Journal of Informetrics 5 (2011) 446–457

Contents lists available at ScienceDirect

Journal of Informetrics

journal homepage: www.elsevier.com/locate/joi

Applying social bookmarking data to evaluate journal usage

Stefanie Haustein[a,b,*], Tobias Siebenlist[b]

[a] Central Library, Forschungszentrum Jülich, 52425 Jülich, Germany
[b] Department of Information Science, Heinrich-Heine-University Düsseldorf, Universitätsstr. 1, 40225 Düsseldorf, Germany

ARTICLE INFO

Article history:
Received 30 November 2010
Received in revised form 1 April 2011
Accepted 4 April 2011

Keywords:
Journal evaluation
Usage statistics
Download data
COUNTER
Reader perception
Social bookmarking
Tagging
Science 2.0
CiteULike
Connotea
BibSonomy

ABSTRACT

Web 2.0 technologies are finding their way into academics: specialized social bookmarking services allow researchers to store and share scientific literature online. By bookmarking and tagging articles, academic prosumers generate new information about resources, i.e. usage statistics and content description of scientific journals. Given the lack of global download statistics, the authors propose the application of social bookmarking data to journal evaluation. For a set of 45 physics journals all 13,608 bookmarks from CiteULike, Connotea and BibSonomy to documents published between 2004 and 2008 were analyzed. This article explores bookmarking data in STM and examines in how far it can be used to describe the perception of periodicals by the readership. Four basic indicators are defined, which analyze different aspects of usage: Usage Ratio, Usage Diffusion, Article Usage Intensity and Journal Usage Intensity. Tags are analyzed to describe a reader-specific view on journal content.

1. Introduction

Informetric studies focusing on scientific journals have recently emphasized the importance of including the readers' perspectives (Bollen, de Sompel, Smith, & Luce, 2005; Darmoni, Roussel, & Benichou, 2002; Gorraiz & Gumpenberger, 2010; Rowlands & Nicholas, 2007). While citation analysis only captures readers, who publish and thus cite, it fails to measure their influence elsewhere (Duy & Vaughan, 2006; Roick, 2006; Scanlan, 1987; Schlögl & Stock, 2004). A journals' content can impact the development of new technology, teaching or everyday worklife, which is not measured by citations.

With the emergence of electronic publishing it became easier to evaluate the influence of periodicals on the whole readership. Click and download data of electronic articles can be analyzed to measure journal perception. Although quite a number of indicators have been introduced, which are based on usage statistics and calculated in analogy to citation measures, data aggregation is still problematic. Despite existing standards like COUNTER (2008), even local download statistics provided by the publishers are often incomparable and lack consistency (Baker & Read, 2008; Lorenz, 2010).

Global usage data are generally wrapped in mystery by the publishers. Attempts have been made to gather global data, but projects like MESUR and by the UK Serials Group compute and compare usage to citation indicators but do not make global usage data available (Bollen, Van de Sompel, & Rodriguez, 2008; Shepherd, 2007). SERUM is a new initiative, which aims to provide access to global usage data and create a Journal Citation Report based on download statistics. However,

* Corresponding author at: Central Library, Forschungszentrum Jülich, 52425 Jülich, Germany.
E-mail address: s.haustein@fz-juelich.de (S. Haustein).

1751-1577/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.joi.2011.04.002

SERUM is currently nothing more but a “blue sky project”, which still needs to win over publishers and libraries to provide and manage the underlying data set (Gorraiz & Gumpenberger, 2010). Hence, usage statistics based on worldwide article downloads are not available. Due to these problems, alternative, publisher independent ways to measure global readership are needed. The authors propose to estimate global journal usage by analyzing data from social bookmarking services. This contribution reports about a pilot study which explored these new data sources.

As other Web 2.0 technologies like Wikis and Blogs, social bookmarking services are entering the academic world. Designed after Delicious,[1] bookmarking services specialized on STM enable users to store, search and share interesting resources on the Web. Platforms like CiteULike, Connotea and BibSonomy were developed to accommodate the special requirements of academics, i.e. managing bibliographic metadata of scientific literature (Hammond, Hannay, Lund, & Scott, 2005; Reher & Haustein, 2010). By bookmarking and tagging articles, academic prosumers generate new information about resources.

Thus, it is proposed to apply social bookmarking data to journal evaluation and examine the extent to which it can be used to describe reader perception. Alt-metrics took a similar approach and emphasized the importance of explore different impact metrics (Priem & Hemminger, 2010; Priem, Taraborelli, Groth, & Neylon, 2010). Their ReaderMeter[2] calculates impact indicators for authors based on the number of users who stored their articles in the reference management system Mendeley.[3] In analogy to download and click rates, usage can be indicated by the number of times an article is bookmarked. Compared to a full-text request as measured by conventional usage statistics, which does not necessarily imply that a user read the paper, the barrier to set a bookmark is rather high. Hence, bookmarks might indicate usage even better than downloads, especially if users took the effort to assign keywords. Tags give the users’ perspective on journal content.

Four basic indicators based on social bookmarking data are defined, which are to reflect the different aspects of journal usage measured through bookmarks: Usage Ratio, Usage Diffusion, Article Usage Intensity and Journal Usage Intensity. Since this pilot study focuses on the applicability of bookmarking data to journal evaluation, it is limited to 168,109 documents published in 45 physics journals between 2004 and 2008. In the following, data acquisition and calculation of the indicators for this 45 journals are described.

2. Data and methodology

Today there are four social bookmarking tools serving academic purposes: CiteULike, Connotea, BibSonomy and 2collab (Reher & Haustein, 2010).[4] The latter has been contending with serious server problems and closed registration to new accounts in 2009. Hence, data collection was limited to bibsonomy.org, citeulike.org and connotea.org (Haustein, Golov, Luckanus, Reher, & Terliesner, 2010).

A great share of the metadata of the bookmarking entries proved to be incomplete or erroneous. This often caused an article bookmarked by more than one user not to be recognized as one and the same publication. Thus, not only the social aspect of the bookmarking service is lost, i.e. similar content or users cannot be identified, but also the distribution of bookmarks among journal articles cannot be analyzed correctly. In order to obtain reliable and comparable results on journal usage, the data has to be normalized by journal output. Thus, the bookmarks should be matched on article level.

2.1. Underlying journal set

The set under analysis was limited to bookmarks to publications from 45 journals from the area of solid state physics published between 2004 and 2008. These journals were compiled for a project evaluating methods of multidimensional journal evaluation. The set of 45 journals results from a selection process which aimed to select periodicals which are similar in terms of publication and citation behavior by analyzing all journal cited by authors from the Institute of Solid State Research (IFF) at Forschungszentrum Jülich between 2004 and 2008 at least 15 times. To exclude multidisciplinary journals, the initial set was limited to periodicals filed exclusively under DDC subject group 530 (physics). Additionally, the set was limited to titles covered by Web of Science and with local download statistics available (Haustein, 2010, in press). As publications in solid state research are present in specialized journals as well as in general physics journals (Pinski & Narin, 1976), the set under analysis includes both types of journals. They are classified into 22 Web of Science Subject Categories with “Physics, Applied”, “Physics, Multidisciplinary” and “Physics, Condensed Matter” being predominant. When classified by the hierarchical ERA scheme of the Australian Bureau of Statistics the division of specialized and general physics journals becomes visible (compare Fig. 1). While the component on the right-hand side contains only journals assigned to top-level divisions of the classification, the cluster on the left contains only journals allocated to groups of lower hierarchy (Haustein, in press).

