

PHYSICS of INFORMATION

An international request for proposals for research and outreach projects on the physics of information from the Foundational Questions Institute.

Grant Timeline:

October 15, 2012	Physics of Information RFP is released
January 16, 2013	Initial Proposals due
April 30, 2013	Full Proposals (invite only) due
August 2013	Grant Recommendations are publicly announced; FQXi Fund conducts due diligence on grants
September 1, 2013	Grants disbursed; Grant period starts
August 31, 2014	End date for one-year Grants
August 31, 2015	End date for multi-year Grants (no extensions beyond this date)



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I. BACKGROUND ON FQXi

The Foundational Questions Institute (FQXi) is an independent, philanthropically funded grant-awarding non-profit organization. Since 2006, FQXi has recommended over \$7.6 million in grants to researchers and outreach specialists, within the US and internationally, focused on foundational questions. A listing of our previous grantees can be found here, <http://fqxi.org/grants>.

Our mission is to catalyze, support, and disseminate research on questions at the foundations of physics and cosmology, particularly new frontiers and innovative ideas integral to a deep understanding of reality, but unlikely to be supported by conventional funding sources.

FQXi offers grants that serve a three-fold purpose:

- To encourage and support rigorous, innovative, and influential scientific research and collaborations on foundational questions in physics and cosmology, which may have significant and broad implications for a deep understanding of reality;
- To redress incrementalism in research programming by establishing or expanding new ‘islands’ of understanding via flexible funding of high-risk, high-reward research in these areas;
- To provide the public with a deeper understanding of known and future discoveries in these areas, and their potential implications for our worldview.

In support of these goals, FQXi will offer grants of varying value to exceptional and rigorous scientific research proposals that meet the criteria described below.

II. FOCUS ON THE PHYSICS OF INFORMATION

FQXi’s programming encompasses both ‘open’ requests for proposals and more targeted programs in particular areas of thought. The current request for proposals targets research regarding “Physics of Information”.

The past century in fundamental physics has shown a steady progression away from thinking about physics, at its deepest level, as a description of material objects and their interactions, and towards physics as a description of the evolution of information about and in the physical world. It has become clear that information lies at the heart of statistical mechanics (and thermodynamics), quantum mechanics, and even general relativity. In turn, deep analysis of these physical theories has led to significant advances in thinking about information.

Moreover, recent years have shown an explosion of research interest at the nexus of physics and information, driven by the “information age” in which we live, and more importantly by developments in quantum information theory and computer science. These studies, however, tend to focus on practical applications and fundamental theory but not *foundational* questions. Moreover, it is often unclear

whether different researchers are even talking about the same fundamental entities, or what the relations are between them.

FQXi requests proposals for rigorous research on the Physics of Information both in physics and also in related fields including cosmology, astrophysics, mathematics, computer science, complex systems, biology, and neuroscience. Funded research will address this gap between research and technological progress on information science on one side, and active study of the true physical nature of information on the other. It will also, by bringing together the community in a focused and intense effort, seek to help develop a common understanding of the different types of information and the roles they play. Most importantly, the research supported by this program should have significant implications for our understanding of the major questions across many scientific disciplines, and address the deep or ‘ultimate’ nature of reality.

III. EVALUATION CRITERIA & PROJECT ELIGIBILITY

In our 2013 competition, grants totaling about \$3.0M will be available to researchers in academic and other non-profit institutions worldwide for projects up to two years in duration. The timeline for all grants awarded will be September 1, 2013 to August 31, 2014 (for one-year grants) or August 31, 2015 (for two-year grants). Grant applications will be subject to a competitive process of external and confidential expert peer review similar to that employed by all major U.S. scientific funding agencies.

Proposals will be evaluated according to their **relevance** and **impact**.

Relevance: Proposals should be topical, foundational, and unconventional.

