How to Write a Dissertation or Diploma Thesis in Physics

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Abstract

This document primarily addresses students who work towards a degree with the department of Physics at the Free University of Berlin and who do their experimental or theoretical work at the Max Born Institute (http://www.mbi-berlin.de) under the supervision of the author. Since it is based on many years of experience with the difficulties students typically have when writing up their thesis, it may also be useful for other students and young scientists.

This brief introduction is on how to write a thesis (for a diploma, master, PhD degree - you name it). Although most candidates believe they know how to do this, practice shows that this is more often not the case. These hints are given to overcome typical difficulties and to avoid standard mistakes frequently made - even by more senior scientists. This document is thus meant to help in developing a truly professional own style and format for writing scientific work, including publications in scientific journals.

Note that this text is not on how to do the actual work. However, the first section gives some - hopefully - stimulating advice on how to start. Students often discover too late that things would have worked out for them much better if the had followed these suggestions from the very beginning.
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1 Some remarks on doing the work

Here only very few general suggestions and experiences are communicated which may turn out useful in the daily laboratory life of a graduate or undergraduate student. The instruction how to do scientific work as such is given in the daily practice of laboratory work by the group or project leader and by the supervising professor. Do not hesitate to ask him or her if you encounter any problems - even if he/she appears to be very busy: it is part of his/her job to help you. But be aware of one basic truth in scientific life: at the end of the day it is your own responsibility to work skillfully, efficiently and successfully and most things you accomplish will probably achieved through "learning by doing".

1.1 Scheduling the work

At the beginning of the work stands the definition of the goals and a good time schedule. This should be agreed upon with the group and/or project leader and has to be discussed and specified in detail with the supervising professor. A realistic formulation of goals and timing, as well as the definition of meaningful milestones and working procedures form the basis of success.

The examination regulations (Prüfungsordnung, Dissertationsordnung) and - well understood - good scientific practice for PhD theses define maximum durations from receiving the thesis theme to submission of the thesis. For diploma theses 12 months are a firm upper limit, while with a doctoral thesis we aim at a maximum of three years - more or less successfully so. Of course, if you manage to obtain a sufficient amount of brilliant results in a shorter time, you are highly welcome to finish much sooner.

Immediately after starting the work students are obliged to register with the examination office at the university. A second advisor/referee has to be found and potential requirements for attend classes, exercise, seminars and teaching labs etc. may be laid out by the chairperson of the committee in contact with the supervising professor.

Nevertheless, you should be aware of the basic and very important fact that science can be never planned accurately in advance - if it is supposed to be genuinely original. And it is only such work that truly counts. Often the most exciting discoveries are made, where in the beginning nobody would ever have expected them to occur. There is a nice English word for this: serendipity. And clearly, the diploma or graduate student has to be open for
unexpected routes of the work. The goals defined at the beginning as well as the schedule originally set up has thus to be "updated" continuously.

In particular, a PhD student must be highly alert to any unexpected development, be it the feasibility of achieving the originally defined goals or the general development of the scientific field as such. You have to ask yourself constantly questions such as: What are my competitors doing? Which new possibilities arise when unexpected results and new methods turn up (own ones or those of other groups)? Which of my goals have possibly been already reached and published by another group - thus potentially obliterating the need for further studies in a particular direction?

You have to bear in mind: each thesis must document a clear, own step of scientific progress, to be proven (as a rule) by publications in peer reviewed scientific journals. Each PhD student is finally responsible for himself in succeeding with this mandatory requirement - this is a responsibility which even the most diligent supervisor cannot take over from the concerned individual.

With a diploma thesis this may be seen somewhat relaxed: here success depends above all on the proven students ability to "work independently according to scientific methods and rules". Clearly, even for a diploma thesis it is particularly nice, if something really new and publishable "comes out".

1.2 Good scientific practice

At all times during the work for a diploma thesis or a PhD Dissertation attention has to be paid to good scientific practice (independently wether this work is done in the laboratory of the institute, at a guest institution abroad, at the PC at home or at a computer terminal). The Deutsche Forschungsgemeinschaft (DFG) has laid down firm rules which have to be obeyed. See also the links on the MBI Website:


The respective group or project leader has to make sure that these rules are strictly followed in the daily work in the lab. It is, however, first of all an obligation of each individual scientist, graduate and undergraduate student to meet the demands of good (international) scientific practice as explicitly spelled out formulated by the DFG.