The bibliographic data of these 168,109 documents were downloaded from Web of Science to generate a database, which allowed to match the bookmarks on article level. The range of number of publications per journal within the 5-year

[1] http://www.delicious.com.
[2] http://readermeter.org.
[3] http://mendeley.com.
[4] Mendeley is not considered, because it did not have a bookmarking function when this study was initiated.

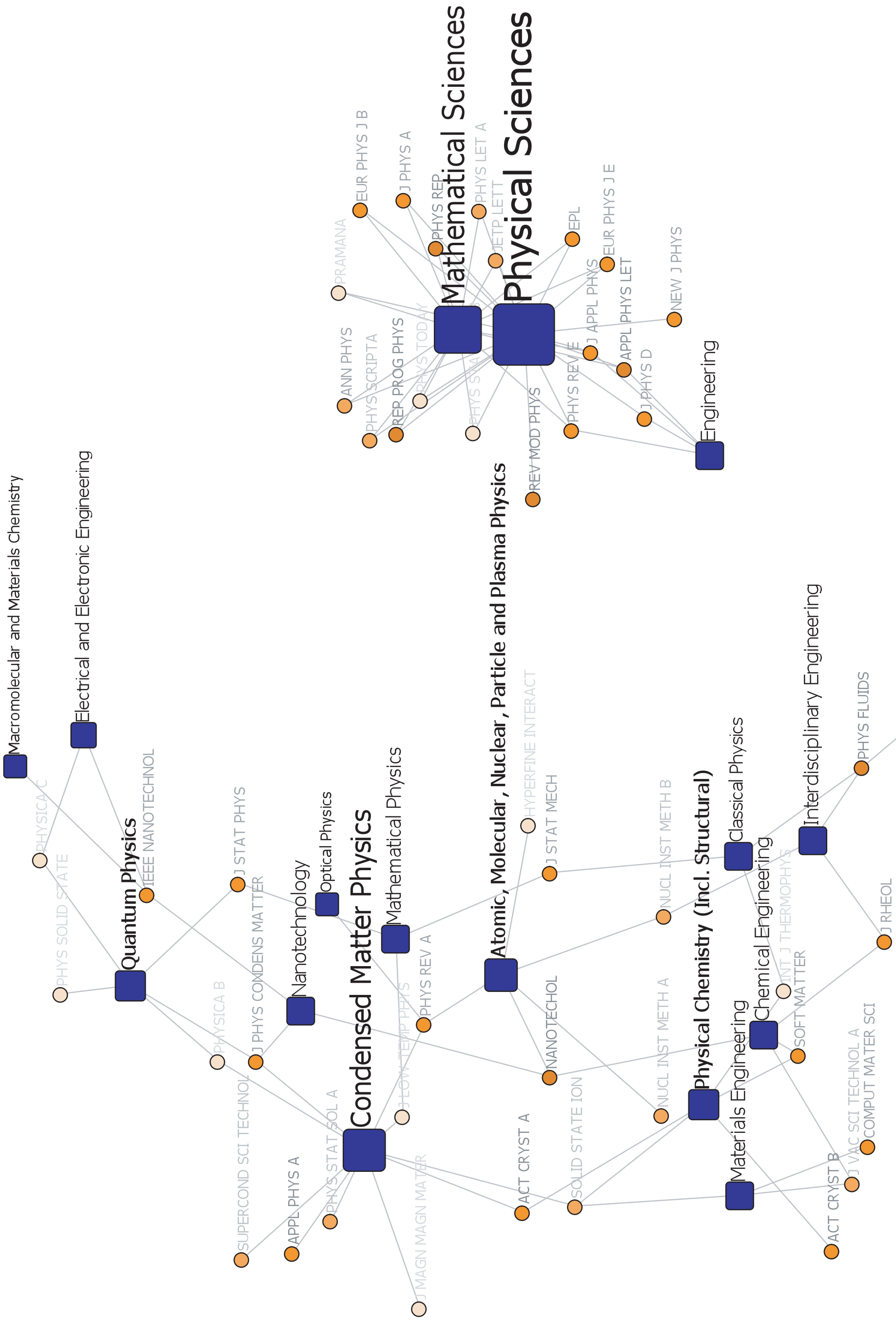

Fig. 1. Map of 45 journals and affiliated ERA-Fields of Research.

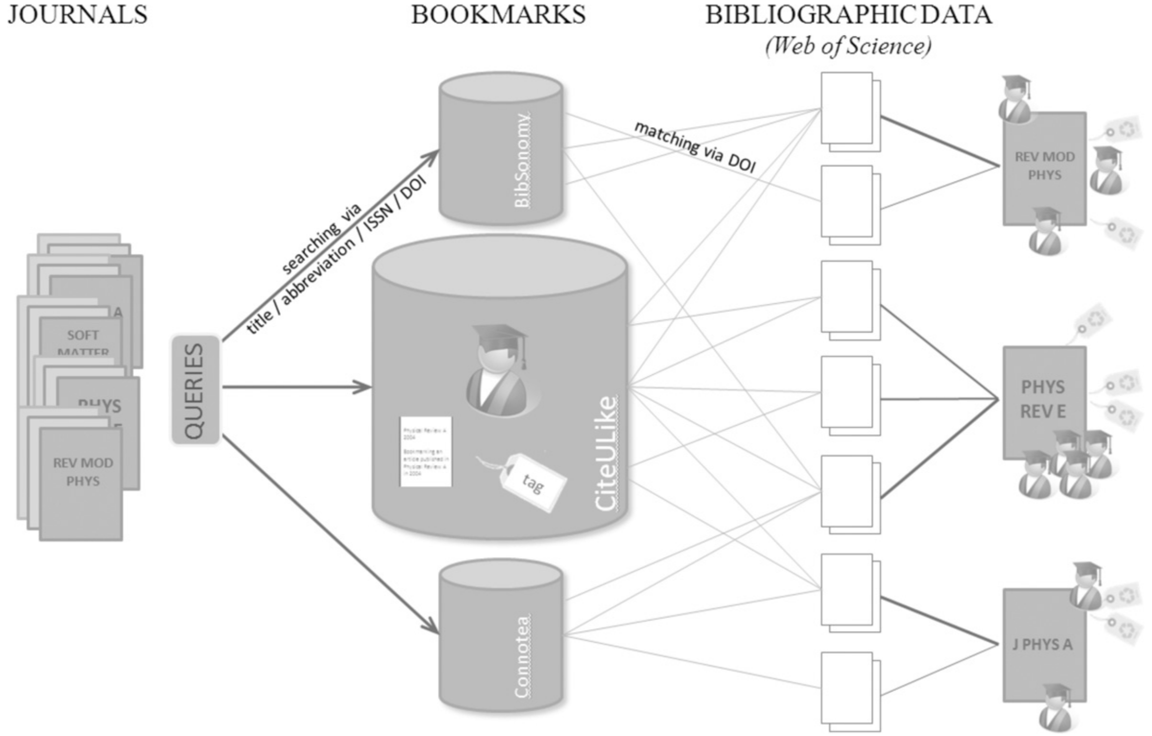

Fig. 2. Schematic representation of data acquisition.

period from 173 (Reviews of Modern Physics) to 25,983 documents (Applied Physics Letters) accentuate the need for usage calculations on article level, which is not possible with COUNTER Journal Report 1a. The matching was done via DOI, since this identifier was available in the bibliographic and the bookmarking data (see Fig. 2 for the schematic representation of data acquisition).

