National Quantum Initiative Act (Public Law 115-368)

The Policy

Synopsis

The National Quantum Initiative Act (enacted as Public Law 115-368) is a set of two related bills (HR 6227 and S 3143) in the House and Senate. They aim to maintain US leadership in quantum information science through three main actions. Firstly, by improving education and training through traineeships and establishing Multidisciplinary Centers for Quantum Research and Education. Secondly, by promoting research through National Science Foundation and other grants, supplemented by industry involvement. Thirdly, by setting up new three new bodies (National Quantum Coordination Office, Subcommittee on Quantum Information Science, National Quantum Initiative Advisory Committee) to provide direction, technical expertise, and long-term sustainability to the initiative. This plan is designed on a 10-year timeframe (with scope for extension) but contains provisions such as funding to help create a sustainable pipeline for quantum science education, research, and development.

Under Title I of the bill, the three new bodies to be formed are:

1. The National Quantum Coordination Office;

   Will provide technical and administrative guidance to the program and facilitate coordination between government agencies, research centers and industry. This office will also be responsible for public outreach to the public and information exchange with academia, industry, and state governments. The director will be appointed by the Office of Science and Technology Policy, and the office will be staffed with members from:

   • the National Institute of Standards and Technology (NIST);
   • the National Science Foundation (NSF);
   • the Department of Energy (DOE);
   • the National Aeronautics and Space Administration (NASA);
   • the Department of Defense (DOD);
   • the Office of the Director of National Intelligence;
   • the Office of Management and Budget;
   • the Office of Science and Technology Policy; and
   • any other Federal agencies, at the discretion of the President.
Established within the National Science and Technology Council, this subcommittee will coordinate research and education activities across federal agencies and examine the scope for R&D collaboration with international allies. Also tasked with developing two successive 5-year plans to set goals and guide activities of the program. It is staffed by members from the same agencies as represented in the National Quantum Coordination Office; and chaired jointly by the directors of NIST and NSF along with the Secretary of Energy.

3. The National Quantum Initiative Advisory Committee.

Responsible for advising the president and the Subcommittee on Quantum Information Science. It will report to the president at least once every two years on the landscape of quantum information science and technology, the progress and effectiveness of the program towards its stated aims, recommended revisions to the program, and opportunities for international cooperation. It will consist of members from academia, federal laboratories and industry appointed by the president with recommendations from Congress, industry, and the science and defense communities.

Under Title II of the bill, The National Institute of Standards and Technology (NIST) is tasked with assisting the Program by:

1. Continuing its support of existing projects in quantum information science and technology, establishing standards to help commercial applications as necessary;
2. Collaborating with other government agencies, National Laboratories, industry, and academia to strengthen efforts in quantum information science and engineering, with the authority to participate in any contracts necessary for this purpose; and
3. Organizing a workshop of quantum science stakeholders within a year to assess current research, future opportunities, and research gaps, and to provide recommendations to NIST.

Within 2 years of the bills’ passing, the NIST will report to the House Committee on Science, Space, and Technology and the Senate Committee on Commerce, Science and Transportation on the findings of the workshop described above. The NIST will receive $80 million per year for the next five years from the Department of Commerce to carry out the activities in Title II.

Title III of the bill outlines how the program will support quantum science education and research through the activities of the National Science Foundation (NSF), namely,

1. Using existing NSF programs in collaboration with other agencies to enhance quality at the undergraduate, graduate, and postgraduate levels, in addition to increasing participation of minorities and underrepresented groups in quantum science.
2. Coordinating existing research between different NSF verticals and facilitating information exchange between federal agencies, research communities, and educational institutions.
3. Providing graduate traineeships to US citizens intending to obtain a masters or doctoral degree in quantum information science.
4. Establishing five Multidisciplinary Centers for Quantum Research and Education at institutes of higher education or eligible nonprofits. These centers will support curriculum and workforce development including industry collaboration.
5. Providing graduate traineeships for these centers on their ability to: support innovation and work with industry, facilitate inter-institution and inter-disciplinary collaboration, contribute to workforce development, and sustain in the long term.

These actions will be funded $50 million per year for the next five years by the NSF.