- **Topical:** This RFP is limited to research in physics (mainly quantum physics, high energy ‘fundamental’ physics, and gravity), cosmology (mainly of the early universe) and closely related fields (such as biophysics, complexity theory, computer science, etc.). Research should bear upon the Physics of Information. Appropriate research topics in this category will address questions such as (a longer list of questions is given in Appendix B):
 - What is the relationship between information and reality? Can information exist without any “material” substance? Can matter exist without any information? Or, are information and reality two sides of the same coin?
 - How does nature (the universe and things therein) process information? Are there fundamental limits? How is nature shaped and transformed by processing information?
 - What are the fundamental differences between classical and quantum information?
 - What can the physics of information reveal about black holes, singularities, physics at the Planck length, and the origins and fate of our universe?
- **Foundational:** This RFP is limited to research with potentially significant and broad implications for our understanding of the deep or “ultimate” nature of reality.
- **Unconventional:** This RFP is intended to fill a gap, not a shortfall, in conventional funding. We wish to enable research that, because of its speculative, non-mainstream, or high-risk nature,

would otherwise go unperformed due to lack of available monies. Thus, although there will be inevitable overlaps, an otherwise scientifically rigorous proposal that is a good candidate for an FQXi grant will generally *not* be a good candidate for funding by the NSF, DOE, etc. – and vice versa.

Impact: Proposals will be rated according to their expected scientific impact per dollar, taking all relevant factors into account, such as:

- Intrinsic intellectual merit, scientific rigor and originality
- Potential for significant contribution to basic science relevant to the topic and a high *product* of likelihood for success and importance if successful (i.e., high-risk research can be supported as long as the potential payoff is also very high)
- The likelihood of the research opening fruitful *new* lines of scientific inquiry
- The feasibility of the research in the given time frame
- The qualifications of the Principal Investigator and team with respect to the proposed topic
- The part a grant may play in career development
- Cost effectiveness: Tight budgeting is encouraged in order to maximize the research impact of the project as a whole, with emphasis on scientific return per dollar rather than per proposal
- Potential to impact the greater scientific community as well as the general public via effective outreach and dissemination of the research results

Because of the unconventional nature of the FQXi mission, we encourage part-time work (15% to 40%), in parallel with the scientist's usual research, rather than full-time appointments or studentships. Acceptable uses of grant funds include:

- Student or postdoctoral salary and benefits for part of the academic year
- Summer salary and teaching buyout for academics
- Support for specific projects during sabbaticals
- Assistance in writing or publishing books
- Modest allowance for justifiable lab equipment, computers, publication charges, and other supplies
- Modest travel allowance
- Experimental equipment (Keep in mind that while FQXi is very interested in experimental proposals, the total available funding means that funding for large equipment purchases will be unlikely.)
- Development of large workshops, conferences, or lecture series for professionals (Note that small programs of this type, and others costing less than US \$15K, are best supported by an FQXi Mini-Grant. Mini-Grant applications, however, are restricted to FQXi Members.)
- Development of outreach or educational programs for laypeople that disseminate knowledge regarding foundational questions in physics and cosmology (The impact criterion, in this case, will be judged primarily on the proposal's ability to disseminate knowledge rather than primarily on the development of knowledge.)
- Overhead of at most 15% (Please note if this is an issue with your institute, you can contact FQXi, mail@fqxi.org, to learn about other organizations that can help administer FQXi grants.)

IV. APPLICATION PROCESS

Applications will be accepted electronically through a standard form on our website, fqxi.org, and evaluated in a two-part process, as follows:

Initial Proposal – DUE January 16, 2013 – Must include:

- A 300 - 500 word summary of the project, explicitly addressing why it is topical, foundational and unconventional
- A draft budget description not exceeding 200 words, including an approximate total cost over the life of the award and explanation of how funds would be spent
- A Curriculum Vitae for the Principal Investigator, which MUST be in PDF format, including:
 - Education and employment history
 - A list of references of up to five previous publications relevant to the proposed research and up to five additional representative publications
 - Full publication list

A review panel assembled by FQXi will screen each Initial Proposal according to the criteria in Section III. Based on their assessment, the Principal Investigator (PI) may be invited to submit a Full Proposal, on or about March 1, 2013, perhaps with feedback from FQXi on improving the proposal. Please keep in mind that however positive FQXi may be about a proposal at any stage, it may still be turned down for funding after full peer review.

