Definition and Evaluation Methods of Low-Cited Papers in Scientific Journals: A Case Study of 65 Condensed Matter Physics Journals in Journal Citation Reports

Authors: Wang Xin, Wang Xin

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Abstract

【Objective】To analyze the distribution characteristics of citations in basic discipline journals and explore the definition and evaluation methods for intervals of low-citation papers.

【Method】Using SCI Expanded as the data source and 65 condensed matter physics journals (CMJ) as the research sample, we employed statistical principles and bibliometric methods to comparatively analyze citation characteristics across distinct regions: papers with citation frequencies greater than the h-index, less than the average citations per paper (Cipp), and where the cumulative citations of the lowest-cited papers constitute 5%, 10%, and 20% of the journal' s total citations (T). This approach determined the most reasonable low-citation region for CMJ.

【Results】First, the overall zero-citation rate (rN0) for CMJ is only 10%, indicating a high-quality journal collection. Second, both the region where cumulative citations of a journal' s lowest-cited papers reach 20% of T (Tci20%) and the region where single-paper citations fall below the journal average (Cicipp) (Tcicipp) are statistically justified as low-citation regions. Third, zero-citation rate (rN0), low-citation rate (RLC, rN x), and low-citation density (DLC, rTcix) exhibit weak correlations with traditional evaluation indicators—including impact factor (IF), h-index, Cipp, Np, and Tci—thereby satisfying the necessary conditions to serve as independent evaluation metrics.

【Conclusion】First, a composite indicator Evel {rN0, rN x%, rTcix%} comprising rN0, RLC, and DLC characterizes a journal' s low-citation features; another composite indicator Evel {h, Ci20%, Cicipp, Cih} comprising the h-index and average citations per paper in specific regions facilitates comparison of citation structure characteristics across journals. Second, our research demonstrates

that journal citation structures can be classified by configuration, with evaluation parameters potentially offering competitive advantages in different citation regions. Therefore, evaluating a journal' s low-citation performance must be grounded in citation structure analysis, and comprehensive journal evaluation should employ multi-parameter, multi-dimensional indicators.

Full Text

Introduction

Academic achievements in basic science are predominantly disseminated, exchanged, and inherited through journal articles, and their impact is primarily evaluated from a bibliometric perspective based on citation data analysis. Less-cited papers have historically constituted a highly prevalent phenomenon within scholarly outputs. However, the two core metrics of bibliometric analysis—the journal impact factor (IF) and the h-index—do not explicitly account for low-citation papers in a strict sense. The impact factor measures the average citation level of a journal's publications within a certain period, focusing on the mean impact of published articles, while the h-index combines the number and citation frequency of highly-cited papers in a journal, emphasizing the measurement of high-citation performance. Consequently, neglecting the bibliometric analysis of low-citation papers—a high-probability event—in academic evaluation clearly compromises the comprehensiveness and objectivity of the assessment.

The essential prerequisite for studying less-cited papers is to define them. Such papers can be divided into three categories: "absolutely uncited papers," "approximately zero-citation papers," and "less-cited papers." Absolutely uncited papers refer to those that receive no citations within a certain citation window after publication—the uncited phenomenon [1-4]. Approximately zero-citation papers are those with citation frequencies limited to 1-2 (very close to zero citations). The domains for these two categories are relatively easy to determine. To date, research on absolutely uncited papers has proliferated. Garfield first drew attention to this phenomenon in the 1950s-60s, B. Barber proposed the concept of "Resisted Discovery" [5], and in 2004, the renowned Dutch scientometrician A. Van Raan endowed this phenomenon with the elegant name "sleeping beauties in science"[6], after which academic interest in uncitedness and delayed recognition surged. Scholars have explored the causes of zero citations [8-9] and discovery patterns across various disciplines. Domestic researchers such as Wu Yishan et al. (2015) provided comprehensive reviews [10-11] and empirical analyses of the "zero-citation phenomenon," while Liu Xueli (2011) proposed "zero-citation rate" as a reverse evaluation indicator for journals [12] and examined its relationship with other bibliometric indicators such as impact factor and h-index. Nevertheless, few studies have investigated "approximately zero-cited" and "less-cited" papers in journal evaluation. Zhou Jie (2015) first conducted quantitative analysis of primary and secondary citations in scientific literature, proposing the use of these metrics as supplementary information to positive indicators in journal evaluation [13]. Yang Lijun (2015) published two consecutive articles [14-15], pioneering the conceptualization of low-citation definitions and empirically exploring evaluation methods using 18 domestic library and information science journals as case studies.