In Title IV, the Department of Energy is also directed toward quantum activities including:

1. The formulation of quantum information science goals for the Department;
2. Compiling and applying current research and knowledge on quantum sciences;
3. Creating research opportunities and trainings for students in the following fields of quantum information science:
   - Quantum information theory, the study of acquiring, storing, transmitting and processing digital information using quantum technologies;
   - Quantum physics, an emerging field of physics focusing on the ways in which classical physics cease to apply to the nature of particles like photons and electrons;
   - Quantum computational science, the application of computers exploiting the nature of quantum technology, to process, simulate, and model data in scientific research, such as in chemistry, which would otherwise be impossible using classical (non-quantum) computing;
   - Applied mathematics and algorithm development;
   - Quantum networking, the transfer of information over quantum communication systems;
   - Quantum sensing and detection, hardware using quantum technology to sense and detect objects; and
   - Materials science and engineering related to the field of quantum science.
4. Organizing and coordinating quantum science efforts at the following DOE facilities:
   - The Nanoscale Science Research Centers;
   - The Energy Frontier Research Centers;
   - The Energy Innovation Hubs;
   - The National Laboratories; and
   - The Advanced Research Projects Agency.
5. Coordinate with other quantum science initiatives throughout the federal government, research communities, and potential users.
6. Creating and directing at least two, but no more than five, National Quantum Information Science Research Centers, each funded with up to $25 million for five years, to conduct basic quantum science research. These research centers will be established through a competitive, merit-reviewed process of eligible applicants, including institutions of higher education and DOE research centers identified above.

The theoretical science based on quantum physics is well respected and has been around for more than seven decades. The engineering aspect of quantum computers and quantum information science had been the limiting factor in the growth of the field. Now, countries around the world are increasing investments in quantum science and technology. China, the biggest competitor of the US in this space, announced that it plans to become to world leader in artificial intelligence and quantum science by 2030. It launched a quantum communications satellite in 2017, which was used to test transmission of a potentially “unhackable” message encrypted by quantum cryptography.

It is worth nothing that China has already overtaken the US in number of patents related to quantum computing science applications. Since 2012, more than 76%
The Science

Science Synopsis

While traditional computers rely on storing and reading information in binary bits, quantum computers[41] make use of new understandings of quantum mechanics that allow information to be read and stored exponentially faster and simultaneously on non-binary quantum bits or “qubits”.

Where quantum mechanics differs from traditional notions of physics that undergird classical computers is in its emphasis on a probabilistic and uncertain world over a more defined and deterministic one. In the case of classical physics, a common application is the measurement and location of bodies in our solar system. Given our understanding of gravity, mass, and inertia, we can track the location of the planets in our solar system continuously along their orbit. In quantum mechanics however, objects, or qubits in the case of quantum computing, are not considered to exist in discrete locations and move in a continuous fashion but instead exist in a state of “superposition” whereby the object is considered to exist in a span of simultaneously different states, each with a given probability. In the case of qubits, their span of possible states exists continuously between 0 and 1. Then, only upon directly observing the object, and to the best of the field of quantum mechanic’s understanding, does the object’s state of superposition collapse to a discrete location and state.

Under controlled settings whereby quantum objects are insulated from measurement or any other kind of influencing energy, strings of objects are considered by the field to be “entangled” and sharing identical state changes. This capacity for entanglement allows for qubits to correspond with one another and communicate, store, and/or translate information in a similar fashion as traditional binary bits. Further, the superposition of quantum objects allows for a system of entangled objects to encode exponentially greater amounts of information than binary bits arranged in a similarly sized system. However, with this increased capability of qubits comes increased temperamentalitly of the system. In the classical binary system incidental and external influences on individual bits are neutralized by their nature of only communicating one of two signals. Any incidental noise is typically insufficient to overwhelm which signal was intended. Qubits, on the other hand, operate at levels of exponentially higher specificity which are more susceptible to change and therefore errors. This temperamentalty and the expensive difficulty of avoiding it is described in greater detail below while more extensive examinations of the technology have been provided by the National Academies[42].

Scientific Controversies / Uncertainties

Qubit Temperamentality – In order to avoid decoherence[43] in quantum systems, that is to ensure the accuracy of quantum computing qubits, the hardware of the system must be drastically more controlled and insulated from physical external manipulations (such as temperature, vibrational, and radiation fluctuations) than classical computing systems. Maintaining this degree of control and insulation can be incredibly energy intensive[44] and limiting to the number of qubits[45] a quantum system can operate, which in turn can limit the applicability and/or accuracy of the system.

