1) Vlatko Vedral recommended that I should speak with you because some of your work on NMR provided the initial motivation for thinking that quantum computation may be possible without the need for entanglement. Is that correct? And if so, when did you perform that work?

**Answer:** Yeah, it is in 2001 entitled “Implementation of a quantum algorithm to solve the Bernstein-Vazirani parity problem without entanglement on an ensemble quantum computer”.

2) At that time, had other groups found similar results with NMR? With other systems?

**Answer:** There are no similar results in NMR or other systems at that time.

3) Within your system, what forms the qubit? (Is each individual atom within a molecule, a qubit? And is information encoded in the nuclear spin of each atom?)

**Answer:** In NMR ensemble, we utilize the statistical result of abundant molecules, as it is hardly to detect the signal of a single atom. Strictly speaking, all the same atoms in the whole ensemble form one qubit. The information is encoded in the nuclear spin.

4) Why is entanglement difficult to establish in NMR?

**Answer:** The state of the NMR ensemble consists of two parts: the huge identity matrix and the polarization part. The characteristic of entanglement is exhibited in the polarization part. The polarization ε is about 10-5

~10-6 at room temperature, which is far away from the requirement of the real entanglement ε>0.3. The effective methods to improve the polarization is decreasing the temperature to an ultra-low level or increasing the magnitude of the magnet to an extreme-high level. Unfortunately, it is hardly to realize in NMR system.

5) Many people assumed that entanglement is essential for quantum computing. Why do they think that?

**Answer:** Firstly, entanglement is very important in quantum communication, such as quantum teleportation etc. Secondly, in early quantum algorithms, most of them exhibit speed-up over the classical ones with the characteristic of entanglement. These two conditions make many people think that entanglement is essential.

6) If entanglement is difficult to establish in NMR, why do researchers think that it is worth looking at NMR-based quantum computing?

**Answer:** The coherent control with high fidelity could be implemented in NMR, better than other systems. Besides, NMR has been enhanced up to 12 qubits until now. In fact, most quantum algorithms are firstly implemented in NMR system.

7) What was the first effect that you saw in NMR that led you to think that discord may be useful in quantum computing?

8) How much easier will it be to build, maintain and manipulate a large-scale quantum computer if it is true that the speed-up is caused by discord, without entanglement?

9) You have sent me some very interesting papers in which you have used NMR to demonstrate a number of important things (Deutsch-Jozsa algorithm at room temperature, deterministic one-way quantum computation, a quantum search algorithm, an algorithm for factorization). Given the large number of things that you have demonstrated, why aren't all quantum physicists convinced that discord could be the basis of quantum computation, without any need for entanglement?

10) Is the fact that you have been able to carry out the D-J algorithm at room temperature (rather than low temperature) particularly important, in terms of making quantum computation more practically feasible?

11) One of the criticisms that people have about the possibility of having quantum computation without entanglement, is that you may be able to perform small tasks without entanglement, but not big exciting tasks (Shor's algorithm, Grover's algorithm). How do you feel about that criticism? Do you think that the algorithms you have achieved with NMR indicate that there is a good chance that quantum computing based on discord could tackle these famous problems?

12) Do you think that entanglement will remain essential for certain computational tasks?

13) Another criticism that people have is that theoretical physicists are only able to handle discord when thinking about two qubit systems. Thinking about higher numbers of qubits, when you are analysing mixed states (as in the case for discord) is much harder. But for a quantum computer you need many qubits. This means it will be a long time before theoretical physicists come up with a "recipe" for harnessing discord in systems with a large number of qubits -- slowing down the possibility of large-scale quantum computing. What do you think of this criticism?

14) How do you experimentally prepare discord in a system, without entanglement? How do you measure discord in a system?

**Answer:** The state of NMR includes quantum discord even in the equilibrium case. Therefore we needn’t to prepare discord in NMR system. The way of measuring discord is very similar to that of measuring entanglement.

15) One thing that Vlatko Vedral mentioned that he would be interested in from a theoretical perspective is whether experimenters could perform experiments to show how much discord there is as a computation is being carried out? Would you be able to test that?

**Answer:** Now we are designing an experiment to test that.

16) What sort of experimental (or theoretical) result do you think would be needed to convince the wider physics community that discord can be harnessed for quantum computation, without the need for entanglement? When could those tests be carried out?

**Answer:** If the experimental result of a quantum algorithm shows that it is superior than the classical one, just with quantum discord, I think it is successful to demonstrate that discord is harnessed for quantum computation, even without the need for entanglement. In my estimation the experiment would be completed around October this year.

17) Are you interested in the work of any other experimentalists looking at discord around the world? Or in the work of any theoretical physicists? If so, what do you find interesting and why?

18) Is there anything else that you would like to mention?