Graphene: ten years of the ‘gold rush’

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Elsevier

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Recommended Citation
Plume, Andrew Dr (2014) "Graphene: ten years of the 'gold rush'," Research Trends: Vol. 1 : Iss. 38 , Article 4.
Available at: https://www.researchtrends.com/researchtrends/vol1/iss38/4

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Section 3: Research Trends

Graphene: ten years of the ‘gold rush’

Dr. Andrew Plume

Since the publication of the famous paper (1) on the ‘sticky-tape method’ for preparing graphene in October 2004 (which helped win authors, Andre Geim and Konstantin Novoselov the 2010 Nobel Prize in Physics), the field of graphene research has seen phenomenal growth in terms of published research articles likened to a ‘gold rush’ (2). With the entrance of so many new and established researchers into the field, we investigate if a new approach to assigning ‘credit’ for article authorship can answer the question: “Who are the authors of high-impact graphene research”?

Graphene is a material comprising carbon atoms packed together in a two-dimensional sheet just one atom thick, and may be the thinnest material in the universe. This unique structure gives graphene some very surprising physical properties – it is some 100 times stronger than steel and conducts heat and electricity at high efficiency. Prior to its isolation by Geim and Novoselov in 2004, it existed only in theoretical models; as such, the field of graphene research can be considered to have appeared almost overnight.

Figure 1 shows the exponential increase in the number of research articles published on graphene in the decade between 2004 and 2013. Using this corpus of literature as a self-defining research field, we have applied a recently-published method for assigning authorship credit to understand who the high-impact authors in graphene research are. Most current approaches to identifying and ranking high-impact authors fail to account for the invisible credit structures which operate in author bylines in most fields of research. Instead, most analyses assume that each author has a full and equal stake in the creation of a research article, and this follows to the assignment of the credit for that article also. While much previous work has been done to examine the intricacies of fractional assignment of credit to authors (e.g. Moed (3) and Stallings et al. (4)), there has recently been renewed interest in algorithmic methods to fractionally assign authorship credit in a way that recognises these unstated community norms. Some of the most recent work along these lines has been published by Nils T. Hagen at the University of Nordland, Norway, and it is this approach which serves at the inspiration for the present study (5).

Figure 1: Scholarly output (articles only) published in the period 2004-13 from a search for “graphene” in the titles, abstracts or keywords. Source: SciVal
The present study aims to compare three methods of assigning authorship credit to the authors of the corpus of research articles on graphene defined above and examine the differences in the resulting lists of high-impact researchers. The first method is the standard ‘full count’ method – each author on the article receives a full count for each article they appear on, and also the full citation credit. The second method is ‘fractional’, where each author gets an equal portion of the credit with all other co-authors; an author on a single-author paper gets 1, while one on a 4-author paper gets 0.25; citation credit is assigned in the same way. For an examination of the rise of fractional authorship over time, see “Publish or perish? The rise of the fractional author…”. Also in this issue (6). Finally, the ‘harmonic’ method (as developed by Hagen, (5)) instead assigns additional weight to the first and last authors and diminishing weights to each additional author in the middle, and assigns citations the same way also. As a vital and important research front, graphene research is typically published in well-known peer-reviewed journals and as such we have assumed that all of the most important research (and researchers) in this topic are represented in the Scopus database.

Citations in this analysis are counted on a 3-year basis, i.e. citations to each article are counted in the same year as publication plus the two following years; i.e. 2011 papers have their cites counted in the period 2011-2013; since the field is therefore self-defining, it is not necessary to field-weight the citation data as we may assume that citation practices within graphene research are reasonably homogenous. Because of the use of this 3-year citation window, this analysis considers only those articles published from 2005 to 2011, focussing on the period of expansion of the field in the wake of Geim and Novoselov’s landmark 2004 publication (1). Importantly, since the corpus is defined as research articles containing the word “graphene” in the title, abstract or keywords, it ignores all other articles on non-graphene topics published by the same authors; by design, these results answer the very specific question “who are the authors of high-impact graphene research?”, and not “who are the high-impact authors working on graphene?”

If each author on every paper is represented in this analysis, when these lists are sorted by citations per article many of those appearing at the top are authors of single well-cited papers who may not yet represent career researchers. To account for this, a productivity threshold was applied to allow authors with relatively lower productivity in graphene research to appear in these lists; in Figure 2 this was set at a relatively ‘relaxed’ minimum of 7 articles in the 7 year period 2005-11 (i.e. on average, 1 article per author per year) for the full count method, and at 2 authorship credits for the fractional and harmonic methods (i.e. on average, less than 0.3 article credits per author per year).

It is clear from a glance that while the three methods have a few authors in common, where the same author does appear in more than one list their rankings are quite variable (see for instance the variability in ranking of the two Nobelists Geim and Novoselov in each list, for example). It is also clear that at this ‘relaxed’ productivity threshold, authors who are newer to the field are likely to appear but may not be as well-recognised as leading figures in the field by other graphene researchers.

Figure 2: Top 25 authors of graphene articles 2005-11: ‘relaxed’ productivity threshold. Source: Scopus

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<th>Author name</th>
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Figure 2: Top 25 authors of graphene articles 2005-11: ‘relaxed’ productivity threshold. Source: Scopus
In Figure 3, the productivity threshold was increased to focus only on authors with relatively high productivity in graphene research; this ‘stringent’ threshold was set at a minimum of 28 articles in the 7 year period 2005-11 (i.e. on average, 4 articles per author per year) for the full count method, and at 7 authorship credits for the fractional and harmonic methods (i.e. on average, 1 article credit per author per year). In these lists there is a somewhat greater degree of agreement between the results overall than in the ‘relaxed’ threshold lists, but especially for the very top names (the two Nobelists head all three lists, for example); below that, the three lists begin to differ and names in one or two lists are absent from the other(s).

It is difficult for anyone not working directly in a field of research to know who the ‘best’ researchers working in that field are, and recognising this we have not sought to make a value judgement here on the which list correlates most closely with peer esteem. Instead, the question remains open to those working on graphene to answer: which researchers are recognised as the ‘highest impact’ in the field, and which list reflects this most closely?

As early as 2008, Andre Geim himself has noted the tendency for graphene to attract large numbers of researchers: “With graphene, each year brings a new result, a new sub-area of research that opens up and sparks a gold rush” (6). Here we have applied a fresh approach to assigning author credit for published research articles to the field of graphene as one way of demonstrating who has made their fortune on the research frontier. It is important to note however that, owing to the inherent complexity in the research enterprise (especially at the frontier of knowledge), simplistic interpretations of author rankings may be dangerous insofar as they may reinforce the status quo and lead to a form of consensus-reaching which may ultimately limit the expansion of knowledge. Instead - as always - metrics informed by expert opinion are preferable.

Figure 3: Top 25 authors of graphene articles 2005-11: ‘stringent’ productivity threshold. Source: Scopus

References: