

The design of a Master Thesis

Andrea Donini

(curso organizado y supervisado con Pilar Hernández)

Motivation

Scientific writing is not taught at school, nor during the undergraduate learning

WE, professional scientists, **LEARN** how to write by **TRIALS AND ERRORS**, after many years of scientific papers publication and refereeing

Many of us **NEVER LEARN!** You can be a very good scientist and a poor writer....

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Volume 50B, number 3 PHYSICS LETTERS 10 June 1974

DETAILED PREDICTIONS FOR THE p-n STRUCTURE FUNCTIONS IN THEORIES WITH COMPUTABLE LARGE MOMENTA BEHAVIOUR

G. PARISI*

Columbia University, New York, N.Y., USA

If strong interactions are described by non Abelian gauge theories, detailed predictions are obtained for the q^2 dependence at fixed ω of the difference of the structure functions of the proton and neutron.

It has been recently recognized that in a particular class of renormalizable theories the large momenta behaviour is computable from perturbation theory [1], at least for sufficient small coupling constant. Some of the non Abelian gauge theories belong to this class [2-4]. In these theories the Bjorken scaling law for deep inelastic scattering is satisfied [5] apart from logarithmical corrections which can be computed.

We consider a model with 3×3 colored quarks: the interaction is carried by an octet of colored gluons and it is symmetric under $SU(3) \times SU(3)'$. In this model the following relation holds [6]:

$$\int_1^{\infty} F_T^2(\omega, q^2) \omega^{-N} d\omega \xrightarrow{q^2 \rightarrow \infty} \sum_{i=1}^4 C_T^{i,N} (\log q^2)^{-A^i N} \quad (1)$$

where T stands for the target name and $A^{i,N}$ are computed numbers which are independent from the target.

Different powers behaviour comes from the contributions of different operators. However in the $l=1$ t -channel only one operator is present; a simple relation is satisfied by the difference between the proton and the neutron structure functions [6]:

$$\int_1^{\infty} F_{p-n}^2(\omega, q^2) \omega^{-N} d\omega \xrightarrow{q^2 \rightarrow \infty} C_{p-n}^N (\log q^2)^{-A^N} \quad (2)$$

$$A^N = \frac{2}{27} \{ 1 - 2/N(N+1) + 4 [\psi(N+1) + \gamma^{-1}] \}$$

where ψ is the logarithmical derivative of the Euler Γ function and γ is the Euler-Mascheroni constant.

A very nice test of the validity of the theoretical scheme would be provided by a comparison of (2) with the experimental data.

The aim of this note is to point out that it is possible to derive from (2) simple consequences on the q^2 behaviour of the structure functions at fixed ω . The final result is:

$$D(\omega, q^2) \equiv q^2 \log q^2 \frac{\partial}{\partial q^2} F_{p-n}^2(\omega, q^2) = \frac{2}{27} \left[3 + 4 \log(1 - 1/\omega) \right] F_{p-n}^2(\omega, q^2) + \int_1^{\omega} \frac{d\mu}{\mu^2} \left[\left(2 - \frac{2}{\mu} + \frac{4}{\mu-1} \right) F_{p-n}^2\left(\frac{\omega}{\mu}, q^2\right) - \frac{4\mu}{\mu-1} F_{p-n}^2(\omega, q^2) \right] \quad (3)$$

Eq. (2) and eq. (3) are mathematically equivalent, however we believe that the second equation is easier to test than the first one. A salient feature of eq. (3) is that the integral in its r.h.s. is done from 1 up to ω : informations on the high ω behaviour of the structure functions are not needed.