2.2. Retrieval of bookmarking data

To make up for the errors and incompleteness of the metadata of the bookmarking entries, four different search strategies were applied to find all bookmarks matching the publications: searching the titles of the periodicals plus their common abbreviations, ISSNs and DOIs of the 168,109 documents. The journal information was obtained from Zeitschriftendatenbank, and Ulrich's Periodicals Directory. For 95.0% of the documents, the DOI was available from the Web of Science-data. When errors were discovered in the Web of Science-data, which seemed to be caused by optical character recognition, all of the DOIs were rechecked via http://dx.doi.org. If the character string from the Web of Science-download was recognized as a correct DOI, it was assumed to be the DOI of the particular article. If the DOI database did not approve the specific character string to be a DOI, it was marked as wrong and corrected subsequently. The checking revealed that 2273 identifiers from the Web of Science data were erroneous. Out of the 10,711 erroneous or missing DOIs, 8286 could be generated with CrossRef or added manually, so that 98.6% of the articles were searchable in the bookmarking services via their DOI.

Data acquisition had to be adapted to the different search and retrieval functionalities available at the platforms. In BibSonomy, bookmarks were retrieved in XML-format via API. Since the API did not provide the possibility to search for a specific field, the full-text was searched for the journal titles, abbreviations, ISSNs and DOIs. The initial results were subsequently checked for whether the query term was found in the correct field, e.g. the periodical's name found in the field for journal title instead of article title. This led to a set of 3537 posts, which was cleaned from incorrect results, e.g. wrong journals or publication years outside the 5-year period. Eventually, 940 bookmarks were retrieved in BibSonomy that linked to the set of articles under analysis. All of these could be matched to 802 unique articles from the Web of Science data (see Fig. 3). Out of the 45 periodicals, articles from 39 were bookmarked at least once in BibSonomy.

As mentioned above, the metadata of all of the three social bookmarking services was incomplete and a lot of of entries suffered from discrepancies in spellings. In BibSonomy, 65.1% of the bookmarks were found by one of the search strategies only, meaning that only one of the particular metadata fields were correct. The most successful strategy was the search for the abbreviations of the journal title (compare Fig. 4). Only 0.7% of the 940 posts contained all the required information, i.e. title, abbreviation and ISSNs of the periodical and DOI of the particular article. 41.5% of the bookmarks in BibSonomy contained a DOI but for the remaining 550 they had to be generated via CrossRef or retrieved manually.

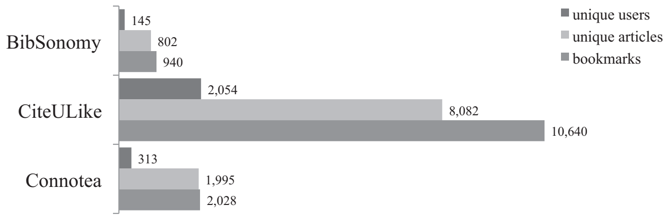

Fig. 3. Number of users, articles and bookmarks retrieved per social bookmarking platform for the 45 journals.

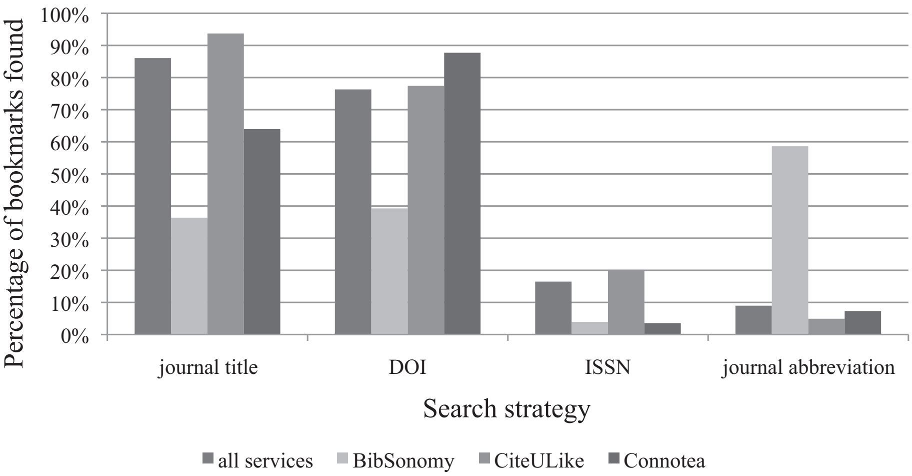

Fig. 4. Percentage of bookmarks found by different search strategies in BibSonomy, CiteULike and Connotea.

CiteULike is the only service where a field search for journal title, ISSN and DOI was possible and the results could be limited to certain publication years. However, CiteULike does not offer an API, so that results were retrieved via web search, parsed and downloaded in RIS-format. Overall, 10,778 posts corresponded to publications during the 5-year period under analysis. Searching for journal title retrieved 93.7% of all bookmarks (compare Fig. 4). For 2404 posts the DOI was missing and retrieved either automatically by CrossRef or manual search. 10,640 bookmarks could be matched to 8082 unique articles of the Web of Science data (Fig. 3). All of the 45 journals had at least one user in CiteULike.

Connotea does offer an API but it only allows searching for a specific tag, user or date. Although it is possible to apply a free text search, phrase searches are not supported. For example, a search for the journal “Soft Matter” would retrieve all items including “soft” and “matter” but the results can neither be limited to the exact phrase nor ranked by occurrence of the phrase. Hence, it was not possible to retrieve all bookmarks for a specific article or even journal via API. The only way to retrieve all bookmarks to the set of documents was to download all Connotea-entries via date search and save them temporarily in a field structure, which allowed filtering for journal title, DOI and ISSN. 2042 bookmarks in Connotea matched the queries. 88.1% of the Connotea posts already contained a DOI, the remaining 242 had to be added additionally. 2028 (99.3%) Connotea entries could be matched to the Web of Science dataset via their DOI. 1995 unique articles from 43 of the journals were bookmarked in Connotea (Fig. 3). 61.4% were found by more than one search strategy with DOI and title being the most successful.

Analyzing the bookmarking services in detail, one discovers a lot of entries including spam, mainly in form of advertisements for watches or pharmaceuticals. A filtering system should be applied in order to prevent such spam from being added to the database of bookmarks.