Endorsements & Opposition

Overall, this is a bipartisan bill and enjoys overwhelming support from lawmakers of both parties. It is also being welcomed by the industry as a much-needed investment.

- Quantum Industry Coalition (industry group, includes Intel, D-Wave, Lockheed Martin among others), statement[46]. June 26, 2018: “The Quantum Industry Coalition strongly supports the National Quantum Initiative Act because we believe it takes important steps toward establishing US quantum leadership... it promotes workforce development, which is key to the US quantum industry’s growth.”
- Intel Corp., blog post[47]. September 13, 2018: “Intel applauds the House passage of the NQIA and looks forward to increased collaboration between industry, academia and the federal government.”
- Rick Perry (US Secretary of Energy), statement[48]. September 24, 2018: “[Quantum information science] represents the next frontier in the Information Age. At a time of fierce international competition, these investments will ensure sustained American leadership in a field likely to shape the long-term future of information processing and yield multiple new technologies that benefit our economy and society.”
- American Physical Society, statement[49]. July 5, 2018: “[We are] supportive of the research principles of the bill [but] concerned with the comments made by Chairman Smith during last week’s hearing that funding for the National Quantum Initiative would be drawn from the agencies’ baseline funding and the potential impact this could have on other research programs.”
- Computing Research Association, statement[50]. June 26, 2018: “While we support the intent of the National Quantum Initiative Act, we do have a concern that the bill defines ‘quantum information science’ without sufficient focus on the computational aspects of the discipline. Without an inclusion of the concepts of ‘representation’ and ‘algorithmic manipulation,’ the definition fails to capture some of the key computational elements, while emphasizing the physical challenges of QIS. We believe the computational challenges — including software and algorithmic development — are just as pressing and require sufficient focus.”

Potential Impacts

Industry experts and politicians from both parties expressed confidence that this bill would create a robust pipeline for training and employment in the quantum science industry, and sponsor research and development that would advance the US forward in its global leadership in the field.

Employers have been expressing concerns about the shortage of trained workers in the field: “Quantum computer scientists are in high demand right now. I would know. IonQ has a lot of trouble hiring people.” says[51] Chris Monroe (co-founder of IonQ, a quantum computing startup). “There’s definitely a shortage of people...
coming,” says Christian Weedbrook (CEO of Xanadu, a Canada-based quantum computing firm). This bill will strengthen the workforce and enable industries and research labs to embark on bigger, more ambitious projects (combined with the significant quantum research budget funded by the NSF).

Breakthroughs in quantum information science are expected to have far-reaching effects in data-intensive industries, such as healthcare, communications, and finance. One of the biggest impacts of quantum science is expected to be in science research itself, with quantum computing enabling more complex scientific models and simulations to be tested with increasing detail, speed and accuracy.

While quantum computing can exponentially increase the abilities of single computers, advancement in high-performance computing enables the simultaneous application of multiple sets of computers, called “clusters”, to solve problems. Both quantum and high-performance computing allow for faster and more efficient problem solving; however, these new capabilities could also be applied to nefarious uses that will have to be guarded against.

**Status**

Bill HR 6227 was introduced in the House on June 26, 2018 and subsequently referred to the House Committee on Space, Science, and Technology. On September 13, 2018, this bill passed the House.

On December 13, 2018 this bill was passed in the Senate and agreed to by the House on December 19, 2018. The bill was presented to the President on December 21, 2018 when it was signed and became public law.

S 3143 was introduced in the Senate on June 26, 2018 and referred to the Committee on Commerce, Science, and Transportation.

**Related Policies**


S 2998, 115th Congress: The ‘Quantum Computing Research Act’ also has the goal of maintaining US leadership in quantum science, emphasizing on technology R&D rather than fundamental research or education. It directs Department of Defense to increase public and private investment for this purpose by establishing the Defense Quantum Information Consortium.

**Recommended Citation**


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**Related Tags**

quantum technology, National Science Foundation (NSF), National Science and Technology Council (NSTC)