Full Proposal – DUE April 30, 2013 – Must include:

- Cover sheet
- A 200 word project abstract, suitable for publication in an academic journal
- A project summary not exceeding 200 words, explaining the work and its significance to laypeople
- A detailed description of the proposed activities, not to exceed 15 single-spaced 11-point pages, including a short statement of how the application fits into the applicant's present research program, and a description of how the results might be communicated to the wider scientific community and general public
- A detailed budget over the life of the award, with justification and utilization distribution (preferably drafted by your institution's grant officer or equivalent)
- A list, for all project senior personnel, of all present and pending financial support, including project name, funding source, dates, amount, and status (current or pending)
- Evidence of tax-exempt status of grantee institution
- Names of 3 recommended referees
- Curriculum Vitae for all project senior personnel, including:
 - Education and employment history

- A list of references of up to five previous publications relevant to the proposed research, and up to five additional representative publications
- Full publication list
- For past awardees only: A 250-word statement explaining what was done with previous funding and how that ties in to the current proposal (if at all)

Completed Full Proposals will undergo a competitive process of external and confidential expert peer review, evaluated according to the criteria described in Section III. A review panel of scientists in the relevant fields will be convened to produce a final rank ordering of the proposals, which will determine the grant winners, and make budgetary adjustments if necessary. Public award recommendations will be made on or about August 1, 2013.

V. FUNDING PROCESS

FQXi will direct these grants through a Donor Advised Fund (DAF) at the Silicon Valley Community Foundation. FQXi will solicit and review grant applications, and on the basis of these reviews, FQXi will advise the DAF on what grants to make. After grants have been made by the DAF, FQXi will work with the DAF to monitor the grantee's performance via grant reports. In this way, researchers will continue to interact with FQXi, while the DAF interacts mostly with their institutes' administrative or grants management offices.

Funds for this RFP were made possible through a grant from the John Templeton Foundation.

APPENDIX A. FREQUENTLY ASKED QUESTIONS

Does FQXi have a preferred philosophical or scientific agenda?

No. We are equally interested in all proposals with great promise and talent falling within the FQXi purview and the parameters of the request for proposals.

Who is eligible for grants?

Researchers and outreach specialists working in academic and other non-profit institutions are eligible. Grant awards are sent to the PI's institute and the institute's administration is responsible for disbursing the awards to the PI. When submitting your application, please make sure to list the appropriate grant administrator that we should contact at your institute. If you are not affiliated with an institute, there are many organizations that will help administer your grant. If you need suggestions, please contact mail@fqxi.org.

Can researchers from outside the U.S. apply?

Yes, applications will be welcomed from any country. The US Government imposes restrictions on the types of organizations to which US nonprofits (such as FQXi) can give grants. Given this, if you are awarded a grant, your institution must a) prove their equivalency to a non-profit institution by providing the institute's establishing law or charter, list of key staff and board members, and a signed affidavit for

public universities and, b) comply with the U.S. Patriot Act. Please note that this is included to provide information about the equivalency determination process that will take place if you are awarded a grant. If there are any issues with your granting institution proving its equivalency, FQXi can help provide a list of organizations that can act as a go-between to administer the grant. More detail about international grant compliance is available on our website: http://fqxi.org/misc/International_Grants. Please contact mail@fqxi.org if you have any questions about whether your institution is eligible, to get a list of organizations that can help administer your grant, or if you want to review the affidavit that public universities must fill out.

Can I submit an application in a language other than English?

