# Cover letter

There is a huge demand for the information processing speed up nowadays. By exploiting the laws of quantum mechanics, a quantum computer could bring exponential speedup in terms of a standard complexity measure (the way in which the number of computational steps required to complete a task grows with the “size” n of the task) for some information processing tasks (e.g.: Shor’s algorithm for factoring an n-digit number). Fascinated by this fact I am happy to be a part of the research community which is trying to make a step towards realization of such a technological advancement.

Basic unit of a quantum computer is called qubit. Demands like high **coherence vs manipulation time and scalability** are major *(should I mention also something else?)* obstacles in realizing the usable quantum processor. Several different approaches to a qubit realization are offered. An approach in our group is based on the hole spin in silicon germanium semiconductor material. Due to the low hyperfine interaction and high spin-orbit coupling for heavy holes in germanium high coherence vs manipulation time ratio is expected. Nanofabrication compatibility of silicon germanium with the CMOS industry fabrication process helps to solve one part of the scalability issue. Previously listed theoretically predicted advantages of the spin qubit realization approach used in our scientific group, makes me motivated to work on solving the other part of the scalability issue related to the qubit state readout, to be able to prove these theoretical advantages experimentally. “Scalability friendly” state readout can be achieved by using already predefined gates for sensing a state of a qubit instead of a conventional charge sensor readout technique which is invasive. Such a state readout technique is called a gate reflectometry which is also the title of this project. In my previous work as a research assistant in the group of dr.sc. Georgios Katsaros I started working on the development of an ohmic reflectometry system, which is a slightly different in respect to the gate reflectometry, for charge readout of the silicon germanium quantum dots. During this project I have gained some knowledge in a printed circuit board designs and a development of python codes for controlling various DC and high frequency signal instruments. I also performed 4 Kelvin measurements on the single hole transistor based on the Ge hut-wire quantum dots fabricated in our group by Hannes Watzinger. In October 2015, and for three months, I went on a research visit to the Center for Quantum Devices, Niels Bohr Institute, Copenhagen. I worked in the group of Ferdinand Kuemmeth. This group is developing spin based qubits in GaAs and Si/SiGe lithographically defined double and triple QDs. They are one of the biggest and the most successful groups in the field of a quantum computation. During my research stay, I learned about high end laboratory equipment including cryogen free dilution refrigerators, waveform and signal generators, RF equipment (amplifiers, filters, special type of coaxial cables… ).

Currently I am PhD student of the professor Georgios Katsaros, at the Institute of Science and Technology (IST) in Austria. It is very international institution with very high and ambitious goals and it makes me happy to be a part of it. Senior scientists here are highly qualified which has an impact on the development of my scientific skills through a direct communication, various talks and journal clubs organized at the institute.

Working on the gate reflectometry as a spin qubit readout system will involve expanding my knowledge in high frequency signal components (amplifiers, filters, attenuators, coaxial cables), high frequency circuit design and possibly COMSOL simulations. If it proves to be very sensitive, as we expect, it would enable our group and me to move towards performing experiments to determine the characteristic spin lifetimes of the silicon germanium nanowire based double quantum dot qubit. Namely, the spin relaxation time T1, the spin dephasing time T2\*, the spin echo T2ECHO  time and the CPMG T2CPMG time. With overall knowledge gained from the gate reflectometry design and from performing all above listed experiments, I hope I can be a good candidate to continue my work in the emerging area of quantum computation, after my PhD.

The DOC fellowship would enable us to buy the necessary laboratory equipment for performing previously listed experiments for determination of the characteristic spin lifetimes. Namely, the vector signal generator needed for performing qubit state manipulation and the UHFLI (ultra-high frequency lock-in amplifier) which is needed for measuring a qubit state by sensing the gate reflectometry signal. Also, it would allow me to visit our collaborators in Copenhagen and it would enable other scientific trips for enriching my scientific knowledge.

So in my view the structure should be

1. What fascinates me about the field? Why does my profile fit well with this field? Why do I think IST Austria is a good place to do my PhD?
2. What do I want to do after my Phd?
3. Why will this fellowship help me in realizing b?