Therefore a thorough reading of the DFG text is recommended! Here we refer in particular to the fundamental recommendation number 1. Good scientific practice requires:
• to work "lege artis" (i.e. according to the general rules of the field),

• to document results,

• to constantly be highly self critical about all results obtained,

• to observe strict honesty with respect to contributions from partners, competitors and predecessors,

• co-operation and responsible leadership within scientific working groups (recommendation 3),

• support and supervision of young scientists (recommendation 4)

• conservation and secure keeping of original data (recommendation 7)

• scientific publications (recommendation 11).

1.3 Data archiving, documentation of publications

Recommendation 7 of the DFG good scientific practise rules is of special importance: It demands the safe keeping of all relevant data for at least 10 years. At Max Born Institute this translates in:

• mandatory keeping or a fully page-numbered laboratory-log-book for each apparatus, experimental setup or theoretical project, which is the property of the institute to be kept by the department heads,

• archiving of all relevant data on CD-ROM with an appropriate table of contents, which is kept in the MBI-library with a copy in the secretaries office.

In the laboratory-log-book a reference to the number of the CD-ROM has to be too made in each case. As far as the data are the basis for publications, lectures or patents, the corresponding MBI-publication number has to be recorded on the CD-ROM.

At MBI all publications, lectures etc. have to be registered by the secretaries of the divisions EndNote data-bank. These data-base are centrally accessible at the MBI Net through \info\Bibliography\endnote and are named mbi-a.enl, .. mbi-b.enl etc.
The type of archiving of the data (type of data medium, location, date) has to be documented in the *EndNote* data-base as soon as the work is registered there. This information is stored in the field ”Notes” of the MBI *EndNote* data-base. Numbering of the CD ROM’s is to be done according to the MBI publication numbers.

1.4 Literature study and further training

Students (as well as more experienced scientists) often tend to forget the remainder of the world over the wonderful work which happens in the laboratory. Thus, it is strongly recommended that from the very beginning one should set aside a certain, well defined amount of time exclusively devoted to studying the relevant literature - i.e. the respective peer reviewed scientific journals and monographs. Take notes of your findings in the literature.

To keep track, it is important that you start from the very beginning with your own literature data-base. I strongly recommend to use the Windows-application *EndNote* for this purpose (until we change it to an even more powerful successor programme). *EndNote* is available through network licenses at the MBI - or even more convenient - on the MS-application servers.

*EndNote* requires relatively little effort to be learned and it helps you later on immensely - it is probably fair to say: to an extent you cannot possibly foresee at the beginning of your work. Thus, start using it immediately!

Your literature collection may/should become rather extensive. *EndNote* will help you to keep track of and control all the literature relevant for your thesis and possibly for your later scientific life. It allows you to sort and search the data for authors, topics, journals and what have you ... It also offers excellent tools to very conveniently, and flexibly reference the literature in any style required for reports, presentations, your own papers and finally for writing your thesis. To make this even more efficient, I strongly suggest that you obey a few simple rules so that you and your collaborators and everyone in your working environment can share literature data in the same, simple way:

- Use essential only one Master-*EndNote* data-base and keep an up to date copy of it on the central file server under \group\Bereich-A\literatur. There you will usually find already a folder for your field of research – otherwise create a new one. Deposit your data bank there and call
<your_name>_diss.enl – and allow other members of your group reading (but not writing) it.

- Use the unique labeling convention which is custom also in the MBI for unambiguous identification of a reference and enter these into the field "label" of the EndNote reference; for examples of the labeling method see the MBI research projects publication pages, e.g. at http://www.mbi-berlin.de/de/research/projects/2-03/publications/

- Use these labels also for storing pdf files if you want to keep a publication at hand on your PC or on the MBI-net \group\Bereich-A\literatur. Do not use cryptic acronyms for special papers which you want to find later again easily. Be assured that you will forget all these acronyms and their meaning within the shortest time after which your sophisticated system becomes just disturbing rubbish. In contrast, your single EndNote data-base with labeled references allows you to search for any attribute of a publication - author, keyword, title, journal etc. - and to identify the label within seconds - as well as the other way round.

