



UNIVERSITÄT  
DES  
SAARLANDES

Naturwissenschaftlich-Technische Fakultät  
Experimentalphysik  
Arbeitsgruppe Dynamics of Fluids

**Bachelor Thesis**

# Title of my work

submitted by

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# Eingie Worte für Freunde der deutschen Sprache

Ich möchte an dieser Stelle ein Paar Worte zur Wahl der Sprache sagen und auch ein paar Zusammenfassungen in Deutsch geben.

Ich weiß, das Deutsch eine sehr schöne Sprache ist und es Euch leicht fällt, Euch in dieser auch auszudrücken. **Dennoch möchte ich Euch wärmstens empfehlen, bereits die Bachelorarbeit in Englisch zu schreiben.** Dafür gibt es mehrere Gründe und wenn Ihr es einmal probiert, werdet Ihr sehen, dass es gar nicht so schwer ist und die Onlineübersetzer sind mittlerweile absolut super. ☺.

## Warum in Englisch?

- Die Sprache der Wissenschaft ist Englisch. Das hat bestimmt jeder schon gemerkt. Wenn Euer Prof dann mal Teile/Abbildungen von Eurer Arbeit in einem Vortrag benutzen will, ist es super, wenn diese bereits in Englisch sind.
- Englisch kommt professionell herüber, ein nicht zu unterschätzender Aspekt bei der Arbeit.
- Die Sprache ist bei uns in der Physik nur das Mittel zum Zweck der Informationsübertragung, Schönheit der Sprache gibt es bei den Geisteswissenschaften.
- Englisch ist einfacher als Deutsch. Im Deutschen: Wenn es kompliziert wird, neigen wir dazu komplizierte Sätze mit viel Grammatik zu bauen. Im Englischen: Je komplizierter der Inhalt, desto einfacher werden die Sätze. Habt keine Angst davor simpel zu schreiben, nein der Inhalt zählt, nicht die Formulierung.
- Mit solchen Supertools wie DeepL kann wirklich jeder Englisch. Diese sind auch nicht verboten, jeder benutzt ja mittlerweile auch die Rechtschreibprüfung. Wenn Ihr den Text in einem klaren einfachen Deutsch schreibt, also kurze Sätze und beschreibende Adjektive, dann kann DeepL so was perfekt für Euch übersetzen. Bei mir muss ich nur einen Text markieren und 2× **Strg+C** drücken und es wird bei der installierten Software sofort übersetzt und ist fertig fürs kopieren oder noch besser mit **Strg+F9** sofort bereit um das Deutsche zu ersetzen. Mit diesem DeepL lernt ihr sogar nebenbei noch gute englische Ausdrucksweise. Probiert es unbedingt aus, selbst wenn Ihr denkt, Ihr seit fit in Englisch.

## Ein paar generelle Tips in Deutsch - ohne Reihenfolge

- Eure Arbeit ist eine wissenschaftliche Arbeit welche sich in einem Forschungsumfeld einbettet. Es ist **kein** tolles Buch. Verzichtet auf so gut wie alles, was schon irgendwo steht, dafür macht eine Referenz. Kein Abschreiben oder Vorrechnen von langen Formeln und Ableitungen, es sei denn, diese sind von Euch neu erschaffen worden für genau diesen bestimmten Zweck. **Keine** Schickimicki-L<sup>A</sup>T<sub>E</sub>X Spielereien als Design verkaufen, keine Widmungen dafür gibt es am Ende eine Danksagung. Einfach und schlicht bleiben.

- Erst ein strukturiertes Inhaltsverzeichnis anlegen, dann Abbildungen dort hin packen und dann den Text mit Formeln als Füllmaterial. Das erste (Literaturüberblick) und letzte (Zusammenfassung und Ausblick) Kapitel schreibt Ihr ganz zum Schluss. Mit der Struktur wisst Ihr wann was besprochen wurde und Kapitel weiter hinten können gerne auf Dinge weiter vorne verweisen. Auf Dinge weiter hinten zu verweisen ist nur in Ausnahmefällen eine gute Idee.
- Alles was zu sehr vom roten Faden ablenkt (lange Rechnungen, Laborprotokolle, zusätzliche Bilder, ...) kommen in den Anhang.
- In der Kürze liegt die Würze: Vermeidet unbedingt künstliches Aufblasen. Ihr werdet sehen, die Seiten werden sich schneller füllen als Ihr denkt.
- Es gibt kein: Zuerst habe ich dies gemacht und dann habe ich das gemacht usw. Das ist 5. Klasse Niveau in der Schule. Es zählt nicht die zeitliche Reihenfolge Eurer Erkenntnisse sondern nur der logische Sinnzusammenhang und so wird es auch dargestellt. Immer vom Einfachen zum Komplexen. In der Reihenfolge, was ist notwendig um das nächste darzustellen.
- Eine Abbildung sagt mehr als 1000 Worte. Das ist wirklich so. Also Mühe geben beim Erstellen der Abbildungen. Guckt gleich zu Beginn, in welcher Größe Ihr die Achsen beschriften müsst, damit es später im Dokument die selbe Größe oder nur wenig kleiner als der Text ist. Dies gilt auch für die Zahlen an den Achsen. Dann wichtig: Abbildungsbeschriftung. Diese muss ausreichend sein. Der Leser sollte die ganze Arbeit zumindest teilweise verstehen können, wenn er die Abbildungen und die zugehörigen Abbildungsunterschriften liest. Wenn mehrere Bilder/Grafen eine Abbildung ergeben, benutzt (a), (b) usw. und dieses links und rechts oder oben mitte unten ganz rechts usw. zu vermeiden. Im Text könnt Ihr dann sagen in Fig. 2.3(a) is shown the setup and in Fig. 2.3(b) is the working principle depicted.
- Wenn math. Symbole im Text auftauchen, diese auch immer korrekt in Mathe  $\$ \dots \$$  schreiben also  $x$ -Achse und  $y$ -Achse oder Geschwindigkeit  $v$  und nicht etwa  $v$  oder  $x$ -Achse oder  $y$ -Achse.
- **!!! Warnung !!!** Beim Arbeiten mit  $\text{\LaTeX}$ , verzichten sie unbedingt auf Lehrzeichen und Umlaute bei den Verzeichnissen und Dateinamen! Viele Programme mögen dies nicht. Also nehmen Sie z.B. das Verzeichnis/Hauptdokument `c:\MeinBachelor\Mustermann-Bachelor.tex` und Abbildungen ebenso, ein Bindestrich für Abtrennungen. **!!! Warnung !!!**

