zbMATH: Reference Database in Mathematics

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Abstract. Managing the ever growing production of mathematical research literature requires specific tools. Besides the digital libraries, of particular importance are the reference databases zbMATH and MathSciNet. Focusing on the former one we describe the remarkable historical developments and major events related to predecessors of zbMATH illustrating the gradual evolution of this tool and putting its current state in context. We describe some important features and functions of zbMATH and present the practical experience and the workflow used by the Prague Editorial Unit which contributes to the creation and maintenance of zbMATH.

Keywords: reference database, zbMATH, Zentralblatt, MathSciNet, Mathematical Reviews, digital libraries

1 Introduction

During the last decades, the number of research publications in mathematics has been growing extremely. In view of the fact that mathematical knowledge is not being rewritten and never becomes obsolete, the mathematical literature represents an immense edifice where each building block is important and stays for ever. To cope with such amount of publications, specific tools are needed.

There are two major reference databases that provide important complement to digital mathematics libraries and repositories, zbMATH [7] and MathSciNet [3]. They cover pure and applied mathematics and also include history, philosophy and university education of mathematics as well as applications in related fields. Both databases provide access to bibliographic data and reviews or abstracts of published articles, books and conference proceedings. Even though there is a large overlap of the literature they cover, the databases differ in data, complement each other and enrich the overall information. In this paper we focus on zbMATH.

zbMATH, well-known under its former name Zentralblatt MATH, contains about 3.5 million bibliographic entries with reviews or abstracts currently drawn from more than 3,000 journals and serials, and 170,000 books. More than 50 percent of these entries contain direct links to electronic versions of the corresponding publications in publishers' websites, electronic libraries or repositories with open access to the full texts (e.g. ELibM, EuDML, NUMDAM). Currently, about 120,000 new items are added every year. zbMATH is produced by the Berlin office of FIZ Karlsruhe – Leibniz Institute for Information Infrastructure. Editors are the European Mathematical

Society (EMS), FIZ Karlsruhe, and the Heidelberg Academy of Sciences and Humanities. zbMATH is distributed by Springer [7].

2 History of zbMATH

The first volume of "Zentralblatt für Mathematik und ihre Grenzgebiete" was published in 1931. It was founded by Otto Neugebauer as the second comprehensive review journal in Germany. The first one was the "Jahrbuch über die Fortschritte der Mathematik" established already in 1868. Both these journals presented the bibliographic data of recently published mathematical publications. Jahrbuch was published once a year, whereas Zentralblatt several times per year. Actually, the promptness was one of the reasons why mathematicians Richard Courant, Otto Neugebauer and Harald Bohr, together with the publisher Ferdinand Springer, took the initiative and founded the new mathematical reviewing journal. The first editorial office of Zentralblatt was on the premises of the Springer publishing house in Berlin. Otto Neugebauer became the first editor-in-chief.

Due to the political situation in Germany after the Nazis assumed power, in 1934 Otto Neugebauer decided to resign from his post at the University in Göttingen. Harald Bohr invited him to move to the University in Copenhagen. Neugebauer took up a professorship there and continued his work for Zentralblatt from Copenhagen. In 1938 he resigned from his post as editor-in-chief and emigrated to the USA. He received a professorship at Brown University in Rhode Island. In 1940 Neugebauer jointly with Roland G. D. Richardson, at that time the secretary of the American Mathematical Society, founded the Mathematical Reviews, a mathematical reviewing journal created on the model of Zentralblatt and published ever since by the American Mathematical Society. The web-based access to electronic version of Mathematical Reviews named MathSciNet has been available since 1996.

In 1939 the Prussian Academy of Sciences in Berlin and the Union of German Mathematicians took over the management of Zentralblatt. At that time both journals Jahrbuch and Zentralblatt had one common editor-in-chief. The editorial offices of these journals continued working independently until 1945, although they shared some information, literature and reviews. In that year the publication of the Jahrbuch was discontinued. During the war time Zentralblatt was managed by Nazi regime exponents and as a result some editors had been removed. After the end of the war, Zentralblatt editorial board revived their contacts with former colleagues, inviting many of them to work again as editors or reviewers for Zentralblatt.