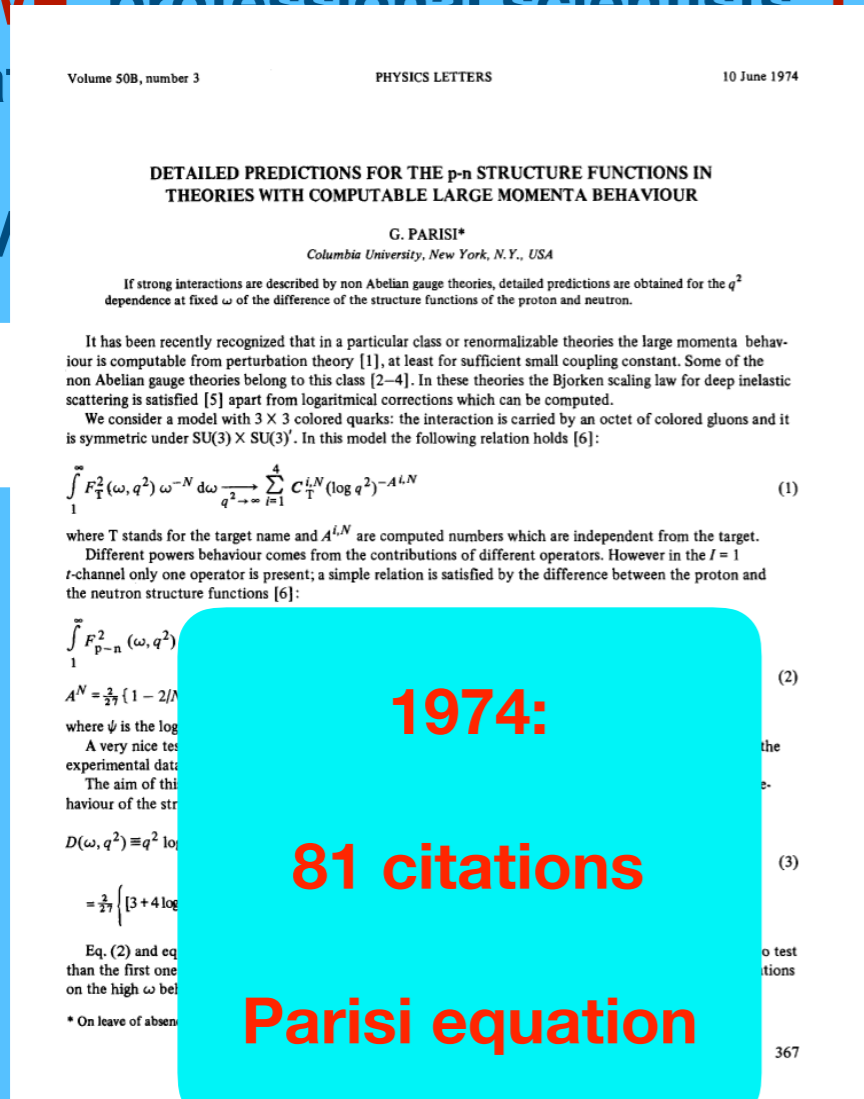
* On leave of absence from Frascati (INFN)

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1974:
81 citations
Parisi equation

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where T stands for the target name and $A^{i,N}$ are computed numbers which are independent from the target. Different powers behaviour comes from the contributions of different operators. However in the $l=1$ t -channel only one operator is present; a simple relation is satisfied by the difference between the proton and the neutron structure functions [6]:

$$\int_1^{\infty} F_{p-n}^2(\omega, q^2) \omega^{-N} d\omega = \frac{2}{27} \psi(1 - 2/N) \quad (2)$$

where ψ is the logarithmic derivative of the gamma function.

A very nice test of the theory is provided by the comparison of the theoretical prediction with the experimental data.

The aim of this paper is to present the detailed predictions for the difference of the structure functions of the proton and neutron at fixed ω and large q^2 .

$$D(\omega, q^2) \equiv q^2 \log \frac{F_p(\omega, q^2)}{F_n(\omega, q^2)} = \frac{2}{27} \left[3 + 4 \log \frac{1 - 2/N}{1 - 2/N'} \right] \quad (3)$$

Eq. (2) and eq. (3) are the main results of the paper. They are more precise than the first one because they take into account the logarithmic corrections on the high ω behaviour.

* On leave of absence from the Istituto di Fisica dell'Università di Roma.

1974:
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Parisi equation

Nuclear Physics B126 (1977) 298-318
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ASYMPTOTIC FREEDOM IN PARTON LANGUAGE

G. ALTARELLI*
*Laboratoire de Physique Théorique de l'Ecole Normale Supérieure**, Paris, France*

G. PARISI***
Institut des Hautes Etudes Scientifiques, Bures-sur-Yvette, France

Received 12 April 1977

A novel derivation of the Q^2 dependence of quark and gluon densities (of given helicity) as predicted by quantum chromodynamics is presented. The main body of predictions of the theory for deep-inelastic scattering on either unpolarized or polarized targets is re-obtained by a method which only makes use of the simplest tree diagrams and is entirely phrased in parton language with no reference to the conventional operator formalism.

1. Introduction

The quark parton model [1] provides us with a very useful and simple description of the physics of deep inelastic phenomena [2]. The theoretical framework which justifies the parton model is given by the asymptotically free gauge theory of strong interactions based on the color degrees of freedom [3] (quantum chromodynamics, QCD). Although scaling is predicted to be broken by logarithms (a fact which appears to be well consistent with present experiments), the deviations from scaling can be and have been computed for deep inelastic structure functions for either unpolarized [4,5] or polarized targets [6,7]. In the leading logarithmic approximation, the results can again be phrased in the parton language by assigning a well determined Q^2 dependence to the parton densities. In spite of the relative simplicity of the final results, their derivation, although theoretically rigorous, is somewhat abstract and formal, being formulated in the language of renormalization group equations for the coefficient functions of the local operators which appear in the light cone expansion for the product of two currents.