# 1 Literature review and Motivation

Each chapter starts with very few sentences about the following content, but except this one. Please give here an brief introduction about the state of the art of your topic, means a literature review. May be, it is helpful if you use a historical order. Please make many citations here. At the end of the review, the reader should be well prepared to understand the motivation of your work. Attention: no pictures, keep short, not more than two, at maximum 3 pages. **Warning: Write this chapter as the very last one.** In the following, you can see a good example (Felix Maurer, Master-Thesis 2021). The original fits on two pages. Note, here the last page is empty because the next chapter must start on an even page number due to `\cleardoublepage`.

Perhaps the first documentation of a density gradient dates back to 1630 when Galileo Galilei described a floating ball of wax in a diffusion gradient between phases of pure and salt-water [1]. Later, in 1855 Fick studied diffusion gradients between connected reservoirs [2]. From 1936 onward, Linderstrøm-Lang investigated the use of density gradient tubes for measurements of the density of macroscopic droplets and particles [2, 3]. Oster et al. gave an overview of different gradient preparation techniques [2]. When two miscible liquids of different density are brought in contact, diffusion leads to gradients. Density gradients can also be formed between liquids of different densities when mixed at different flow rates. Furthermore, gradients form on their own due to a thermodynamic distribution of suspension particles or macromolecules. Under high centrifugal pressure, even pure liquids form density gradients. However, due to the low compressibility, such gradients are small. This can be overcome with solutions that form gradients matching the density distribution of particles being studied. The self-forming gradient of a density medium was particularly introduced by Meselson, Vinograd and others [2]. Meselson et al. reported in 1957 that the concentration gradient of a solute of low molecular weight and compression of the solvent results in a continuous increasing density along the direction of centrifugal force, and studied band shapes [4]. In 1961, Hearst and Vinograd gave theoretical insights in the equilibrium in a density gradient [5]. Density gradient centrifugation is an efficient method for the separation of particles by density or size. If the centrifugation is continued until particles reach their equilibrium positions, the separation depends only on the particle density. On the other hand, if it is stopped prematurely, the separation occurs according to the sedimentation rates which depend on size. Large particles sediment faster than small ones. This method is referred to rate zonal separation [3, 6]. The distribution of particles in a density gradient might not always be true to the density of individual

particles. Back in 1950, Brakke et al. stated that aggregation leads to a non-ideal sedimentation [3]. Price et al. reported that aggregates cause spurious distributions and anomalously high sedimentation rates [6].

Mateyko et al. assessed the usability of various density media for cell studies in 1963. They concluded, that a suspension of silica nanoparticles was the most suited available option [7]. Pertoft and Laurent introduced improvements in the following years like the development of modified colloidal silica and finally *Percoll* in 1978, a commercial density medium consisting of a suspension of coated silica particles, which had an improved non-toxicity to cells and low surface charge [8, 9]. Nowadays, Percoll is a standard medium for the density separation of erythrocytes, leukocytes, liver cells, leydig cells, bone marrow cells, macrophages and many more cell types, subcellular particles including plasma membranes and cell organelles, as well as microorganisms like bacteria, viruses, parasites and algae [10].

As the main constituent of human blood, erythrocytes, also known as red blood cells (RBCs), were the subject of many studies in recent years. The flow properties of blood are mostly determined by red blood cells [11]. Their high deformability optimizes flow, enables passage through tiniest capillaries and is vital for nutrient transport and gas exchange [11–14]. The elastic properties are a result of the membrane structure [14]. Besides, the membrane owns a variety of ion channels, essential for nutrient and gas exchange [12, 15–19], some of them are linked to deformation by mechanical sensation [20]. It is known, that the density of red blood cells increases with their age [21, 22] during the life time of 120 days [16]. Therefore, centrifugation of erythrocytes in a density gradient allows a sorting by age. In 1980, Vettore et al. described a rapid method for the separation of RBCs in age-dependent fractions [23]. This led to a variety of studies on the relation of morphological parameters to cell age. The deformability of red blood cells declines during the aging process [24]. Lutz et al. found the deformability to be a reliable indicator for cell age [25]. The membrane protein 4.1 gives a reliable measure for cell age. While the total amount stays constant during the life time of a cell, the ratio between its forms 4.1a and 4.1b increases during ages as a conversion process takes place. Measurements of the protein ratio can be used to determine the exact cell age independent of other physiochemical parameters such as cell density [16, 17, 26].

The distribution of red blood cells after centrifugation in a self-forming Percoll gradient is surprisingly not homogeneous but characterized by a heterogeneous structure of discrete bands [23, 25, 27–32]. Bogdanova et al. suggested, that fractionation is linked to the activation of mechano-sensitive ion-channels and a resulting uptake of  $\text{Ca}^{2+}$  and loss of  $\text{K}^{+}$  [31]. Lutz et al. observed a redistribution of cells extracted from the gradient and concluded that a uniform density of cells from a particular fraction in the gradient is not guaranteed. Additionally, they suspected a contamination of dense cells in light fractions that reflected in the 4.1a to 4.1b measurements, and considered aggregation as a possible reason [25].