In August 1961 the Berlin Wall, separating West Berlin from the eastern part of the city, was built. It was difficult to work in the situation when the editorial office was located in East Berlin and the publishing house Springer as well as some key personnel of the editorial board in West Berlin. Documents were being delivered on a weekly basis by some editors, who were given special permits to enter East Berlin. Due to this situation a temporary editorial office located in the Springer publishing house was established. Under those conditions Zentralblatt functioned for four years.

The split-up of Zentralblatt became official in 1965. The German Academy of Sciences and the Heidelberg Academy of Sciences agreed to continue Zentralblatt with the editing duties to be shared equally by both Berlin offices and with the printing and distribution to be performed by the Springer publishing house. Surprisingly this cooperation continued successfully until 1977.

The number of published mathematical papers increased substantially in the seventies and reached the level which could not be handled manually any more. Several partnerships with other scientific institutions were established in order to use their computing facilities for the editorial work at Zentralblatt. Moreover the Federal Republic of Germany reorganized all information and documentation activities in the country. In response, the Academy of Sciences of the German Democratic Republic withdrew from the cooperation contract with Heidelberg Academy and refused any further collaboration. All the reviewers from GDR were forced to discontinue their services for Zentralblatt.
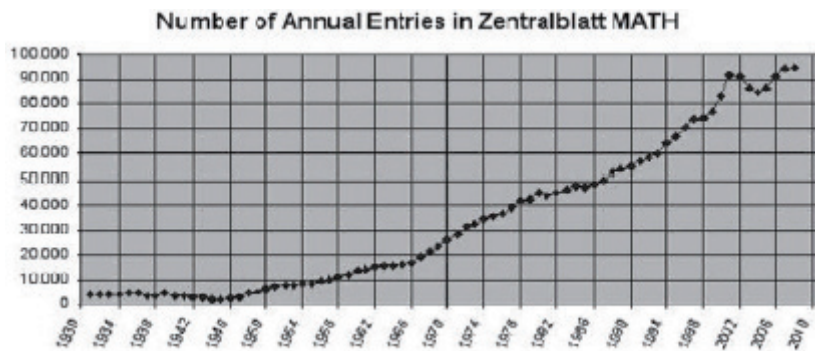

Fig. 1. Growing for centuries: Annual publications indexed in JFM and zbMATH [6]

To improve and centralize institutions handling scientific information and documentation in Germany the Fachinformations Zentrum Energie Physik Mathematik in Karlsruhe was set up in 1979. The Zentralblatt office became formally its subsidiary. The Heidelberg Academy remained responsible for the content of Zentralblatt, while Springer continued to publish the journal and was responsible for printing, marketing and distribution.

In the eighties there were discussions about a potential merger with Mathematical Reviews. Despite the failure of the negotiations both journals continued to cooperate. An important example has been the agreement on the joint maintenance of the specific classification scheme known as "Mathematics Subject Classification" (MSC) which will be discussed below.

In 1989 the first version of Zentralblatt as a searchable database was released to the public. Following the change of political circumstances in 1989 some former members of East Berlin Zentralblatt editorial office resumed work. In 1990 the first offline electronic version on CD-ROM called CompactMATH was published. To typeset mathematical formulae the typesetting system TeX has been used since 1992. The Zentralblatt database was transitioned to a service directly accessible through

the internet in 1996. It was named MATH and later changed to zbMATH. In 2004 Zentralblatt MATH incorporated the Jahrbuch data from the period 1868-1942. Moreover the backward data of the "Journal für die Reine und Angewandte Mathematik" known as "Crelle's journal", which began in 1826, were added. We can say that zbMATH is the most comprehensive and longest running reviewing service in mathematics.

