# A COMPREHENSIVE BIBLIOGRAPHY FOR SETI

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**Abstract**

A comprehensive bibliography for academic papers and other works published on the topic of SETI is motivated, created, and announced. The bibliography is made using the libraries functionality of the NASA Astrophysical Data System, allowing it to be publicly viewed and manipulated by any interested party. A criterion for what constitutes a SETI work is established to vet the citations in the bibliography, for our purposes defined as "any academic work which broadly: 1) advances knowledge within SETI, 2) deals with topics that are fundamentally related to or about SETI, or 3) is useful for the better understanding of SETI." Future work for the continued development and curation of the library is also discussed, which includes the creation of a SETI tag for future publications. Suggestions for additions in the case of new or missed works are welcomed and can be submitted to the author's email. The library can be found by following this link.

## 1 Introduction

The Search for Extraterrestrial Intelligence (SETI) has been a formal pursuit of generations of scientists stretching back to the mid-20th century. Although thousands of works have been published on the subject, it is difficult to see the complete volume of SETI works due to a lack of a definitive bibliography. The goal of this work is to deliver such a bibliography.

There are several key motivations for why such a bibliography for SETI is warranted and would be an important asset for the field. One reason is that it has been somewhat difficult to trace the field's historical development or natural progression of ideas, especially in the case of those ideas that were either not published in an academic journal or even at all. One example of this is the confusion surrounding the proper citation for the Drake Equation; often it is given an improper citation or no citation at all. The correct attribution for the equation was identified by Frank Drake in private correspondence to be an excerpt from a 1965 textbook published in the Oxford University Press entitled "The Radio Search for Intelligent Extraterrestrial Life". There is in fact no ADS entry for this citation, and hence no access to the ADS BibTeX citation generator. There is also a lack of uniformity in the jargon used by SETI practicioners. Having a complete bibliography would help authors better trace the emergence of specific terms and understand their context and meanings, which should foster an environment whereby a future consolidation of SETI lexicon is imaginable.

More broadly, some other arguments in favor of a bibliography include the following:

1. SETI has historically had a difficult struggle with public perception, especially at the legislative level. When politicians - with the ability to set budgets and allocate funding for scientific endeavors - have a gross misunderstanding of what SETI is, and even more so of the level of rigour and seriousness followed by its practitioners, the field is negatively impacted. This perception has resulted in the wholesale defunding of SETI-related research. Having a comprehensive bibliography would help to formalize the field and improve public perception, and reintroduce the possibility of funding.

2. For a field as small as SETI, it ought to not be difficult to keep tabs on all publications in an organized manner. The low publication rate and small overall literature volume is a unique advantage that SETI has over larger fields when it comes to cataloging.

3. A bibliography would complement the "Cosmic Haystack" of Jill Tarter, an approach to quantify the extent of searched parameter spaces, by providing a record of past observations.

4. In response to an establishment of a definitive criteria for SETI papers, the ADS may implement a SETI tag or keyword to streamline the process of classification for future publications.

5. Perhaps the most important utilitarian justification for the creation of such a repository would be that it would provide the SETI community with a streamlined way to generate BibTeX citations. Attribution is a fundamental and important part of the scientific process. Therefore, having an easy way to identify relevant citations and extract their bibliographic records for purposes of attribution promotes engagement with the literature and facilitates connections between or progressions of ideas.

No well-maintained and definitive compilation of SETI works that can be universally accessed by any interested party is yet in existence. Several attempts at partial compilations have been made, but none were exhaustive or easily accessible. In many instances, access was held privately and only available upon request from the maintainer. The lack of uniform formatting between compilations implies a difficulty with systematic, large scale entry manipulation. In spite of these shortcomings, they are a healthy place to begin development of an ADS library.

In § 2, I discuss the specific goals of this work, with emphases on the scale of the project and its intended outcomes. In § 2.1, I set the vetting criteria for papers or other citations to be considered viable additions to the bibliography. Then in § 3, I discuss the exact procedure that was undertaken to produce the bibliography. Lastly, in § 4, I reflect on what has been accomplished, what work still needs to be done, and conclude.

# 2 Goals

Before delving into the specific procedure that was undertaken, it is important to clarify the intentions of this effort. It should be noted that a bibliography which is both cross-disciplinary and comprehensive across all media is not feasible. Therefore, I have restricted the scale of this work to focus on only those academic works which are directly a part of SETI, according to a general criterion established later. The end product is a master SETI library hosted on the NASA ADS. The decision for this format was made based on the close relationship between SETI and traditional astronomy, which means that many SETI works already had entries in the ADS. Another reason is that publications to the arXiv system get linked with the ADS, meaning even those SETI papers which are not directly connected to astronomy can ultimately have entries in the ADS.

While in the process of amassing citations for consideration to the master library, other formats than traditional academic and peer-reviewed publications (which are nonetheless relevant to SETI) were frequently encountered and noted. Alongside these were also academic works not necessarily in the domain of the hard sciences but also on the SETI topic, such as the social ramifications of a first contact. While it is recognized that these works on the whole do belong with SETI, for purposes of uniformity it is suggested that a separate repository be created and maintained for them. Also, the ADS may not be the most appropriate place to create a library of social science SETI papers, since they are not well represented on the system.