Recently, the quantification of band patterns by image processing was investigated and the applicability in diagnostics discussed. Sadafi et. al studied severity predictions of sickle cell anemia using graph convolutional networks [32]. While predictions based only of images of distributions in Percoll are not sufficient for a classification yet, a combination with complementary clinical data can improve accuracy.

The aim of our investigations was to study the dependency of the band structure on different physical and biochemical conditions. Furthermore we want to discuss a potential underlying mechanism, the aggregation of red blood cells.



## 2 Introduction

A few introductory words, two or three sentences as maximum, **before the first section**. Write here, what will the reader find in this chapter. This helps the reader to see the structure of the document and to see what is the main content of this chapter.

### 2.1 Structure of your thesis

At first you need a structure. You can see my suggestion in this template

1. Literature review and Motivation
2. Introduction
3. Experimental Setup or Numerical Methods
4. Results
5. Conclusions and Outlook

A Appendix

**Bibliography** - does not have a number

**Eidesstattliche Erklärungen** - does not appear in the table of context

**Danksagung/Acknowledgment** - does not appear in the table of context

Keep this structure in mind. Before writing, think about, what did you need to explain in introduction for later references from Setup or Methods. The same thought processes for the Results chapter.

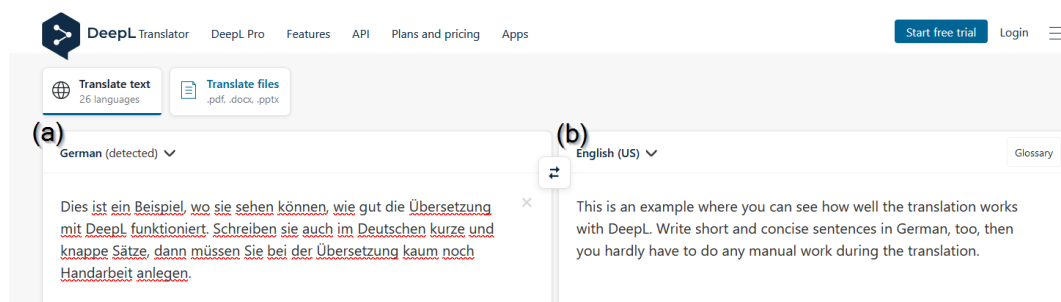
### 2.2 General comments

Few general comments from my personal point of view.

- This is a scientific thesis. Avoid flourishes and dedications in the main document, use the Acknowledgment/Danksagungen.

- This is a thesis, not a textbook. Avoid long derivations, which have already been written down elsewhere, use references as much as you can. Your work must be embedded in the state of the art on your particular topic.
- Write short and clear sentences. Scientific English must be understandable also for non native English speakers, like Chinese, Japanese, French or Finns.
- Avoid direct spoke, like 'you can see', 'I have calculated', ..., use 'In Fig. is shown', 'the calculation is as follow', ...
- You can use <https://www.deepl.com/en/translator>. It helps indeed.

In the Fig. 2.1 an example for an translation is shown. Keep in mind, every figure needs a reference from the text and the figure must appear after those reference in the text. The simple idea: if someone looks for the detailed explanation of a figure in the text he/she will always look for the figure number and in text before the figure never in the text after the figure placement.



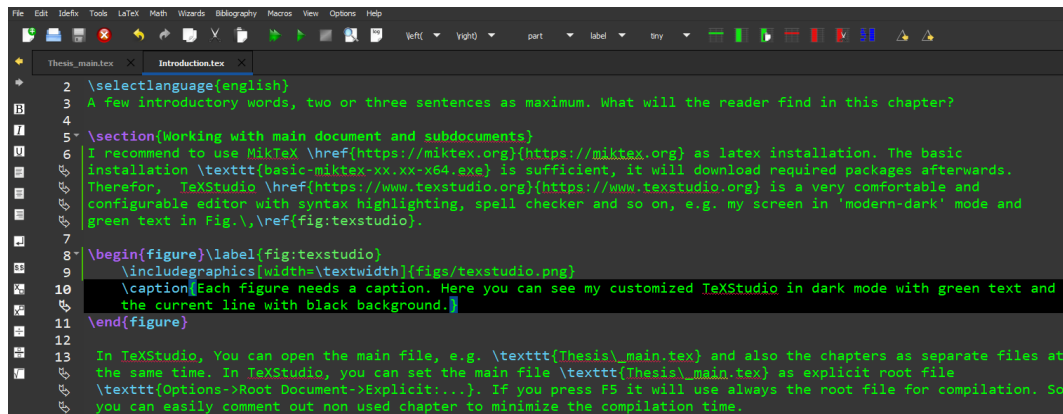
**Fig. 2.1:** This is example for a translation from German to English using DeepL. There exist also a very useful desktop App, you can mark something and with **ctrl+C+C** (double press 'C') it translates the text, ready for copy and paste. Do not trust everything, read it before copy and paste. In (a) the original in German, but containing here 'Sie' and so on, do not do so. In (b) the translated text. Note that, In English, closed brackets are always used around letters, not as in German a) and b). Use letter to identify subfigures, avoid something like in the left figure and in the right figure or top and bottom. This makes references in the text clear, e.g. Fig. 2.1(a).

## 2.3 Working with main document and subdocuments

I do not recommend Overleaf, it is fine for small projects, but it becomes in trouble when the documents become much bigger like a thesis. The compilation is done on those servers, not locally, and if it takes too much time, the job will be canceled, and you are not able to create a pdf. Except you get a license, see <https://www.overleaf.com/user/subscription/plans>.

I recommend to use MikTeX (<https://miktex.org>) as local latex installation. The basic installation `basic-miktex-xx.xx-x64.exe` is sufficient, it will download required packages afterwards. Hence, the first compilation of this document and only the first takes a bit more time.

