The set of authors with over 100 articles published is comprised of six individuals belonging to institutions in USA (3), China (2) and Singapore (1). Their articles add up to 696 in total reaching 24.476 citations within the period and an average of 35 citations per article (Table 3).

Table 3: 100 or More Published Articles' Authors

Authors	Affiliation	Country	N. Articles	Cites
Li Y.	Institute of Lightwave Technology, Jiaotong University	China	127	2.365
Sarabandi K.	Dept. of Elec. Eng./Comp. Science, University of Michigan	USA	127	5.197
Volakis J.L.	Radiation Laboratory, Department of Electrical Engineering and Computer Science, University of Michigan	USA	119	4.380
Hong W.	State Key Laboratory of Millimeter Waves, School of information Science and Engineering, Southeast University	China	114	3.802
Chen Z.N.	Department of Radio Systems, Institute for Infocomm Research, 117674 Singapore, Singapore	Singapore	109	4.863
Kishk A.A.	Department of Electrical Engineering, University of Mississippi	USA	100	3.869

The co-words map for the 250 keywords (authors and index) with at least 10 occurrences shows three clusters defined over time. The oldest cluster revolves around electromagnetic wave scattering, the most recent revolves around microwave antennas and the middle cluster revolves around bandwidth).

Regarding electromagnetic wave scattering there are representative topics linked to the modelling process such as algorithms, mathematical models, computer simulation and integral equations. Electric impedance, antenna feeders and natural frequencies appeared in terms of bandwidth. The topics highlighted in recent periods include microwave antennas subsequent to microstrip antennas and slot antennas. The articles often deal with polarization, circular polarization, frequency bands, impedance bandwidths and antenna grounds

Figure 3: Keyword map from 1989 to 2019. Size indicates average per year of publication. This map excludes the keywords directional patterns, antenna arrays and antennas. Source: Authors

The most referenced articles refer to bandwidth, computer simulation, optimization, finite difference method, meta-materials and electromagnetic wave polarization. The least referenced articles are related with microwave antennas, numerical methods and method of moments.

The map of article origin with 53 countries that published at least 10 articles and one citation shows that USA and China have the highest affiliation ranks. USA (5.035 articles) became a prominent source of publications since 2006 while China (2.128 articles) since 2014. In the next line, the following countries can be mentioned regarding the presence over the last 10 years: Italy (936), Canada (845), United Kingdom (770), France (612), Spain (646), Hong Kong (469) and Singapore (511), along with Taiwan (575) and Japan (454) which have prior presence. These countries are most representative in the origin of articles published (**Error! Reference source not found.**).

Figure 4: Origin of the articles with 10 or more citations. Size indicates average per year of article publication. Source: Authors

Additionally, the evidence shows that co-authorships between USA-China and USA-Italy have the most publications followed by China-Singapore, USA-Hong Kong, USA-Canada and China-Canada. Iran (231 articles) stands out amongst the origin countries of the most recent articles along with China, Japan, Hong Kong, Canada and USA.

IV. CONCLUSIONS

Over the last 30 years there has been an increase in the number of articles published each year, changes in topics and

appearance of new countries as sources of publications and references of cited literature.

The number of articles per year went from 230 in 1989 to over 800 since 2017. However, the annual citation has seen a reduction since 2005 going from 23.39 citations per article down to 3.74 citations per article in 2018. This can be explained by the arrival of new less renowned authors and articles with interdisciplinary features, which would require more time to be documented and quoted within the academia [1].

The SJR indicator has allowed the journal to remain in the Scopus base over the last twenty years and its IF has diminished since 2018. This reveals a trend of longer lifecycles within the journal, with articles being quoted even 5 years after being issued.

The journal has evolved in terms of the topics discussed going from electromagnetic wave scattering at the beginning of the period to bandwidth and microwave antennas in recent times. Furthermore, persistent topics include circular polarization, frequency bands, impedance bandwidths and antenna grounds. The evidence shows that the journal has moved from modelling and simulation-oriented goals to applications with microstrip antennas and slot antennas that are related with early 2010 topics such as wave propagation, wave scattering, wireless systems and communications that reflect consolidation of this literature.

Regarding the origin of the articles, USA has been the main source of publications over the last three decades both in terms of volume as in presence throughout the analyzed period. Secondly, China has earned participation by becoming significantly relevant in the last five years. These countries are followed by Italy, Canada, United Kingdom, France, Spain, Hong Kong, Singapore and Taiwan, from which between 500 and 1.000 articles have been published per country. The most relevant co-authorships in terms of number of publications can also be found amongst these countries.

Hence, the identified dynamics leads to conclude: i) the sustained growing impact of the publications measured by SJR and IF, ii) the consolidation of a group of topics revolving around microwave antennas, their modelling, simulation and applications, iii) the growth of production in China and its co-authors USA, Singapore and Canada and iv) the progress strived in terms of volume and impact of the articles with Iranian origin and its co-authors (China, Japan, Hong Kong, Canada and USA).

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