* On leave of absence from the Istituto di Fisica dell'Università di Roma.
** Laboratoire propre du CNRS associé à l'Ecole Normale Supérieure et à l'Université de Paris-Sud. Postal address: 24, rue Lhomond, 75231 Paris Cedex 05, France.
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298

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$$\int_1^{\infty} F_{p-n}^2(\omega, q^2) \omega^{-N} d\omega = \frac{2}{27} (1 - 2/N) \quad (2)$$

where ψ is the logarithm of the ratio of the structure functions. A very nice test of the theory is the comparison of the experimental data with the theoretical predictions. The aim of this paper is to provide a detailed prediction for the behaviour of the structure functions at large momenta.

$$D(\omega, q^2) \equiv q^2 \log \frac{F_p(\omega, q^2)}{F_n(\omega, q^2)} = \frac{2}{27} \left[3 + 4 \log \frac{1}{\omega} \right] \quad (3)$$

Eq. (2) and eq. (3) are valid for $q^2 \rightarrow \infty$ and ω fixed. The first one is valid for ω fixed and $q^2 \rightarrow \infty$. The second one is valid for $q^2 \rightarrow \infty$ and ω fixed.

* On leave from the University of Padua.
** On leave from the University of Padua.
*** On leave from the University of Padua.

367

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1. Introduction

The quantum chromodynamics (QCD) justifies the parton model of the interactions (strong interactions). Although the parton model is well established and has been used for many years [4,5] or possibly can again be used in the future, the derivation of the parton distribution functions being formalized in the parton model is the product of the asymptotic freedom.

* On leave from the University of Padua.
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1977:
7691 citations
Altarelli-Parisi equations

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Many of us **NEVER LEARN!** You can be a very good scientist and a poor writer....

However,

we may learn from **more experienced professional scientists**

and

we may learn from **more experienced professional writers**

A Pulitzer Prize's suggestion

The 2006 Pulitzer Prize's winner Cormac McCarthy wrote a basic set of rules (suggestions...) on how to write a scientific article (in english)

Nature 574, 441-442 (2019)

Some of them:

On the choice of the subject:

Decide on your paper's theme and two or three points you want every reader to remember. This theme and these points form the single thread that runs through your piece.

On simplicity:

If something isn't needed to help the reader to understand the main theme omit it. Keep sentences short, simply constructed and direct. Concise, clear sentences work well for scientific explanations.

On the style:

Inject questions and less-formal language to break up tone and maintain a friendly feeling. [...] Similarly, use a personal tone because it can help to engage a reader. If you must talk about arbitrary colours of an abstract sphere, it's more gripping to speak of this sphere as a red balloon or a blue billiard ball.

Maybe the most important:

Just enjoy writing.

Not everybody enjoys writing!

Accelerated learning

**Our main objective is that you may learn
the basic rules to write your Master's Thesis
by this summer...**

**Our final goal is to have a uniform (minimum) level in the Theses,
so as to simplify reading **both for referees and normal readers**
(this may be useful for us to read your theses, and for you to sell your thesis
outside the academy)**

**Starting from a “standard recipe”, you may then evolve into your
own scientific style**

General view

- 1. Two classes on basic rules to write the Master's thesis**
- 2. Practical exercise: organising the Thesis (email submission)**
- 3. Correction of the practical exercise (either by mail or skype?)**
- 4. Presentation to the class of one or two exercises**
- 5. My opinion on the usage of ChatGPT-like software**
- 6. One class on basic rules to present your Master's thesis**

Outline of the lectures

- 1. STARTING**
 1. Choosing a language
 2. Choosing an editing language
 3. Choosing an editor

- 2. ORGANIZATION OF THE THESIS**
 1. Understanding your subject
 2. What is “old”
 3. Appendices
 4. What is “new”
 5. Introduction and conclusions

- 3. GRAPHICS AND EQUATIONS**
 1. Drawing and inserting plots
 2. Explaining plots (captions!)
 3. Equations

- 4. REFERENCING**

1.

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 1. Drawing and inserting plots
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 3. Equations

4. **REFERENCING**

What this class it is not

We are not teaching you to write

**We are not teaching you the language you use to write:
scientists write in a non-uniform language
that approximately resembles English**

We are not teaching you physics

Part I: STARTING

1. Choose a language to write

Possible choices:

ENGLISH

CASTELLANO

VALENCIÁ

Part I: STARTING

1. Choose a language to write

Possible choices:

ENGLISH

CASTELLANO

VALENCIÀ

I strongly suggest **ENGLISH**:

1. It is the (current) language of science
2. You read books and articles in english
3. It may be your first (or last) chance to write in english
4. Your thesis will be easier to show outside (to do a PhD abroad, to go to a private company, ...)