Less-cited papers can be described as those with citation frequencies below a certain threshold, yet no clear consensus exists in the academic community regarding this definition. Some scholars define the h-index core as the core region and consider everything outside as the low-citation region [16], while others, based on the Pareto principle (80/20 rule), arrange citation frequencies in descending order and define the region outside the top 20% as low-citation, or customize top percentages according to analytical needs. However, systematic research on the properties of less-cited papers within these demarcated regions remains virtually nonexistent. This study examines 65 CMJ journals, using the h-index core region as a reference, to analyze citation characteristics and related factors in several minimally-cited zones, aiming to explore reasonable approaches, methods, and evaluation indicators for defining low-citation regions, thereby providing empirical evidence for bibliometric analysis of less-cited papers and objective journal evaluation.

1.1 Research Subjects

Condensed matter physics, as a subdiscipline of physics, encompasses the largest research community and produces the greatest volume of scientific output within physics. Over the past decade, significant breakthroughs and advances have emerged in both fundamental theory and practical applications, with China taking a leading global position in unconventional superconducting materials, topological insulators, and related theoretical research. Therefore, selecting condensed matter physics journals (hereinafter referred to as CMJ) as research subjects is both representative and practically meaningful for understanding academic output and evaluation in physics. According to the subject classification list in the Journal Citation Reports (JCR) sub-database of Web of Science (WOS), 65 journals meet the research criteria. Data were sourced from the SCI Expanded sub-database of WOS, retrieving four document types—article, review, correction, and letter—published between 2009-2013, with data collection and cleaning performed using conventional methods [17]. Additionally, partition data and three-year impact factors (IF3) from the 2014 Journal Partition Report published by the Chinese Academy of Sciences Library (LAS) were referenced. The LAS report classifies SCI journals into four tiers based on IF3: the top 5% in each discipline are designated as Tier 1, the next 15% (6–20%) as Tier 2, the subsequent 30% (21–50%) as Tier 3, and the bottom 50% as Tier 4.

1.2 Research Methods

Using citation frequency and per-paper citation data from each journal's h-index core region as references, this study analyzes the distribution characteristics of zero-citation papers and papers in regions where cumulative citations constitute

5%, 10%, and 20% of total citations (T), aiming to determine a reasonable definition domain for less-cited papers in CMJ, analyze journal citation structures, and explore effective bibliometric methods and descriptions for low-citation regions. Variables involved in the research process are shown in Table 1 . Data analysis and plotting were primarily conducted using Excel' s data analysis tools and OriginPro 9.0.

Table 1 Variables and indicators used in this study

Variable/Indicator	Description	Data Source
m, CMJ partition	Number of journals, partition values for condensed matter physics journals	JCR, Intelligence Center
Np, N0	Number of citable papers, number of zero-citation papers	JCR, Intelligence Center
h-index	Number of papers in h-core and their minimum citation count (h=Nh=Cih)	J.E. Hirsch, 2005; WOS
Tci, Tcih	Total citations of journal, total citations in h-core	WOS
Rp, Rpp	Number of cited references, citations per paper (Rpp=Rp/Np)	WOS
Cipp, IF3	Citations per paper, 3-year impact factor (Cipp=Tci/Np)	WOS, Intelligence Center
Evel {h, Ci20%, Cicipp, Cih}	Composite citation structure indicator for journals	This study; WOS
rN0, rh	Zero-citation rate, high-citation rate (ratio of h-index to total papers, also called relative h-index)	L. Egghe (2008-06) [17], Rousseau R (2006-06) [18]; WOS

Variable/Indicator	Description	Data Source
Nx%, Ncipp	Number of citable papers in lowest-cited region accounting for x% of total citations; number of papers with Tci < Cipp	This study; WOS
RLC: rx% rcipp	Low-citation rate: rNx% = Nx%/Np, rNcipp = Ncipp/Np	This study; WOS
DLC: rTcix rTcicipp	Low-citation density: rTcix% = Tcix/Tci, rTcicipp = Tcicipp/Tci	This study; WOS
rTcih	High-citation density: rTcih = Tcih/Tci	This study; WOS
Evel(rN0, rNx%, rTcix%)	Composite low-citation indicator for journals	This study; WOS