2.3. Merging data from different sources

Since all of the bookmarking tools offer the same service, i.e. storing, managing and sharing literature, it can be assumed that in general researchers choose one service to store and share their literature and do not bookmark the same articles in different services parallely. This assumption was confirmed by a check for doubles among the user names of the three services: only one user name was listed in all three tools and 70 user names appeared in two. Hence, the overlap was 2.8%. A double of user names was defined as an identical charaacter string. Due to the fact that user names can be freely chosen, it cannot be guaranteed that each character string represents a distinct person (Kipp, 2006).

In BibSonomy our set of articles was bookmarked by 145 unique users and by 2054 and 313 users in CiteULike and Connotea, respectively. Although BibSonomy, CiteULike and Connotea currently have a comparable amount of users as

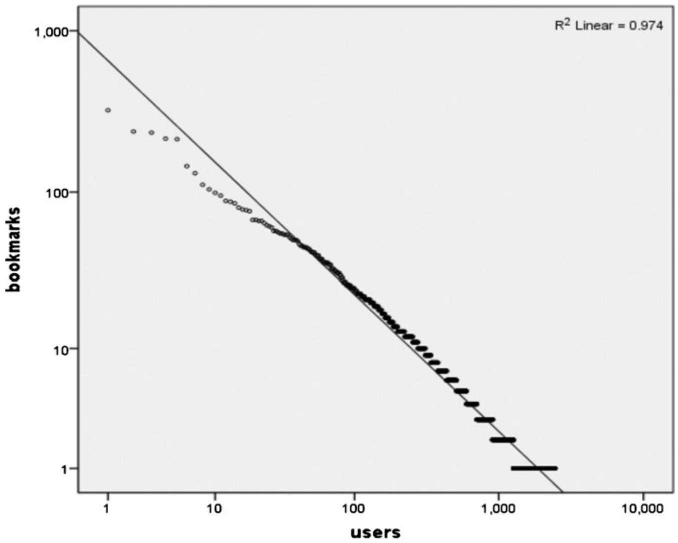

Fig. 5. Log–log distribution of number of bookmarks per user in BibSonomy, CiteULike and Connotea.

measured by traffic statistics (Reher & Haustein, 2010), CiteULike is by far the most important service for the 45 journals from solid state research (compare Fig. 3). This confirms results by Reher (2010), who found that out of the three services, CiteULike covered the most publications in physics, chemistry, biology and medicine. It was only outdone in computer and information science by BibSonomy.

Since for the evaluation of journal usage the source platform of the bookmarks is irrelevant, the result sets of BibSonomy, CiteULike and Connotea were combined. The final dataset contained a total of 13,608 bookmarks from 2441 unique users, which matched 10,280 articles from Web of Science-dataset.

The distributions of the bookmarking activity per user (see Fig. 5) and the number of bookmarks per article both conform to power-law. 75% of the content was created by 21% of the users. The most active user stored 322 articles from the set of journals. Since bookmarking in STM is still in its infancy a certain bias towards a Web 2.0-savvy readership is conjecturable. However, local statistics are influenced by institution specific biases as well. The publication with the highest number of users from the analyzed set of physics articles was bookmarked 67 times. On the opposite, there were 1179 users that bookmarked one publication and 8511 articles that were bookmarked only once.

3. Results

The combined set of bookmarks from BibSonomy, Connotea and CiteULike provides the basis for the calculation of four alternative indicators of global journal usage, which are described in the following: Usage Ratio, Usage Diffusion, Article Usage Intensity and Journal Usage Intensity. It should be noted, that these indicators represent a basic way to represent journal usage and function primarily as tools to explore the potential of bookmarking data. The Usage Impact Factor introduced by Bollen and Van de Sompel (2006) and built in analogy to the citation-based original, could not be computed due to inconsistencies of date and time the bookmark was set, which is required to calculate all bookmarks in year y to articles published in the two preceding years. The same applies to Usage or Download Immediacy Index (Rowlands & Nicholas, 2007; Wan, Hua, Rousseau, & Sun, 2010) and Usage Half-Life (Rowlands & Nicholas, 2007; Schlögl & Gorraiz, 2010). The application of more complex algorithms based on iterative calculation methods of Pinski and Narin's influence weight (Pinski & Narin, 1976) like Eigenfactor™ and Article Influence™ (West, Bergstrom, & Bergstrom, 2010b) or SCImago Journal Rank (Gonzalez-Pereira, Guerrero-Bote, & Moya-Anegon, 2010) would also be possible, when allocating weight to the bookmarks, for example through the importance of the bookmarking user. The application of network measures would also be possible (Bollen et al., 2008; Leydesdorff & Rafols, 2011). However, due to the rather small database of this exploratory study the validity of the results of these indicators is limited. As soon as a critical mass of users bookmark their literature online, a large number of measures based on citations and downloads should be applicable to bookmarking data as well. Furthermore the authors explore tags assigned to the publications to discover a user-specific view on journal level.

3.1. Usage indicators

With 2214 papers, Applied Physics Letters was the journal with the highest absolute number of bookmarked articles, followed by Physical Review E (1822 articles) and Physical Review A (1259 articles, Table 1). Since the number of bookmarks depends on the total number of articles published in the journal, normalization is needed. Usage Ratio gives the percentage

Table 1
Usage indicators for the 45 journals based on social bookmarking data.