Although the ADS and arXiv are both powerful and widely-reaching, they are not comprehensive. Some publications do not have a presence in those systems. Therefore another aspect of this project is to document as many such cases as possible, with the eventual goal of creating ADS entries for them.

An important side goal of this work is to develop an informal canon of SETI publications, or a repository of seminal works. The intention is that this list covers a broad range of topics in and surrounding SETI, which would give the interested reader a deep understanding of the field. This resource could then be used as the basis for the curriculum of a graduate course on SETI, the first of which was pioneered by Prof. Jason Wright of Penn State.

## 2.1 Criteria

An important question to tackle when attempting to construct a comprehensive bibliography is: "What constitutes a SETI paper or work?" There must be a rigorous selection criteria which allows for the decisive categorizing of works. Towards this end, Table. 1 lists some broad areas or classes of papers that were frequently encountered while processing the bibliography, separated into what is considered SETI and non-SETI by this library. Most obviously, those papers which discuss formal observational campaigns, apparati, and results are included. Importantly, null results are included, as they often demonstrate the level of scientific rigor involved in SETI, as well as contributing to the overall searched space. Papers which attempt to formalize or sharpen the Fermi Paradox, as well as those which offer solutions to it (many of which go

Table 1: Distinguishing SETI vs non-SETI

| SETI: | Non-SETI: |
|---|---|
| SETI observation papers and null results | Pure Astrobiology |
| Fermi Paradox and attempted solutions | Physics or General Radio Instrumentation |
| Artifact SETI theory and searches | UFOlogy/Crank Aliens/Pseudoscience |
| Meta-SETI | Sociology/Anthropology/Humanities Papers |
| Papers that made it to the Canon | |

by "[insert] hypothesis/scenario"), are also included. Artifact SETI is a branch of SETI which takes the approach of searching for evidence of the activity of extraterrestrial intelligent civilizations as opposed to their radio communications. As it is itw own subfield, Artifact SETI publications merit inclusion. Also to be included are those citations which deal with SETI on a "meta" level, namely those papers or other media about SETI as a field rather than on a topic within SETI. Those citations that made it to the informal canon but which were not already circumscribed by the other categories are added by default due to their pedagogical relevance. Based on these categories, the criterion for a citation to be included in the bibliography can be summarized as: "Any work which either: 1) advances knowledge within SETI, 2) deals with topics that are fundamentally related to or about SETI, or 3) is useful for the better understanding of SETI."

Those types of citations which were excluded include papers on what is dubbed "pure" astrobiology. Although SETI is fundamentally a part of astrobiology, the formal study of life in the universe, it is mostly concerned with the search for evidence of technological life, and hence technosignatures. (Generally speaking, SETI is concerned with the search for any form of intelligent life, but a non-technological intelligent species may not leave detectable traces.) Therefore, by this distinction, "pure" astrobiology encompasses all other works on life in the universe, on such topics as the abiogenesis or the search for alien biosignatures, and is excluded from a "pure" SETI bibliography.

Another class of paper frequently cited by SETI papers are papers from physics journals. SETI searches are grounded by their underlying physical soundness, which is often worked out in such texts. However, while they are certainly relevant for understanding the context of any given SETI approach, a general physics paper is not necessarily appropriate for inclusion to the bibliography. Similarly, papers describing general radio facilities or instruments which do not primarily serve SETI are likewise excluded, even if they have SETI time allotments on them.

As with many fields, SETI is not immune from an inflow of crank or quack papers. In fact, because of its subject matter, SETI is uniquely susceptible to them. While it is important to be inclusive of a variety of unconventional ideas, some carefully-considered limitations ought to be set on how deviant a paper can be from the traditional scientific approach. A handful of such citations were encountered that were therefore deemed inappropriate for inclusion in what is supposed to be a collection of scientific SETI papers. Moving forward, careful vigilance will be observed to guarantee the scientific authenticity and integrity of included works.

Lastly, as previously discussed, papers in the social sciences are not being incorporated into the ADS library at this time. Some other excluded styles of paper were those on post-biological evolution, animal communication, and speculative linguistics or reply construction.

All of the previously discussed constitute publications in the academic journals or at least on the arXiv. However, a variety of media types were encountered, including but not limited to papers, popular articles, books, book reviews, poster abstracts, talk or presentation abstracts, conference proceedings, private letters or correspondences, videos and video books, lecture slides, and even government documents. Many of the aforementioned media formats do not constitute academic works and thus ought to not belong in this compilation. Therefore, a second layer of criteria needs to be established to distinguish between academic and non-academic media, which can often times have blurred boundaries, as in the case of non-peer-reviewed works. For the purposes of this bibliography, only papers, books, and abstracts (which also obeyed the first criterion) were admitted without further consideration. While it may be beneficial to have repositories of popular articles or government documents, it may be difficult to track down every instance of a SETI-related work in that medium, and therefore should be relegated to a secondary, later project. While the bibliography