Until 2010 Zentralblatt was available both in electronic format and in print. The printed version represented 25 volumes of 600 pages each annually [2]. When publishing printed version was discontinued, new printed service "Excerpts from Zentralblatt MATH" was temporarily available until 2013. The new zbMATH interface, which offers a number of new features, has been used since August 2013. The system is based on HTML5 now. Display of mathematical formulae is guaranteed by the integration of MathML (Mathematical Markup Language).

3 Searching in the database

There are two possibilities for searching, which may be characterized as "one line search" and "structured search". One line search allows searching in the fields Documents, Authors, Journals, Classification, Software, Formulae. It is possible to use Boolean operators (and, or, not) between fields or terms to get more specific search result, as well as phrase search. The results of searching are ordered chronologically from the newest to the oldest. The structured search allows more precise, fast and convenient search by combining different types of queries.

Fig. 2. "Structured search" in the database

Numerous kinds of data shown in Fig. 3 serve as hypertext: author's name, journal title, reviewer's name, particular MSC codes, keywords, software title etc.

MSC codes represent a unique, mathematics specific classification system reflecting the richness of mathematics and allowing sufficiently fine sorting of topics into approx. 6,000 categories. Individual fields of mathematics are distinguished by two-, three- and five-digit codes. For instance, 35 represents "partial differential equations", 35K represents "parabolic equation and systems" and 35K91 represents "parabolic Monge-Ampère equations". The current version is MSC 2010 [8], the system is updated approximately every 10 years.

Corless, R.M.; Gonnet, G.H.; Hare, D.E.G.; Jeffrey, D.J.; Knuth, D.E.
On the Lambert w function. (English) [Zbl 0863.65008]
Adv. Comput. Math. 5, No.4, 329-359 (1996).

The tree function T defined by series $T(v) = v + \frac{2}{2!}v^2 + \frac{3^2}{3!}v^3 + \frac{4^3}{4!}v^4 + \cdots$ converges for $|v| < \frac{1}{e}$. It equals $-w(-v)$, where $w(z)$ is defined to be the function satisfying $w(z)e^{w(z)} = z$. This paper discusses both w and T, concentrating on w. The authors present a new discussion of the complex branches for w, an asymptotic expansion valid for all branches, an efficient numerical procedure for evaluating the function to arbitrary precision, and a method for the symbolic integration of expressions containing w.   Reviewer: R.S.Dahiya (Ames)

MSC:
65E05   Numerical methods in complex analysis
30B10   Approximation in the complex domain
65D20   Computation of special functions, construction of tables

Cited in **1** Review
Cited in **84** Documents

Keywords:
Lambert w function; tree function; asymptotic expansion; symbolic integration

Software:
Maple

BibTeX   Full Text: DOI

References:
[1]   G. Alefeld, On the convergence of Halley's method, Amer. Math. Monthly 88 (1981) 530–536. · Zbl 0486.65035 · doi:10.2307/2321760

Fig. 3. Example of a search result of the paper

Clicking on the journal title leads to the journal profile which presents the ISSN, publisher, link to journal website, total number of publications in the journal, list of authors who have published in the journal, research fields via MSC codes and clickable bar chart displaying number of publications in particular years.

The user can download the item reference in BibTeX for preparing own reference list.

Most items include also links to electronic versions of full texts. The more recent items include lists of references with links to the cited papers.

Each item is identified with a unique Zbl number.

Author's profile provides the following information related to zbMATH:

• Various forms of author's name appearing in zbMATH besides the one printed in the original pdf of the article
• Total number and list of author's publications registered in zbMATH
• Total number and list of reviews the author has written for zbMATH

- List of co-authors organised according to frequency with links to co-authors profiles and the joint publications
- List of journals in which the author published
- Overview of MSC codes in author's publications (this indicates author's expertise)
- Clickable bar chart displaying number of author's publications in particular years
- Overview of citations of author's publications contained in zbMATH with large amount of information having similar structure as for publications of the authors (this feature has been available since April 2015). Citation data are for the time being labeled as "collection of data to be completed". Currently there are approximately 10 million references contained in zbMATH, connected to more than 400,000 documents (of a total of 3,500,000) [5].