Part I: STARTING

2. Choose a editing language

Possible choices:

NONE

Part I: STARTING

2. Choose a editing language

There is only one choice possible:

LATEX

Possible choices:

NONE

MAC: TEXSHOP <https://pages.uoregon.edu/koch/texshop/>

WINDOWS: MIKTEX <https://miktex.org/download>

LINUX: TEXLive (depends on which Linux)

<https://repology.org/project/texlive/versions>

Part I: STARTING

3. Choose an editor

**This is up to you
(however, most Latex releases
have their own editor)**

Part II: ORGANIZATION

1. Understanding your subject

Usually, you and your advisor are **the two persons that understand most of your thesis**

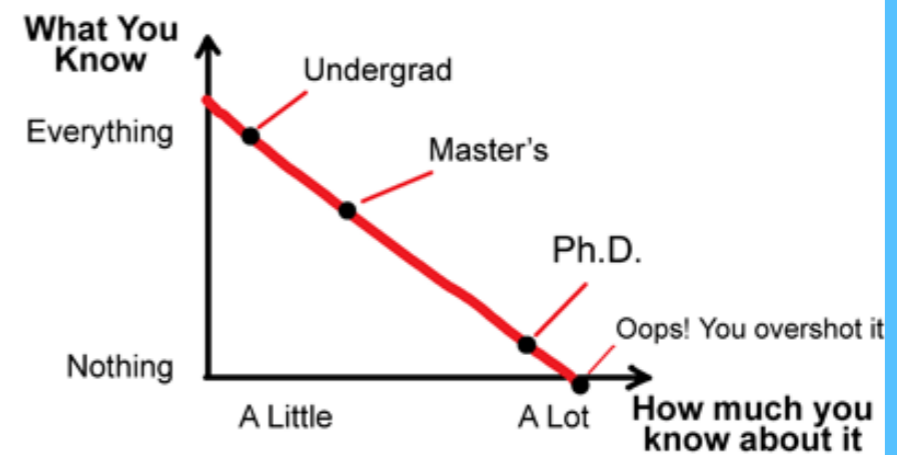
Part II: ORGANIZATION

1. Understanding your subject

Usually, you and your advisor are **the two persons that understand most of your thesis**

Sometimes, **only your advisor understand (most of) your thesis**

What You Know vs How much you know about it



DCOMICS.COM

Part II: ORGANIZATION

1. Understanding your subject

Usually, you and your advisor are **the two persons that understand most of your thesis**

The rest of the physicists that read your thesis divide into:

those that **know the subject**
and those that **do not know the subject**

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The jury that will examine you will be composed
by both

Part II: ORGANIZATION

WRITE FOR THE LATTER GROUP! ... r subject

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Part II: ORGANIZATION

1. Understanding your subject

You should imagine that those that read

**DO NOT KNOW DEEPLY THE SUBJECT
OF YOUR THESIS**

(give an overview of the subject)

but

THEY KNOW AND UNDERSTAND THE BASICS
(do not start with undergraduate stuff)

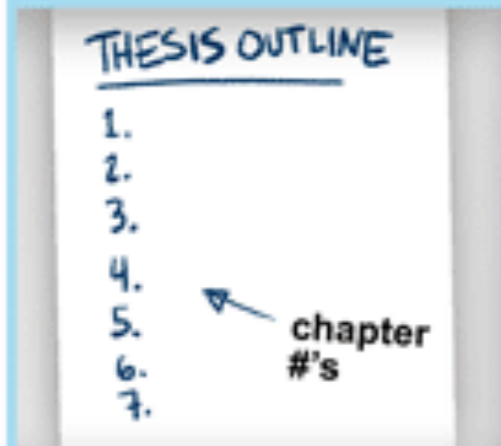
Part II: ORGANIZATION

1. Understanding your subject

WRITING YOUR THESIS OUTLINE

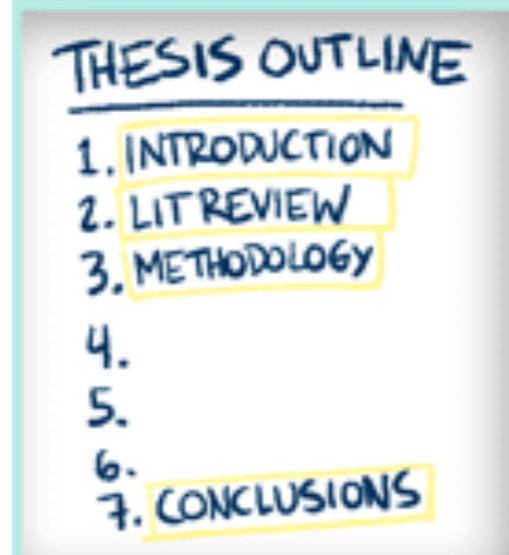
NOTHING SAYS "I'M ALMOST DONE" TO YOUR ADVISOR/
SPOUSE/PARENTS LIKE PRETENDING YOU HAVE A PLAN

