Nobel Laureate Anthony J Leggett: A scientometric portrait

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This paper attempts to analyse the publication productivity of Anthony J. Leggett, the 2003 Nobel Prize winner in physics. His contributions peaked in 1987, 1994, and 1998 with 10 papers each. He had 194 publications during 1964 - 2004 in domains like Superfluid 3He (65), Foundations of Quantum Mechanics (36), Dissipative Quantum Systems (24), Atomic Alkali Gases (18), and Miscellaneous (51) which were analysed for authorship pattern with his 70 collaborators. Most active collaborators with Anthony J Leggett were: A. Garg with six papers and A. O. MCaldeira, D. M. Ginsberg, D. J. Vanharlingen , F. Sols, S. Takagi and D. A. Wollman with five papers each. His productivity coefficient was 0.60 which clearly indicates that his productivity increased after 50 percentile age. The highest degree of collaboration (1) for Anthony J. Leggett was found during 1964, 1971 and 1983. Journals have been the most preferred channel of communication, where as many as 139 papers out of 194 have been published. The core journals publishing his papers were: Phys. Rev. Lett. (42), Phys. Rev. B (9), J. Low Temp. Phys. (8), Phys. Rev. A (7), Ann. Phys. (6), Foundations of physics (6), J. Phys.(5), Prog. Theor: Phys. (5), and Rev. Mod. Phys. (5). Publication density was 3.02 and publication concentration was 3.59.

Introduction

The Royal Swedish Academy of Sciences has awarded to Anthony J. Leggett, as one of the three recipients the Nobel Prize (2003) in Physics for pioneering contributions to the theory of superconductors and superfluids. Leggett's co-recipients of the 2003 Nobel Prize are Alexei A. Abrikosov, Argonne National Laboratory Argonne, IL, USA (born 1928), and Vitaly Ginsburg, P.N. Lebedev Physical Institute Moscow, Russia (born 1916). Srinivasan and Narayanan have briefly reviewed the work of three Nobel laureates on understanding the phenomena of superfluidity and superconductivity¹.

Sir Anthony James Leggett (born March 26, 1938 in Camberwell, London, England), is John D. and Catherine T. MacArthur Chair and Center for Advanced Study Professor of Physics at the University of Illinois at Urbana-Champaign. He is widely recognized as a world leader in the theory of low-temperature physics, and his pioneering work on superfluidity was recognized by the 2003 Nobel Prize in physics. He has shaped the theoretical understanding of normal and superfluid helium liquids and other strongly coupled superfluids. He set directions for research in the quantum physics of macroscopic dissipative systems and use of condensed systems to test the foundations of quantum mechanics.

He is a member of the National Academy of Sciences, the American Philosophical Society, the American Academy of Arts and Sciences, the Russian Academy of Sciences (foreign member), and is a Fellow of the Royal Society (U.K.), the American Physical Society, and the American Institute of Physics. He is an Honorary Fellow of the Institute of Physics (U.K.). He was knighted (KBE) by Queen Elizabeth II in 2004 “for services to physics.” He holds dual US/UK citizenship. His current research focuses on cuprate superconductivity, conceptual issues in the foundations of quantum mechanics, and superfluidity in highly degenerate atomic gases.

The term 'Bio-bibliometrics' was first coined by Sen and Gan for the quantitative and analytical method for
discovering and establishing functional relationships between bio-data and biblio-data elements. There are many bio-bibliometric studies, but have hardly used the term ‘bio-bibliometrics’ in the titles of the papers. Recently the term ‘Bio-bibliometrics’ is being used by Stapley and Benoit for a method of retrieving and visualizing biological information that uses co-occurrence of gene naming terms in Medical Sciences to generate semantic links between genes. Therefore, it is suggested that ‘Scientometric portrait’ is the appropriate phrase for the studies on scientists, and ‘Informetric portrait’ for the studies on researchers in other disciplines such as arts, humanities, and social sciences.

A few scientometric studies on Nobel laureates and others have been published. Kademani et al have studied the publication productivity, collaboration and authorship trend among eight Nobel laureates of past and present.

Presently, individual scientists including the Nobel laureates, are becoming the focus of scientometric studies. Nobel prize is regarded as the most honourific recognition of scientific achievement. The prestige of Nobel prize is so great that it enhances the standing of nations and institutions as well as reputation of its “laureates.”

Garfield and his colleagues have continuously published many studies inspired by the Nobel prize and other awards. The earliest is a paper presented at the Office of Naval Research Conference on Research Productivity in 1965 in which Sher and Garfield have demonstrated with data, the key characteristics of Nobel prize winners. It has been noticed that they publish five times more number of papers than the average scientist and their papers are cited 50 times more than the average.

There are many papers by Garfield forecasting of Nobel Prize winners. There are also many studies conducted by other noted scholars in this area of scientometrics.

Objectives
Anthony J Leggett has been taken as a case study for the present scientometric analysis. The detailed biographical details and his brief resume can be found at (http://www.physics.uiuc.edu/People/Faculty/profiles/Leggett/).

This study highlights A J Leggett’s:

- domainwise contributions
- domainwise authorships
- prominent collaborators
- use of channels of communications, and
- documentation of keywords from titles of the papers.

The main concept of working on individual scientists especially on Nobel laureates is to provide an example of ‘Role Model Scientist’ for the younger generation to emulate and create scientific temper among them. Success of others may teach many things to follow their path. Knowledge is valuable for its own sake and research has cultural values. Narrating success stories will always have an encouraging effect on the younger generation who aspire to be scientists.

Methodology
Present study is limited to the 194 papers by A J Leggett (1964-2004). A list of publications was obtained from Prof. A J Leggett. The database of publications of A J Leggett was created using CDS-ISIS software and the data was analysed as per the requirements of the study. The bibliographic fields were analysed by normal count procedure. Full credit was given to each author regardless of whether he happens to be the first author or the last author. Similarly one score was allotted to subject, journal, and keyword etc.

Results and discussion
Domainwise contributions
A J Leggett had research communications in the following domains:

- A = Superfluid 3He
- B = Foundations of Quantum Mechanics
- C = Dissipative Quantum Systems
- D = Atomic Alkali Gases
- E = Miscellaneous

Domainwise and Decennial distribution of publications by Leggett is presented in Table 1.
Domain wise contribution of Leggett's output has been grouped into four distinct periods (1964-1973, 1974-1983, 1984-1993, and 1994-2004). The highest publication output was (69) in the last block (1994-2004) closely followed by the third block (1984-1994) with 59 publications. The domain Superfluid 3He has topped the list with 18 and 25 papers during the first and second period respectively. During the third period maximum 19 papers were published in the domain Foundations of Quantum Mechanics. The domain Miscellaneous topped during the fourth period with 31 papers.

Activity Index (AI) was calculated for Leggetts's papers in four ten year blocks in different domains. Fig.1 gives the graphical representation of AI. In the first and second blocks, maximum emphasis was on domain A (Superfluid 3He), while in the third block the emphasis has shifted to domains B (Foundations of Quantum Mechanics) and C (Dissipative Quantum Systems). In the last block the emphasis was on domains D (Atomic Alkali Gases) and E (Miscellaneous).

Collaboratorship

Domainwise authorship pattern and number of publications and authorships in each domain are presented in Table 2. Anthony J Leggett had 122 single – authored (62.88%) papers in various domains such as Superfluid 3He (45), Foundations of Quantum Mechanics (28), Miscellaneous (25), Dissipative Quantum Systems (13) and Atomic Alkali Gases (11). Year - wise collaboration trend of Anthony J Leggett is shown in Fig. 2.

To measure the collaborative research pattern, a simple indicator called Degree of Collaboration is used. The degree of collaboration in a discipline was defined as the ratio of the number of collaborative research papers...
Table 2 - Domainwise productivity of number of papers and authorship pattern of the Nobel Laureate A J Leggett (1964–2004)

<table>
<thead>
<tr>
<th>Authorships</th>
<th>Domains</th>
<th>Total No.</th>
<th>%</th>
<th>No of Authorships</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>Single-authored</td>
<td>45</td>
<td>28</td>
<td>13</td>
<td>11</td>
<td>25</td>
</tr>
<tr>
<td>Two-authored</td>
<td>16</td>
<td>4</td>
<td>9</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Multi-authored</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td>65</td>
<td>36</td>
<td>24</td>
<td>18</td>
<td>51</td>
</tr>
<tr>
<td>Percentage</td>
<td>33.50</td>
<td>18.55</td>
<td>12.37</td>
<td>9.27</td>
<td>26.28</td>
</tr>
<tr>
<td>Authorships per paper</td>
<td>1.4</td>
<td>1.36</td>
<td>1.67</td>
<td>1.56</td>
<td>2.29</td>
</tr>
</tbody>
</table>

A = Superfluid 3He, B = Foundations of Quantum Mechanics, C = Dissipative Quantum Systems, D = Atomic Alkali Gases, E = Miscellaneous

The productivity coefficient was obtained by the simple formula – 50 percentile age per total productivity age. The productivity coefficient was 0.60 which clearly indicates that Leggett’s productivity increased after 50 percentile age. He had published highest (10) number of papers in 1987, 1994 and 1998. He did not publish any paper in the year 1967.

Domainwise Authorships

Table 2 shows domainwise authorship pattern and distribution of papers in various domains. The research group of A J Leggett had the credit as number of authorships in various domains: Superfluid 3He (91), Foundations of quantum mechanics (49), Dissipative quantum systems (40), Atomic Alkali gases (28) and Miscellaneous (117).

Prominent Collaborators

Researchers and their authorships in collaboration with A J Leggett in chronological order of their association are documented in Fig. 3. Most active researchers having number of publications with Anthony J Leggett were: A. Garg (6); A. G. Caldeira (5); D. M. Ginsberg (5); D. J. Vanharlingen (5); F. Sols (5); S. Takagi (5) and D. A. Wollman (5). Two scientists having collaboration in four papers each were: Yu, C C and Lee, W C. Five scientists had collaboration in three papers each. Sixteen scientists had collaboration in two papers each.
Table 3 - Channels of communication preferred by A J Leggett during 1964 - 2004

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Channel of communication</th>
<th>No. of papers</th>
<th>Cumulative No.</th>
<th>FPY- LPY</th>
<th>TY</th>
<th>IF</th>
<th>Country</th>
</tr>
</thead>
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<tr>
<td>1</td>
<td>Phys. Rev. Lett.</td>
<td>42</td>
<td>42</td>
<td>1965-2000</td>
<td>36</td>
<td>7.035</td>
<td>USA</td>
</tr>
<tr>
<td>3</td>
<td>J. Low Temp. Phys.</td>
<td>8</td>
<td>59</td>
<td>1970-2002</td>
<td>33</td>
<td>1.171</td>
<td>USA</td>
</tr>
<tr>
<td>5</td>
<td>Ann. Phys.</td>
<td>6</td>
<td>72</td>
<td>1968-1983</td>
<td>16</td>
<td>2.525</td>
<td>USA</td>
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<tr>
<td>6</td>
<td>Found. Phys.</td>
<td>6</td>
<td>78</td>
<td>1988-2003</td>
<td>16</td>
<td>0.601</td>
<td>USA</td>
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<td>8</td>
<td>Prog. Theor. Phys.</td>
<td>5</td>
<td>88</td>
<td>1966-1980</td>
<td>15</td>
<td>2.188</td>
<td>Japan</td>
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<tr>
<td>9</td>
<td>Rev. Mod. Phys.</td>
<td>5</td>
<td>93</td>
<td>1975-2003</td>
<td>29</td>
<td>28.172</td>
<td>USA</td>
</tr>
<tr>
<td>10</td>
<td>Phys. Scr.</td>
<td>3</td>
<td>96</td>
<td>1982-2002</td>
<td>21</td>
<td>0.688</td>
<td>Sweden</td>
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<tr>
<td>11</td>
<td>Endeavor</td>
<td>2</td>
<td>98</td>
<td>1975-1976</td>
<td>2</td>
<td>0.024</td>
<td>England</td>
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<tr>
<td>12</td>
<td>J. App. Phys.</td>
<td>2</td>
<td>100</td>
<td>1988-1993</td>
<td>6</td>
<td>2.171</td>
<td>USA</td>
</tr>
<tr>
<td>17</td>
<td>Science</td>
<td>2</td>
<td>110</td>
<td>1996-2002</td>
<td>7</td>
<td>29.162</td>
<td>USA</td>
</tr>
<tr>
<td>18</td>
<td>Can. J. Phys.</td>
<td>1</td>
<td>111</td>
<td>1987-1987</td>
<td>1</td>
<td>0.777</td>
<td>Canada</td>
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<tr>
<td>19</td>
<td>Chemphyschem</td>
<td>1</td>
<td>112</td>
<td>2004-2004</td>
<td>1</td>
<td>3.316</td>
<td>Germany</td>
</tr>
<tr>
<td>20</td>
<td>Collective Phenomena</td>
<td>1</td>
<td>113</td>
<td>1975-1975</td>
<td>1</td>
<td>-</td>
<td>USA</td>
</tr>
<tr>
<td>23</td>
<td>Contemp. Phys.</td>
<td>1</td>
<td>116</td>
<td>1984-1984</td>
<td>1</td>
<td>1.543</td>
<td>England</td>
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<td>24</td>
<td>Current Sci.</td>
<td>1</td>
<td>117</td>
<td>1994-1994</td>
<td>1</td>
<td>0.694</td>
<td>India</td>
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<tr>
<td>25</td>
<td>Int. J. Mod. Phys.</td>
<td>1</td>
<td>118</td>
<td>2003-2003</td>
<td>1</td>
<td>-</td>
<td>Singapore</td>
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<tr>
<td>27</td>
<td>J. Magn. Magn. Mat.</td>
<td>1</td>
<td>120</td>
<td>1987-1987</td>
<td>1</td>
<td>0.910</td>
<td>Netherlands</td>
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<td>28</td>
<td>J. Phys. Chem. Sol.</td>
<td>1</td>
<td>121</td>
<td>1998-1998</td>
<td>1</td>
<td>1.026</td>
<td>USA</td>
</tr>
<tr>
<td>30</td>
<td>J. Supercond.</td>
<td>1</td>
<td>123</td>
<td>2000-2000</td>
<td>1</td>
<td>0.794</td>
<td>USA</td>
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<tr>
<td>31</td>
<td>Mod. Phys. Lett.</td>
<td>1</td>
<td>124</td>
<td>2000-2000</td>
<td>1</td>
<td>-</td>
<td>Singapore</td>
</tr>
<tr>
<td>33</td>
<td>New Scientist</td>
<td>1</td>
<td>126</td>
<td>1976-1976</td>
<td>1</td>
<td>0.277</td>
<td>England</td>
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<tr>
<td>34</td>
<td>Nihon Buturi Gakkai Si</td>
<td>1</td>
<td>127</td>
<td>1966-1966</td>
<td>1</td>
<td>-</td>
<td>Japan</td>
</tr>
<tr>
<td>36</td>
<td>Physica A</td>
<td>1</td>
<td>129</td>
<td>1983-1983</td>
<td>1</td>
<td>1.180</td>
<td>Netherlands</td>
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<tr>
<td>37</td>
<td>Physica B</td>
<td>1</td>
<td>130</td>
<td>1994-1994</td>
<td>1</td>
<td>0.908</td>
<td>Netherlands</td>
</tr>
<tr>
<td>38</td>
<td>Physica B &amp; C</td>
<td>1</td>
<td>131</td>
<td>1994-1994</td>
<td>1</td>
<td>-</td>
<td>Netherlands</td>
</tr>
<tr>
<td>39</td>
<td>Physica C</td>
<td>1</td>
<td>132</td>
<td>1994-1994</td>
<td>1</td>
<td>1.192</td>
<td>Netherlands</td>
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<tr>
<td>40</td>
<td>Phy. Lett.</td>
<td>1</td>
<td>133</td>
<td>1964-1964</td>
<td>1</td>
<td>-</td>
<td>Netherlands</td>
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<tr>
<td>41</td>
<td>Phys. Today</td>
<td>1</td>
<td>134</td>
<td>2004-2004</td>
<td>1</td>
<td>5.020</td>
<td>USA</td>
</tr>
<tr>
<td>42</td>
<td>Physica Penn.</td>
<td>1</td>
<td>135</td>
<td>1973-1973</td>
<td>1</td>
<td>-</td>
<td>Finland</td>
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<tr>
<td>43</td>
<td>Proc. Nat. Acad. Sci.</td>
<td>1</td>
<td>136</td>
<td>1999-1999</td>
<td>1</td>
<td>0.335</td>
<td>USA</td>
</tr>
<tr>
<td>44</td>
<td>Prog. Low Temp. Phys.</td>
<td>1</td>
<td>137</td>
<td>1995-1995</td>
<td>1</td>
<td>-</td>
<td>Netherlands</td>
</tr>
<tr>
<td>45</td>
<td>Prog. Theor. Phys. Suppl.</td>
<td>1</td>
<td>138</td>
<td>1985-1985</td>
<td>1</td>
<td>0.368</td>
<td>Japan</td>
</tr>
<tr>
<td>46</td>
<td>Synth. Met.</td>
<td>1</td>
<td>139</td>
<td>2004-2004</td>
<td>1</td>
<td>1.303</td>
<td>Switzerland</td>
</tr>
</tbody>
</table>

47-101 Others in Books, Conf/Sem., etc 55 194

(FPY = First Paper Year, LPY = Last Paper Year, TY = Total Years, and IF=Impact Factors taken from Journal Citation Reports – 2003)
papers each. Forty scientists could collaborate in only one paper each. Total number of authors in the research group were 71 and total number of authorships were 325.

**Use of Channels of Communication**

Distribution of Anthony J Leggett's 194 publications were spread over 139 journal articles, 26 conference papers, 26 edited books and 3 translations. Channelwise scattering of publications of Anthony J Leggett is provided in Table-3 and Fig.4. He has published 42 papers in *Phys. Rev. Lett.* (1965 - 2000), 9 papers in *Phys. Rev. B* (1981 - 2003), 8 papers in *J. Low Temp. Phys.* (1970-2002), 7 papers in *Phys. Rev. A* (1965 - 2003), 6 papers each in *Ann. Phys.* (1968-1983) and *Foundations of Physics* (1988-2003), and 5 papers each in *J. Phys.* (1970-2001); *Prog. Theor. Phys.* (1966-1980, ), and *Rev. Mod. Phys.* (1975-2003). More than 50 percent of the publications were published in the journals with impact factors ranging from 0.0 to 0.49 and rest were published in the journals having impact factors ranging from 0.50 to 30.98. The distribution of journals as per impact factors is given in Fig.5. Publication density was 3.02 and publication concentration was 3.59. Publication Density is defined as the ratio of total number of papers published to the total number of journals in which the papers were published and publication concentration is the ratio in percentage of the channels having half of the papers published to the total number of journals in which those papers were published.

**Country-wise Distribution of Journals**

The publications have been spread over 46 journals published in 11 countries. Fig.6 gives the country-wise distribution of journals. The largest numbers of journals are from USA with 96 publications in 16 journals, followed by England with 18 publications in 11 journals, Netherlands with 8 publications in 8 journals and Japan with 7 publications in 3 journals.

**Distribution of A J Leggett's Publications in Different Types of Communication Channels**

It is clearly evident from the Table-3 that his 71.65 percentage of publications were published in scientific journals followed by 28.35 percentage of publications in conferences, books, translations etc.

**Keyword Tomography**

Titles of publications convey precisely the thought contents of the papers. The potency of information concentration on the titles of the papers is more than the rest of the sections of the papers. Therefore, if a word occurs more frequently than expected to occur, then it reflects the emphasis given by the author about the domain of his research. These important words called ‘keywords’ are one of the best indicators to understand and to grasp instantaneously the thought content of the papers, methodologies used and areas of research addressed to. The keyword frequencies appeared in the titles of the papers is provided in Table-4.
Conclusion

A J Leggett has published 194 papers during 1964–2004. He published his first paper in 1964 when he was 26 years of age. The percentage of collaborative work (37.12) of the scientist was found to be low though he had as many as 71 collaborators whom he guided as a mentor. The percentage of solo research papers (62.88) has been found to be very high. His highest degree of collaboration 1.0 was found during 1964, 1971 and 1983. A J Leggett worked in highly specialised fields such as Superfluid 3He, Foundations of Quantum Systems, Dissipative quantum systems and Atomic Alkali gases. He has received several professional awards and honours which is indicative of his highly specialized and original work in his field. His productivity coefficient was 0.60 which is a clear indication that his productivity increased after 50 percentile age. His papers have been scattered
in 140 high impact factor scientific journals. It will be very interesting if one attempts to study the sociological aspects and citation studies on A J Leggett which may give many interesting insights into his scientific career. Nobel laureates are an altogether different kind of intellectual geniuses highly dedicated to unravel the mysteries of nature. Studying the lives of Nobel laureates and documenting systematically the varied experiences may help to inspire the younger generation.

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References


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