- For the same reason, it is advisable to keep the stored publication you need for your thesis in one file directory. Do all the necessary sorting with the tools offered by EndNote Reference-Search. You may even link the references in the data-base to the files on your PC or on the MBI-net.

- Keep track of the literature in regular intervals. Today the internet makes this very easy and convenient. Almost all important journals are directly accessible through the MBI intranet http://intern.mbi-berlin.de/de/library-at-mbi/own-libr/online_journals.html.

- For entering data into your EndNote data-base there exists another very useful tool: ISI Web of Science http://isiknowledge.com/. It is the universal tool for searching the literature and for entering it into your EndNote data base. It also allows you to find out how important a paper is considered by your colleagues worldwide - by simply checking the "Times Cited" parameter. I recommend that you store along with other parameters such as authors, title, year, journal, volume, pages, abstract, key words, addresses of authors also this information (e.g. into
the field "Notes"). Altogether, this makes your EndNote data-base an extremely helpful tool in daily life throughout your whole thesis work.

- Use your one and only general EndNote data-base for all tasks and connections. Smaller subunits can easily be extracted for specific tasks - for a paper, a report, a presentation. And use the BibTeX styles provided by EndNote which allows you to create any BibTeX library needed for any specific task done in \LaTeX\ (see section 3). It takes only a few seconds to convert many hundreds and even thousands of references from EndNote into BibTeX format from which \LaTeX\ then generates your bibliographies automatically.

Beyond your immediate research interests, you should - on a regular basis - also be concerned with reading scientific publications of general interest. Look regularly into Physical Review Letters (PRL) [http://prl.aps.org/](http://prl.aps.org/), into Nature [http://www.nature.com/nature/current_issue](http://www.nature.com/nature/current_issue) and Science [http://www.sciencemag.org/current.dtl](http://www.sciencemag.org/current.dtl), in order to know what the "Hot Topics" presently are. You may also want to look on and off into more popular magazines such as Scientific American [http://www.sciam.com/](http://www.sciam.com/) or its German counterpart Bild der Wissenschaft [http://www.wissenschaft.de/wissen/](http://www.wissenschaft.de/wissen/) and of course as a scientist working in Germany and hopefully a member of the DPG, read regularly the Physik Journal [http://www.pro-physik.de/Phy/External/PhyH/](http://www.pro-physik.de/Phy/External/PhyH/) etc. in order to cultivate and maintain your general scientific background.

At the MBI we also have regular graduate students tea meetings [http://intern.mbi-berlin.de/de/events/seminars/sem_w/index.html](http://intern.mbi-berlin.de/de/events/seminars/sem_w/index.html) within division A, during which reports are given on current literature from the own and from neighbouring fields of research in an informal style with ample time for discussion and questions – a good exercise for later examinations and presentations such as the defense of a PhD thesis.

You should also attend the institute’s colloquium [http://www.mbi-berlin.de/en/events/colloquium/index.html](http://www.mbi-berlin.de/en/events/colloquium/index.html), the divisional seminars [http://www.mbi-berlin.de/en/events/seminars/sem_a/index.html](http://www.mbi-berlin.de/en/events/seminars/sem_a/index.html) and other seminars of relevance for special research areas (e.g. afternoons of the SFB 450 [http://www.physik.fu-berlin.de/~abtpeter/sfb450/welle.htm](http://www.physik.fu-berlin.de/~abtpeter/sfb450/welle.htm)).

All these activities will keep you mentally fit, well informed, and prevent you from becoming just a lab-mouse.
2 Actually writing the thesis text

2.1 General requirements

The written representation of your work must meet at least the following requirements:

1. It must be readable (with benefit) by a generally interested and educated physicist, even if he/she is not close to the subject of your work.

2. The thesis must be a concise and clearly structured documentation of
   - the scientific background of your work
   - the goals posed
   - the experimental and theoretical methods applied
   - the results and
   - their evaluation as well as
   - an appropriate summary.

3. It must contain all substantial information, which allows a following generation of undergraduates, graduate students and other coworkers to immediately continue the work.

4. Beyond that it must - at least in principle - put a third, expert person into such state that he/she can rebuild the experimental setup and reproduce thus your results unambiguously - and as far as relevant reconstruct the theoretical results accurately.