2.1 Overall Metrics of Condensed Matter Physics Journals

Understanding the overall landscape of condensed matter journals is a necessary step for low-citation analysis. Table 2 presents statistical data for 65 CMJ journals as of December 2015 for the period 2009-2013. The dataset comprises over 133,000 published papers with 1.99 million total citations, 3.87 million cited references, an overall average of 15 citations per paper, 29 references per paper, 13,600 zero-citation papers, and an overall zero-citation rate of 10.2%. The distribution across four tiers is 3, 4, 13, and 45 journals respectively. Tier 1 journals include *Nature Materials*, *Advances in Physics*, and *Surface Science Reports*, with IF3 values of 36, 24, and 18 respectively, while the average IF3 for all 65 journals is 4. The correlation coefficients between Cipp and CMJ tier values and IF3 are 0.993 and -0.896 respectively, with significance tests confirming high consistency between the LAS partition report' s IF3 and CMJ tier classifications and SCI Expanded data, allowing for cross-referencing in this study.

Table 2 Main data for 65 journals

Metric	Value
Total papers (Nps)	133,057
Total citations (Tci)	1,991,279

Metric	Value
Total references (Rp)	3,872,866
Zero-citation papers (N0s)	13,569
Zero-citation rate (rN0)	10.2%
Citations per paper (Cipp)	15
References per paper (Rpp)	29

2.2.1 Distribution Characteristics of N0 and rN0

N0 offers the advantage of intuitively describing zero citations in journals. Figure 1 Figure 1: see original paper shows the probability distribution of N0, with 46 CMJ journals concentrated below 200 zero-citation papers, while the remaining 19 journals are scattered in regions exceeding 200, forming a clear positively skewed distribution. Figure 1(2) displays the mean and maximum N0 values across four tiers. Notably, except for two outliers in Tier 3 with N0 values exceeding the mean of 262—*Applied Surface Science* (mean 375) and *Physical Review B* (mean 1,159)—all other high zero-citation data are concentrated in Tier 4 (17 journals). Overall, zero-citation rates are negatively correlated with journal quality tiers, with Tier 4 showing substantially higher zero-citation levels than Tiers 1–3.

The rN0 metric is a relative measure that reflects the proportion of uncited papers in a journal, facilitating inter-journal comparisons. As shown in Table 3 , ranking by N0 ascending, *Critical Reviews in Solid State and Materials Sciences* (h-index=20, Np=47, N0=0) ranks first, while *Physical Review B* (h-index=141, Np=28,953, N0=1,109) ranks 65th. However, *Physical Review B* is widely recognized as a highly influential core journal in condensed matter physics, ranking 4th by h-index and 14th by rN0 (rN0=0.040), demonstrating that rN0 ranking is significantly more objective than N0 ranking.

Figure 1(3) illustrates the probability distribution of rN0, with over 25% of journals having rN0 < 0.05, another 25% between 0.05–0.10, and nearly 20% between 0.10–0.15, with the remainder representing a minority of journals with higher proportions of ineffective papers. The rN0 distribution is also non-normal. Figure 1(4) shows that average rN0 values in Tiers 1–3 range from 0.008–0.038 with only one outlier, while Tier 4' s average is 0.153. The overall trend of rN0 averages aligns with N0, where higher tier values correspond to higher proportions of ineffective papers, though Tier 2 shows the minimum value, highlighting rN0' s superior analytical utility over N0.

2.2.2 Analysis of rN0 by Document Type and Publication Year

Figure 2 Figure 2: see original paper presents the distribution of total N0 for 65 CMJ journals from publication year to the statistical cutoff of December 2015 (spanning 6, 5, 4, 3, and 2 years). Generally, N0 decreases with publication age, with the highest rN0 (14%) observed for 2013 publications. For papers published more than two years prior (2011), rN0 stabilizes at 8-9%, indicating that 90% of CMJ papers are discovered by the academic community within 2-3 years, while the remaining 10% may become "sleeping beauties." Figure 2(2) shows the relationship between rN0 and journal tiers across publication years. Although rN0 values vary substantially across tiers, their temporal trends and amplitudes are remarkably consistent. Tier 1 peaks in 2011 (6%), Tier 2 reaches a plateau of 1% two years post-publication (starting 2013), Tier 3 plateaus at 3-4% after three years, and Tier 4 stabilizes at 12-15% after three years (from 2012). This suggests that the discovery cycle for CMJ papers is largely independent of journal quality tiers.

Analysis of zero-citation paper types (Figure 3 [Figure 3: see original paper]) shows that articles constitute the primary component, accounting for the majority of zero-citation papers.