TeXStudio <https://www.texstudio.org> is a very comfortable and configurable editor with syntax highlighting, spell checker and so on, e.g. my screen in 'modern-dark' mode and green text in Fig. 2.2.



**Fig. 2.2:** Each figure needs a caption. The figure caption should be meaningful, rather a little too long than too short. Here you can see my customized TeXStudio in dark mode with green text and the current line with black background.

In TeXStudio, You can open the main file, e.g. `Thesis\_main.tex` and also the chapters as separate files at the same time. In TeXStudio, you can set the main file `Thesis\_main.tex` as explicit root file `Options->Root Document->Explicit:....`. If you press F5 it will use always the root file for compilation. So you can easily comment out not currently used chapters to minimize the compilation time.

!!! Warning !!! When working with L<sup>A</sup>T<sub>E</sub>X, do not use spaces or umlauts in directories and file names! Many programs do not like this. So take e.g. the directory/main document `c:\MeinBachelor\Mustermann-Bachelor.tex` and figures likewise, a '-' for separations.

## 2.4 Few hints regarding typesetting

### Quotations – English versus German

Please note: „Beachte die dt. Anführungsstriche“. In English we have only single upper quotes 'like those ones'. But use it only for direct citations, means words what someone has said. Avoid the usage of quotes if don't know a better name for it. It sounds like 'mir viel gerade kein besseres Wort ein und ich bin zu faul darüber weiter nachzudenken'. May be adding adjectives helps to specify better the thing what you want to describe.

### 2.4.1 Past and presence in English

In general, keep you English free from complicated English tenses. Nothing else than simple past, presence and future. Do not use 'We have been measured', use 'We measured' (simple past). The classical way is, what you did in the past, write in simple past, 'The temperature was measured and recorded'. What the reader can see here is in presence, 'bla bla, see Fig. blubli'. Your conclusions are also valid for all times, write it in presence, 'all investigated metals shrink when the temperature was reduced, the expansion coefficients are therefore positive'. And finally 'Maybe someone will answer this question in the future.'. In some modern articles in journals, you can see, everything is written in presence 'we measure, we calculate ...'. This is also possible, however I prefer the classical way.

### 2.4.2 Emphasize

In order to emphasize a single word or phrases use the  $\LaTeX$ -command `\emph{blabla}` as *blabla*. Avoid **bold** or *italic*. Italic looks similar, however internally it is mostly used for math letters, the tilt is a bit different from `\emph`.

## 2.5 Units

You will have frequently numbers with units, e.g.  $k_B = 1.38 \times 10^{-23} \text{ J K}^{-1}$  or  $k_B = 1.38 \times 10^{-23} \text{ J/K}$  in comparison to the German version  $k_B = 1,38 \cdot 10^{-23} \text{ J K}^{-1}$ . Using `\usepackage{siunitx}` you can simply write `$k_{\text{B}}=\qty{1.38e-23}{J.K^{-1}}$`. Note the number is simply typed in computer notation, and to create the small space between the J and the K, this is made by a dot. Please don't use fractions in units, unless there is only a single quantity after the fraction like this  $F = 1.234 \text{ kg m/s}^2$ , not so  $p = 4.5 \text{ J/(m}^2 \text{ s)}$  or  $p = 4.5 \frac{\text{J}}{\text{m}^2 \cdot \text{s}}$  and the typing  $p = 4.5 \text{ J/m}^2 \text{ s}$  is simply wrong.

## 2.6 The Basics about Equations

### 2.6.1 At that time, ...

Again, note the structure, only between the main heading and the first section comes a short description. Therefore – collect and group the topics and give this a heading.

A bit of text and filler text. The publications „Beachte die dt. Anführungsstriche“ [33] from 1873 and later still [34–38]. Some more work on this [36, 37, 39]. You see, BibTeX and  $\LaTeX$  summarize correctly themselves alias [xx–yy], if it works. Sorting is always done according to the order of occurrence in the document.

Something about mathematical equations. These are always numbered, even if you do not refer to them explicitly in the text. Maybe a reader wants to refer to this equation later. This is such an equation

$$E = mc^2 \quad (2.1)$$

with the energy  $E$ , the mass of the particle  $m$  and the speed of light  $c$  - always describe which symbols were used. Later it is very easy to refer to this equation in the text as Eq. (2.1), don't forget the brackets so `Eq.\,(\ref{eq:Einstein})`, if the equation has a label in the `.tex` (see source text) – don't forget the brackets, you must add it manually. There are also systems of equations

$$\oiint_{\partial\Omega} \mathbf{E} \cdot d\mathbf{S} = \frac{1}{\varepsilon_0} \iiint_{\Omega} \rho dV \quad (2.2)$$

$$\oiint_{\partial\Omega} \mathbf{B} \cdot d\mathbf{S} = 0 \quad (2.3)$$

$$\oint_{\partial\Sigma} \mathbf{E} \cdot d\boldsymbol{\ell} = -\frac{d}{dt} \iint_{\Sigma} \mathbf{B} \cdot d\mathbf{S} \quad (2.4)$$

$$\oint_{\partial\Sigma} \mathbf{B} \cdot d\boldsymbol{\ell} = \mu_0 \iint_{\Sigma} \mathbf{J} \cdot d\mathbf{S} + \mu_0 \varepsilon_0 \frac{d}{dt} \iint_{\Sigma} \mathbf{E} \cdot d\mathbf{S} \quad (2.5)$$

Here all aligned at `=`. It also works as a listing with centered alignment:

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0} \quad (2.6)$$

$$\nabla \cdot \mathbf{B} = 0 \quad (2.7)$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \quad (2.8)$$

$$\nabla \times \mathbf{B} = \mu_0 \left( \mathbf{J} + \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} \right) \quad (2.9)$$

What also often happens are formulas with cases

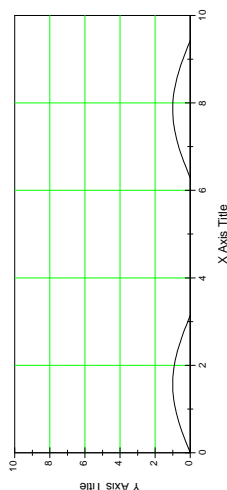
$$f(n) = \begin{cases} n/2 & \text{if } p \equiv 0 \\ (3n+1)/2 & \text{if } p \equiv 1. \end{cases} \quad p = n \pmod{2} \quad (2.10)$$

You see,  $\text{\LaTeX}$  leaves nothing to be desired, it all looks like professionally typeset. What symbols there are, see the caption of the Fig. 2.3 and something about images with a reference see Fig. 2.4.