5. It must report all necessary information to allow its evaluation with clear criteria and free of doubts by an outside expert and critical reader (who must not necessarily be familiar with the details of this particular work): from which conditions of the research did the author proceed at the beginning of the work? Which experimental (if necessary theoretical or computational) starting conditions were given for the work presented now. Which own theoretical developments, programmes and experimental apparatus did the present author build up himself? Which assistance and aids did he have in doing so? Which specific results are the genuine work of the author.
6. One important aspect of the discussion of results must be to critically evaluate possible systematic and statistic errors and to assess the validity of the conclusions drawn. It must also become evident, which progress the field of research as a whole took during the duration of the work presented and how the undergraduate/graduate student values his/her own contribution to this evolution.

2.2 Some formal aspects

1. Such strong demands can only be met with the help of a very stringent and clear structure laid out at the beginning of the writing process. The most clear structuring is - to my taste at least - given by a rigorous "legal numbering" (1, 1.1, 1.1.1 etc.). It is good to know that \LaTeX{} does all this formatting business for you without any need to renumber things yourself at each iteration and so on. Of course, you have to start the process by an initial mental structuring process yourself! Thus I strongly recommend using \LaTeX{} for your thesis. Anything else (e.g. Word) is a pain in the neck when writing an elaborate scientific text with many graphics and formulas (see also section 3). I have provided a \LaTeX{} package (shell documents) for writing your thesis at http://staff.mbi-berlin.de/hertel/hinweise/texshell/texshell.zip.

2. Select meaningful, at the same time short chapter and section headings. Thus e.g. *Photoelectron spectra of water clusters* and not *Measurement and evaluation of the photoelectron spectra of water clusters in the molecular beam*.

3. Different types of information should - wherever possible - not be mixed. Rather, they should be communicated in separate sections or chapters such as:

- excerpts/summaries from the literature with a careful evaluation of the state of research
- genuine own contributions to the scientific discussion and possibly description of own theoretical derivations/models
- own methodical developments, pieces of apparatus constructed and/or built up by the author
own experimental and/or theoretical results (use as many sections/chapters as necessary to structure the bulk of your material).

These chapters must include:

- error critical discussions of the results and conclusions
- critical evaluations of own data and results
- comparisons with results and predictions of others, wherever possible in the context of each of theses complexes (preferentially through diagrams and/or tables when summarizing results - rather than by using text).

4. **Even a particular elusive reader should be able to quickly glean the most important** thoughts, experiments and results from just looking at illustrative schematics, diagrams, and pictures with self explaining, extensive figure captions.

5. There are always parts/chapters/sections of text which are complex and important for a full description and documentation of the work, but not absolutely necessary for following the main lines of thought. It is very helpful for the somewhat more interested, but temporally limited reader if such passages of text are correspondingly marked, e.g. by a brief introductory remark to such sections, or even by moving them into appendices.

6. Definitively each chapter and ideally also each section should begin with a short guide: what is communicated in the following text, which sources (quote clearly) have been used, what are the basic concepts used and which goals are to be reached. Similarly, at the end of larger elaborations a short synopsis of the communicated content should be offered.

### 2.3 Arrangement, structure and presentation

Start with developing a clear concept of what you want to communicate. What are your most important results? How can you present them in the
best light? What do you want to communicate about the general status of your field of research?

Aim at a thesis which is good to read! To those who subjugate themselves into the slavery of reading your work, it should generate the feeling that it is really worthwhile doing so. Do not write your thesis as a historical account of all the mischiefs that have occurred to you on a long tedious way! Do not present your results as something which came upon you by accident or mere luck!

Try to communicate an exciting story about new discoveries on a very important subject which every potential reader always wanted to know. Try to show how things are connected and how nature has unfolded under your skillful hands and opened her secrets which you now want to share with your privileged reader. And do this in a merciful manner by making it as brief as possible and only as long as absolutely necessary.

What is a reasonable length for a PhD-thesis? I feel that the maximum tolerable length is about 200 pages (typical LaTeX- DIN A4 format). Some of the best theses I have witnessed were substantially shorter but very heavy with content. However, to be honest: I also saw some exceptionally good theses who were longer. There simply is no obvious correlation between length and quality. Nevertheless, a lengthy, boring text clearly reflects insufficient efforts to concentrate on the important issues.

