

Title: Composing A Review Paper on "one type of superconducting circuit qubit, Flux qubit"
--Demonstrating one open, cross-platform, and scalable article organization and research scheme

project descriptions: Its objective is to compose a review paper on my selected topic "flux qubit" in PHYS 533. Based on at least 2 papers from the recent literature, the completed article should not only paraphrase them but emphasize my own understandings. To achieve this task, I aim to deeply explore the brilliant ideas presented by those articles for possibilities of developing my own ideas, convey a global view of this topic to readers, and also search for seamless connections between article organizations and daily research tasks. Research Strategies are presented as follows.

Step 1: Seeking "Entrance": Wikipedia and other introductory web pages and books in the shelves for intuitive understandings, key properties of flux qubit and active research groups.

I first search Wikipedia and other web sites to help me be fast involved with "flux qubit". Although with a strong theoretical background in it, the Wikipedia website shown in Fig. 1 still presents a good summary of flux qubit with intuitive images and discussions to convince newbies which is also what I want to learn from this project. More useful, it also presents links to active groups on this topic. In this case, I browse the website of one group in TU Delft, which shows basic configurations, realizations and measurements of flux qubit. More important is that they also highlight references to prestigious papers related to flux qubit as a practical entry to begin my research. In this step, I also read books to broaden my views on this topic, the details of which is omitted here.

The image is a screenshot of the Wikipedia article for "Flux qubit". The page layout includes a top navigation bar with "article", "discussion", "edit this page", and "history" tabs. On the right, there are links for "Try Beta" and "Log in / create account". The main content area starts with the title "Flux qubit" and a sub-header "From Wikipedia, the free encyclopedia". The introductory paragraph defines flux qubits as micro-metre sized loops of superconducting metal interrupted by Josephson junctions. It explains that the junction parameters are engineered during fabrication so that a persistent current will flow continuously when an external flux is applied. The computational basis states of the qubit are defined by the circulating currents which can flow either clockwise or counter-clockwise. These currents screen the applied flux limiting it to multiples of the flux quantum and give the qubit its name. When the applied flux through the loop area is close to a half integer number of flux quanta the two energy levels corresponding to the two directions of circulating current are brought close together and the loop may be operated as a Qubit. A second paragraph describes computational operations performed by pulsing the qubit with microwave frequency radiation which has an energy comparable to that of the gap between the energy of the two basis states. Properly selected frequencies can put the qubit into a quantum superposition of the two basis states, subsequent pulses can manipulate the probability weighting that qubit will be measured in either of the two basis states, thus performing a computational operation. To the right of the text is an SEM image of a 4-junction Flux Qubit Fabricated at Royal Holloway University of London. Below the main text is a "Contents" table of contents with links to "1 Fabrication", "2 Flux qubit parameters", "3 Readout", and "4 References". The "Fabrication" section begins with a paragraph explaining that like most mesoscopic devices such as solid state qubits, single-electron transistors, quantum dots, etc., flux qubits are fabricated using techniques similar to those used in the micro-electronics industry. The devices are made on silicon wafers using electron beam lithography and metallic thin film evaporation processes. To create the Josephson junction a technique known as shadow evaporation is normally used, this involves evaporating the source metal alternately at two angles through the lithography defined mask in the electron beam resist. This results in two overlapping layers of the superconducting metal, in between which a thin layer of insulator (normally aluminum oxide) is deposited. The "Flux qubit parameters" section starts with a paragraph explaining that the flux qubit is distinguished from other types of superconducting qubit such as the charge qubit or phase qubit by the coupling energy and charging energy of its junctions. In the charge qubit regime the charging energy of the junctions dominates the coupling energy, while in a flux qubit the situation is reversed and the coupling energy dominates. Typically in a flux qubit the coupling energy is 10-100 times greater than the charging energy. It is this ratio that allows the Cooper pairs to flow continuously around the loop, rather than tunnel discretely across the junctions as in a charge qubit. The "Readout" section begins with a paragraph explaining that like all quantum bits, Flux qubits require a suitably sensitive probe coupled to it in order to measure its state after a computation has been carried out. Such quantum probes should introduce as little back-action as possible onto the qubit during measurement. Ideally they should be decoupled during computation and then turned "on" for a short time during read-out. Read-out probes for flux qubits work by interacting with one of the qubit's macroscopic variables, such as the circulation current, the flux within the loop or the macroscopic phase of the superconductor.