2.2.3 Relationship Between rN0 and Other Journal Evaluation Indicators

The above analysis demonstrates rN0's unique advantages as an evaluation metric. However, whether rN0 exhibits strong correlations with traditional journal evaluation indicators remains underexplored. Figure 4 [Figure 4: see original paper] analyzes correlations between rN0 and CMJ tiers, Np, Tci, IF3, Cipp, h-index, and Rpp. Results reveal weak correlations between rN0 and traditional core indicators reflecting journal impact (h-index, Cipp, IF3, CMJ tiers), with correlation coefficients ranging from 0.4-0.5, and virtually no correlation with Np and Rpp.

This finding indicates that rN0 offers a distinct evaluation perspective that cannot be simply linearly replaced by existing metrics. From a statistical standpoint, this weak correlation constitutes a sufficient condition for rN0 to serve as an independent journal evaluation indicator. If h-index represents journal quality, Np represents scale, Tci represents audience reach, and IF and Cipp reflect impact magnitude, then rN0 can reflect the proportion of ineffective papers within a journal during a specific period. The rN0 metric is scientifically sound, reasonable, practical, easy to calculate, and not subject to fluctuations from individual irrelevant factors.

3. Analysis Methods for Low-Citation Regions

3.1 Defining Low-Citation Regions

Defining the low-citation region is critical for bibliometric analysis of less-cited papers. For CMJ, this demarcation must be based on the citation distribution structure of journals in this field.

3.1.1 h-Index Core Region vs. Low-Citation Region The h-index is a metric describing highly-cited papers. Across 65 CMJ journals, the h-index core region contains 2,705 papers with 445,564 cumulative citations. Defining the ratio of core papers to total papers as rh (=h/Np)—the high-citation rate (core size)—and the ratio of core citations to total citations as rTcih (=Tcih/T) —the high-citation density (core density)—yields average values of rh=0.020 and rTcih=0.224 for CMJ. The h-core, representing only 2% of papers, contributes over 20% of total citations, indicating a relatively high average h-index for CMJ. However, is it reasonable to define everything outside the h-core as the low-citation region?

Table 4 presents statistical descriptions of key h-index core parameters for 65 CMJ journals. The average h-index is 41.6, with mean rh and rTcih values of 8.4% and 28.5% respectively, indicating that fewer than 10% of highly-cited papers contribute nearly 30% of total citations. Due to substantial dispersion in h-index, rh, Tcih, and rTcih values, not all journals conform to these proportions; in other words, journals with high h-index values do not necessarily exhibit high high-citation rates or densities. The probability distributions in Figure 5 [Figure 5: see original paper] show pronounced long tails, indicating individual journal variations requiring special consideration. These variations stem primarily from each journal' s citation characteristics and scale. For example, *Laser Photonics Review* and *J Magn Mater* share the same h-index of 51, yet their rTcih values are 58.1% and 12.3% respectively (Table 5). If the h-index core exterior is defined as the low-citation region, the former' s low-citation region accounts for 41.9% of total citations, while the latter accounts for 87.7%. Similarly, *Adv Phys* and *Phys Rev B* differ dramatically in scale (Np=38 vs. 28,953; h=29 vs. 141; rTcih=98% vs. 6.9%). Using the h-index as a divider results in 9 low-citation papers for *Adv Phys* (Np-h) versus 28,812 for *Phys Rev B* (Np-h=28,953-141), representing vastly different sample sizes.

Therefore, the study concludes that the statistical average h-index for 65 CMJ journals is unsuitable for defining low-citation regions, and individual journal h-index values are likewise inappropriate for demarcating their own low-citation zones.

3.1.2 Determining the Definition Domain for Less-Cited Papers 1) Minimum Citation Percentile Method

Inspired by the classic Pareto principle, we identify low-citation regions from a citation structure perspective by defining regions where cumulative citations of low-cited papers represent 5%, 10%, and 20% of total journal citations (Tci) as low-citation zones. The mathematical description is as follows: Assume a journal has Np citable papers (value n), sorted in descending order by citation frequency with sequence numbers i=1,2,3,···,k,···,n from top to bottom. Let Tcii denote the citation count of the ith citable paper. The total citations T of all citable papers is given by:

$$\sum Tcii = T \quad (1)$$

In this ranking, counting citations from the least-cited nth paper upward toward highly-cited papers until reaching 5%, 10%, and 20% of T yields Tci5%, Tci10%, and Tci20% respectively. These three cases are unified in the following formula:

$$Tcix\% = Tcii \quad (2)$$

where kx corresponds to the paper number when cumulative citations reach x% of T, and Tcix% represents the sum of citations for all citable papers in the interval kx ≤ i ≤ n, defined as the low-citation paper region corresponding to x%.