All proposals must be in English. Since our grant program has an international focus, we will not penalize applications by people who do not speak English as their first language. We will encourage the review panel to be accommodating of language differences when reviewing applications. All applications must be coherent.

How and when do we apply?

Apply online at fqxi.org. Please submit an Initial Proposal by January 16, 2013. After screening, you may then be invited to submit a Full Proposal, due April 30, 2013. Please see Section IV for more information.

Does FQXi provide grant extensions?

Please note that FQXi has aimed to be accommodating with grant extensions in the past, but for this grant program we are not able to do so beyond August 31, 2015. Please ensure that you can complete the research or outreach project you plan to apply for within the following period, start date September 1, 2013 and final date August 31, 2014 or August 31, 2015 depending on whether the grant is for one or two years. FQXi will require all unused grant funds to be returned after this date.

What kinds of programs and requests are eligible for funding?

- Student or postdoctoral salary and benefits for part of the academic year
- Summer salary and teaching buyout for academics
- Support for specific projects during sabbaticals
- Assistance in writing or publishing books
- Modest allowance for computer equipment, publication charges, or supplies, provided that these items are clearly justified in the proposal
- Experimental equipment (Keep in mind that while FQXi is very interested in experimental proposals, the total available funding means that funding for large equipment purchases will be unlikely.)
- Modest travel allowance
- Development of large workshops, conferences, or lecture series (Note that small programs of this type, and others costing less than US \$15K, are best supported by an FQXi Mini-Grant. Mini-Grant applications, however, are restricted to FQXi Members.)
- Development of outreach or educational programs for laypeople that disseminate knowledge regarding foundational questions in physics and cosmology (The impact criterion, in this case, will be judged on the proposal's ability to disseminate knowledge rather than develop it.)

- Overhead of at most 15% (Please note if this is an issue with your institute, you can contact FQXi, mail@fqxi.org, to learn about other organizations that can help administer FQXi grants.)

What is your policy on overhead?

The highest allowed overhead rate is 15%. (As mentioned before, if this is an issue with your institute, you can contact FQXi, mail@fqxi.org, to learn about other organizations that can help administer FQXi grants.)

How will proposals be judged?

After screening of the Initial Proposal, applicants may be asked to submit a Full Proposal. All Full Proposals will undergo a competitive process of external and confidential expert peer review. An expert panel will evaluate and rank the reviews according to the criteria described in Section III.

Can you give me any guidance on my research proposal, and on whether or not our project fits within the funding vision?

Please see Appendix B below for example topics that appropriate research proposals will tackle. Occasionally, FQXi may provide feedback on Initial Proposals invited for a Full Proposal, and also limited advice during the preparation of the Full Proposal. Please keep in mind that however positive FQXi may be about a proposal at any stage, it may still be turned down for funding after peer review.

Can I submit multiple proposals?

We will consider multiple Initial Proposals from the same PI; however, we will invite at most one Full Proposal from each PI or closely associated group of applicants.

What if I am unable to submit my application electronically?

Only applications submitted through the form on our website are accepted. If you encounter problems, please contact mail@fqxi.org.

Is there a maximum amount of money for which we can apply?

No. You may apply for as much money as you think is necessary to achieve your goals. However, you should carefully justify your proposed expenditure. Keep in mind that projects will be assessed on potential impact per dollar requested; an inappropriately high budget may harm the proposal's prospects, effectively pricing it out of the market. Referees are authorized to suggest budget adjustments.

What will an average award be?

We expect that research awards will typically be in the range of \$50,000-\$150,000 total over the life of the award (usually one to two years), with outreach awards substantially smaller.

What are the reporting requirements?

Grantees will be asked to submit annual grant renewal applications consisting of narrative and financial reports. Renewal of multi-year grants will be contingent on satisfactory demonstration in these applications that the supported research is progressing appropriately, and continues to be consistent with the spirit of the original proposal. Grantees will also submit a final report within one month of the awarded grant's end date.