STEP 1 Aim for a respectable number of chapters:



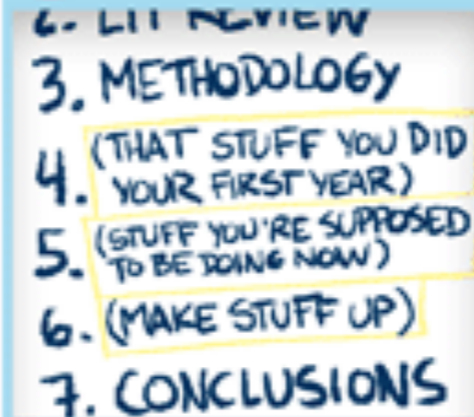
5 = "That's IT??"
6-7 = "Not bad"
8+ = "Are you crazy??"

STEP 2 Fill in the "freebies":



You're half way done!

STEP 3 Make up titles for the "meat" chapters:



(It'll be years before you actually have to work on that later chapter, and by then your thesis topic will have changed anyway)

STEP 4 Voilà! You just bought yourself another two years



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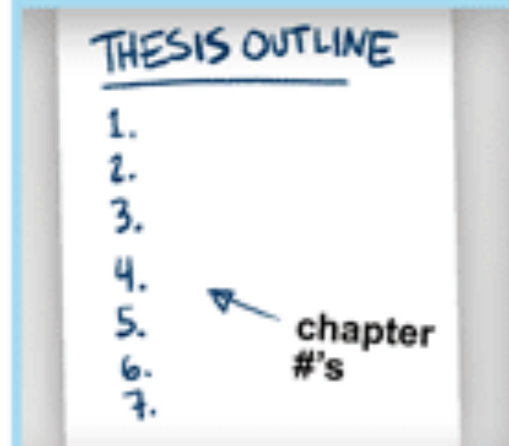
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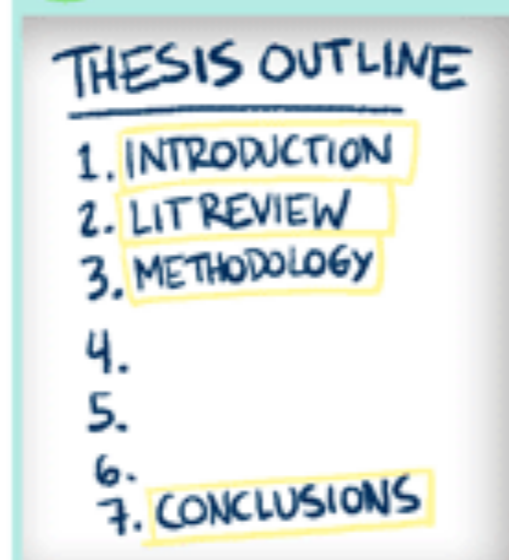
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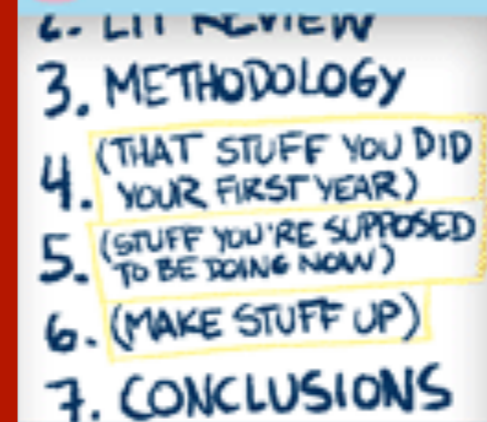
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Part II: ORGANIZATION

An example from old theses

Thesis on SUSY

Contents	
1 SM Problems	1
1.1 Observable Problems	3
1.1.1 Neutrino Masses	3
1.1.2 Dark Matter	4
1.1.3 Baryon Asymmetry (Baryogenesis)	5
1.1.4 Inflation Mechanism	5
1.2 Hierarchy Problem	5
1.3 Theoretical and Phenomenological Problems	8
2 The SUSY Way	9
2.1 LSP - Dark Matter	11
2.1.1 R-parity	12
2.2 Stability in the Hierarchy Problem	13
2.3 Grand Unification	15
2.4 Unification of Couplings	15
2.5 Locality and Supergravity	16
3 Introducing SUSY	17
3.1 SUSY Algebra	17
3.1.1 Massless Supermultiplet	18
3.1.2 Massive Supermultiplet	19
3.2 SUSY Lagrangians	20
3.2.1 Non-interacting Wess-Zumino model	20
3.2.2 Interacting chiral supermultiplet	22
3.2.3 Gauge supermultiplet lagrangians	24
3.2.4 Gauge and Chiral interactions	26
3.3 Necessity of Soft SUSY Breaking	27
4 MSSM	28
4.1 Electroweak symmetry breaking in the MSSM	29
4.2 MSSM mass spectrum	30
4.2.1 Gluinos	30
4.2.2 Neutralinos	31
4.2.3 Charginos	31
4.2.4 Chiral supermultiplet mixing	32