Fig.1, Description of "flux qubit" in the [Wikipedia](#).



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Quantum computation with superconducting rings

In the "flux-qubit" team, we study mesoscopic superconducting circuits containing tunnel junctions in order to use them as building blocks for a quantum computer.

INTRODUCTION

Mesoscopic quantum systems

Our group studies mesoscopic circuits (typical size : 1 μm) in which a few superconducting islands are connected by tunnel junctions (see figure 1 as an example). A number of experiments have shown recently that the electrical variables of such a circuit - the charge on each island and the current flowing through the junctions - exhibit a quantum mechanical behavior when the sample is cooled at a sufficiently low temperature (about 30 mK). The charge and flux variables (the currents through the junctions are directly related to the magnetic flux threading the circuit) are *conjugate* : a Heisenberg-type uncertainty relationship was indeed experimentally demonstrated [1]. Incoherent tunneling of the flux variable through an energy barrier was also observed [2]. Microwave spectroscopy experiments performed on such structures show quantized energy levels [2], and it has even been possible to demonstrate coherent superpositions of these levels [3].

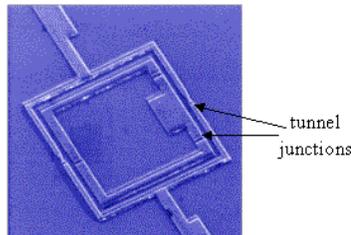


Fig.2, Website of one group in TU Delft working in flux qubit. The "[original link](#)" in Wikipedia is moved to a [new one](#).

Step 2: [Web of Science](#), a web reference website, coping with [Zotero](#), a local article database.

Web of Science almost possesses all of the articles published in the world. Yet, one big problem is how we spend limited time to track thousands of papers to do our own research. In my opinion, even illuminated by the citation mapping tool shown in fig. 3, this search engine only endows us informations of articles in static and non-interactive style, lacking a method to manipulate each article collected manually which can be provided by Zotero.

