

석사학위논문  
Master's Thesis

양자 통신의 근원적 이론과 응용

Theoretical Study on Quantum Communication with  
Some Applications

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전산학부

# 양자 통신의 근원적 이론과 응용

박 상 우

위 논문은 한국과학기술원 석사학위논문으로  
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# Theoretical Study on Quantum Communication with Some Applications

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A dissertation submitted to the faculty of  
Korea Advanced Institute of Science and Technology in  
partial fulfillment of the requirements for the degree of  
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Approved by

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The study was conducted in accordance with Code of Research Ethics<sup>1</sup>.

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<sup>1</sup> Declaration of Ethical Conduct in Research: I, as a graduate student of Korea Advanced Institute of Science and Technology, hereby declare that I have not committed any act that may damage the credibility of my research. This includes, but is not limited to, falsification, thesis written by someone else, distortion of research findings, and plagiarism. I confirm that my thesis contains honest conclusions based on my own careful research under the guidance of my advisor.

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### 초 록

이 논문에서는 부 쓰는이가 여러 안테나를 쓰는 협력 인지 무선통신망을 다루었다. 안테나 개수는 이제까지의 방법과 같도록 유지하면서 부 쓰는이가 다다를 수 있는 전송률을 높이는 방안을 제시하였다. 좀 더 자세히 말하면, 동시 송수신 안테나를 써서 부 쓰는이끼리 전 이중으로 신호를 주고받을 수 있게 하여 부 쓰는이가 다다를 수 있는 전송률을 높이는 방안을 제시하고 그 성능을 살펴보았다. 제안한 협력 인지 무선통신망이 나타내는 다다를 수 있는 전송률이 이제까지의 다른 협력 인지 무선통신망에서 얻을 수 있는 것과 견주어 꽤 높음을 해석적인 방법과 계산적인 방법으로 보였다.

핵심 낱말 인지 무선 통신, 협력 통신, 중계, 전 이중, 동시 송수신

### Abstract

We address cooperative cognitive radio networks (CCRN) with secondary users (SUs) exploiting multiple antennas. In order to expand the achievable rate region by enabling full-duplex communication between SUs, we adopt simultaneous transmitting and receiving antennas for the SUs. The link capacities of the proposed framework are analyzed theoretically. It is shown through numerical analysis that the proposed framework can provide a considerable performance gain over the conventional CCRN framework.

Keywords Cognitive radio, cooperation communication, relay, full-duplex, simultaneous transmission and reception

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## Chapter 1. Introduction

Cognitive radio (CR), a key technology of resource-efficient wireless communications, can be employed to solve the problem of frequency resource shortage. However, due to the uncertainty of the secondary users' (SUs') usage of frequency band, the original CR has failed to gain sufficient interests. Recently, a new paradigm termed cooperative cognitive radio networks (CCRN) has been proposed [1]-[3]...

There ...

## **Chapter 2. Related Works and Contributions of this Dissertation**

### **2.1 Quantum Communication**

There have been extensive studies on cognitive radio in recent years. To enhance the performance gain of original cognitive radio networks (CRNs), leveraging cooperative diversity has attracted a lot of attention [4]...

#### **2.1.1 Examples**

### **2.2 Applications of Quantum Communication**

Despite its potential to improve the throughput, spatial domain diversity was not fully considered in the studies of original CCRNs. Utilizing the spatial domain for the communications, the concept of MIMO has been adopted in many cases to increase the wireless capacity [5, 6]...

## Chapter 3. Proposed Architecture and Its Application

### 3.1 Proposed Architecture

Let us consider an MIMO-CCRN with one PL and one SL. Each PU has one legacy antenna and each SU has two STAR antennas. The duration of one communication time frame is divided into two phases [7, 8] ...

### 3.2 Application

The achievable rates can be calculated by finding the statistics of the five signals transmitted that maximize the mutual information between  $s_{t,XY}$  and  $y_{t,XY}$  for  $(X, Y) = (T, C), (C, N)$ , and  $(N, C)$  when  $t = 1$ , and  $(X, Y) = (C, R), (C, N)$ , and  $(N, C)$  when  $t = 2$  [9, 10]...

Table 3.1: Energy stability  $E$  (eV) per molecule of all meta-stable isomer states of  $C_{60}$  opening process for forming the (5,5) cap. In the SW-I and SW-II, both ferromagnetic (Ferro) and paramagnetic (Para) spin configurations are obtained, whereas only non-magnetic configuration is obtained in the BF, SW-III, and CAP(5,5).  $M$  is total magnetization  $n_{\text{up}} - n_{\text{down}}$  in unit of  $\mu_B$ , where  $n_{\text{up}}(\text{down})$  is the number of up (down) spins.

	BF	SW-I		SW-II		SW-III	CAP
		Para	Ferro	Para	Ferro		
$E$ (eV)	0	7.796	7.832	10.418	10.408	11.5	13.2
$M$ ( $\mu_B$ )	0	0	1.94	0	2.06	0	0

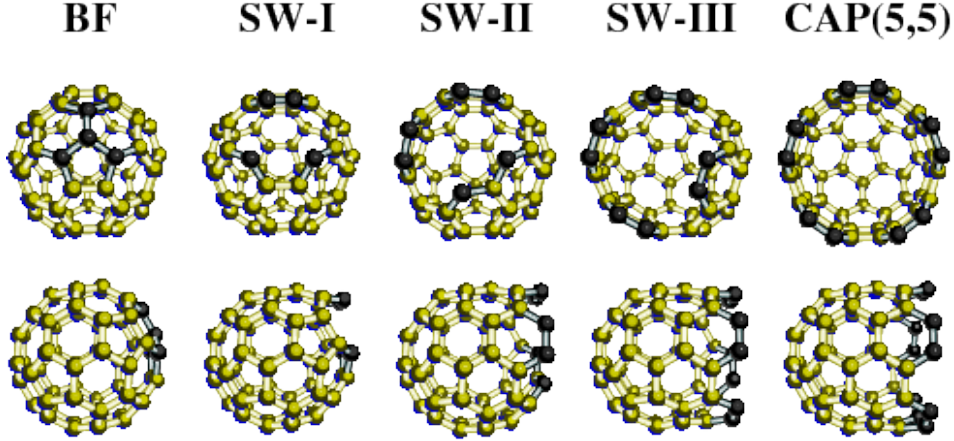


Figure 3.1: Ball-and-stick models of meta-stable isomers in cage opening process from a  $C_{60}$  buckminsterfullerene to a (5,5) capsule. We name them BF and CAP(5,5). Depending on the number of the Stone-Wales (SW) transformation, we call the intermediate isomers with SW-I, SW-II, and SW-III. Highlighted atoms are undercoordinated except BF.

## Chapter 4. Concluding Remark

We have proposed a novel FD MIMO-CCRN framework providing a reasonable performance improvement compared with the conventional MIMO-CCRN framework...

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## Curriculum Vitae in Korean

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