A common figure:

An image with caption beside is automatically always such that the text is on the outside, a distinction is made between even and odd pages.

A little filler text : Laber laber laber Laber laber laberLaber laber laberLaber laber laberLaber laber laberLaber laber laberLaber laber laberLaber



**Fig. 2.3:** Images will be included as pdf exactly as they are. If it looks like this, you must go to qtiplot/origin page setup page and set it to landscape, or change it to portrait. Here something else important for lines in caption, always put in `protected`, otherwise it won't work. See source code for `(\bullet,--)` or something like this `(\color{green}\square,--)` or something like this `(\color{blue}\star,--)` much darker in printout!). See also <http://www.tex.ac.uk/tex-archive/info/symbols/comprehensive/symbols-a4.pdf> and when it comes to references in the figure caption just use a `\cite` like this [36] or a reference to an equation or figure with `\ref` aka Eq. (2.1) or Fig. 2.3.



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**Fig. 2.4:** Here a label on the side. Note, if the fig. is at the top or bottom of the page, it gets a thin line to separate it from the text, this can also be turned off in `Thesis-main.tex`.

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**Fig. 2.5:** One more caption on the side, illustration is smaller and the text adjusts to the available width.



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 One more line of text to finish, note also Tex only moves figures backwards, never  
 forwards and that makes sense.



**Fig. 2.6:** Image at the bootom of a page (here forced, otherwise always use bth at figure),  
 ! Always make a sufficiently precise/long captions so that it is clear what is to be seen.

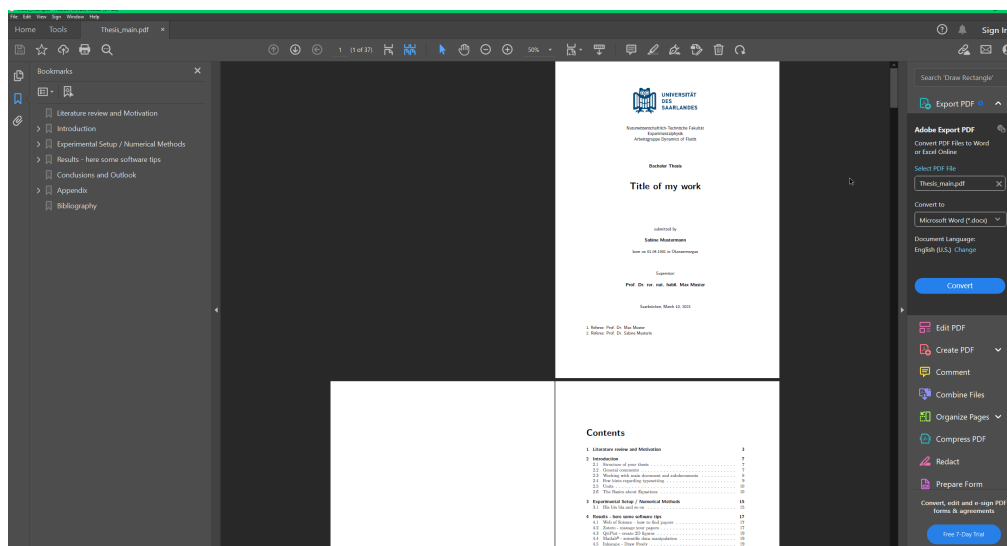


### 3 Experimental Setup / Numerical Methods

Again few words in the beginning, what the reader can find in this chapter, e.g.: This chapter describes the assembled experimental setup. Modifications of the setup, with respect to to setup in [37] are explained in detail. The numerical methods to investigate the problem bla bla are described in detail. The extensions to the scheme in [37] are explained in succeeding complexity.

### 3.1 Bla bla bla and so on

Look in the next chapter to get some more hints. Note, a Chapter always starts on a right page. In Acrobat Reader you can select **View->Page Display->Two Page Scrolling** like in Fig. 3.1. Avoid also references like, 'you can see here', even if the figure comes directly. Maybe later, the figure is moved to another place by TeX, therefore use always figure references as numbers, this is always correct if you use different labels.



**Fig. 3.1:** Here you can see a screenshot from the acrobat reader to see the two page scrolling mode. Note the document starts with a page at right, exactly as the printed document. All new chapters starts at the right side. However, is the main document open in Acrobat Reader, you can't compile it, because it is locked/in use.



## 4 Results - here some software tips

Again few sentences. We found out, the absolute value of the Euler number  $e$  is slightly smaller as the constant  $\pi$  and  $i^i \approx 0.208$  is smaller than both<sup>1</sup>. Note that the constant  $e$  is written as `\text{e}`, as well as the imaginary constant  $i$ .

...

I will use this chapter to explain some useful free software, in short:

- **Web of Science** - how to find literature, and perform a backward search
- **Zotero** to manage your literature database in collaboration with **BibTeX**,
- **QtiPlot**, similar to **OriginPro**® without annoying registration stuff,
- **MATLAB**® to create nice figures, publication ready pdf-vector graphics,
- **Inkscape** to draw sketches and
- **GIMP** to handle pixel based images.