There is a new important feature which enables to improve or correct author's profile and disambiguate author related data. This feature is used e.g. for excluding a publication which has been listed in author's profile by mistake or for merging the profiles that use different forms of names for the same person. All suggestions are, of course, verifies by the zbMATH editors.

Another specific feature is a prototype for the formula search. It uses the MathWebSearch system, which is a content-based search engine for MathML formulae based on substitution tree indexing [7].

Recently the database swMATH has been integrated in zbMATH. swMATH is a free open-access information service for mathematical software. It provides linking mathematical software packages and relevant mathematical publications. The first prototype of the swMATH was published in autumn 2012 [1]. Currently swMATH contains information about more than 10,000 software packages with approx. 100,000 references to zbMATH articles [4]. It provides the following information for every software package: short description of the software package, URL of its homepage, authors, programming language, operating systems, current version, dependencies on other software packages, similar software, keywords (generated from the keywords of the corresponding publications in zbMATH), MSC classification, a graph shoving the number of references over time and clickable list of publications in zbMATH that references this software (there is also a useful filter for these publications). Users can also suggest modification of software metadata using the button "Add information on this software". Simple or advanced search can be used with the possibility to combine in a query the names of software and authors, description, keywords, programming language, and MSC codes. Browsing software by name, keyword or MSC is also possible.

Tao, Terence Chi-Shen

Author-ID: tao.terence-c
Published as: Tao, Terence; Tao, Terence C.; Tao, Terry; Tao, Terrence; Tao, Terence C. S.

Documents indexed: 268 Publications since 1992, including 23 Books
Documents reviewed: 110 Reviews

Co-Authors	all ▾	Journals	all ▾	Classification	all ▾
28 Green, Ben		13 Geometric and Functional Analysis. GAFA		74 Partial differential equations (PDE) (35-XX)	
28 Vu, Van H.		10 Mathematical Research Letters		68 Fourier analysis (42-XX)	
18 Keel, Markus		9 Annals of Mathematics. Second Series		65 Number theory (11-XX)	
18 Thiele, Christoph Martin		8 American Journal of Mathematics		35 Dynamical systems and ergodic theory (37-XX)	
16 Colliander, James E.		8 Journal of the American Mathematical Society		32 Linear and multilinear algebra; matrix theory (15-XX)	

Publications by Year
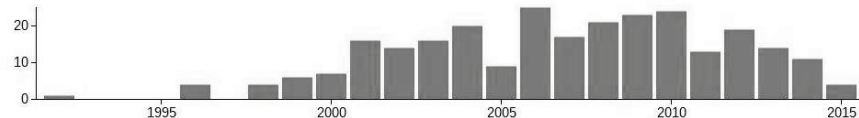
Citations contained in zbMATH (collection of data to be completed)   all cited Publications ▾

181 Publications have been cited 2249 times in 1406 Documents

	Cited by ▾	Year
Robust uncertainty principles: exact signal reconstruction from highly incomplete frequency information. `Zbl 1231.94017` Candès, Emmanuel J.; Romberg, Justin K.; Tao, Terence	**200**	2006
Endpoint Strichartz estimates. `Zbl 0922.35028` Keel, Markus; Tao, Terence	**175**	1998
The Dantzig selector: statistical estimation when p is much larger than n. (With discussions and rejoinder). `Zbl 1139.62019` Candès, Emmanuel; Tao, Terence	**155**	2007
Stable signal recovery from incomplete and inaccurate measurements. `Zbl 1098.94009` Candès, Emmanuel J.; Romberg, Justin K.; Tao, Terence	**137**	2006
Decoding by linear programming. `Zbl 1264.94121` Candès, Emmanuel J.; Tao, Terence	**93**	2005