2) Journal Average Citation (Cipp) Method

Given the widespread acceptance and application of per-paper average citations in journal evaluation, we propose the Cipp demarcation method following similar logic. The mathematical description is: Sort each journal' s papers by citation frequency in descending order with sequence numbers i=1,2,3,···,k,···,n from top to bottom. Calculate the journal' s per-paper average citation Cipp from total citations T. Then locate the kth paper (kcipp) where Cik=Cipp, using this sequence number as the cutoff point. Papers satisfying i ≥ kcipp (with citation frequencies below Cipp) are defined as less-cited papers. The total number of papers in this region is NCipp, with cumulative citations Tcicipp, expressed mathematically as:

$$\sum_{i=kcipp}^{n} Tcii = Tcicipp \quad (3)$$

3) Data Comparison and Analysis

Based on these methods, we calculated the proportions of papers in the 5%, 10%, 20%, and Cipp regions for 65 journals: N5%, N10%, N20%, and Ncipp. Figure 6 Figure 6: see original paper visually displays the value ranges, medians, means (in box plots), and error bars for each %Nx region. Comparing data across three regions (Table 6), we find that rN20% and rNcipp have medians of 0.613 and 0.706 respectively, very close to their means of 0.627 and 0.709, with smaller ranges between maximum and minimum values and more symmetric probability distributions (Figure 6(2)). These characteristics demonstrate that the 20% point data possess stronger statistical advantages than the 5% and 10% points (Table 6). Therefore, the lowest-cited 20% region and the region with citations below the per-paper average have statistical justification as low-citation zones for CMJ.

3.2 Citation Characteristics Analysis of CMJ Low-Citation Regions

3.2.1 Low-Citation Rate (RLC) and Low-Citation Density (DLC) Indicators Analogous to the analysis of the highly-cited h-core region, we define the low-citation rate (RLC) as the percentage of low-citation region papers relative to total citable papers: RLC20% = rN20% = N20%/Np and RLCcipp = rN-cipp = Ncipp/Np. The low-citation density (DLC) is defined as the percentage of cumulative citations in low-citation regions relative to total journal citations: DLCcipp = rTcicipp = Tcicipp/T and DLC20% = rTci20% = Tci20%/T, with DLC20%   0.2.

The RLC20% indicator' s advantage lies in providing a common benchmark for comparing journals, making the proportion of 20% low-citation papers immediately apparent, though some data are not directly available from WOS. The RLCcipp and DLCcipp indicators benefit from the long-established understanding of per-paper average citation (Cipp), facilitating comprehension of overall journal citation structure.

3.2.2 CMJ Citation Structure Analysis 1) Prerequisites for Journal Evaluation

Understanding a journal' s citation structure is fundamental to its evaluation. Table 6 reveals: First, in the lowest-cited 20% Tci region, approximately 60% of citable papers in the low-citation end contribute 20% of total journal citations—in other words, 80% of citations originate from 40% of papers in the high-citation end.

Second, in the region with citations below the per-paper average, DLCcipp has actual and statistical means of 29.9% and 28.0% respectively, while RLCcipp has actual and statistical means of 70.0% and 70.9% respectively. Thus, papers with citations above Cipp constitute less than one-third of high-citation end papers but account for 70% of total journal citations.

Neither region conforms to the classic Pareto principle, yet both are statistically meaningful for citation structure analysis. For CMJ with relatively high average h-index values, selecting too low a citation threshold for low-citation evaluation is meaningless, while positioning the low-citation region too close to the high-citation end increases overlap with the h-core. Analysis using the below-Cipp definition domain shows that with a low-citation density upper limit of 30%, only six of 65 journals exhibit intersection between h-core and low-citation regions (see appendix table), with error below 10%. Furthermore, Table 6 demonstrates that the below-Cipp definition domain yields more consistent data, with superior statistical characteristics (range, standard deviation, mean) compared to the 20% definition domain, making Cipp a particularly meaningful cutoff for understanding citation structure. While low-citation definition domain cutoffs likely vary across disciplines, this method should serve as a valuable reference for other scientific fields.