### 4.1 Web of Science – how to find papers

Surely you have received an important paper on your topic from your supervisor. Now let's also see something outside the box. With the service of the website <https://www.webofscience.com> you can find this paper and then it becomes important, you can also see who all has referred to this paper. So you may find more recent publications on this topic. In any case, you can also find other papers on this topic.

### 4.2 Zotero and BibTeX - manage your papers

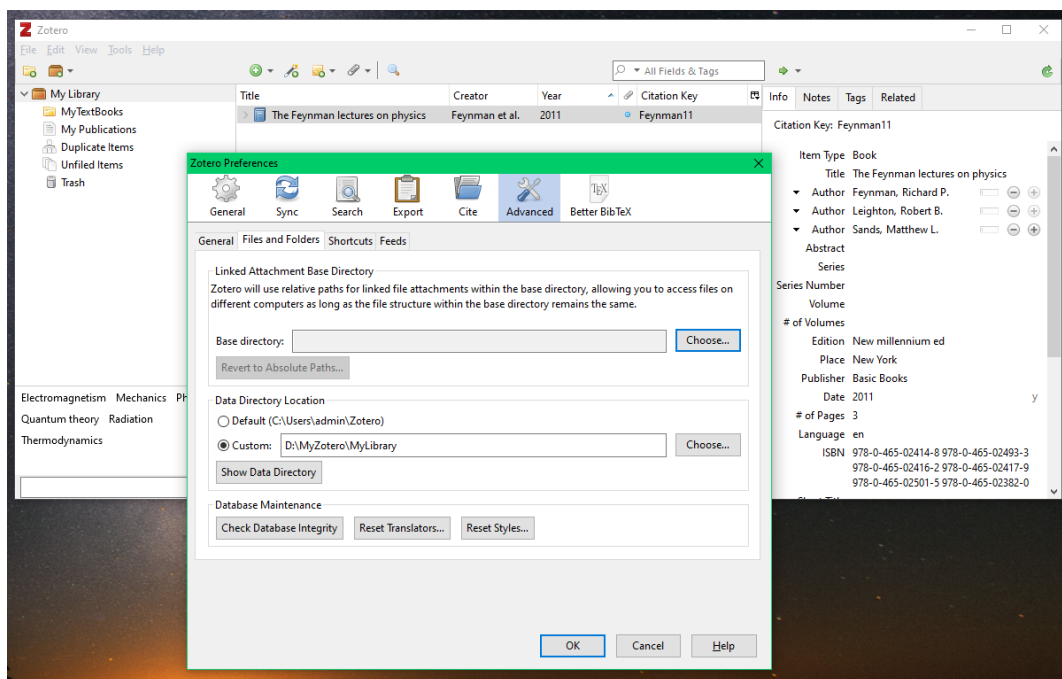
Zotero is a free program to handle references. It stores everything in a database, pdfs from papers, whole books, websites and so on. The program itself as well as your collected material (pdfs, snapshots of Websites) is stored in a folder structure. Therefore you can move it to other computers, without any installation. Unfortunately, the original propose was not directly **BibTeX**, but the program has the extension **Better BibTeX** to create a `.bib` file what can be used for **L<sup>A</sup>T<sub>E</sub>X** and **BibTeX**. In Zotero,

---

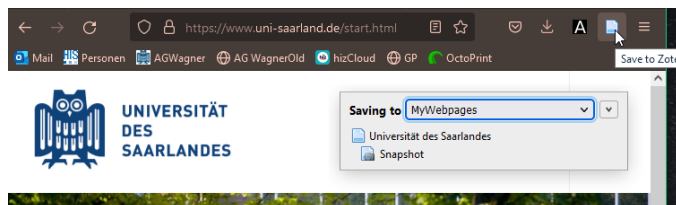
<sup>1</sup><https://math.hmc.edu/funfacts/i-to-the-i-is-a-real-number/>

you can easily create a structured tree with all your books, papers, webpages ... I created an installation, including the extension better Bibtex and pre-configured to have your main program located in `d:\MyZotero` and your database located in `d:\MyZotero\MyLibrary`, see Fig. 4.1. You can also add an extension, called Zotero Connector, to your Browser, see <https://www.zotero.org/download/connectors>. It enables you to save Webpages and in particular to create a BibTEX-Key for further referencing, see Fig. 4.2 and Fig. 4.3.

Finally, you can export your whole collection as `literature.bib` in the same folder as your main document and it can be used by L<sup>A</sup>T<sub>E</sub>X/BibT<sub>E</sub>X.

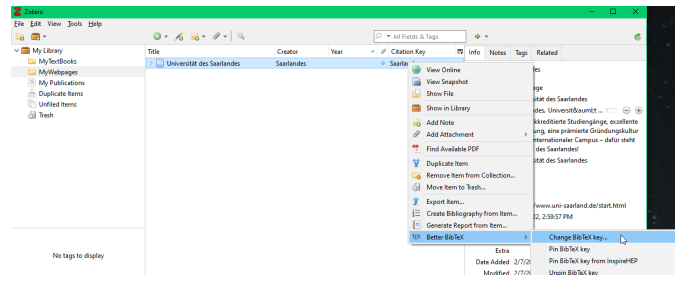


**Fig. 4.1:** The Zotero program to manage your references. You can create subcollections. You can add items by drag and drop, move the pdf to the main window and the program will try to find out the meta data from the internet. If you extract Zotero to a different drive, e.g. c: change the path accordingly. Note: Sometimes the MetaSearch works fine, but sometimes not perfect, check the important fields (Authors, Name, Date, Journal, ect.) to be sure, everything is correct.



**Fig. 4.2:** A smaller figure with a caption beside. You can add a Connector in your Browser. If Zotero is already open, you can save a snapshot of this page in your Library too.

