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Powerful supercomputers validate ^{12}CQ qubit material uniqueness

Highlights

- Some of the most powerful supercomputers have been used to pinpoint the origins of a key tech-enabling quantum phenomena observed in the ^{12}CQ qubit material.
- The supercomputer analysis is a first, providing the most accurate simulations of Archer's unique ^{12}CQ qubit material, confirming a metallic-like nanocarbon.
- Archer will use the simulations to support the design and development of complex quantum electronic devices required for the future operation of the ^{12}CQ chip.
- Archer is the only ASX listed company and one of a few players in the world developing qubit processor technology.

Archer Materials Limited ("Archer", the "Company", "ASX: AXE") is pleased to announce that the Company for the first time has used some of the most powerful supercomputers in the world to obtain the most realistic and efficient simulations of the ^{12}CQ qubit material.

The complex atom-structure of the ^{12}CQ qubit material requires the enormous power of supercomputers for predictive modelling and realistic simulations of the qubit material properties. The results of such computation often take the form of material behaviour and can be used to validate (or refute) the material properties of interest for technological applications.

Archer is working with world-leading theoretical physicists at the prestigious research institute École Polytechnique Fédérale de Lausanne, Switzerland ("EPFL"), to computationally model Archer's unique qubit material.

For the first time, powerful supercomputers have been used to provide the most accurate simulations of Archer's ^{12}CQ qubit material. The quantum chemistry simulation work employed a Density-Functional Tight-Binding ("DFTB") methodology[†], *i.e.*, a combined density functional theory and tight binding model of the ^{12}CQ qubit material at the atom-scale.

The most relevant result of the computationally intensive calculations performed is the Density of States ("DOS") for the ^{12}CQ qubit material. The DOS is an effective measure of the available electrons that can contribute to physical processes within a material at a given energy. The DOS is of crucial importance to many physical properties of solid materials, such as their electrical conductivity. For the ^{12}CQ qubit material, the resulting DOS pinpointed the physical origins of the observed metallic-like properties.

The results of the work validate Archer's unique qubit material properties, including confirming an intrinsic metallic-like character of the qubit material. This directly translates to supporting the material structure-property paradigm that gives way to the quantum properties described in Archer's internationally patented qubit technology architecture.

[†] Further technical information on DFTB: https://www.tandfonline.com/doi/full/10.1080/23746149.2019.1710252

The supercomputer models used now increased the simulation capacity of the material system 10x more than previous modelling performed by Archer and EPFL. In the context of accurate atomistic modelling of complex materials systems, the order of magnitude increase in simulation capacity is significant. The outcomes of the supercomputing simulations will be used to fast-track and support the development of Archer's more advanced quantum electronic devices required for ^{12}CQ chip operation.

Modern electronics rely on conducting electronics that exhibit metallic properties, and the quantum information in Archer's patented qubit technology architecture is stored in and represented by the '*spin*' quantum property of electrons. So it is critical to have developed accurate models simulating the electronic properties of the qubit material for the successful development of the ^{12}CQ chip.

Computations were performed in a joint effort with collaborators at EPFL, at the Swiss National Supercomputing Centre ("CSCS") and the facilities of the Scientific IT and Application Support Center ("SCITAS") of EPFL. For the computations performed by Archer and EPFL, one of Europe's most powerful supercomputers[‡], the *Piz Daint*[§], was utilised.

Image 1. Photograph representative of the Swiss supercomputing cluster used by Archer and EPFL in this work. *Reproduced from the Swiss National Supercomputing Centre website.*

Commenting on the ^{12}CQ chip progress, Archer CEO Dr Mohammad Choucair said: "Archer's development strength has advanced to a stage that calls for high-power computing facilities, and draws on the few people and institutions in the world that can perform this type of work.

"Supercomputers are powerful tools, and with them, Archer and colleagues at EPFL have run important simulations on the ^{12}CQ qubit material more realistically and more efficiently than ever before, which would never be possible with theory and experimentation alone.

"The simulations will be used to support the design and development of the more complex quantum devices required for the future operation of the ^{12}CQ chip technology."

[‡] In November 2022, the *Piz Daint* ranked 26 out of the top 500 of the most powerful supercomputers in the world: https://www.top500.org/lists/top500/list/2022/11/
[§] https://www.cscs.ch/computers/piz-daint/ and https://www.cscs.ch/computers/overview/ and https://www.epfl.ch/about/

Further information on Archer's global competitive advantage and tech differentiation

The scientific breakthrough made in 2016 to realise Archer's ^{12}CQ qubit material is available online in the peer-reviewed scientific journal Nature Communications, which reports the advantages, technological trade-offs, and the technological barriers that have been overcome towards realising practical quantum computing, over several other qubit proposals.

Patent information related to the ^{12}CQ chip qubit and proposed device(s) is available online, including examiner reports, through the WIPO website.

About Archer

Archer is a technology company developing advanced semiconductor devices, including processor chips that are relevant to quantum computing. Archer is developing the ^{12}CQ chip, a world-first qubit processor technology, that could potentially allow for quantum computing powered mobile devices ('QPMDs'). For more information, visit www.archerx.com.au.

The Board of Archer authorised this announcement to be given to ASX.

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