2) Citation Structure Patterns

To investigate whether CMJ citation distributions exhibit typical structural patterns, we analyzed the ratio of low-to-high citation density (Tcicipp/Tcih), finding it increases with journal tier number (Figure 7 [Figure 7: see original paper]). In Tier 1, low-citation regions are approximately 0.5 times the high-citation region, while in Tier 4 they are about 1.8 times larger, indicating that low-citation papers constitute an increasingly dominant evaluation component from Tier 1 to Tier 4. Table 6 shows *Nature Materials* and *Physical Review B* have similar h-index values (154.9 vs. 141) but vastly different IFs (36 vs. 3.7) and Cipp values (154.9 vs. 15.7). Due to scale differences (Np=749 vs. 28,953), their high-citation density indicators (DHC) are 0.644 and 0.069 respectively, while low-citation density indicators (DLCcipp) in the below-average region are 0.285 and 0.305 respectively, demonstrating a density inversion (Figure 8 [Figure 8: see original paper]). Figures 9 [Figure 9: see original paper]–10 [Figure 10: see original paper] illustrate per-paper citations and citation patterns across three regions for both journals. Their citation structures can be described as starting with a high h-core, one with a short thick tail and the other with a long thin tail. Additional structural patterns exist, requiring further empirical and theoretical investigation.

3.2.3 Citation Structure and Evaluation Strategy Based on appendix table data, we divided 65 journals into three segments sorted by high-citation density (DHCh=rTcih) in descending order: H-segment (high-citation dominant, rTcih$ $0.78), L-segment (low-citation dominant, rTcih<0.1), and M-segment (intermediate). Figure 11 [Figure 11: see original paper] analyzes relationships between Tci and h-index, Cipp, and Cipp20% across segments. In the H-segment, journals are generally small-scale with moderate h-index values but high DHC, where Tci shows greater sensitivity to h-index and Cipp20% than to Cipp (Figure 11(1)). In the M-segment, Tci sensitivity decreases progressively from Cipp20% to Cicipp to h-index, indicating differential evaluation advantages among the three metrics across regions (Figure 11(2)). In the L-segment with low DHC, low-citation papers become the dominant evaluation component, Tci sensitivity to h-index drops to the same level as Cipp, while sensitivity to Cipp20% rises to the highest across all segments, demonstrating Cipp20%' s absolute evaluation advantage in the L-segment (Figure 11(3)).

Current evaluation systems are primarily derived from h-index and IF. From a citation structure perspective, these metrics fall into two categories: those evaluating high citations (h-index, rNh, rTcih) and those evaluating low citations (IF, Cipp, rTcicipp, rTci20%). These metric categories may compete within an evaluation system, with the composition ratio of high- versus low-citation papers determining their relative effectiveness. Studying citation structures and metric competition is crucial for selecting appropriate evaluation indicators, achieving nuanced journal assessment, and conducting comparative analyses of citation configurations. Moving beyond traditional one- or two-metric evaluation models has become an academic necessity, and increasingly sophisticated citation databases and analytical tools now enable personalized and refined journal evaluation. However, further empirical and theoretical research is needed on the dependency and competitive relationships between different evaluation metrics and citation configurations.

3.2.4 Description and Evaluation of Journal Low-Citation Regions

Table 7 shows correlation strengths between low-citation indicators, high-citation indicators, and traditional metrics, revealing: First, rN0, RLC (rN20%, rNcipp), and DLC (rTci20%, rTcicipp) show no significant correlation with traditional indicators (h, Tci, IF, Np, Cipp), satisfying the prerequisite for independent low-citation metrics. Second, the two low-citation regions' RLC values are strongly correlated (r=0.686), with zero-citation exerting more direct influence on low-citation indicators (see rN0 column in Table 7); zero-citation shows essentially no correlation with overall journal indicators Np and Tci. Notably, N20% correlates strongly with Tcicipp (r=-0.717), while Ncipp correlates moderately with Tcicipp (r=-0.367). Third, correlation analysis further demonstrates the complexity of low-citation factors, making single-indicator evaluation impractical and necessitating multi-parameter, multi-dimensional evaluation approaches.