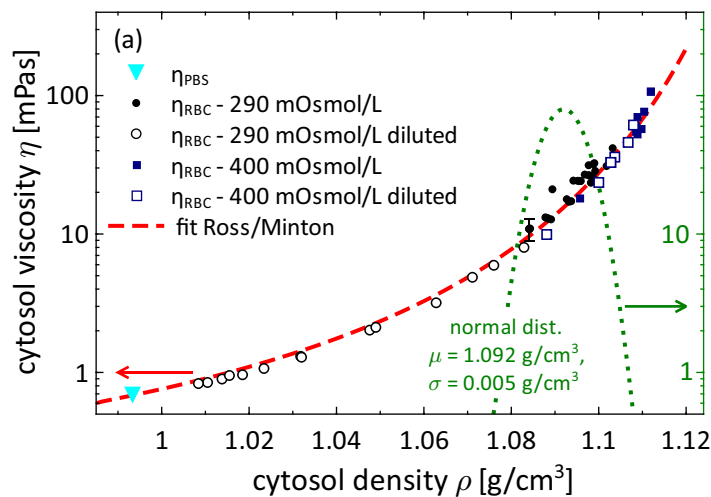
**Fig. 4.3:** Of course, you can and you should change the BibTeX-Key in Zotero.



## 4.3 QtiPlot - create 2D figures

QtiPlot is similar to Origin and from my point of view more clear in usage. In addition, you will never have trouble with registration stuff. Simply download it from the <https://www.hiz-saarland.de/dienste/software-lizenzen> and install it. In the Fig. 4.4(a) you can see a funny picture. The part (b) is missing.

**Fig. 4.4:** A nice picture, created with QtiPlot. Keep in mind, not everyone can distinguish different colors, therefore, note the different symbol shapes and line styles. Few symbols are in  $\text{\LaTeX}$ -font. A (a) at upper left was used, because this figure was a sub-figure in a set of two figures with the same caption.

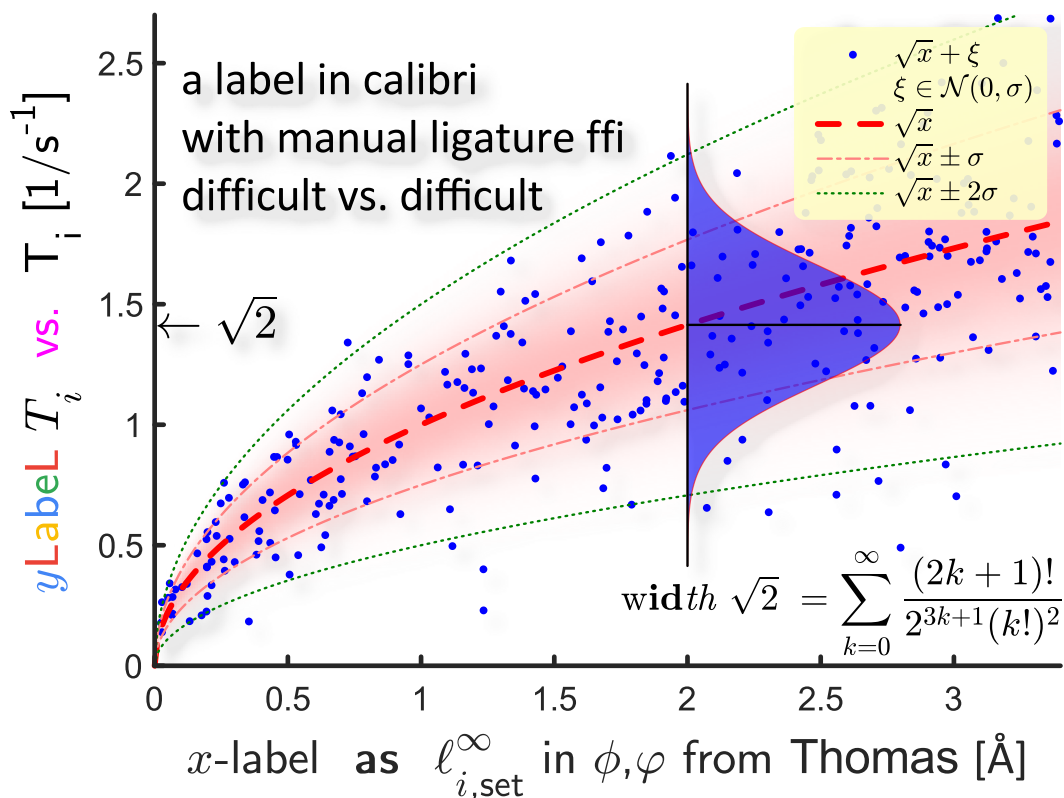


## 4.4 Matlab® - scientific data manipulation

From my point of view, the software Matlab® is the best for scientific data manipulation. If you are interested in, how to create such funny figures as in Fig. 4.5, please note on the example script in `Matlab_-_Export_Fig_to_pdf_and_png.zip`, located on the Webpage of Ag Wagner in Batchlor-Topics, <https://www.uni-saarland.de/lehrstuhl/wagner/bachelor-und-masterthemen.html>.