Before beginning to write, make a table of contents. Begin with a coarse structure and refine it step by step until for each chapter, section and subsection you can write down a few keywords and sketch your lines of thought on the specific topics.

There are not obligatory rules how to compose your table of contents but experience has lead to a viable scheme which over the decades has proven useful. Show your draft table of contents to your supervising professor and discuss it with him before you finally enter into the writing process as such. But remember: it is your thesis and it is you - not your professor, assistant or supervisor - who is responsible for the final outcome!

2.3.1 Title

It begins with the title of your work. It should be short and informative. A clear title reflects a clear mind. To quote just one particularly deterring example of how you should not call your thesis:

Contributions to the generation of ultrashort light pulses in the UV and
near VUV by nonlinear optical frequency conversion processes of second order in crystals and generation of laser pulses of high peak intensity by post amplification in ArF excimer lasers.

This would signal that you have focused on a very special aspect of a diffusively posed question. A much better choice of title would be e.g.:

*Generation and application of ultrashort, intense laser pulses in the UV and VUV*

### 2.3.2 Introduction

The main text starts with an introduction, an opportunity for you to reflect (also for your own benefit) what you wanted to achieve, what you have achieved and what you want to communicate. To explain this should typically take not more than about 3 pages. You simply have to introduce the reader very briefly into your field of research and its significance, lead him to the open problems and questions when you started, sketch the situation you found in your laboratory (which equipment existed, which programmes were ready for use etc.). Then formulate the key goals, indicate which potential solutions were anticipated at the beginning and finally indicate very briefly to which main result your efforts have lead you.

### 2.3.3 Basics and theory

Then a chapter with a general description of the field of research follows, usually including the relevant theory. As an example, this could be the basics of the generation of ultrafast laser pulses. The chapter may be substructured in *(i) state of research, (ii) theoretical foundations, (iii) specific procedures and methods* etc. All fundamental theoretical and experimental tools have to be specified as far as they reflect the knowledge at the beginning of the work. Developments reported later in the literature close to your work should also be included.

When presenting the theoretical foundations one can follow two strategies:

- Either one develops the relevant theory with pedagogical talent in a comprehensive manner (hopefully profitable for the reader as well) up to a point where the results are really used in later parts of the thesis.
One should state clearly at the beginning which sources are used and why one selects such a full presentation (e.g. because there are no good or comprehensive textbooks available).

- Alternatively one presents only a minimal collection of definitions, formulas and physical explanations which are actually used in later parts of the thesis and refers the reader for details and derivations to the relevant literature.

There is no useful compromise between these two approaches. A compromise could only mean: incomplete derivations, jumps from one development step to the next and finally an agglomeration of formulas without connection, only partially needed in later parts of the thesis which nobody can follow or reconstruct.

In summary, in the theory chapter/section one should gather all formulae and theoretical concepts which are later on used in the thesis - and only these. In any case, one should avoid to generate a scattered collection of formulae distributed over the whole thesis without clear connection.

2.3.4 Own models, computations

Next follows an overview of one’s own initial considerations, computations of expected effects, estimated orders of magnitude of signals etc. This should clearly be distinguished from the literature survey as a separate chapter or section, illustrating what was considered or computed, which methods and algorithms were used, which formulas from the theory chapter are the basis of your estimates etc.

Clear diagrams of the outcome and a descriptive physical interpretation are useful. Often a reference to experimental setups and results of test measurement to be described later may be useful at this point, although one should be somewhat careful with giving the full story already here.

2.3.5 Experimental setup

A chapter describing the experimental setup comes next, possibly also describing tests which were carried out before the actual measurement, as well as (if relevant) measuring procedures, evaluation methodology, and a description of how certain parameters were determined (e.g. a procedure for determining a laser beam profile, its power etc.).
If necessary, this chapter can be divided also according to individual sub-subjects which and may be placed as sections in front of various chapters for major groups of physical topics.

At any rate, the experiments are to be described in such a way that one could copy and reconstruct them if necessary. Details of critical components and considerations, which led to this or that particular setup, are to be elaborated on.

It is important that unsuccessful attempts are documented too if one can learn from them. Note, that at this point it is not sufficient to say ”this or that step did not lead to success”. Rather one should describe why and what did not work, which were the detection limits etc.