Journal	P_j	B_j	P_b	UR_j	UD_j	UI_p	UI_j
Act Cryst A	326	39	29	0.089	21	1.34	1.86
Act Cryst B	493	10	9	0.018	8	1.11	1.25
Ann Phys	296	21	18	0.061	17	1.17	1.24
Appl Phys A	2685	94	88	0.033	75	1.07	1.25
Appl Phys Let	25,983	2587	2214	0.085	581	1.17	4.45
Comput Mater Sci	1299	50	46	0.035	32	1.09	1.56
EPL	3291	414	316	0.096	223	1.31	1.86
Eur Phys J B	2056	229	140	0.068	155	1.64	1.48
Eur Phys J E	707	104	79	0.112	56	1.32	1.86
Hyperfine Interact	1006	9	9	0.009	6	1.00	1.50
IEEE Nanotechnol	519	28	19	0.037	15	1.47	1.87
Int J Thermophys	757	15	14	0.018	8	1.07	1.88
J Appl Phys	17,827	1002	909	0.051	327	1.10	3.06
J Low Temp Phys	1260	38	36	0.029	20	1.06	1.90
J Magn Magn Mater	7549	128	111	0.015	73	1.15	1.75
J Phys A	5244	299	225	0.043	186	1.33	1.61
J Phys Condens Matter	7427	558	438	0.059	244	1.27	2.29
J Phys D	4554	199	177	0.039	125	1.12	1.59
J Rheol	347	5	4	0.012	3	1.25	1.67
J Stat Mech	958	222	134	0.140	136	1.66	1.63
J Stat Phys	1049	79	67	0.064	52	1.18	1.52
J Vac Sci Technol A	1580	28	27	0.017	17	1.04	1.65
JETP Lett	1487	31	28	0.019	21	1.11	1.48
Nanotechnol	4852	311	276	0.057	177	1.13	1.76
New J Phys	1926	436	307	0.159	239	1.42	1.82
Nucl Instrum Meth A	7670	235	215	0.028	91	1.09	2.58
Nucl Instrum Meth B	5973	129	122	0.020	52	1.06	2.48
Phys Fluids	2702	259	220	0.081	101	1.18	2.56
Phys Lett A	5328	159	137	0.026	99	1.16	1.61
Phys Rep	341	221	76	0.223	164	2.91	1.35
Phys Rev A	11,027	1575	1259	0.114	278	1.25	5.67
Phys Rev E	12,117	2916	1822	0.150	820	1.60	3.56
Phys Scr	2543	57	54	0.021	38	1.06	1.50
Phys Solid State	1970	6	6	0.003	6	1.00	1.00
Phys Stat Sol A	2721	73	66	0.024	50	1.11	1.46
Phys Stat Sol B	2691	81	76	0.028	56	1.07	1.45
Phys Today	1780	43	35	0.020	36	1.23	1.19
Physica B	5561	65	64	0.012	40	1.02	1.63
Physica C	3947	65	55	0.014	29	1.18	2.24
Pramana	1258	14	14	0.011	13	1.00	1.08
Rep Prog Phys	220	184	89	0.405	134	2.07	1.37
Rev Mod Phys	173	424	109	0.630	240	3.89	1.77
Soft Matter	654	109	93	0.142	51	1.17	2.14
Solid State Ion	2270	12	12	0.005	9	1.00	1.33
Supercond Sci Technol	1685	45	36	0.021	31	1.25	1.45
All journals	168,109	13,608	10,280	0.035	2441	1.17	1.63

of bookmarked articles towards the total number of articles published between 2004 and 2008 in the particular journal. The indicator analyzes the share of articles with users, i.e. the publications that have been read compared to those that were not. This normalization is not possible with COUNTER Journal Report 1a, which does neither indicate how many articles were downloaded nor lists the span of years when used articles were published. The Usage Ratio of a journal is defined as the number of bookmarked articles divided by the total number of articles published in the same journal during a certain period of time:

$$UR_j = \frac{P_b}{P_j} \tag{1}$$

where P_b represents the number of unique articles bookmarked and P_j stands for the number of articles published in journal j.

As can be seen in Fig. 6 for the journals under analysis the Usage Ratio is highly skewed. It ranges from 0.003 for Physics of the Solid State to 0.630 for Reviews of Modern Physics. With 173 articles published within the timespan under analysis, the latter has published the smallest number of documents of the 45 journals. However, 109 of these were bookmarked. The median Usage Ratio for the whole journal set is 0.074.

Usage Diffusion depicts the absolute number of unique readers and thus the diffusion of journal content into the scientific community.

$$UD_j = R_j \tag{2}$$

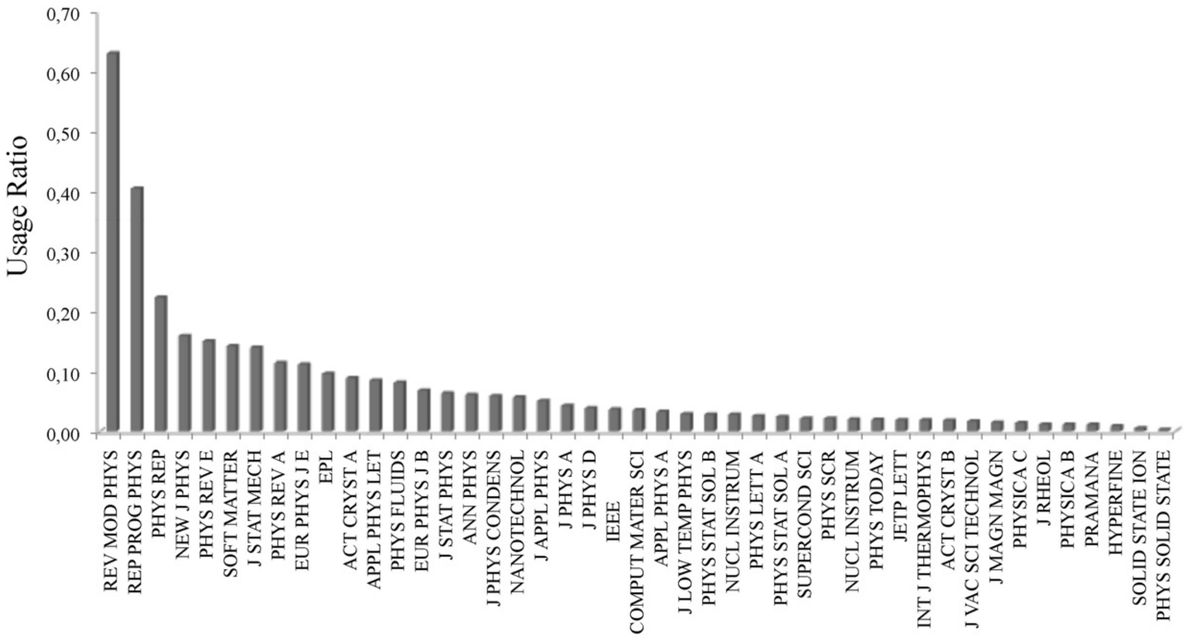

Fig. 6. Usage Ratio for 45 journals.

where R_j is the number of unique readers of journal j. Usage Diffusion indicates whether the periodical is perceived by a broad audience or a narrow readership. It should be kept in mind, that in general journals covering more general topics within the field can reach a larger amount of readers than a periodical focusing on a specific area of research and thus targets a small number of specialists. For the analyzed journals the mean number of users per periodical was 114.6. The median Usage Diffusion is 52. The number of different users ranges from only 3 for Journal of Rheology to 820 for Physical Review E.

Usage Ratio and Usage Diffusion give information about the share of the articles used and the number of unique readers, but they do not analyze the intensity with which the contents of a journal are used. Article Usage Intensity does so by computing the distribution of readers per article. The mean number of posts, i.e. the number of unique users per bookmarked article are given.

$$UI_p = \frac{B_j}{P_b} \tag{3}$$

where B_j represents the total number of bookmarks to articles published in journal j and P_b is the number of unique articles bookmarked. The mean Article Usage Intensity for the journals under analysis was 1.32 and the median was 1.17, so on average there is only one user per article. This is due to a highly skewed distribution of readers and articles. As stated above, 82.79% of all 10,280 articles were only bookmarked once. The article that was bookmarked most within the publications analyzed had 67 unique readers and was published in Physics Reports. With a citation score of 1049 in Web of Science it was also among the most frequently cited articles within the whole dataset. This would confirm assumptions of usage data being an early indicator of citation impact (Brody, Harnad, & Carr, 2006). However, hardly any correlation (Pearson's $r = 0.215$) could be found between the citation and bookmarking distribution on article level. This would support the assumed difference of publishing and pure readers. With an Article Usage Intensity of 3.89 Reviews of Modern Physics was the periodical with the most intensively read publications.