Part II: ORGANIZATION

An example from old theses

Introduction (motivation)

Thesis on SUSY

Contents

1	SM Problems	1
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Part II: ORGANIZATION

An example from old theses

Introduction/ Motivation

Thesis on SUSY

“ Lil’ ” review

Contents

1	SM Problems	1
1.1	Observable Problems	3
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Part II: ORGANIZATION

Another example from old theses

Thesis on GR

Contents

1	Introduction	3
2	General relativity background	6
2.1	Differential Geometry	6
2.2	Einstein field equations	9
3	Modified gravity theories	13
3.1	$f(R)$ theories	15
3.2	Born-Infeld inspired gravity	20
3.2.1	Born-Infeld electromagnetism	20
3.2.2	Eddington inspired Born-Infeld gravity	22
3.2.3	Physical relevance of the auxiliary metric $q_{\mu\nu}$	26

Part II: ORGANIZATION

Another example from old theses

Introduction (motivation)

Thesis on GR

“ Lil’ ” review

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Part II: ORGANIZATION

Introduction/Motivation: 3-6 pages

**“Old” Literature: 10 to 20 pages
(from textbooks and articles)**

START FROM HERE! START NOW!

Your stuff: 10 to 20 pages

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**SECOND PART TO WRITE...
(third if you have appendices)**

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Introduction/Motivation: 3-6 pages

**MOST IMPORTANT PART OF THE THESIS!
LAST TO WRITE!**

**“Old” Literature: 10 to 20 pages
(from textbooks and articles)**

START FROM HERE! START NOW!

Your stuff: 10 to 20 pages

**SECOND PART TO WRITE...
(third if you have appendices)**

First: What is “old”

You should determine which amount of basic information is needed to introduce the subject

Who is your reader: a physicist that understand what you are doing, but do not know the basic literature on the subject (except for textbooks)

First: What is “old”

Example: Thesis on some topic in General Relativity

**Do not explain what is General Relativity from scratch
If you need some non-standard formalism,
introduce it**

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**This part of the thesis is the place where it is most probable to take a short-cut:
Cut&Pasting from holy books and articles**

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**A sensible excuse:
how may I write something about THIS
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**This part of the thesis is the place where it is most probable to take a short-cut:
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**This is NOT ALLOWED!
It is better to read the holy sources,
try to understand and
TRY TO WRITE BY YOURSELF**

First: no Cut&Paste

<https://top-papers.com/how-to-avoid-plagiarism-in-research-papers/>

1. Paraphrasing: your own words, same concept
2. Citing: (small) text from other paper [citenumber]
3. Quoting: “(complete) text from other paper” [citenumber]



Second: Appendices

They are the place where you must move
TECHNICAL STUFF
that you used but is:

- A) boring to read in the main text
- B) something that may be skipped

Thesis on Quantum Systems

Appendices	38
A Weak coupling ME calculations	38
A.1 $\text{Tr}_E [V_t H_I(t), \hat{\rho}(0)] = 0$ for an arbitrary state of the environment.	38
A.2 Computation of $\text{Tr}_E [V_t^0 H_I(t), [V_\tau^0 H_I(\tau), \hat{\rho}(0)]]$	38
A.3 Switching to the Schrödinger picture	39
B Commutators of weak coupling ME for different OQS operators L	40
B.1 $L = \sigma_-$ ($L^\dagger = \sigma_+$)	40
B.2 $L = L^\dagger = \sigma_z$	40
B.3 $[H_S, \rho_S(t)]$	40

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As many as you need....

No more than a
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Thesis on Quantum Systems

Write these **SECOND! TOMORROW!**

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$L^\dagger = \sigma_z$	40
$L^\dagger = \sigma_x$	40

Third: Your “new” stuff

It must be very clear
WHAT is NEW, and WHAT is NOT NEW

A typical question at the defense:

“Ok, very nice. But....
Can you explain me **PRECISELY** which is the
difference between what **YOU** have done
and the **LITERATURE?**”

