

Proposal for a virtual access to the IGFAE-CESGA QuantumLab

Title: An analog quantum simulator for hadron and nuclear physics – QuantHad

The Galician Institute of High Energy Physics (IGFAE) and the Galician Supercomputing Center (CESGA) have created a common laboratory to foster quantum simulation for particle and nuclear physics research. The core of this laboratory features a trap-ion computer device provided by Alpine Quantum Technologies (AQT), spin-off from the University of Innsbruck and the Institute of Quantum Optics and Quantum Information at the Austrian Academy of Sciences. In January 2026 an AQT Pine Set-Up will be installed at the new IGFAE-CESGA laboratory. Moreover, an independent R&D program on trapping devices will be launched by commissioning an additional ion trap setup, which will support the scaling of services and enable an intense R&D program within the laboratory. It is expected that the facility will be available in July 2026, in time for the start of the HORIZON-INFRA-2025-01-SERV-03 action.

With this LoI we would like to propose virtual access to this new facility, thereby providing access to the hadronic and nuclear physics community in Europe with the opportunity to explore and benefit from the advances enabled by quantum computing. The ion-trapping computer will mostly serve as an analog quantum computer, for which a coordination between the hardware and the theory implementation is necessary. The main goals of the facility are many-body dynamics in particle and nuclear physics, thermalization, and other relevant fields of research in our community.

As the infrastructure is not yet installed, we provide some estimate of the costs. The primary aim of this proposal is to make this new technology available to the community.

Research objectives

Quantum computing is becoming an increasingly interesting tool in our field. While the available technology is still far from being useful for the applications in particle and nuclear physics, developing new algorithms is paralleled with new theoretical implementations. A very promising avenue is to use the quantum devices as analog computers in which a target Hamiltonian containing the problem to solve is mapped into a physical Hamiltonian for which the hardware has to be configured. While most of the applications of quantum computing developed in the last years in our field use digital quantum computing techniques, the analog counterpart provides a potentially more powerful implementation of a given problem, at the price of not being universal (but tailored to the specific problem).

The device to be installed at the IGFAE-CESGA QuantumLab will work both as an analog and digital quantum computer. The access to such infrastructures is still difficult for most of the European groups in our field, especially those interested in analog quantum computing. This proposal aims to introduce researchers in the field of hadron physics to this innovative technology, enabling them to gain hands-on experience and fostering the development of a new emerging community interested in exploring these advanced solutions. The capabilities of this laboratory will be boosted by introducing a unique collaboration scheme: researchers may request assistance to map complex nuclear Hamiltonians onto ion-trap analogue simulators, leveraging the expertise of IGFAE-CESGA scientists in quantum control and simulation

techniques to model nuclear interactions, explore many-body phenomena, and validate theoretical predictions through precise, experimentally accessible quantum simulations.

Estimated budget

We propose to provide a minimum 15% of the available computing time of the infrastructure to the present network – another 25% is reserved for access within the Spanish Supercomputing Network and the remaining 60% will be provided to local users. The operation costs are still to be computed, but an estimate would be 100 Euro/hour, including the time of the technicians, consumables, electricity, etc. Assuming a conservative 800h of efficient time per year, we estimate 12.000 Euros/year the cost to be funded by the present grant. The hiring of a PhD (3 years) and a postdoc (2 years), in charge of the development and mapping the quantum algorithms and providing support to the external users will be made, with an estimated cost of 200.000 Euros.

Three workshops will be organized at IGFAE. A first startup meeting to make the infrastructure known to the whole community; and two meetings during the rest of the period reporting on actual calculations performed by the community which can be useful for other users. These workshops will be co-funded by IGFAE and CESGA. Total cost 50.000 Euros

Total request: 298.000 Euros

Proposal of virtual access by

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