all cited Publications ▾

Cited by Authors	all ▾	Cited in Journals	all ▾	Cited in Fields	all ▾
40 Tao, Terence Chi-Shen		69 Journal of Mathematical Analysis and Applications		456 Partial differential equations (PDE) (35-XX)	
16 Bourgain, Jean		69 Journal of Functional Analysis		237 Fourier analysis (42-XX)	
13 Guo, Zihua		64 The Annals of Statistics		187 Statistics (62-XX)	
12 Candès, Emmanuel J.		56 Communications in Mathematical Physics		161 Numerical analysis (65-XX)	
12 Miao, Changxing		49 Advances in Mathematics		138 Probability theory and stochastic processes (60-XX)	

Citations by Year

Fig. 4. Author's profile in zbMATH

4 Practical experience of the local editorial unit

All items in the database are subject of a review process. The entries are updated daily. About 7,000 registered reviewers from all over the world contribute their reviews to zbMATH [7]. Occasionally also other mathematicians, not registered as reviewers in zbMATH, write reviews. The reviewing is a valuable voluntary service to the community of mathematicians. The reviews and abstracts are written almost solely in English, but some also in German or French.

In order to minimise time lag between the publication and the recording of the information in the database so called Preliminary data are used. It is a useful tool because it may sometimes take a long time to process the final data. Preliminary data items contains basic bibliographic information about the publications.

The central editorial office of zbMATH located in Berlin cooperates with several mathematical institutions in other countries (currently Bulgaria, China, Czech Republic, Hungary, Serbia, Romania, Russia, Slovakia and Ukraine) that handle articles from selected journals.

In the Prague Editorial Unit of zbMATH the processing of items is carried out as described in Fig. 5. As soon as an issue of a journal is published the editor creates TeX-file containing metadata for all the papers in the volume, namely identifier of the journal and of the paper, volume, issue, pages, authors, author's full name if not mentioned in the paper (it is important for authors' identification in the database), title, MSC codes, keywords and summary. The editorial work is important for the database quality because the extent and completeness of metadata published in different journals varies, sometimes it is necessary to correct or add some missing information. The file is sent to a specialist - a mathematician with expertise corresponding to the fields covered by the journal. The specialist decides whether the paper should be included in the zbMATH. If yes, then he/she adds missing MSC codes and keywords as necessary, and suggests if (i) the paper should be reviewed in a standard way, (ii) author's summary should be used, or (iii) just bare metadata should be recorded. The editor checks the data and delivers them as Preliminary data to the central editorial office in Berlin.

In the basic option (i) the review procedure is initiated. The specialist proposes a reviewer with corresponding expertise. The editor consequently assures administration of the review process and dispatches request to the reviewer. For the time being the Prague Editorial Unit communicates with the reviewers via emails but a new online Editorial system is under preparation. The reviewer is asked to propose MSC codes and keywords corresponding to the content of the paper and to write a review providing a brief and clear description of the paper content and putting the paper in context of the current developments in the corresponding subject area.

