Grant Writing in the Physical Sciences

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Physics Dept.

Acknowledgement:: based on a presentations by Peter Schiffer and Nitin Samarth
Outline

• A little about my own background and experience with funding

• Funding agencies

• Types of grants

• Useful resources for grant writing

• Questions & discussion
My Interests: Experimental Atomic Physics

Laser cooling and Optical lattices

1D Gases

Quantum computing

Precision measurements

Bloch et al.

Quantum Newton’s cradles

Individual atoms in a 3D array

Electron electric dipole search
My History

PhD: Stanford, 1993
Post-doc: ENS (Paris) 1993-94
Faculty: 1994 - present (currently Associate Head)

I’ve reviewed for NSF, ARO, ONR, Research Corporation & other agencies.

~20 successfully funded proposals from Packard, Sloan, NSF, ONR, ARO, DARPA
<10 unsuccessful proposals
Introduction

• My assumptions about the audience:

  ✴ You are a senior graduate student or post-doctoral student;

  ✴ You can’t wait to make a splash in some area of science through creative discovery;

  ✴ You intend to achieve this goal by getting a job at an academic institution (or a research laboratory).
Introduction

• What you will get from this presentation:

✿ Specific facts and pragmatic advice -- funding sources, funding realities;

✿ General advice about successful grant writing -- what to include in a proposal? what to avoid? what are reviewers looking for?

• What you will NOT get from this presentation: detailed advice about scientific grant writing -- no such thing as an ideal “template”, “style” etc.
## Total Funding Rates for 2015 for NSF

<table>
<thead>
<tr>
<th>Org</th>
<th>Number of Proposals</th>
<th>Number of Awards</th>
<th>Funding Rate</th>
<th>Average Decision Time (months)</th>
<th>Mean Award Duration (years)</th>
<th>Median Annual Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSF</td>
<td>49,630</td>
<td>12,016</td>
<td>24%</td>
<td>5.75</td>
<td>2.59</td>
<td>$118,160</td>
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<tr>
<td>BIO</td>
<td>5,122</td>
<td>1,382</td>
<td>27%</td>
<td>5.39</td>
<td>2.75</td>
<td>$150,000</td>
</tr>
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<td>CSE</td>
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<td>1,885</td>
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<td>5.01</td>
<td>2.63</td>
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<tr>
<td>EHR</td>
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<td>7.48</td>
<td>2.86</td>
<td>$155,372</td>
</tr>
<tr>
<td>ENG</td>
<td>12,330</td>
<td>2,509</td>
<td>20%</td>
<td>4.96</td>
<td>2.35</td>
<td>$114,500</td>
</tr>
<tr>
<td>GEO</td>
<td>5,810</td>
<td>1,465</td>
<td>25%</td>
<td>7.40</td>
<td>2.61</td>
<td>$129,000</td>
</tr>
<tr>
<td>MPS</td>
<td>9,130</td>
<td>2,590</td>
<td>28%</td>
<td>6.07</td>
<td>2.90</td>
<td>$112,917</td>
</tr>
<tr>
<td>O/D</td>
<td>671</td>
<td>312</td>
<td>46%</td>
<td>6.53</td>
<td>1.62</td>
<td>$5,070</td>
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<tr>
<td>SBE</td>
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<td>1,042</td>
<td>24%</td>
<td>4.79</td>
<td>2.25</td>
<td>$62,171</td>
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$1.4 Billion in single investigator awards, out of a total $7.3 Billion budget.
### Funding Rate from FY 2015 for Direct For Mathematical and Physical Sciences and Biological Sciences