strives to be academic, due to the holistic nature of

# 3 Procedure

The foundation for the bibliography was set by Jason Wright, who constructed an ADS library based on a network of papers linked by citations. It included papers that were frequently cited by other SETI papers and originally had some ∼1900 vetting entries in it, some of which did not fit the inclusion criterion. The point of this was to put together an unrefined library of all potential SETI citation candidates, and only then later refine its constituents. To further build it up, a manual search of citations based on SETI-themed keywords appearing in title and body was conducted and a further several hundred candidates were added. For example, one of the kinds of searches done was for citations which contained any combination of the body keywords "extraterrestrial intelligence civilization" using the OR logic of the ADS search system. Another could be for titular keywords "Fermi paradox" using AND logic. A wide net was purposefully cast so as to be as inclusive as possible, and to catch those missed by the citation tree. Next, older compilations were folded in by going one by one through their lists of citations and adding them. The largest of these was a 227 page portable document format (pdf) file maintained by Stephane Dumas which contained records on papers, popular books, proceedings, reports, IAC conferences, special journal issues, a popular magazine, and miscellaneous meetings.[1]. Lastly, all entries maintained by the SETI.news website were added. In its most latest version, the unrefined, bulk list of candidate citations numbered 2343.

The next task was to vet and condense the library. The first step in this process was exporting all of the citations to a spreadsheet where they could be assigned a variety of disposition flags. A total of eight distinct dispositions were given to entries. Going one by one through the list of candidates and vetting them based on their title, all suspect citations were given the "check flag" disposition, coded as "1". Those with "check flag" meant that a decision could not be made based solely on the title, and hence would require a further inspection of their abstract. The list of "check flag" numbered 445. Those entries which repeat titles were assigned "2" for "duplicate". There were only a handful of these, and a decision was made to include the one which held the citation seniority. Those entries which were "broken" - in the sense that they did not transfer properly when migrating from the ADS to the spreadsheet - were assigned "4" for "broken entry" and revisited later to fix them. At this point, the abstracts of the 445 "check flag" entries were examined one by one and were further assigned "3" for "marked for removal", as in those which were deemed unsuitable for the Master Library, "5" for "examined, with no action taken", "6" for "examined and marked for addition" , "7" for "examined, but tentative" for inclusion to a list of tentative entries, and "8" for "examined and found to be missing an abstract." Of the 2343 original entries, 67 were lacking abstracts. Of the 445 checked, 303 were rejected, and 79 were marked as tentative. In each case a separate repository was created on the ADS for each flag type.

To summarize again, the disposition flags were: 1 = "check flag", 2 = "duplicate", 3 = "marked for removal", 4 = "broken entry", 5 = "examined, no action", 6 = "marked for addition", 7 = "examined, tentative", and 8 = "examined, no abstract". These disposition flags were used internally and are not meant for public use, but are included here for the posterior understanding of the development process.

As of the time of writing, the master library has 1795 entries.

# 4 Discussion and Future Work

Throughout this document, the term "comprehensive" has been used in lieu of a more precise meaning, which is to be "as complete as possible given the selection criteria". That is, this library strives to be as high fidelity a representation of the body of academic works published in SETI as is possible given the tools and resources available as well as the accepted selection criteria. Therefore, as far as capturing the most seminal publications, the bibliography should be considered definitive. However, in the case of more obscure works, the bibliography will not have perfect coverage, and it can be expected that some percentage slip through and are not added. That is why the bibliography will be continually updated as more citations are discovered, as well as why suggestions from the public are welcomed. In cases where an entry has been

[1] Due to the scale of some of these compilations, this task is still on-going.

missed or the bibliography is found to be out of date, we are open to receiving requests for additions to the library via email. Due to the ADS library being in private ownership, there is no direct way to append entries without permission. For now, this status should suffice in that would allow for all subsequent entries to be properly vetted before inclusion to the master list. A future goal would be to devise some interface where interested parties can follow the vetting guidelines and directly contribute their additions to the list, but that is a task for the future.

Other future work for this project include the completion of folding in previous compilations, the continued tab-keeping on SETI works from other non-ADS covered disciplines as well as media formats, and the continued integration of SETI.news publications as they are released. For popular articles, an online spreadsheet can be a starting point for documenting publications of that format. Importantly, there is the intent to collaborate in the future with librarians to create bibliographic entries using professional software for non-ADS entries. Similarly, the creation of ADS entries for those lacking an ADS presence is warranted, as in the case of the Drake Equation citation. A principal continued goal would be the petition for the creation of a SETI tag or keyword that can be used for quickly classifying new publications, given the criterion that was formalized in this document.

For the purposes of advertising and dissemination of this bibliography, a formal document will be submitted to a journal or at the very least an arXiv document which announces its existence. For the time being, the bibliography will be hosted on the course webpage for ASTRO 585 SETI at The Pennsylvania State University, where a popular summary of this work is also included. It will be continuously maintained and updated there. The library is directly linked to here. The author hopes that this bibliography will be a useful resource for current and future researchers in the field that fosters engagement with and utilization of the SETI literature.