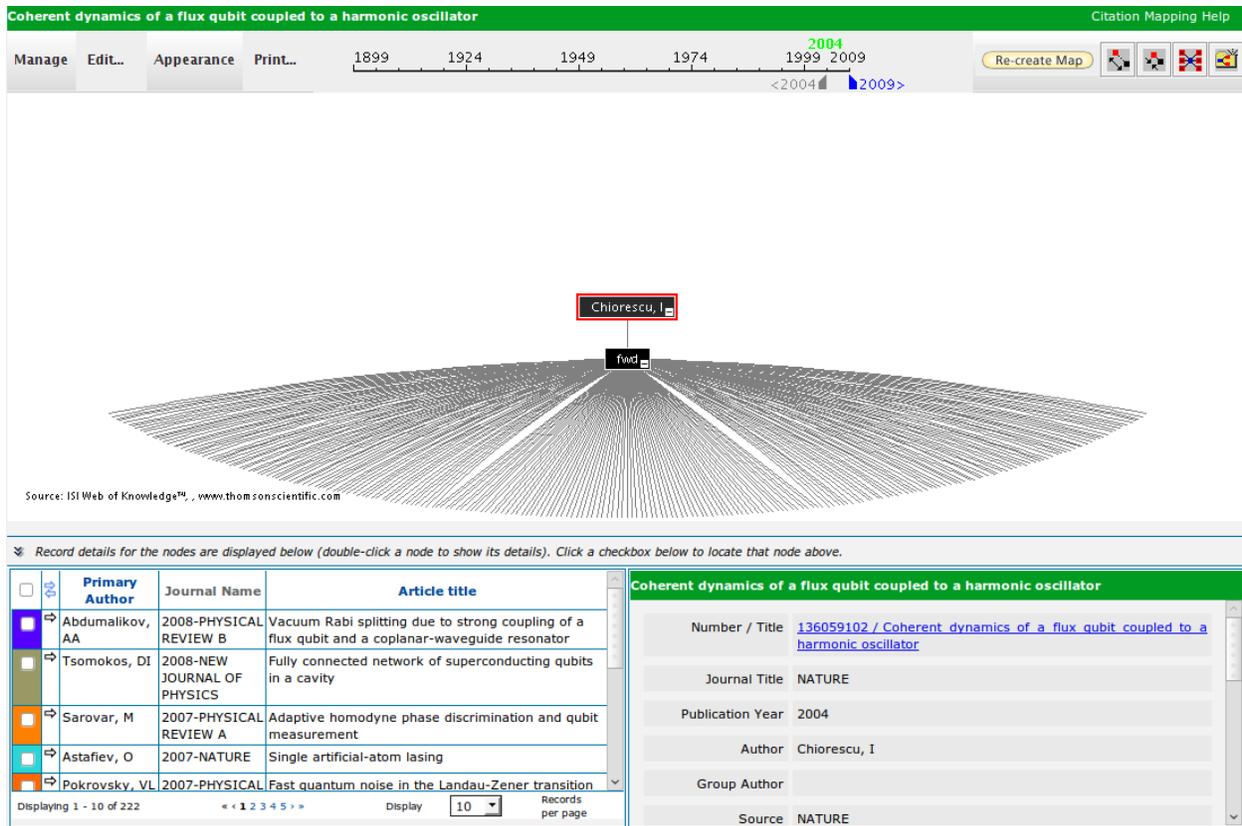


fig.3, Citation mapping tool in Web of Science

Zotero, as a local paper database, is based on [firefox](#), a cross-platform web browser. Besides noting or other useful tools, it provides one solution for me to treat one article as a unique entity in different contexts. Three categories "Groups", "Topics" and "Journals"("Magazine") shown in fig.4 are created to trace back "who" publish "what" in "which journal" for each article which only holds one copy of the corresponding ".pdf" file in the entire database. A tag "nano-final-term" selected by typing "nano-" indicates the related articles in "My Library" including web pages and articles. In Fig. 5, the category "Magazine:Science" with the tag "nano-final-term" demonstrates all of the papers published in this magazine. There should be a limited number of entities in one category; if one category holds too many articles, I always consider to break down it into several sub-categories because I find that I cannot dedicate myself into a large amount of items when one inspiration coming out forces me to search for some familiar articles. It is worth noting that unlike finding out items via typing key words this kind of "active" searching style coherent with our minds maintains a more efficient way to figure out the relationships between different articles. Therefore, the categories and tags evolve dynamically with my understanding of this topic, which solidate my knowledge and present more clear impressions of those articles in my brain.