Having received the review the editor prepares the final TeX-file fixing possible errors, typos or English expressions. The TeX-file together with all necessary metadata is then converted in a special format and submitted to the central editorial office in Berlin.
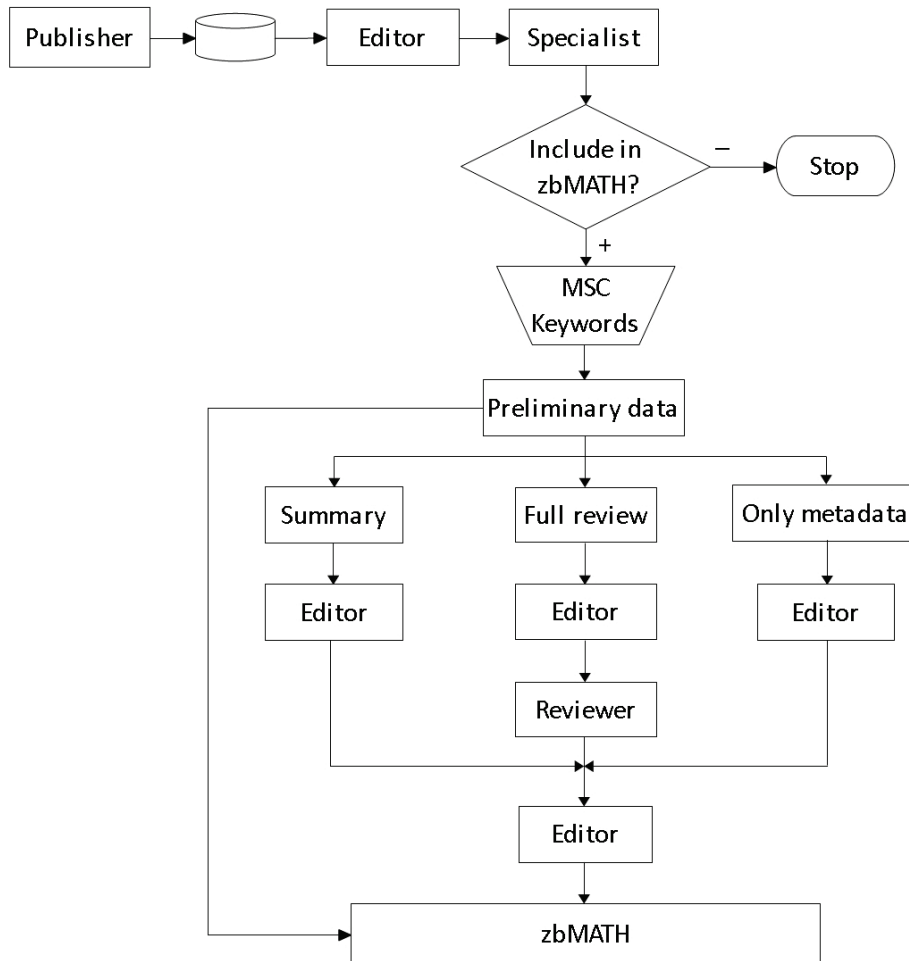
Fig. 5. Workflow in the Prague Editorial Office

5   Conclusions

The reference database zbMATH is a very useful tool for access to systematically sorted and structurally interconnected information concerning the ever growing corpus of publications in mathematics. It is the most comprehensive database in this field. zbMATH is maintained and continually developed in cooperation of several public organisations with a wide community of mathematicians thus being able to react on changes and development of new technologies and remaining up to date tool widely used by mathematicians.

References

1. Bönish, S.; Brickenstein, M.; Chrapary, H.; Greuel, G.-M.; Sperber, W.: swMATH – A New Information Service for Mathematical Software. In: Carette, J. (ed.) et al., Intelligent computer mathematics. MKM, Calculemus, DML, and systems and projects 2013, held as part of CICM 2013, Bath, UK, July 8-12, 2013. Proceedings, pp. 369-373. Springer, Berlin (2013)
2. Göbel, S.: Glimpses into the history of Zentralblatt MATH. In: Teschke, O., Wegner, B., Werner, D. (eds.) 80 years of Zentralblatt MATH: 80 footprints of distinguished mathematicians in Zentralblatt, pp. 1-16. Springer, Berlin (2012)
3. MathSciNet, http://www.ams.org/mathscinet/, accessed July 14, 2015
4. swMATH, http://www.swmath.org/, accessed July 14, 2015
5. Teschke, O.: Citation Profiles in zbMATH. Eur. Math. Soc. Newsl. 96, 62-63 (2015)
6. Wegner, B.: Completeness of reference databases, old-fashioned or not? Eur. Math. Soc. Newsl. 80, 50-52 (2011)
7. zbMATH, https://zbmath.org/, accessed July 14, 2015
8. zbMATH, https://zbmath.org/classification/, accessed July 14, 2015