Third: Your “new” stuff

**Literature:
first chapters**

**INTRODUCE
WHAT IS OLD**

**You should have written
this first; it is useful for you
to explain differences**

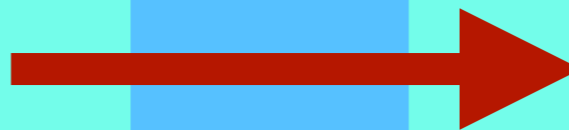
**Your work:
last chapters**

Third: Your “new” stuff

**Literature:
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**INTRODUCE
WHAT IS OLD**

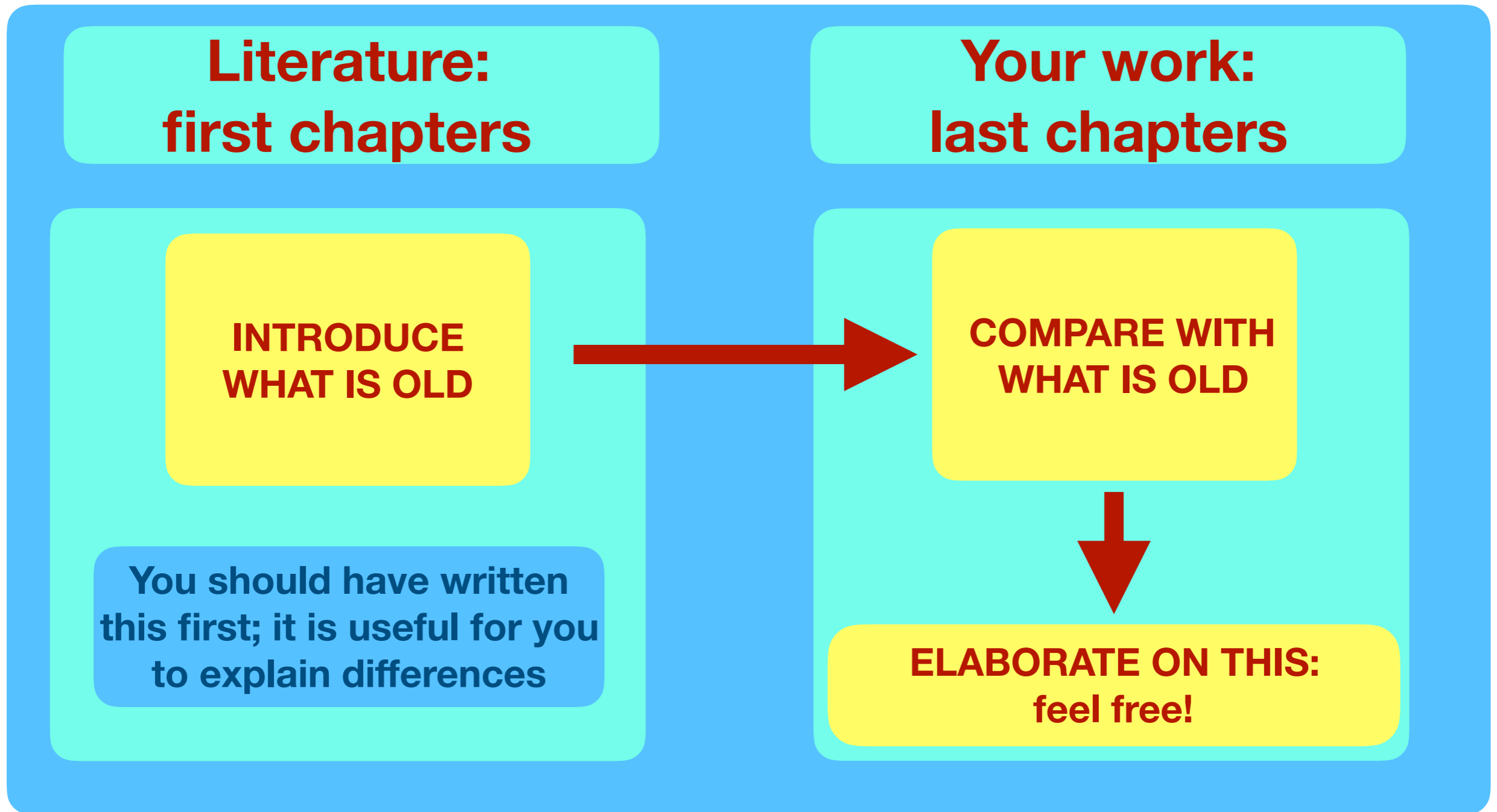
**You should have written
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**Your work:
last chapters**

**COMPARE WITH
WHAT IS OLD**

Third: Your “new” stuff



Four: Introduction

YOUR THESIS COMMITTEE

Also known as: an impossibly difficult group to get together in one room but who nevertheless hold your future in their hands depending on their ability to reach a civilized consensus.



Your Professor

Simultaneously your biggest ally and your worst enemy. Will be the first to suggest you do more work.



The Guru

Only here for the free cookies. Don't forget to bring cookies.



**Adversary
The Asshole**

Has bitter rivalry with your Professor and will argue the exact opposite view. Work this to your advantage.