2.3.6 Experimental measurements (in theoretical work: computation) and results

The transition to this chapter may be somewhat floating. It is, however, again mandatory to clearly indicate which are own results of the present work in contrast to data quoted from the literature on which the work relies or to which it compares. A qualitative and if possible quantitative assessment of systematic and statistical errors of the measurements (calculations) have to be communicated here along with experimental data.

2.3.7 Discussion of the results

Finally a thorough discussion of the results follows. Here a physical understanding of the observations is to be developed as far as possible - using whenever necessary and illustrative the theoretical framework reported in the earlier chapters. Results of measurement are to be compared (referencing the appropriate formulae and procedures) with it. Results from other groups are to be included into the discussion, both quantitatively and qualitatively. Each discussion should end with a critical evaluation of results obtained.

2.3.8 Conclusion and outlook

This chapter rounds it all up. Here the main results are to be summarized and a few key theses on the progress achieved are presented (quasi as a counterpart to the objectives listed in the introduction). An evaluation of the potential usefulness of these results and finally some perspectives for future
possibilities or desirable further developments of the topic will conclude the
text. This chapter too should not exceed 3 to 4 pages.

2.3.9 Abstract
An abstract is absolutely indispensable and should be written after every-
thing else is said and done. It is placed of course before the introduction
and should not exceed one page, summing up the most important highlights
of the work. The abstract should be given in both English and German
language, independent of the language in which the thesis itself is written.

2.3.10 Acknowledgment etc..
At the end follow:
  • thanks to all those, who have helped with the work (with a short spec-
    ification of their assistance)
  • a list of papers published, in press or submitted resulting from this
    thesis (including titles)
  • a comprehensive list of references
  • the cv of the author (only for PhD dissertations)
  • an explanation of any additional help or support used, as required by
    the official examination rules of the university.

2.3.11 Appendices
Particularly elaborate calculations and derivations, important or sophisti-
cated computer codes and measuring programmes developed by the author,
particular innovative electronic circuits should be moved into appendices.
The same holds for all parts of the text, which are understandable and rele-
ant only for the specialist.
2.4 Formatting, style, language and figures

2.4.1 Recognizability of chapters, sections etc.

It is very important to visually clarify the documents structure at all levels down to the last sub-sub-section or paragraph. Modern word processing systems offer outstanding possibilities to organize the text and guide the reader by visual sign posts (character sizes, fonts, styles, indentions etc.). \LaTeX even does it all for you by using more or less automated functions. However, the desired effect becomes visible only if you make active use of these tools.

Paragraphs e.g., are intended to clarify, where an extended line of thought begins and ends, so that one can follow it easily. They should not be too short and not too long. 3 - 6 paragraphs per page are optimal as long as no formulas or numbered lists are concerned. Whether block or left justification is used is to some extend matter of taste. The former looks usually more calm. It can, however, lead to disturbing gaps. Use automatic hyphenation!

An attractive typeface and clear layout should be kept throughout the whole work. Clear figures, page headers indicating the chapter and an overall running title, standardized styles for numbering, labelling, text markings and layouts for particularly important cross-references and special results make a significant contribute to the legibility of the work and justify serious additional efforts.

However, avoid baroque typefaces, avoid too many different fonts, styles and character sizes! Otherwise the overall appearance of the thesis becomes irritating.

\LaTeX has many useful tools to help you with this. Do not make to many own modifications with the well established formats, styles and lettering. The package \texttt{hyperref} if properly applied does many good and useful things to your thesis. I strongly recommend its use.

Of course, the most important aspect of your thesis is its contents. But this may come into full view only if it receives a proper and attractive frame combined with a flawless and elegant usage of the English or German language.

2.4.2 Simple sentences, no laboratory jargon

Try to write in simple, not too deeply nested sentences. This is good practice for any writing but specifically so for scientific texts. Some linguistic polish
and precision is highly advisable. Laboratory jargon should be avoided. This holds in particular when writing in German: try to refrain from bad usage of standard words (use *Test* instead of *Testung* and *Impuls* instead of *Pulse* etc.) and avoid by all means the new "German-English" such as *Gainprofil*, *Switchen*, *gedownload* and so on.

Rather disturbing is also the frequent use of highly unspecific words such as *effect*. There is always a more precise word to describe what is actually happening.

