REPORT

ROUNDTABLE "SCIENTIFIC SUPPORT TO POLICY MAKING: QUANTUM TECHNOLOGIES FOR COMPUTING, COMMUNICATIONS, METROLOGY AND SENSING"

BRUSSELS, MARCH 7TH, 2013

The Roundtable was organised by the JRC with the participation and support of DGs ENTR and CNECT. The objectives were: to examine the latest progress in science; to present potential technological applications and the time frame for their development; to identify future challenges; to assess the place of Europe compared to its global competitors; and to identify future needs in terms of policy making and scientific support to policy making. This roundtable brought together approximately 80 high-level scientists and business representatives with EU policymakers. High-level scientists from many of Europe's leading quantum laboratories participated in the event, as did representatives of the principal industrial research and technology laboratories with an interest in quantum science (Intel, Thales, Nokia, Siemens, ST Microelectronics…).

Following the introductory remarks by Dominique Ristori, the 2012 Nobel Laureate in Physics, Professor Serge Haroche (College de France) gave a presentation on quantum science, including current progress and future orientations. The participants also heard a US perspective on the promise of quantum technologies from Dr Carl Williams, of the US National Institute of Science and Technology.

The roundtable was divided into three sessions, which explored the potential of quantum technologies from various *sectorial* perspectives:

- Quantum computers and simulators;
- Quantum communication;
- Quantum metrology and sensing.

The Opening Session: The opening session noted that the various technological applications of quantum science have very different times to market: 2 year horizon for quantum-based atomic clocks, 10 years for quantum simulators, 25 years for the quantum computer. These new technologies, while disruptive in their own right, may also revolutionise more traditional industries, and considerably boost the services sector, which already accounts for more than 70% of European GDP.

The session made the link with a recent JRC Roundtable on *"Scientific Support to the Internal Market"* (21st Feb 2013) with Commissioner Barnier, which concluded that one major challenge to take-up of eCommerce in Europe was perceived lack of security of transactions, and to an upcoming JRC Roundtable on 25th April 2013 entitled *"Key Enabling Technologies and Innovative SMEs"*, both of which can learn and take inspiration from the discussions on quantum science. The opening session concluded with a reflection that we are entering *"the second quantum revolution"*. The first brought us transistors, lasers and superconductors, and even magnetic resonance imaging. With the recent advances in measurement and manipulation of single quantum systems, we can expect in the short and medium term to see a host of disruptive technologies based on a better understanding of the behaviour and properties of materials at the atomic and molecular levels.

The session also served to underline the clear disconnect between the potential of quantum technologies on the one hand, and the almost total lack of basic knowledge of quantum science at the level of the citizen. Thus, there is a need to consider carefully how scientific facts are communicated to the public, at which stage, and by whom.

The traditionally long time frame from basic research to world changing applications poses a number of particular problems for policy makers – notably, the continuity of funding and the need for "time and trust" and the need for longer term policy making typically beyond the democratic life cycle.

Finally, it was noted that the US has already captured the market for quantum detectors, having developed some of the most sensitive photon sensors ever built (95-98% accuracy). Such devices are providing the building blocks for further quantum research. The US speaker warned that *"being late to the game will mean not owning the technology - and whoever owns the technologies will own the markets"*.

Quantum computers and simulators: Professor Blatt focused on whether Moore's law of scalability was set to hit a wall in 5-6 years when the single transistor reaches the size of an atom. For the scientists present, quantum phenomena will need to be taken into account beyond this level. Intel however felt that many engineering tips and tricks not necessarily related to miniaturisation (e.g. strained silicon, trigate transistors) would continue to extend Moore's law for at least 25 years as long as transistor leak and impurity levels in the channels are managed. One discussion touched on the holy grail of quantum devices - the need for these to operate at room temperature. The arrival of quantum simulators can allow a better understanding of behaviour at high temperatures, which may in fact set the path for room temperature applications in the medium term.

Quantum Communication: This session addressed primarily the area of secure communication. Quantum cryptography is an early successful application of quantum science and European SMEs (including *id Quantique* who were present) have exploited it successfully in settings as varied as the South Africa Football World Cup. Quantum random number generation products have been on the market for over 10 years and have clients as diverse as banks and national lotteries. Paris-based SME Sequrenet is also active in the area of quantum-based key encryption and distribution.

After a first successful experiment in Europe several years ago, the race is now on to ensure secure communication over longer distances, with 250 km the current record in Europe. *(NB: China recently beat this with an experiment at 260 km distance, with the US company Battelle currently planning a 770 km test on US soil).* There appears to be currently a hard scientific wall/limit at approximately 400 km, which may be overcome by advances in quantum entanglement. Another technology of note in this area is quantum memories, which can provide parking spaces for encrypted information to bridge to longer range secure communication, as can the use of satellites as trusted nodes. The discussion also considered the list of critical infrastructures (e.g. the Swiss model presented) which need to be protected from cyber-attack). In this context, there was an interesting discussion on the hypothesis that a quantum computer may be capable of breaking all current encryption schemes, a word of warning about the future threat if such technologies are available first to, for example, non-democratic regimes.

Quantum Metrology and Sensing: This session focused on the race to ever smaller and ever more accurate atomic clocks – beyond single ion clocks (which already have a precision of 1 sec in 100 million years). Such further precision can help in the development of more accurate location based services (from metres to centimetres) and play a role, for example, in earthquake detection. It was noted by Professor Walmsley that *"metrology - the requirement to measure - underpins all commerce"* – by way of example, the recent stock market crash attributed to high-frequency algorithm trading may be avoided by more accurate time-stamping of transactions.

During the discussions, scientists indicated that thanks to early EU funding, Europe currently has up to 2,000 trained physicists ready to embark on the next journey of quantum. This human capital potential should be maintained and even reinforced as a prerequisite for further significant progress in the quantum field.

By way of conclusion, the JRC Director General Dominique Ristori stressed the potential of new quantum developments to boost growth and jobs in the EU. He highlighted the leading role of European research in this area and called for a transformation of this knowledge into concrete market applications, a step where Europe is traditionally weaker than its competitors. He also identified several challenges that lie ahead, not only scientific, industrial or commercial, but also linked to the need of a better communication of the potential of science to European citizens. Dominique Ristori underlined that international collaboration will play a crucial role, in particular between the EU and the US and he mentioned the example of the cooperation that was initiated recently between the JRC and the US Department of Energy in the field of e-mobility and smart grids. This is a model that might be followed in due time concerning several of the applications of quantum technologies. Last but not least, he stressed that it is important that this Roundtable does not remain a one-off event and that the cooperation between policy makers, scientists and industry participants continues in the weeks and months to come. He mentioned in particular that the JRC will examine how it can further develop its cooperation with NIST and with ETSI on quantum related issues. He also announced that the present Roundtable would serve as an important input to the upcoming JRC Roundtable on "Key Enabling Technologies and Innovative SMEs" and that he would ensure that the quantum technologies sector would be duly represented in this meeting.

After the meeting, Dominique Ristori and all the speakers met with Maroš Šefčovič, Vice-President of the European Commission, in order to inform him about the main conclusions of the Roundtable. Vice-President Šefčovič underlined the importance of horizon scanning activities for the European Commission and stressed the interest of the College in the potential of quantum technologies. He mentioned in particular the important role standardisation will now have to play in order to boost innovation and to turn science into the needed products and markets. Mr Šefčovič concluded by saying that he would inform the College, and in particular Ms Geoghegan-Quinn, Commissioner for Research, Innovation and Science, about the results of this important meeting and he asked the JRC to keep him informed about the future developments.