Personal Report on the Performance in the Qualify Exam February 2015 (NST)

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I want to share my experience in the Oral Qualifying Exam (Division: Nuclear Science and Technology) of the Department of Nuclear Science and Engineering taking place on February 4th, 2015. This report mainly focuses on the procedure of the exam, the contents of the QA, and several important things that I learned from the exam. Also, I will provide the exam problems this year and several sample problems that might be helpful for the preparation of the qualify exams in the following years.

I. PROCEDURE OF THE EXAM

This section introduces how the exam is carried out. The exam is divided into two parts: Research presentation and Quiz section.

A. Research presentation

For the research presentation, you have to prepare 15 minutes of presentation about your **research background**. You also have to prepare a five to ten pages paper about your research. The paper should be submitted ten days before your exam date. It seems that the professors only read your abstract. After you delivered your presentation, the professors are going to ask you questions. Questions are completely related to what you present in your presentation. Their expectations are the following:

1. You can convince them that your assumptions are reasonable in terms of physics.
2. You can demonstrate that your research can contribute to the current research project of the group you belong to.

Advice from Professor Yip

Professor Yip said that the most important thing here is to be able to convince the professors that you are ready for the Ph.D instead of showing how much you know about your research. He also said that the students were expected to emphasize why their research is important, how their research relates to their group projects, and how their research can contribute to the projects. Students are expected to write and present these points clearly and convincingly.

B. Quiz section

In the second part, in my case, two problems were asked, and in each problem, there were two sub questions which are closely related to each other. The characteristics of the problems were: **you can totally solve the problems by your intuition and your knowledge.** You can solve the problems even without the derivation. In my case, I started to solve the first problem by demonstrating a detailed derivation. But, Professor Li stopped me. His points were the following:

1. You have to give the answer because the problems require the direct answer.
2. You have to explain the assumption you make and the physics behind your assumption.
3. Then, you can go to the board and derive the equations to make your solution more precise.

1. For Problem 1

Problem 1 ask you to set up several reasonable assumptions, and solve the problem based on your assumptions. Usually, you have different acceptable answers. The most important things about problem 1 are:

1. You have to convince the professors that your assumptions are reasonable in terms of physics.
2. You have to show the conditions of the different answers in different cases.

Problem 1 seems to test your physical intuition.

2. For Problem 2

Problem 2 is completely different from Problem 1. They ask me a very concrete problem where I do not have much degree of freedom to solve the problem. Problem 2 combines all of the fundamental concepts that you learned from your specialization classes. So, it is very very important to **combine your knowledge from different field of specialization classes.** All of the questions are also testing that you can give an answer quickly based on your intuition. They also ask me about some terminologies in the specialization classes. Finally,the most important things are

1. Professors expect you to solve all of the problems.
2. The problems are all coming from only the specialization classes.

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C. Test time

The test time is very important. Although they say one hour for Part 1 and one hour for Part 2, and it was completely different. I spent one and half hour for Part 1, and only half hour for Part 2. Between Part 1 and Part 2, I had five minutes of break. It was not break anymore. They gave me question sheet after Part 1, and I only had five minutes for the preparation.

II. FOR NON-NATIVE SPEAKERS

I was born in China and spent seventeen years in Japan. So my mother tongue is Chinese and Japanese. For non-native speakers, this kind of exam is very tough. At least, for me, it was absolutely a nightmare. I want to share my experience here. In the exam, since I was very nervous, it was really hard for me to speak up and this caused many misunderstandings between me and the professors. Sometime the conversations were not smooth. These things happened a lot, and the students always felt scared. I was absolutely the person. While I knew the answer and how to solve it, many times, it was hard to deliver my idea and sentences. At the very beginning, since I did not want to be silent, I tried to keep talking. But, I quickly figured out that it was not a good thing to do. I changed my strategy. What I did was: I told the professors that I wanted to think a little bit about the problem. I knew the answer, I knew how to solve it. But I still asked them time for thinking. I stayed calm and started to organize my sentences and then spoke up. If you felt too nervous that it was completely hard for you to speak in English, you could write down the answers or the outline of your derivation on the board.

After the qual, Professor Lanza came to me and said "We understand that this kind of exam was very hard for foreign students. Don't worry, from your effort, from what you wrote on the board, we know that you really understand." I was very glad to hear this. However, my suggestion is that students should try to make and effort to speak to the professors. If you felt too nervous, you could ask them for time to think, and then deliver your answer.

III. REAL EXAM OF NST DIVISION

This section presents the real exam problems of NST division. I have to say I am very sorry that I have no choice but to show these problems based on my memory.

Problem 1

Let us suppose that there are two spin 1/2 particles, A and B. These two particles are interacting with each other.

(1)

Let us firstly suppose that the two particles are identical to each other. Are they entangled? Next, if these two particles are different from each other, are they entangled?

(2)

If we can only measure A and cannot have any information about B, is the time evolution of A unitary?

Problem 2

Let's think about the electron spin of NV center (Nitrogen-vacancy center in the diamond lattice), which has spin 1. Therefore they have three levels: $|m_s = -1\rangle, |m_s = 0\rangle$ and $|m_s = +1\rangle$.

(1)

Can we drive the direct transition $|m_s = -1\rangle \longleftrightarrow |m_s = +1\rangle$ by electromagnetic field? If not, why? Do you have any idea how to realize this transition?

(2)

If we want to avoid $|m_s = 0\rangle$ state for the transition $|m_s = -1\rangle \longleftrightarrow |m_s = +1\rangle$, what do you do, and what do you call this method in the atomic-molecule-optical physics?

IV. SAMPLE PROBLEMS

Here, I want to give some sample problems for the practice.

(1) [Solid state physics + 22.51]

Suppose that we want to make a solar cell. What kind of physical properties should your semiconductor have to be a good material for the solar cell?

(2) [22.51]

We know that the coherent state is the eigenstate of the annihilation operator $\hat{a}$. What is the eigenstate of the creation operator $\hat{a}^\dagger$? If we do not have such a state, please prove that the state does not exist.

(3) [Atomic-Molecule-Optical Physics I]

Is it possible to make an artificial atom whose atomic number Z is larger than 137?

(4)[Solid State physics+ 22.51]

Let us consider the entanglement generation between two two-level atoms which are coupled to the surface plasmons excited on a nano-ring wire. Here, we consider an open quantum system. What kind of phenomena can you think of in this system? Explain how you analyze whether the entnaglement between two two-level atoms is generated.

(5)[22.51]

Consider the scattering of a thermal neutron by an unknown nucleus (mass A) in the lattice. Can we identify this nucleus by the cross section of the neutron? If we can, how can we identify it? Usually we assume that our sample is very thin, and we can assume that there is only one collision. If we assume a little bit thicker sample, how can you calculate the probability of the second collision.