2.4.3 Explanation of formulas and computing procedures

At the beginning of lengthy derivations of formulas a short explanation should be given of the goal to be achieved with the following set of operations. All formulas which will be referenced more then once in the text are to be numbered consecutively and coherently. Each calculation step has to be described briefly, e.g. *inserting the value of μ derived by eq. (7.5) into eq. (7.7) results in......*. And not just hope that the reader sees what you have done!

Computing procedures, which are not immediately evident, are to be described at least verbally. For example: *One obtains A as function of parameter B by numeric integration of equation (xyz). For this we used a simple PC programme by Meyer et al. <ref> which employs the Simpson - formula. Another variety could be: ... for this a particularly fast numeric procedure was developed, which is documented in appendix A3.1. A numeric example is reported in Fig. 3.20.*

2.4.4 Symbols and terminology

Pay attention to a consistent usage of symbols and terms. Try to use the same letters or symbols for the same quantities throughout the entire work. New terms or symbols should be introduced formally before or immediately after their first appearance in a formula or text.

If a symbol or a term has not been used for several sections or even chapters it is quite appropriate to recall its definition before or right after using it again. Some redundancy of this type in a comprehensive work is helpful for the reader.
2.4.5 Captions for tables and figures

All tables and figures must have clear and descriptive captions (see also 3). When reporting experimental results or theoretical data in tables and diagrams the caption, a legend or a footnote must very clearly specify the source of these data or indicate that these are present results. If it is own data the caption should state by which experimental and/or theoretical procedures they were obtained and briefly how it was evaluated. The caption or legend may cross-reference explicitly to the corresponding preceding chapter when necessary.

In any case own results must be clearly distinguished from those obtained by other groups. Typically one would write e.g.: .. crosses: measurements from this work obtained with the XYZ procedure as described in chapter 4, rectangles: values from reference /abc/ converted according to eq. (1.1), full lines: theoretical model according to eq. (5.10) from Ref. /abc/. If a similar graph follows shortly after a first, it suffices to refer to the former: .... otherwise as defined in Fig. 4.3 and Tab. 4.2.

2.4.6 References and quotations

One may sort references by number of appearance, possibly chapter by chapter (/1.1/ through /99.999/) or use alphanumerical labels (see also 1.4), e.g. /MHH90/ for Mueller, Huber and Meier Phys.Rev.Lett.55 (1990) 22-28. \LaTeX\ has many options and BibTeX styles for your bibliography generated by EndNote which do this for you (in this case one uses harvard.bst). Word – if you really want to use it – makes efficient use of EndNote for this purpose.

For important quotations, on which e.g. a whole chapter or fundamental Ansatz relies, one should in all fairness cite the names of the authors in the text, e.g. as Mueller and Huber (1990) show .... - or: In the following we orient ourselves on the very clear monograph by Born and Wolf /BWo75, chapter 11/.

2.4.7 Units

Pay attention to a precise specification of units in formulas, proportionalities, graphics, tables and so on. Often units are a great help for the reader to understand the underlying relations or make a quick check on the plausibility of a formula. Use consistent units, preferably the international standard (SI)
units. In some context atomic units may also be acceptable, preferably when the units $a_0, E_0, t_0$ are explicitly included in the formulas so that a cross check becomes possible.

2.4.8 Figures

A field, where most sins are committed. Consider for each figure what it is supposed to communicate or to express. The old word that a picture says more than 1000 words holds true a fortiori for scientific texts. On the other hand, with modern computer power often a lot of data garbage is communicated – and scientific publications make no exception to this general observation! Typical examples are endless variations of parameters in numerically computed curves – the computer makes it possible – which are an annoyance for the reader, if their purpose is not introduced, their significance not discussed and comparison with experiments is not made.

- Pay attention to a reasonable size of your illustrations and labelling. The reader should be able to view the graphs without magnifying glass and recognize individual data points as well as scales and legends! It is helpful to adhere to a consistent scheme of line patterns and data points for different graphs which report corresponding data. Theoretical results should be represented if possible by lines, experimental data by symbols. Avoid, however, too thin lines and too small symbols.