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</tr>
<tr>
<td>AST</td>
<td>1,041</td>
<td>216</td>
<td>21%</td>
<td>6.26</td>
<td>2.92</td>
<td>$128,698</td>
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<tr>
<td>CHE</td>
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<td>527</td>
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<td>6.53</td>
<td>3.13</td>
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<tr>
<td>DMR</td>
<td>2,211</td>
<td>504</td>
<td>23%</td>
<td>5.73</td>
<td>3.11</td>
<td>$131,370</td>
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<tr>
<td>DMS</td>
<td>3,074</td>
<td>947</td>
<td>31%</td>
<td>5.80</td>
<td>2.67</td>
<td>$60,989</td>
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<tr>
<td>PHY</td>
<td>1,023</td>
<td>396</td>
<td>39%</td>
<td>6.65</td>
<td>2.84</td>
<td>$116,621</td>
</tr>
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<td>$150,000</td>
</tr>
<tr>
<td>DBI</td>
<td>993</td>
<td>288</td>
<td>29%</td>
<td>5.95</td>
<td>2.57</td>
<td>$110,859</td>
</tr>
<tr>
<td>DEB</td>
<td>1,525</td>
<td>459</td>
<td>30%</td>
<td>4.68</td>
<td>2.60</td>
<td>$81,372</td>
</tr>
<tr>
<td>EF</td>
<td>239</td>
<td>57</td>
<td>24%</td>
<td>6.68</td>
<td>2.28</td>
<td>$149,897</td>
</tr>
<tr>
<td>IOS</td>
<td>1,061</td>
<td>383</td>
<td>36%</td>
<td>6.10</td>
<td>2.93</td>
<td>$175,578</td>
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<tr>
<td>MCB</td>
<td>1,304</td>
<td>195</td>
<td>15%</td>
<td>5.00</td>
<td>3.04</td>
<td>$187,948</td>
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</table>
Types of Grants

- Single investigator projects;

- Multi-investigator projects within a particular institution or across institutions (in US and international);

- Instrumentation grants (no support for personnel or supplies);

- Proposals for large research centers (e.g. Materials Research Science & Engineering Center, Nanoscience Science & Engineering Center, Physics Frontiers Center);

- Research/training grants to support students (e.g. NSF-IGERT, Dept. of Education, etc.)
Agencies: the Big Ones

• National Science Foundation

• National Institutes of Health

• Department of Energy & ARPA-E

• NASA


• Department of Education
Some general comments

- NSF, DOE, NIH awards: extensively rely on peer review;

- DOD awards: expert reviews are used as additional criteria for decisions, but program officer has key influence on final decision; so: networking with program officers is crucial!
Other sources of funding

• Several opportunities for new faculty (often restricted to 3-5 years beyond PhD);

• See Eberly College of Science website for comprehensive list: NSF CAREER award, Packard Foundation Fellowship, Sloan Foundation Fellowship, Cottrell Scholars (Research Corporation), Beckmann Foundation, etc.

• All these typically rely on your references and your earlier record.
The well-crafted proposal:

- Presents an innovative scientific idea;
- Explains why this project would make an important difference in the state of knowledge in a particular field;
- Establishes why the investigator is the right person for the project;
- Has a proposal summary (abstract) that succinctly summarizes the key ideas in the project and that is readily understood by a non-expert scientist;
- The PI’s central plans can be readily extracted from glancing through it.

Look at the proposal from the perspective of the reviewer.
Items to include

• Cover all the relevant literature—references usually don’t count toward page limits (Professor X will be annoyed if you have not cited her work);

• Identify possible criticisms and preempt them;

• Check particular agency’s requirements: e.g. NSF requires that you address both “intellectual merit” and “broader impact”; DOD agencies require that you address relevance to DOD mission;

• Use illustrations (figures) where possible to convey ideas.

• An non-expert should be able to understand the proposal. An expert should be able to judge whether it will work.
What to avoid!

• Ideas aimed at incremental advances in a field;

• Too many dense, technical details (this is NOT a scientific article!)

• Sloppy presentation (unclear figures, typos, grammatically incorrect language, etc.)

• Vague and meaningless statements: e.g. “novel routes towards new technology.”

• Plagiarism -- may seem obvious but you would be surprised...
Plagiarism: case study 1

Proposal Intro (not Samarth)

The miniaturization of semiconductor electronic devices is rapidly approaching chip features smaller than 70 nanometers, leading device engineers and physicists to face the challenges of quantum mechanics where electrons behave like waves. This offers us an unprecedented opportunity to define a radically new class of device that would exploit the peculiar properties of the quantum world to improve the performance of existing information technologies. One such peculiarity is a quantum property of the electron known as spin, which is closely related to magnetism. Devices that rely on an electron’s spin to perform their functions form the foundation of spintronics (“spin-based electronics”), also known as magnetoelectronics. Information-processing technology has thus far relied on purely charge-based devices—ranging from the vacuum tube to today’s complex microchips. Those conventional electronic devices move electric charges around but ignore the spin. In this proposal, we describe plans for experiments that make important new advances towards the realization one such spintronic device known as the “spin transistor.”