Journal Usage Intensity identifies the mean number of articles per unique user for each journal and thus measures how intensively the average user reads publications from a specific journal.

$$UI_j = \frac{B_j}{R_j} \tag{4}$$

where B_j is the number of bookmarks to articles published in journal j and R_j represents the total number of unique readers of the particular journal. Journal Usage Intensity reflects the loyalty of the readers towards the periodical. In the set of 45 journals, the median number of articles a reader bookmarked per journal is 1.63. Physical Review A was the periodical that was used most intensively by its readers: 278 unique users bookmarked Physical Review A 4.53 times on average.

3.2. Comparison with citation indicators

Table 2 shows Pearson and Spearman correlations for the four bookmark based and eight citation indicators and the number of publications P_j, bookmarks B_j and bookmarked publications P_b per journal. The citation indicators include simple

Table 2
Pearson correlation r (lower half) and Spearman rank order ρ (upper half) of number of publications (P_j), bookmarked publications (P_b), bookmarks (B_j), Usage Ratio (UR_j), Usage Diffusion (UD_j), Article Usage Intensity (UI_p), Journal Usage Intensity (UI_j), Impact Factor (IF), Immediacy Index (II), h-index (h), SCImago Journal Rank (SJR), Eigenfactor™ (EF), Article Influence™ (AI), share of highly cited papers(C^{rel}_{max}) and Cited Half-Life ($T^{cited}_{1/2}$) computed for 45 solid state physics journals.

	P_j	P_b	B_j	UR_j	UD_j	UI_p	UI_j	IF	II	h	SJR	EF	AI	C^{rel}_{max}	$T^{cited}_{1/2}$
P_j		.643**	.547**	−.116	.509**	−.226	.423**	−.185	−.135	.452**	−.150	.627**	−.266	−.149	−.340*
P_b	.876**		.981**	.650**	.959**	.420**	.581**	.371*	.414**	.804**	.202	.886**	.380*	.408**	−.506**
B_j	.803**	.983**		.722**	.987**	.513**	.555**	.446**	.494**	.842**	.240	.893**	.463**	.479**	−.452**
UR_j	−.092	.114	.198		.737**	.764**	.349*	.690**	.621**	.580**	.440**	.545**	.768**	.684**	−.270
UD_j	.723**	.906**	.949**	.333*		.533**	.444**	.482**	.520**	.856**	.258	.888**	.501**	.502**	−.422**
UI_p	−.162	.015	.113	.899**	.267		.218	.693**	.800**	.469**	.395**	.375*	.770**	.653**	−.199
UI_j	.753**	.833**	.794**	.087	.654**	−.030		.136	.154	.374*	.164	.508**	.186	.250	−.280
IF	−.166	−.058	−.011	.571**	.046	.591**	−.025		.814**	.614**	.747**	.500**	.925**	.870**	−.172
II	−.136	−.032	.045	.866**	.163	.894**	−.033	.560**		.596**	.596**	.428**	.801**	.757**	−.239
h	.695**	.730**	.722**	.499**	.776**	.462**	.591**	.201	.396**		.506**	.887**	.545**	.713**	−.394**
SJR	−.161	−.061	−.005	.708**	.058	.650**	−.019	.900**	.768**	.218		.364*	.683**	.815**	−.194
EF	.927**	.922**	.855**	.113	.782**	.030	.743**	.015	.028	.796**	.013		.452**	.533**	−.343*
AI	−.172	−.047	.030	.893**	.146	.914**	−.050	.754**	.958**	.392**	.868**	.024		.844**	−.094
C^{rel}_{max}	−.064	.096	.158	.906**	.273	.897**	.050	.562**	.809**	.596**	.612**	.158	.859**		−.235
$T^{cited}_{1/2}$	−.171	−.178	−.162	.020	−.239	.086	−.136	.227	.154	−.223	.199	−.169	.212	.062	

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

citation–publication ratios like Impact Factor and Immediacy Index, a time-based measure like Cited Half-Life, the journal h-index and PageRank-like weighted measures based on Pinski and Narin's (1976) influence weight as Eigenfactor™, Article Influence™ and SCImago Journal Rank (Braun, Glanzel, & Schubert, 2006; Garfield, 1972; Gonzalez-Pereira et al., 2010; Pinski & Narin, 1976; West et al., 2010b). The lower half of the matrix displays Pearson's correlation coefficient r and the upper half lists the results of Spearman's rank order correlation ν for each of the indicator pairs on the basis of the 45 journals under analysis. Pearson's r calculates the differences between two sets of values, while Spearman analyzes changes in rank order. In general high values of ν are found between P_j, P_b and B_j, which is to be expected, since the number of bookmarked articles depends on the number of documents published in a journal. There is also a high positive correlation between the number of users and number of bookmarked articles and total bookmarks (r = 0.906 and r = 0.949). The Impact Factor as the most commonly used measure of journal impact shows only a correlation of r = 0.571 to Usage Ratio and no correlation with the number of readers UD_j. Hence, at least for the data under analysis, users of social bookmarking services seem not to be influenced by the Impact Factor. Pearson values for h-index, Eigenfactor™, number of publications, bookmarks and users show positive correlations, which can be explained by dependence on size of these indicators (West, Bergstrom, & Bergstrom, 2010a). On the contrary, Immediacy Index, Impact Factor, SCImago Journal Rank, Article Influence™ and Usage Ratio are normalized by number of publications and thus size-independent measures. They show positive correlations among each other as well. Usage Ratio and Usage Intensity (Article) show a high value of r = 0.899. This might show a social effect of the bookmarking platforms: the higher the share of bookmarked publications per journal, the more people bookmark these articles. No correlation can be found between UI_j and UR_j.

For some values Pearson and Spearman values differ significantly. If ρ is higher than r, difference in indicator results did not have a large effect on the ranking produced on the basis of these indicators. Vice versa, small differences of measured values effect the rank orders, if ρ is significantly larger than r. The latter can be observed for URj and UDj with ρ = 0.737 and r = 0.333.