1) Composite Description Indicator Evel {rN0, rNx, rTcix}

The three metrics rN0, rNx, and rTcix collectively reflect low-citation region characteristics and can form a composite indicator. This includes: a journal' s proportion of uncited papers (rN0), high/low citation rate RLC (RHC) (rNx), and citation density DHC (DLC) (rTcix). When x is 20 or Cipp, the indicator applies to low-citation regions; when x is h, it applies to the h-core region. Examples:

- *Nature Materials*: Evel {rN0, rNcipp, rTcicipp} = {0.032, 0.694, 0.285}
- *J Nanosci Nanotechno*: Evel {rN0, rNcipp, rTcicipp} = {0.140, 0.709, 0.296}

2) Composite Evaluation Indicator Evel {h, Ci20%, Cicipp, Cih}

This indicator describes journal citation configuration through per-paper average citations in different regions. The appendix table contains per-paper citation data for all 65 CMJ journals. Examples:

- *Nature Materials*: Evel {h, Ci20%, Cicipp, Cih} = {180; 51.8, 154.9, 415.2}
- *J Nanosci Nanotechno*: Evel {h, Ci20%, Cicipp, Cih} = {41; 1.6, 4.9, 70}

Conclusion

This study examined 65 condensed matter physics journals from WOS to explore low-citation definition methods and patterns, assuming the h-index core region represents the high-citation zone. H-core analysis reveals that papers in this region constitute 2% of total journal papers but contribute over 20% of total citations. Although nearly half of journals exceed this average, the asymmetric distribution, large dispersion, and high standard deviation of h-index and Tcih indicate that h-index lacks statistical justification as a demarcation point for low-citation regions in condensed matter physics journals.

CMJ' s rN0 is only 10.2%. The degree of zero-citation shows moderate negative correlation with journal quality tiers, but its temporal evolution shows no significant tier-related patterns. CMJ' s discovery cycle by the academic community is approximately three years and shows no necessary connection with IF3. rN0 is essentially uncorrelated or weakly correlated with traditional indicators (Np, Tci, IF, h, Cipp), giving it statistical characteristics of an independent evaluation metric. In practice, rN0 facilitates easier inter-journal comparisons than N0.

Comparative analysis of citation characteristics in regions below per-paper average Cipp and in the three regions where lowest-cited papers cumulatively account for 5%, 10%, and 20% of total citations T defines the lowest-cited 20% region and the below-Cipp region as CMJ low-citation zones. The former region encompasses approximately 60% of citable papers, meaning 40% of high-citation end papers contribute 80% of total citations. The latter region includes about 70% of citable papers, whose cumulative citations account for 30% of total citations. Though neither result conforms to the classic Pareto principle, both possess statistical significance for citation structure analysis, providing theoretical justification for defining low-citation regions.

Extensive correlation analysis demonstrates that evaluating less-cited papers is complex with multiple factors, making single-variable assessment inadequate. This paper proposes two multi-factor composite indicators:

- **Composite Description Indicator**: Evel = {rN0, rNx, rTcix}
- **Composite Evaluation Indicator**: Evel {h, Ci20%, Cicipp, Cih}

Low-citation evaluation must be based on citation distribution structure analysis. Using high-citation density DHC (rTcih), we divided 65 CMJ journals into high, medium, and low segments, analyzing how Tci sensitivity to h-index, Cipp, and Cipp20% varies across segments. The findings reveal dependency relationships between citation structure and evaluation metrics, suggesting competitive advantages among different metrics across high- and low-citation regions, and supporting the modeling of journal classification and citation structure patterns.

Zero-citation and low-citation are high-probability events in scholarly literature. Establishing systematic evaluation methods for less-cited papers or incorporating low-citation analysis into traditional evaluation systems holds practical significance for assessing both journal academic standing and the scholarly impact of low-citation paper producers. Although this study focuses on physics subfield journals, it aims to provide exploratory insights for broader disciplines. With maturing citation databases, improving citation standards, rising data quality, and increasingly powerful analytical software, bibliometric analysis will emphasize more comprehensive, multi-dimensional journal evaluation.