## 4.5 Inkscape - Draw Freely

Inkscape is very good vector drawing program. I think, you know the difference between a vector picture and a pixel based picture, e.g.: .jpg or .png. It is perfect to create nice sketches, see Fig. 4.6. Jep, this figure is moved far away by latex,



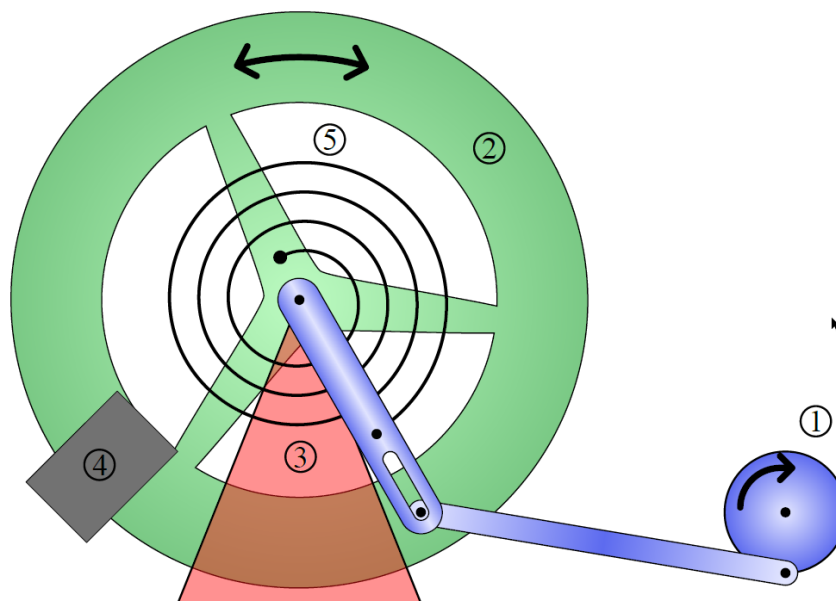
**Fig. 4.5:** A Matlab<sup>®</sup> figure. From the mathematical point of view, here are example data points from a Gaussian distribution  $pdf(x, y)$  with the mean  $\mu(x) = \sqrt{x}$  and a  $\sigma(x) = 0.25\sqrt{x}$ . At  $x = 2$ , the  $pdf$  is shown as transparent, blue curve. The background contains the density plot of the  $pdf(x, y)$ . The figure has an additional drop shadow, can you recognize it? The figure was exported from the suggested Matlab script as vector-graphics `.pdf` and `.png` as high resolution pixel graphics. Note also: the used fonts are latex fonts, e.g. `cmmi10.ttf` without serif's; the axis labels can have mixed colors; the legend has round corners and is slightly transparent; and finally all lines and the axis ticks have round ends, use magnification.

but don't care about this, if you add more text in your document, the figures will be placed on the right position.

## 4.6 GIMP – GNU Image Manipulating Program

GIMP is a pixel based image manipulating software. Use pixel images only if it really necessary and if so, prefer `.png` instead of `.jpg` files to avoid compression artifacts.





**Fig. 2.1:** Schematic of a Pohl's Pendulum with ① power unit, ② rotating pendulum, ③ bearing bracket, ④ eddy current brake and ⑤ coil spring [20]

**Fig. 4.6:** A screenshot from a figure in 'Setup and measurements on a computer-controlled Pohl's pendulum' by Jann Steuer 2022, UdS. It was created using inkscape. The symbols ①, ② are from pifont, you can find many many symbols as Dingbats therein, see symbols-a4.pdf.



# 5 Conclusions and Outlook

Keep in mind, Motivation and Conclusions are chapters without sections. May be the conclusions can have two subsections 'summary' and 'outlook'. A chapter with a single section does not make sense. The Motivation and Conclusions are the most carefully read chapters of your thesis. Please read over the English 3 times. The outlook is also important, make suggestions for further work. This proves that you have thought outside the box. some other points regarding this chapter:

- summarize your results here, keep short, again keep compact, not more than 2 pages
- use short, very short and clear sentences, make clear statements
- here you give the answers to your motivation questions (see first chapter)
- no figures, no long equations, no derivations here, make references to figures/equations in the document
- do not forget the outlook



# A Appendix

This chapter includes the details about the experiental setup and the long calculations. Only use sections and subsections, if you have more than one.

## A.1 Section in appendix

Here you can place your topics for the appendix. Note: Do not include long calculations or many small details about your experiments in the main document. The main document should contain mainly the important prerequisites and results. Try to keep the main thread in the document. Place here the details. Of course, those details are also very important for the student, working on the same topic as you. A good thesis contains all details, so that the reader can reproduce the experiments and calculations.

## A.2 My second Section

This is the text of my second appendix section.



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# Eidesstattliche Erklärungen

Hiermit versichere ich an Eides statt, dass ich die vorliegende Arbeit selbstständig und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt habe. Die aus anderen Quellen oder indirekt übernommenen Daten und Konzepte sind unter Angabe der Quelle gekennzeichnet. Die Arbeit wurde bisher weder im In- noch im Ausland in gleicher oder ähnlicher Form in einem Verfahren zur Erlangung eines akademischen Grades vorgelegt.

Saarbrücken, den 10. März 2023

Sabine Mustermann

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Die/der Kandidatin/Kandidat: Sabine Mustermann

geboren am: 01.04.1901 in Schlumpfhausen

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Saarbrücken, den 10. März 2023

Sabine Mustermann



# Danksagung

Hier könnt Ihr Euch bedanken. Bitte nicht versuchen im Hauptdokument zu viele Spielereien (Widmungen, verschnörkelte Kapitelnummern oder andere 'kreative' Gestaltungen. Es ist eine wissenschaftliche Arbeit, kein Kunstwerk. Dies kann auch wieder in Deutsch sein. Dafür im  $\text{\LaTeX}$ -Dokument auch die Sprache umstellen.

Ich danke meiner Oma und meinen Opa für den leckeren Grießbrei den sie mir vom 5. bis zum 7. Lebensjahr gekocht haben.

Ich hoffe diese Zusammenstellung hat Euch ein wenig geholfen, die Bachelor/Masterarbeit anzufertigen. Ich wünsche Euch viel Erfolg beim Schreiben Eurer Arbeit und möget Ihr auf Euren weiteren Wegen noch viel Spass an der Physik haben.

I hope this compilation helped you a little bit to write your Bachelor/Master thesis. I wish you a lot of success in writing your thesis and may you have a lot of fun with physics on your further ways.



Euer/Yours Thomas