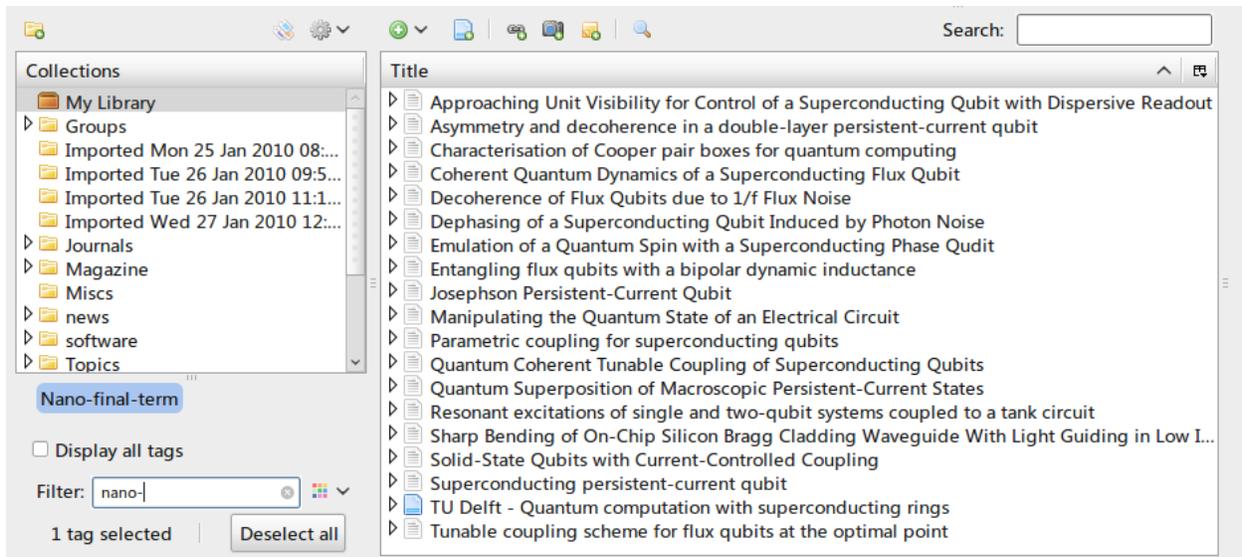


fig.4, Tags and Filters in Zotero.

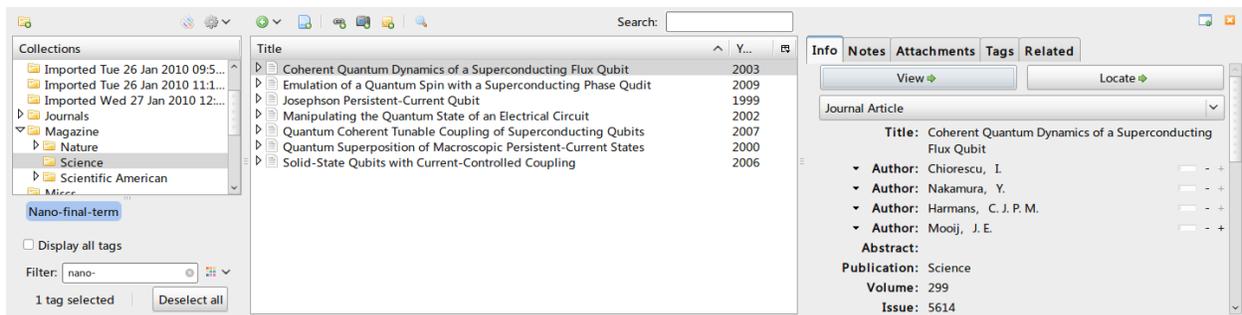
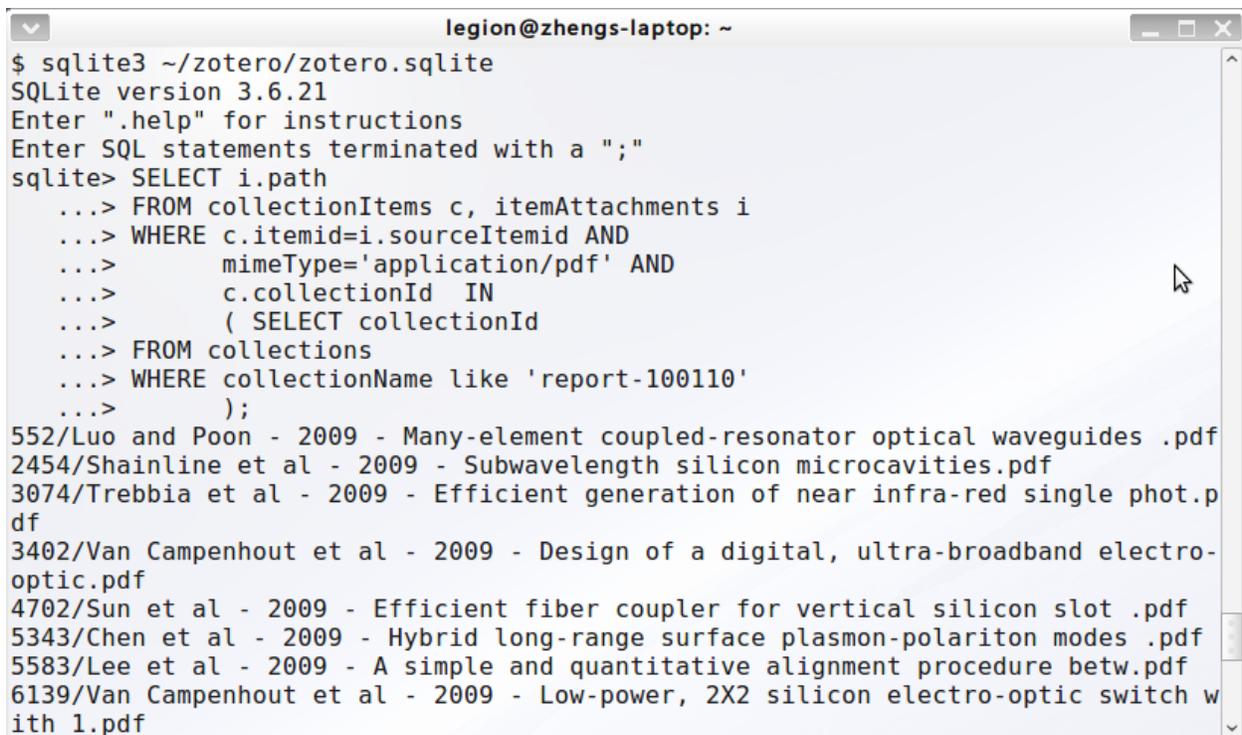