3.3. Tags

Like other Web 2.0 platforms social bookmarking services enable their users to annotate electronic documents with freely chosen keywords. These so-called tags can be chosen on the fly without adhering to indexing rules. Tags can help both, the user that picked them to organize his documents and other users to find new content (Mathes, 2004; Peters, 2009; Strohmaier, Körner, & Kern, 2010). With social tagging a new dimension of indexing evolves, which represents the users', i.e. readers' point of view on content. Another study by Haustein, Peters, and Terliesner (in press), which compared the tags of a subset of the 10,280 physics articles to indexer-generated subject headings from Inspec, author keywords, automatically generated KeyWords Plus™, title and abstract terms, could prove that tags differed significantly from these traditional indexing methods. Lin, Beaudoin, Bul, and Desai (2006) suspect that the difference of tags and professional metadata is due to their different goals. Tagging users seem to have other demands than professional indexers. While the latter aim to cover all topics of a document with controlled vocabularies, users seem to focus on specific topics that they are interested in. Hence, tags provide a basis for user-specific content description of scientific journals (Haustein et al., in press). We propose that journal evaluation can profit from the application of user-generated tags for content analysis to add another layer of perception to author and indexer perspectives. Due to the dynamic nature of social bookmarking and tagging, these

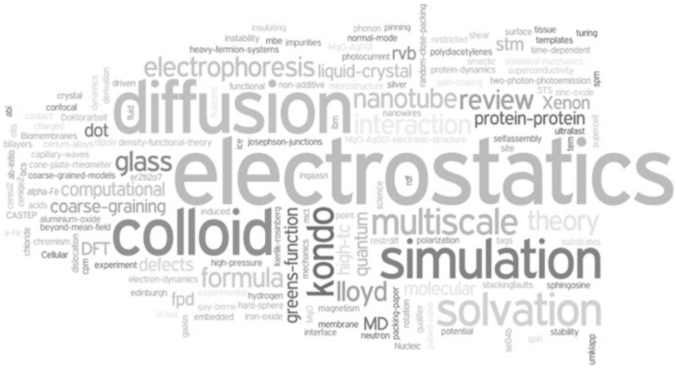

Fig. 7. Tag cloud generated with Wordle™ for articles published in Journal of Physics – Condensed Matter in 2004.

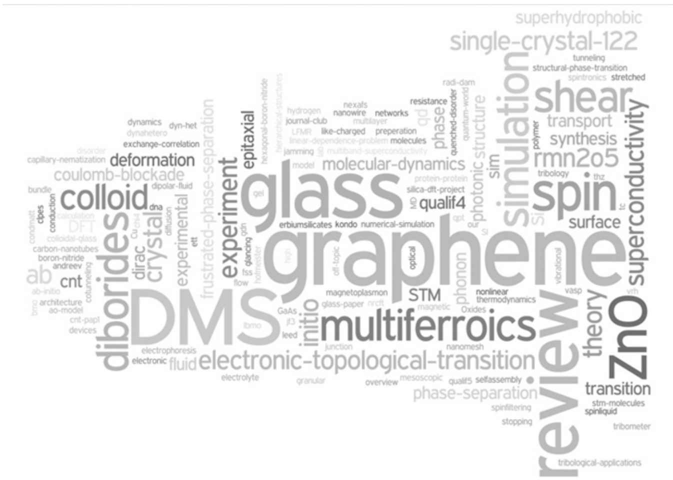

Fig. 8. Tag cloud generated with Wordle™ for articles published in Journal of Physics – Condensed Matter in 2008.

descriptions evolve in realtime. They offer direct channels to the readers' opinions and additionally depict trends in the language of a specific discipline (Haustein et al., in press).

To 88.4% of the 13,608 bookmarks, tags were assigned by the users to describe the topics of the articles. Due to their uncontrolled nature and the information included in frequencies differences in spellings were adjusted. After merging singular and plural forms, unifying special characters and deleting content-unrelated tags (i.e. "imported" and "jabref:noKeywordAssigned") a total of 8208 different tags, appearing 38,241 times, could be identified. Tag frequency conforms to a power-law distribution: the most frequent tag ("network") was assigned 687 times, the second most ("quantum") 344 times and 4494 unique tags were posted once.

Through the linkage of bookmarking entries to publications via DOI the tags were aggregated on journal level. Thus, the thematic scope as perceived by the readership can be depicted in the form of tag clouds. Since bookmarks and thus tags are linked to the article, tags can be analyzed separately by publication year. Thematic trends and hot topics can be discovered at a glance. Figs. 7 and 8 show tag clouds generated with Wordle™[5] for the bookmarks to 2004 and 2008 publications from Journal of Physics – Condensed Matter, respectively. While in 2004 the most frequently assigned tag was "electrostatics", "graphene" became important in 2008. This reflects the growing importance of "graphene", which culminated in the Nobel Prize in Physics, which was awarded to Andre Geim and Konstantin Novoselov in 2010 "for groundbreaking experiments regarding the two-dimensional material graphene" (Nob, 2010).

4. Conclusion

It has been shown that bookmarks of journal articles can be analyzed to measure journal usage independently from publishers. Three major bookmarking sources have been analyzed to explore the potential of this new data source. Data can

[5] http://www.wordle.net.

be extracted about how often journal articles are used on a global scale. Tags assigned by users can give a new perspective on journal content and visualize trends of journal perception from the readers' point of view.

Social bookmarking in academics is however still in its infancy. Inconsistent and incomplete entries made retrieval cumbersome and a matching to other bibliographic data necessary. Metadata quality is crucial for the services to successfully keep old and gain new customers. So it was surprising to discover, that the entries were of bad quality, although the lacking information could easily be completed by free services such as CrossRef or http://dx.doi.org. Currently the three platforms are competing for a critical mass of users. For the set of journals under analysis, 78% of bookmarks and 84% of users appeared in CiteULike. Similar results were found for medical, biological and chemical journals (Reher, 2010). CiteULike also had the largest retrieval functionality (Reher & Haustein, 2010) and most complete metadata: 93.7% of the physics articles were retrievable via journal title and 77.4% bookmarks contained a DOI. CiteULike recently made their bookmarking datasets freely available[6] for research, so global usage data and user tags can now be collected without much effort. Also, Mendeley has become a very popular tool and although it started out as a local reference management system it now has the same social functions of bookmarking and tagging. Within the past six month the number of articles has almost doubled from 44 to 80 million articles (Jack et al., 2010). As of March 2011, Mendeley reports almost 850,000 users.[7] Their data[8] has recently been made available and since bibliographic entries are cross-checked[9] against external sources, Mendeley looks like a suitable and applicable source for future usage-based journal evaluations.

Compared to local download statistics provided by publishers, bookmarking data can be computed in greater detail and for a global community of readers. Furthermore additional information can be gained. Indicators based on these detailed data can provide information on the number of unique readers, the share of publications read and the intensity with which journals are used. Tags can depict content from the readers' point of view.

Acknowledgements

The authors would like to thank three anonymous reviewers for their detailed comments and valuable suggestions which helped to improve the paper.

