Theoretische Physik III
Quanteninformation

PD Dr. Hermann Kampermann

Telefon +49 211 81 14679
Telefax +49 211 81 11337
Hermann.Kampermann@hhu.de

Sekretariat:
C. Glowacki
Telefon +49 211 81 13992
Sekretariat.TP3@hhu.de

Düsseldorf, 4.04.2022

Heinrich-Heine-Universität Düsseldorf
Universitätsstraße 1
40225 Düsseldorf
Gebäude 25.32
Ebene 03 Raum 44

www.hhu.de

www.tp3.hhu.de

Advanced Quantum Information Theory (SS 22)

Start:
Tuesday, **05.04.2022 at 8:30 in room 25.32.03.51**
(Lecture time and day can be discussed/shifted if necessary)

Summary:
This lecture is a continuation of the quantum information concepts treated in “Theoretical Quantum Optics and Quantum Information”. Previous attendance of this lecture is helpful but not mandatory.
After a short repetition of some basic concepts of Quantum Mechanics and Quantum Information Theory we will discuss the notion of “non-locality” and how this can in principle be confirmed in experiments. The principle of information causality is introduced and the consequences with respect to the strength of correlations are discussed. In connection with the concept of non-local boxes we try to give an information theoretic reasoning for “why quantum mechanics is as it is”.
In the third chapter, I will focus on the general problem of obtaining information about quantum states. We introduce parameter estimation and extend it to quantum state tomography methods focusing on state tomography via linear inversion and maximum likelihood estimation.
It follows a characterization of multipartite entangled states. We introduce the concept of SLOCC classes of entanglement and especially treat bound entangled states. Finally, the concept of generalized quantum correlations is discussed and basic properties are discussed.

Lectures: Tuesdays (sometimes, see schedule),
8:30-10:30, seminar room 25.32.03.51
Wednesdays (sometimes, see schedule),
10:30-12:30, seminar room 25.32.03.51

Exercises: Every second week (lecture time-slot, see schedule)

Advanced Quantum Information Theory (SS 22)

(Material/Info's: http://www.tp3.hhu.de/lehre.html)

Content:

1. Basic concepts in quantum mechanics
    a. Postulates
    b. Measurement

2. Non local correlations
    a. Bell inequalities
    b. Non-local boxes
    c. Information causality

3. Quantum state tomography
    a. Parameter estimation
    b. Linear inversion
    c. Maximum Likelihood

4. Quantum correlations
    a. SLOCC entanglement classes
    b. Bound entanglement
    c. Generalized quantum correlations

Literature:

M.A. Nielsen, I.L. Chuang, *Quantum Computation and Quantum Information*, Cambridge University Press (2000).

D. Bruß and G. Leuchs, *Lectures on Quantum Information*, Wiley-VCH (2007).

A. Peres, *Quantum Theory: Concepts and Methods*, Kluwer Academic Publishers, Dordrecht (1998).

J.S. Bell, *Speakable and unspeakable in quantum mechanics*, Cambridge University Press (1987)

M. Pawlowsky *et al.*, *Information causality*, Nature 461, 1101 (2009) [arXiv:1112.1142]

Horodecki$^{\otimes 4}$, *Quantum entanglement*, Rev. Mod. Phys. 81, 865–942 (2009)

K. Modi *et al., The classical-quantum boundary for correlations: Discord and related measures*, Rev. Mod. Phys. 84, 1655 (2012)