fig.5, Collections in Zotero

Zotero hosts a sqlite database (a handy but almost complete relational database) background to record all of the entities which I can write SQL scripts to interact with. It is demonstrated in fig. 6. Due to the efficiency of Sqlite3 database, Zotero is scalable for manipulating more than tens of thousands of articles which I think is enough for one person's research career. Cooperating with [Dropbox](#), a web service for file storage, I utilize the same Zotero in all of my Computers running different operating systems. Another well-known solution for organizing articles is to record articles with Endnote or other softwares, to save the contents of those files in one directory of one file-system and to search for useful informations via using google desktop. Yet, this solution is hard to be shared in different platforms. Another big problem is that users should be responsible for how one record in Endnote refers to its physical file in users' disks, which may totally mess up the article organization system sometimes.



```
legion@zhengs-laptop: ~
$ sqlite3 ~/zotero/zotero.sqlite
SQLite version 3.6.21
Enter ".help" for instructions
Enter SQL statements terminated with a ";"
sqlite> SELECT i.path
...> FROM collectionItems c, itemAttachments i
...> WHERE c.itemid=i.sourceItemId AND
...>       mimeType='application/pdf' AND
...>       c.collectionId IN
...>       ( SELECT collectionId
...> FROM collections
...> WHERE collectionName like 'report-100110'
...> );
552/Luo and Poon - 2009 - Many-element coupled-resonator optical waveguides .pdf
2454/Shainline et al - 2009 - Subwavelength silicon microcavities.pdf
3074/Trebbia et al - 2009 - Efficient generation of near infra-red single phot.p
df
3402/Van Campenhout et al - 2009 - Design of a digital, ultra-broadband electro-
optic.pdf
4702/Sun et al - 2009 - Efficient fiber coupler for vertical silicon slot .pdf
5343/Chen et al - 2009 - Hybrid long-range surface plasmon-polariton modes .pdf
5583/Lee et al - 2009 - A simple and quantitative alignment procedure betw.pdf
6139/Van Campenhout et al - 2009 - Low-power, 2X2 silicon electro-optic switch w
ith 1.pdf
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fig.6, Executing SQL inquiries to Zotero's sqlite3 database.

Here I only demonstrate some simple but practical ways of how to organize articles to complete this project. Further developments on Zotero may expand its functionalities such as smarter automatic collections.

Step 3: Link all of the informations and complete the task in the help of Zotero and a paper notebook.

Since Zotero provides dynamical tags/categories to organize the collected papers, reading, taking notes of and digest the related articles emerge. Originally I prefer mind mapping softwares, and highlighting words in the corresponding ".pdf" files. However, compared with the traditional paper-and-pen noting, the latter one renders a more convenient way for me and those writings can also be scanned and recorded in Zotero, although this project only cites less than 30 articles and no extra-intense note is required to help me figure out the relationships between different articles.

Summary:

Online searching from Wikipedia to Web of Science may be the main resources to obtain the informations of the related articles, and Zotero provides a cross-platform, scalable and interactive tool to help us develop our own ideas. Finally, writing and noting in papers still stands as the most convenient way to finish the final assignment in my opinion.