References

Baker, G., & Read, E. J. (2008). Vendor supplied usage data for electronic resources: A survey of academic libraries. *Learned Publishing*, *21*, 48–57.
Bollen, J., & Van de Sompel, H. (2006). Usage Impact Factor: The effects of sample characteristics on usage-based impact metrics. *Journal of the American Society for Information Science and Technology*, *59*, 136–149.
Bollen, J., Van de Sompel, H., & Rodriguez, M. A. (2008). Towards usage-based impact metrics: First results from the MESUR project. In *Proceedings of the Joint Conference on Digital Libraries 2008 (JCDL08)* Pittsburgh, Pennsylvania, USA,
Bollen, J., Van de Sompel, H., Smith, J. A., & Luce, R. (2005). Toward alternative metrics of journal impact: A comparison of download and citation data. *Information Processing & Management*, *41*, 1419–1440.
Braun, T., Glanzel, W., & Schubert, A. (2006). A Hirsch-type index for journals. *Scientometrics*, *69*, 169–173.
Brody, T., Harnad, S., & Carr, L. (2006). Earlier web usage statistics as predictors of later citation impact. *Journal of the American Society for Information Science and Technology*, *57*, 1060–1072.
COUNTER, P. (2008). *The COUNTER code of practice. Journals and databases release 3*. Technical Report COUNTER.
Darmoni, S. J., Roussel, F., & Benichou, J. (2002). Reading Factor: A new bibliometric criterion for managing digital libraries. *Journal of the Medical Library Association*, *90*, 323–327.
Duy, J., & Vaughan, L. (2006). Can electronic journal usage data replace citation data as a measure of journal use? An empirical examination. *Journal of Academic Librarianship*, *32*, 512–517.
Garfield, E. (1972). Citation analysis as a tool in journal evaluation. Journals can be ranked by frequency and impact of citations for science policy studies. *Science*, *178*, 471–479.
Gonzalez-Pereira, B., Guerrero-Bote, V. P., & Moya-Anegon, F. (2010). A new approach to the metric of journals' scientific prestige: The SJR indicator. *Journal of Informetrics*, *4*, 379–391.
Gorraiz, J., & Gumpenberger, C. (2010). Going beyond citations: SERUM – A new tool provided by a network of libraries. *Liber Quarterly*, *20*, 80–93.
Hammond, T., Hannay, T., Lund, B., & Scott, J. (2005). Social bookmarking tools (I). *D-Lib Magazine*, *11*.
Haustein, S. (2010). Multidimensional journal evaluation. In *Proceedings of the 11th International Conference on Science and Technology Indicators* (pp. 120–122).
Haustein, S. Taking a multidimensional approach towards journal evaluation. In: *Proceedings of the 13th International Conference of the International Society for Scientometrics and Informetrics*, in press.
Haustein, S., Golov, E., Luckanus, K., Reher, S., & Terliesner, J. (2010). Journal evaluation and science 2.0: Using social bookmarks to analyze reader perception. In *Proceedings of the 11th International Conference on Science and Technology Indicators* (pp. 117–119).
Haustein, S., Peters, I., & Terliesner, J. Evaluation of reader perception by using tags from social bookmarking systems. In: *Proceedings of the 13th International Conference of the International Society for Scientometrics and Informetrics*, in press.
Jack, K., Hammerton, J., Harvey, D., Hoyt, J. J., Reichelt, J., & Henning, V. (2010). Mendeley's reply to the DataTEL challenge. *Procedia Computer Science*, *1*, 1–3.
Kipp, M. E. I. (2006). Tagging practices on research oriented social bookmarking sites. *Canadian Journal of Information and Library Science*, *30*, 99.
Leydesdorff, L., & Rafols, I. (2011). Indicators of the interdisciplinarity of journals: Diversity, centrality, and citations. *Journal of Informetrics*, *5*, 87–100.
Lin, X., Beaudoin, J., Bul, Y., & Desai, K. (2006). Exploring characteristics of social classification. In *Proceedings of the 17th Annual ASIS&T SIG/CR Classification Research Workshop* Austin, TX.

[6] http://www.citeulike.org/faq/data.adp.
[7] http://www.mendeley.com.
[8] http://dev.mendeley.com/datachallenge/.
[9] http://www.mendeley.com/bibliography-maker-database-generator/.

Lorenz, M. (2010). Elektronische Nutzungsstatistiken – oder: Zu Fuß ist es kürzer als über den Berg. In B. Mittermaier (Ed.), *WissKom2010 "eLibrary – den Wandel gestalten" – 5. Konferenz der Zentralbibliothek im Forschungszentrum Jülich* (pp. 137–149). Jülich, Germany: Forschungszentrum Jülich, Zentralbibliothek.

Mathes, A. (2004). Folksonomies – Cooperative classification and communication through shared metadata. http://www.adammathes.com/academic/computer-mediated-communication/folksonomies.html.

Peters, I. (2009). *Folksonomies: Indexing and retrieval in web 2.0. Knowledge & information. Studies in information science*. Berlin: De Gruyter Saur.

Pinski, G., & Narin, F. (1976). Citation influence for journal aggregates of scientific publications – Theory, with application to literature of physics. *Information Processing & Management*, *12*, 297–312.

Priem, J., & Hemminger, B. (2010). Scientometrics 2.0: Toward new metrics of scholarly impact on the social Web. *First Monday*, *15*

Priem, J., Taraborelli, D., Groth, P., & Neylon, C. (2010). alt-metrics: A manifesto. http://altmetrics.org/manifesto/.

Reher, S. (2010). *Repräsentativität wissenschaftlicher Disziplinen bei CiteULike, Connotea und BibSonomy*. Master's thesis, Heinrich-Heine-University Düsseldorf.

Reher, S., & Haustein, S. (2010). Social bookmarking in STM: Putting services to the acid test. *ONLINE: Exploring Technology & Resources for Information Professionals*, *34*, 34–42.

Roick, C. (2006). Medical journals for authors and/or readers? Opinions of different reader groups about the Journal "Psychiatrische Praxis". *Psychiatrische Praxis*, *33*, 287–295.

Rowlands, I., & Nicholas, D. (2007). The missing link: Journal usage metrics. *Aslib Proceedings*, *59*, 222–228.

Scanlan, B. D. (1987). Coverage by Current-Contents and the validity of Impact Factors – ISI from a journal publishers perspectives. *Serials Librarian*, *13*, 57–66.

Schlögl, C., & Gorraiz, J. (2010). Comparison of citation and usage indicators: The case of oncology journals. *Scientometrics*, 567–580.

Schlögl, C., & Stock, W. G. (2004). Impact and relevance of LIS journals: A scientometric analysis of international and German-language LIS journals – Citation analysis versus reader survey. *Journal of the American Society for Information Science and Technology*, *55*, 1155–1168.

Shepherd, P. T. (2007). *Final report on the investigation into the feasibility of developing and implementing journal usage factors*. Technical Report. United Kingdom Serials Group.

Strohmaier, M., Körner, C., & Kern, R. (2010). Why do users tag? Detecting users' motivation for tagging in social tagging systems. In *Proceedings of the 4th International AAAI Conference on Weblogs and Social Media (ICWSM2010)* Washington, DC, USA,

The 2010 Nobel Prize in Physics – Press Release. (2010). http://nobelprize.org/nobel_prizes/physics/laureates/2010/press.html.

Wan, J. K., Hua, P. H., Rousseau, R., & Sun, X. K. (2010). The journal download immediacy index (DII): Experiences using a Chinese full-text database. *Scientometrics*, *82*, 555–566.

West, J. D., Bergstrom, T. C., & Bergstrom, C. T. (2010a). Big Macs and Eigenfactor scores: Don't let correlation coefficients fool you. *Journal of the American Society for Information Science and Technology*, *61*, 1800–1807.

West, J. D., Bergstrom, T. C., & Bergstrom, C. T. (2010b). The Eigenfactor Metrics™: A network approach to assessing scholarly journals. *College & Research Libraries*, *71*, 236–244.