Università degli Studi di Ferrara

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DEPARTMENT OF ENGINEERING
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On the Design of Quantum Communication Systems with non-Gaussian States

Candidate:
Federico Forzano
Matricola 143528

Supervisor:
Chiar.mo Prof. Andrea Conti

Co-Supervisor:
Dott.Ing Stefano Guerrini

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Chapter 1

Quantum Mechanics Abstract

In this chapter, a bief overview of quantum mechanics postulates and of the notation used in this thesis is given. The target of that is to explain to the reader the essential concept [...]

1.1 Postulates

Like every phisics theory, quantum mechanics is builded from few essential postulates. In this section are briefly introduced the six Dirac-Von Newman postulates of Quantum Mechanics [1][2].

1.1.1 First Postulate

Postulate 1 (State Representation) *The state of an isolated quantum system is represented by a complex unitary vector in an Hilbert space:*

$$|\psi\rangle \in \mathcal{H}$$

The space of possible states of the system is called state space and it is a separable complex Hilbert space.

Observation *Differently from the classical physics, in quantum mechanics the concept of state of system is introduced. In classical mechanics a system is described by his observables, like position or four-wheeled.*

1.1.2 Second Postulate

Postulate 2 (Observables) *Every observables of the system is represented by an Hermitian operator acting on the state space:*

$$\mathcal{M} : \mathcal{H} \rightarrow \mathcal{H}$$

The outcomes of the measurement can only be one of the eigenvalue of the operator $\mathcal{M}$.

Observation *The possible outcomes of the measurement are real number because $\mathcal{M}$ is self-andjoint.*

1.1.3 Third Postulate

Postulate 3 (Born's Rule) *The probability to get the measurement λ_i from the observable $\mathcal{M}$ in the system in state $|\psi\rangle$ is:*

$$\mathbb{P}(\lambda_i) = \langle\psi| \mathcal{P}_i |\psi\rangle$$

where $\langle\psi|$ is the correspondent vector of $|\psi\rangle$ in the dual space of $\mathcal{H}$ and where $\mathcal{P}_i$ is the projection operator of λ_i in the correspondent space.

1.1.4 Fourth Postulate

Postulate 4 (Wavefunction Collapse) *The state after measurement of λ_i is $\mathcal{P}_i |\psi\rangle$ (with the necessary normalization):*

$$|\psi'\rangle = \frac{\mathcal{P}_i |\psi\rangle}{\langle\psi| \mathcal{P}_i |\psi\rangle}.$$

1.1.5 Fifth Postulate

Postulate 5 (Time Evolution) *The time evolution of an isolated quantum system is given by an unitary operator $\mathcal{U}$:*

$$|\psi(t)\rangle = \mathcal{U}(t_0, t) |\psi(t_0)\rangle .$$

Observation (Time dependent Shrodinger Equation) *From postulate 5, is possible to found the time dependent Shrodinger Equation:*

$$i\hbar\frac{\partial}{\partial t} |\psi(t)\rangle = H(t) |\psi(t)\rangle$$

where $H(t)$ is the Hemiltonian matrix.

1.1.6 Sixth Postulate

Postulate 6 (Composite System) *The state space of a system composite from $\mathcal{H}_1$ and $\mathcal{H}_2$ is given by*

$$\mathcal{H} = \mathcal{H}_1 \otimes \mathcal{H}_2.$$

Bibliography

[1] P.A.M. Dirac. *The Principles of Quantum Mechanics.* Oxford University Press, 1981.

[2] J. Von Neumann. *Mathematical foundations of quantum mechanics.* Princeton University Press, 1995.