What are FQXi “Mini-Grants”?

FQXi has initiated an on-going program to fund small projects (approximately US\$1-\$15K) by FQXi Members only. See fqxi.org/grants/mini/intro for details.

What are the qualifications for a Principal Investigator?

Since this is a program run by researchers for researchers, FQXi may be a bit more flexible than traditional funding agencies in the definition of a Principal Investigator; thus, we may accept applications from postdoctoral fellows as the PI or a co-investigator if his/her institution allows this. Should a postdoctoral fellow be invited to submit a Full Proposal, s/he must obtain co-signatures on the proposal from the department head, as well as a department host with a post extending the duration of the grant.

My colleague(s) and I would like to apply as co-PIs. Can we do this?

Yes. For administrative purposes, however, please select a primary contact for the life of the award. The primary contact, which must be a Principal Investigator, will be the reference for your application(s) and all future correspondence, documents, etc.

Can you fund PhD student research assistantships?

Yes. However, because of the unconventional nature of the FQXi mission, full-time student support is discouraged. Potential students cannot directly apply for a studentship.

Will the grants pay for laboratory expenses?

Yes, however due to budgetary limitations FQXi cannot fund capital-intensive equipment. Also, laboratory expenses must be clearly required by the proposed research, which must clearly fulfill the ‘foundational’ relevance criterion.

I have a proposal for my usual, relatively mainstream research program that I may be able to neatly repackage as an appropriate proposal for FQXi. Sound OK?

FQXi is very sensitive to the problem of “fishing for money”—that is, the re-casting of an existing research program to make it appear to fit the overall thematic nature of this Request For Proposals. Such proposals will not be funded, nor renewed if funded initially.

APPENDIX B: QUESTIONS THAT MIGHT BE ADDRESSED BY SUCCESSFUL PROPOSALS

To aid prospective applicants in determining whether a project is appropriate for FQXi, we include here lists of questions and topics that make suitable targets for research funded under this program. The lists are very far from exhaustive—we are sure there are many more questions out there and these should be taken as an illustration rather than guide as to what questions are appropriate. The topics of previous awardees give further examples, albeit under different topical concentrations; these can be found online at fqxi.org/grants/large/awardees/list.

Example questions particular to the Physics of Information include, but are not limited to (Note that proposals on these subjects are likely to be topical, but proposals also must be sufficiently **foundational** and **unconventional**):

- What IS information? What is its relation to “Reality”?
 - What sorts of information are definable and useful? What are the relations between them?
 - What is the physical foundation of information? Are information and reality two sides of the same coin?
 - Is some information principle prior to (or more fundamental than) the laws of physics? Or, are the laws of physics necessary to have information processing?
 - Is information an emergent feature of the deeper laws and structure of the world, or is the macroscopic world emergent from information?
- How does nature (the universe and things therein) “store” and “process” information?
 - Are there fundamental limits to information storage and processing?
 - What new perspectives can *quantum* information storage and processing give us?
 - What is the connection between information and probability?
 - How is nature shaped and transformed by processing information? How do physical, chemical, biological, or “mental” systems process information?
 - In isolated systems, is the total “amount” of information always preserved? Or is there a Second Law of information? If so, how does this law relate to the Second Law of thermodynamics?
- How does understanding information help us understand physics, and vice-versa?
 - Is information “discrete”? How does a continuous or discrete description of a physical system relate to its information content and processing? Can information theory shed light on open “discrete” questions such as the nature of space?
 - What can information tell us about foundational questions in quantum mechanics, such as the true status of the wavefunction, or what exactly defines a quantum system?
 - What is the relationship between information and statistical and thermodynamic entropy? Can information tell us about the relationship between these entropies?
 - Is there a role for information physics in the study of quantum gravity? What might information-theoretic reasoning reveal about black holes, the universe before the Big Bang, or physics at the Planck scale?