- In general, estimates for experimental errors belong to a serious report of results. Note that usually calculations too have errors, e.g. if the initial parameters are uncertain or an approximative method is used. This is equally important when comparing experimental and theory or your data with results from other groups. If disagreements are observed one expects at least an attempt to explain it.

- Adopt as far as possible one scheme for the symbols, fonts and sizes of data points, labels and scales at the axes of graphs throughout the entire work. Use error bars to indicate the accuracy of data and refrain from using symbol sizes to indicate accuracy - except that lines and symbols should not be thicker/larger than error limits. Error bars are particularly important if one wants to assess the significance of measurements!
• **Units at the axes of graphs** are characterized according to internationally valid rules by fractions behind the symbol. For example *intensity/Wcm⁻²* or *laser pulse energy/mJ*. If necessary it is acceptable to use the American style: *intensity [Wcm⁻²]* or *laser pulse energy [mJ]*. Please use the abbreviation *arb. un.* or *work un.* (German: *willk. Einh.**) for arbitrary units and not *a.u.*. The latter stands for atomic units. Another often misused unit is *a.m.u.*: the correct symbol for the atomic mass unit is according to SI specifications *u* (without any addition such as a point).

• Try, whenever possible, to **explain a functional connections** in formulas or graphics or a remarkably characteristic behaviour of measured curves by a qualitative physical model - and do not just refer to the result of a calculation etc.

• In papers to be published in journals, one is usually restricted to **schematic sketches** when describing experimental setups. This also holds for a PhD or diploma-thesis. However, specially crucial experimental setups and their **key components** should be communicated with all necessary details, if possible drawn to scale. That does, on the other hand, not mean that each screw of a technical design (today done with ACAD etc.) has to be depicted, since this would blow up the work without increasing the information content for the reader.

• One often misses any information on detector systems, data acquisition, measuring algorithms etc. At least in the form of **block diagrams** important issues should be communicated in a thesis. For crucial construction elements and measuring devices it is important to mention the manufacturer, model number and construction principles.

### 3 Publication and archiving of dissertations

#### 3.1 Significance of a dissertation

The finally written and accepted thesis is called dissertation. Dissertations have to report new scientific knowledge. They are regarded as genuine publications in a general sense and are often referenced in the literature.
3.2 Publication of partial results

Thus, if you want to publish some first partial results prior to writing your thesis, which is usually unavoidable in our fast developing world of science, then you must inform the promotions-committee of the university about this. This is a mere formality and an informal note is sufficient.

3.3 Archiving and online access

The thesis itself has to be archived and to be kept accessible permanently. In former times the graduate student had to deliver 70 obligational hard copies which were kept in different libraries (this was a necessary requirement for receiving the doctoral diploma without which one is not allowed to bear the doctor title). Today, in the age of electronic media, publication can be done online in the WWW.

The Berlin universities offer a special service to this goal. It is strongly recommended that you use this possibility to make your thesis freely accessible and give it the chance to be widely read. For the FU the relevant link is to Digitale Dissertationen http://jorge.ub.fu-berlin.de/work/DissSearch where you may also obtain the necessary tools. The final version is provided as a pdf - File. A combination of HTML and pdf files is deposited. As source texts you can use both Word as well as \LaTeX- the latter is certainly optimal for professionals.

Even if this sounds a little complex, the necessary effort to train yourself is certainly worthwhile: on the one hand you will be able to use later what you have learned for normal publications and other documentations. On the other hand your thesis remains in this way alive and accessible for many years, without any need to worry personally about it. You can reference your thesis at any time and access it without any problems.

3.4 The language

Your thesis as a publication becomes even more effective if you decide to write the work in English language. Since you have read this text up to here, I trust that there is no barrier for you to actually write your thesis in the lingua franca of science. While at the moment at the Free University of Berlin you still have to ask the promotions-committee for permission to write in English language, this permission has never been denied according to my
knowledge. Thus I also recommend to all German students with sufficiently powerful knowledge of the English language, to use this possibility. It simply means that your efforts will not be lost in the future.

3.5 Using advanced tools for writing in \LaTeX

At MBI we offer a very comfortable user interface for \LaTeX, called Scientific Workplace (SWP). This powerful programme is installed on the application servers. It comprises also a very useful mathematical processor, MAPLE. Those who have worked with SWP and got used to it will never again want to rely exclusively on raw \LaTeX.