**The
Strawman/woman**

Nice guy.
No opinions.

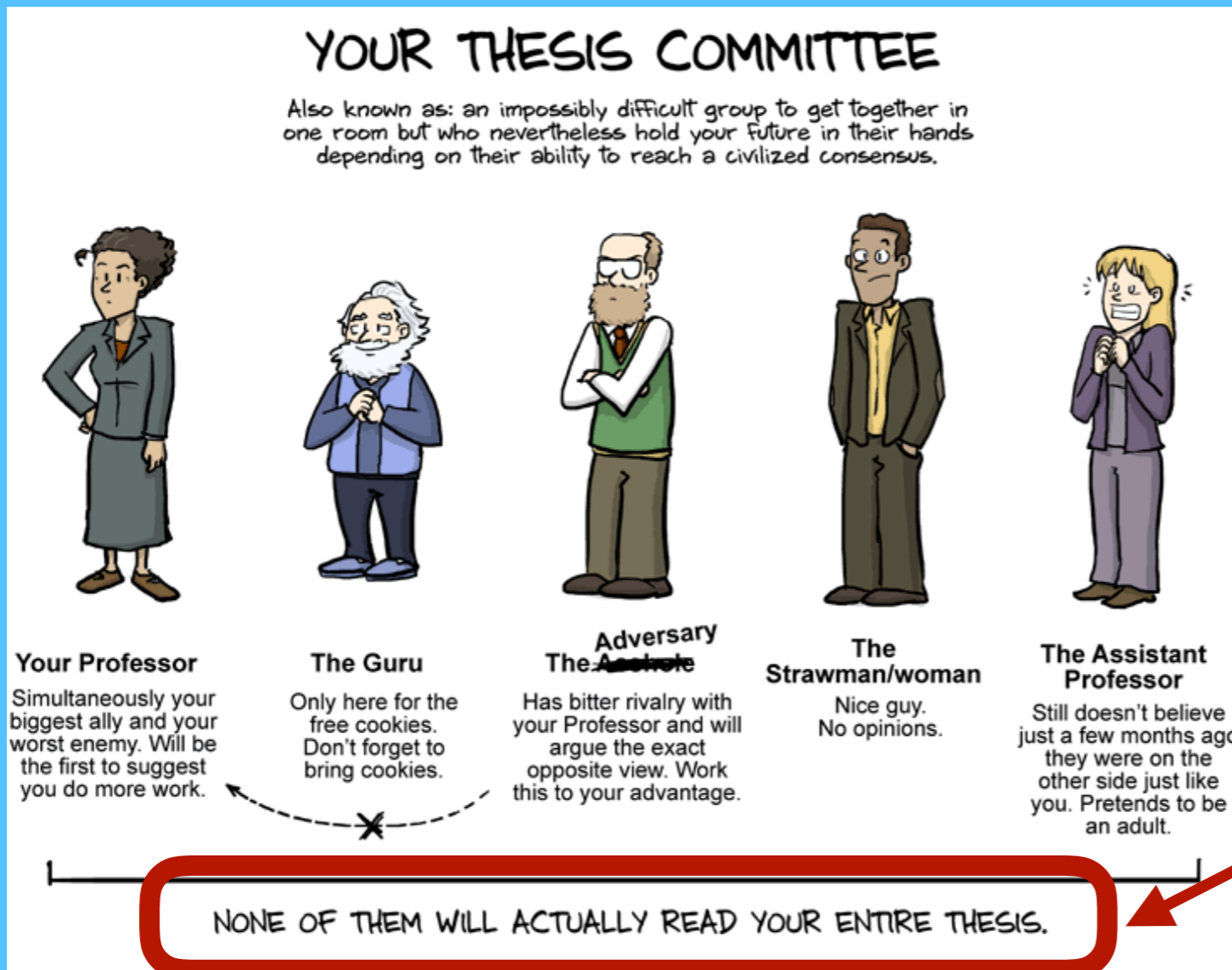


**The Assistant
Professor**

Still doesn't believe just a few months ago they were on the other side just like you. Pretends to be an adult.

NONE OF THEM WILL ACTUALLY READ YOUR ENTIRE THESIS.

Four: Introduction



This sounds as a joke, but many times overlaps one-to-one with reality

Four: Introduction

It is a complete **summary of the thesis**:
one should understand what is written in the main body just from
reading this. **If you succeed, the reader will feel happy!**

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Examples:

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**Most important part of
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Organization of the thesis: “In Chapt. 1 I review; in Chapt. 2....”

Five: Conclusions

It is a short **summary of the thesis:**
remind shortly the motivation and the results
with respect to the literature

This is the place to insert your work as
just **one single brick in a big construction**
to be carried over many years

Use a few words to explain possible future development,
“beyond the scope of this thesis.”