As rapid progress in the miniaturization of semiconductor electronic devices leads toward chip features smaller than 100 nanometers in size, device engineers and physicists are inevitably faced with the looming presence of quantum mechanics—that counterintuitive and sometimes mysterious realm of physics wherein wavelike properties dominate the behavior of electrons. Pragmatists in the semiconductor device world are busy conjuring up ingenious ways to avoid the quantum world by redesigning the semiconductor chip within the context of “classical” electronics [see “A Vertical Leap for Microchips,” by Thomas H. Lee; Scientific American, January]. Yet some of us believe that we are being offered an unprecedented opportunity to define a radically new class of device that would exploit the idiosyncrasies of the quantum world to provide unique advantages over existing information technologies. One such idiosyncrasy is a quantum property of the electron known as spin, which is closely related to magnetism. Devices that rely on an electron’s spin to perform their functions form the foundation of spintronics (short for spin-based electronics), also known as magnetoelectronics. Information-processing technology has thus far relied on purely charge-based devices—ranging from the now quaint vacuum tube to today’s million-transistor microchips. Those conventional electronic devices move electric charges around, ignoring the spin that tags along for the ride on each electron.
Plagiarism: case study 2

Graphic in a proposal:

• Proposal idea: carry out experiment done by Lou et al but in different system.
• Lou et al paper is cited in proposal.
• Caption to graphic in proposal: “Schematic diagram of the device for spin transport in a semiconductor.” (Does not cite source of graphic.)

Source graphic: [Lou et al, Nature Physics, (2007)]

Discussion: Is this plagiarism? Is it unethical? Does it matter? What would be your reaction as a reviewer? (Also based upon a true incident.)
Typical proposal outline

• Abstract (or executive summary)
• Project description
  • Introduction
  • Results from prior support (if any)
  • Proposed work (including technical aspects + broader impact)
  • References
• Supporting material
  • CVs of personnel (usually 2 pages): format varies, pay attention to requirements
  • Facilities (departmental + central)
  • Budget
  • Current & pending support (list all currently funded projects and submitted proposals)
  • Letters from collaborators (not investigators on proposal, not supporters)
“Broader impact” (NSF)

- Advance discovery and understanding while promoting teaching, training, and learning (e.g. training of graduate students, mentoring postdoctoral researchers and junior faculty, involving undergraduates in research experiences, and training, professional development of K-12 math & science teachers).

- Broaden participation of under-represented groups (recruitment of students, partnering with relevant institutions).

- Enhance infrastructure for research and education (e.g. collaborations with researchers in industry and government laboratories, partnerships with international academic institutions and organizations, building networks of U.S. colleges and universities.)

- Broaden dissemination to enhance scientific and technological understanding, (e.g. presenting results of research and education projects in formats useful to students, scientists and engineers, members of Congress, teachers, and the general public.)

- Benefits to society (e.g. research and education projects applied to other fields of science and technology to create startup companies, to improve commercial technology, to inform public policy, and to enhance national security.)
Some annoying details (Sponsored Projects offices can provide a LOT of help)

- Milestones: some agencies (DOE, DOD) require the identification of key milestones -- often contrary to the serendipitous nature of creative science!

- Budgets -- key items:
  - Personnel salaries & fringe benefits;
  - Operating expenses & equipment;
  - Travel expenses;
  - Publication expenses;
  - Overhead! (40% - 60%)
Example Budget (rough)

- 1/2 time RA (grad student) for 12 months: $24000
- Principal investigator summer salary: $6000
- Fringe & benefits: $5600
- Materials/supplies: $20000
- Computing needs (software/hardware) $5000
- Central facilities (e.g. nanofab, TEM) $12000
- Travel (for PI + student) $8000
- Publication charges $1500
- Communications & photocopying $500
- Overhead (57% of total above) $40000
- Tuition (post-comps): $5000
- Capital equipment (cost > $5000) $7000
Useful Resources

- National Science Foundation Guide to Writing Proposals

- National Institutes of Health Grant Tutorial