References

[1] GARFIELD E. I had a dream···about uncitedness [J]. *The Scientist*, 1998 (14):10
[2] GARFIELD E. Uncitedness and Identification of Dissertation Topics [J]. *Current Contents*, 1972, 14
[3] GARFIELD E. Uncitedness III—importance of not being cited [J]. *Current Contents*, 1973, (8):5-
[4] GARFIELD E. To be an uncited scientists to scientific discovery [J]. *The Scientist*, 1991
[5] BARBER. Resistance by scientists to scientific discovery[J]. *Science*, 1961:596-601
[6] VAN RAAN A. Sleeping beauties in science [J]. *Scientometrics*, 2004(3):467-472
[7] L.EGGHE. The distribution of the Uncitedness Factor and its Functional Relation with the Impact Factor[J]. *Scientometrics*, 2010, 83:689-695
[8] Gao Jiping, Pan Yuntao, Wu Yishan. Analysis of factors contributing to zero-citation papers: A case study of national-institutional and thematic distribution of cited papers in spectroscopy [J]. *Science & Technology Review*, 2015, 33(8):112-119
[9] Xu Xiaoqin. Analysis of causes for zero-citation papers: A case study of *Journal of Plant Nutrition and Fertilizer Science* [J]. *Chinese Journal of Scientific and Technical Periodicals*, 2015, 26(7):763-768
[10] Zhu Mengjiao, Wu Yishan. Zero-citation phenomenon: A literature review [J]. *Information Studies: Theory & Application*, 2013, 36(8):111-116
[11] Wei Ruibin, Shi Lei, Wu Yishan. Empirical study on zero-citation phenomenon in academic journals: A case study of library and information science journals [J]. *Library and Information Service*, 2015, 59(1):82-88
[12] Liu Xueli, et al. Reverse indicator for scientific journals—zero-citation paper rate and its relationship with other bibliometric indicators [J]. *Chinese Journal of Scientific and Technical Periodicals*, 2011, 22(4):525-528
[13] Zhou Jie, Wang Xin. Investigation and discussion of low-citation papers in scientific journals [J]. *Chinese Journal of Scientific and Technical Periodicals*, 2015, 26(8):851-
[14] Yang Lijun, Wan Xiaoyu. Method for defining low-citation standards for journal papers [J]. *Information Studies: Theory & Application*, 2013(36):51-
[15] Yang Lijun, Wan Xiaoyu. Study on evaluation methods for academic value of low-citation journal papers [J]. *Information Studies: Theory & Application*, 2015(37):95-101
[16] Tang Yechen. Research guide on dependency relationships within and outside the h-core based on information value [J]. *Journal of Intelligence*, 2011(30):
[17] Wang Xin. Empirical analysis of h-index, IF5 and hTci-median for discipline journals [J]. *Library and Information Service*, 2014, 58(6):105-112
[18] L. EGGHE. The mathematical relation between the impact factor and the uncitedness factor[J]. *Scientometrics*, 2008, 76:117–123

[19] ROUSSEAU R. A case study: evolution of JASIS' Hirsch index [J]. *Science Focus* (in Chinese), 2006, 1(1):16-17

Appendix

Table 65 Main analytical indicators for 65 journals (sorted by rTcih descending)
C: CMJ tier; A: rTci20%/rTcih; B: rTcicipp/rTcih
Low/High Citation Rate RLC/RHC (paper ratio) | Citation Density DLC/HLC | Citation Ratio

Journal Title: ADV PHYS, SURF SCI REP, ANNU REV CONDEN MA P, CRIT REV SOLID STATE, SOLID STATE PHYS, PROG SURF SCI, NAT MATER, CURR OPIN SOLID ST M, LASER PHOTONICS REV, SEMICONDUCT SEMIMET, SOLID STATE NUCL MAG, ADV ENERGY MATER, SOLID STATE TECHNOL, FERROELECTRICS LETT, ADV COND MATTER PHYS, SMALL, ADV MATER, CHEM VAPOR DEPOS, CONDENS MATTER PHYS, ADV FUNCT MATER, NANO LETT, PLASMA PROCESS POLYM, PHIL MAG LETT, SEMICOND SCI TECH, IEEE T SEMICONDUCT M, J MECH PHYS SOLIDS, PHASE TRANSIT, PHYS STATUS SOLIDI-R, J PHYS-CONDENS MAT, SUPERCOND SCI TECH, PHYS CHEM LIQ, SURF REV LETT, PHYSICA E, SOLID STATE ELECTRON, SUPERLATTICE MICROST, MOD PHYS LETT B, IONICS, INT J MOD PHYS B, SURF SCI, PHYS STATUS SOLIDI B, EUR PHYS J B, SOLID STATE IONICS, J LOW TEMP PHYS, SOLID STATE COMMUN, MAT SCI SEMICON PROC, PHILOS MAG, PHYS STATUS SOLIDI A, J COMPUT THEOR NANOS, SOLID STATE SCI, INTEGR FERROELECTR, RADIAT EFF DEFECT S, J SUPERCOND NOV MATER, SCI ENG B-ADV, J PHYS CHEM SOLIDS, J MAGN MAGN MATER, SYNTHETIC MET, THIN SOLID FILMS, FERROELECTRICS, J MATER SCI-MATER EL, SEMICONDUCTORS+, J NANOSCI NANOTECHNO, PHYSICA B, PHYS SOLID STATE+, PHYS REV B, APPL SURF SCI

Note: Figure translations are in progress. See original paper for figures.