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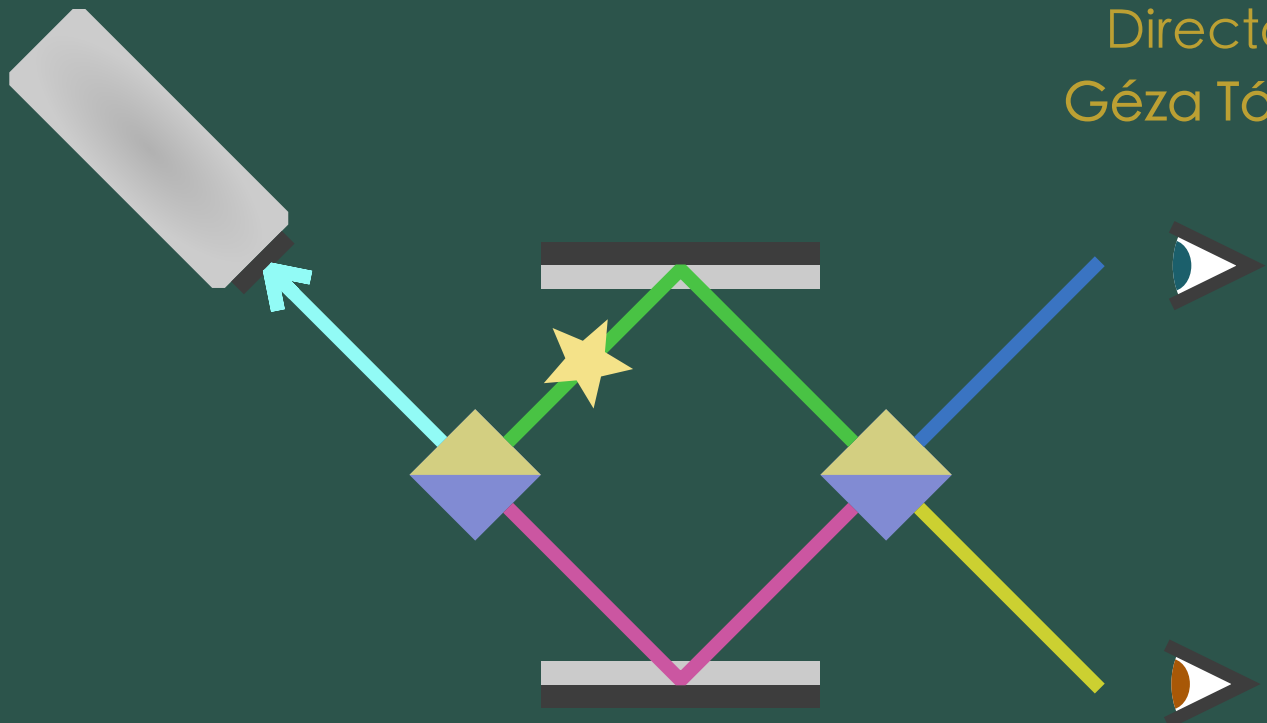
PhD Thesis



# LOWER BOUNDS ON QUANTUM METROLOGICAL PRECISIONS

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# Prologue

This work is part of the doctoral project of M. Sc. Iagoba Apellaniz in order to obtain the necessary qualification to promote himself to become a PhD. This work also tries to collect almost all the research discoveries done by the author on those previous years in a clear and concise way to make it understandable for a general reader with a basic background in mathematics and physics.

The aim of this thesis is to present to the reader some important results of quantum metrology as well as guide possible interested ones into the fascinating field that is quantum metrology and its applications.

This is the prologue



# Publications

Iagoba Apellaniz *et al* 2015 *New J. Phys.* **17** 083027  
Detecting metrologically useful entanglement in the vicinity of Dicke states

## Preprints

### Out of the scope of this thesis

Géza Tóth and Iagoba Apellaniz 2014 *J. Phys. A: Math. Theor.* **47** 424006  
Quantum metrology from a quantum information science perspective

Giuseppe Vitagliano *et al* 2014 *Phys. Rev. A* **89** 032307  
Spin squeezing and entanglement for an arbitrary spin





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# Tables, figures and abbreviations used in this book

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SLD – Symmetric logarithmic derivative.

qFI – Quantum Fisher information





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# Lower bounds on quantum metrological precisions

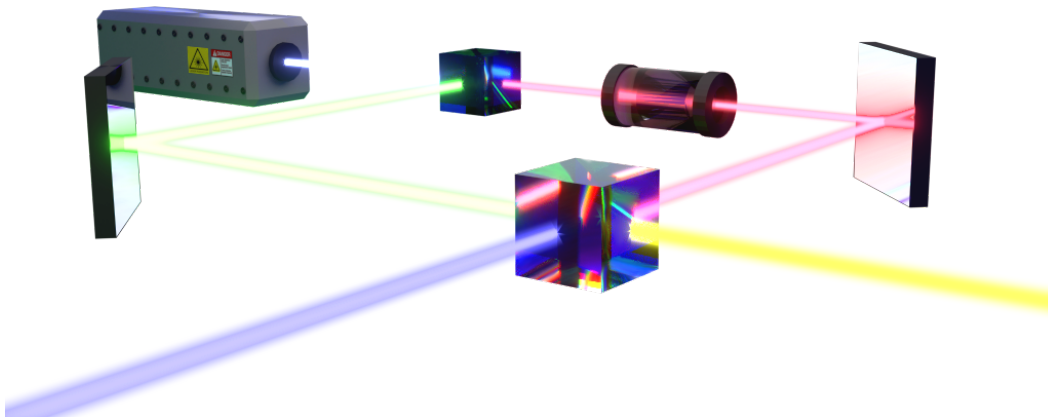
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*Author:*

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*Director:*

Prof. Géza TÓTH



November 17, 2015



*To my parents and my family*





## 1

# Introduction

THIS thesis is the final work of the PhD project spinning around the subject of Quantum Metrology.



## 2

## Historical development fo Quantum Metrology

**M**ETROLOGY as the science of measuring has played an essential role for the development of the technology as it is nowadays. It studies several aspects of the actions involved on a measurement. Metrology covers from the physical design of a precise measuring device until the most basic concept of nature which lead in ultimate instance to the better understanding of the process.

In this sense, with the discovery of the Quantum Physics and the development of Quantum Mechanics, new doors for advances in metrology were open on the earlies decades of the 19th century. Later on, the Quantum Theory lead to the so called field of Quantum Information which merges the notions of the computer science among others with the quantum mechanics. The role of the so-called entanglement, an esclusive feature of Quantum Mechanics, is esential in this context. Its complete understanding has integrated efforts of many researches world wide. Said this, the entanglement also is in the center of theoretical concepts included in Quantum Metrology.

### 2.1 Classical estimation theory

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### 2.2 Step in quantum estimation theory

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## 2.3 Quantum Metrology

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3

## Quantum metrology with Dicke like states

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4

## Bounding quantum Fisher Information with observables

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Accuracy bound for gradient field estimation with atomic ensembles

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## References

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