Title of your proposal

Lead PI Name, PI Name 2, …

# Formal information

1 page, please delete instructions (blue text)

## Lead PI and other PIs

Names, institutions, ORCID Link (please update your records there!)

## Resource request by institution and justification

Proposals can ask for PhD and/or postdoc positions. Each position comes with € 8500/yr (tentative) for consumables and travel. The COE does not foresee the purchase of equipment; therefore, all research infrastructure has to be in place or funded from other sources. For each position specify

* at which institution it will be located,
* by who it will supervised,
* the extent of requested funding (full or fractional), and
* the duration in months (30 months max.)

## Approval of compatibility with institutional contributions

Be aware that every partner institution has committed to contributing 40 % of the total funding, or, equivalently, for every Euro of FWF money spent, the institution has to contribute 66 Cents in cash or in kind. Verify your proposal with the respective site leaders.

# Scientific aspects

2 pages max., please delete instructions

## Scientific innovation and importance

What are your research questions or objectives? Describe how your proposed research is original, breaks new scientific ground, why it is important, and what impact it will have on the field, discipline or beyond.

## Collaboration and synergies

Why is your consortium optimal for the proposed research objectives, how is the collaboration set up, including relevant external ones, and which synergies do you expect from the collaborative work?

## Alignment with quantA

Show how your research works towards achieving the objectives of quantA as outlined below. Which research area(s) questions and objective(s) of the COE proposal does it belong to?

## Approach, methods, work plan, risks

Explain how you are going to implement the research program and, if you foresee any risks, how you would mitigate the same. Give a (very coarse) work plan with intermediate goals after 2.5 years and final goals after 5 years.

# quantA research program outline

## Research areas

### Quantum nature of space, time, and gravity (STG)

STG 1 – *How can we understand genuine quantum concepts in the framework of general and special relativity?*  
Objective: Combining the theoretical study of conceptual challenges at the gravity-quantum interface with unique high-precision quantum measurements of gravitational and special-relativistic phenomena

STG 2 – *How far can we push the quantum-classical border, or how does classicality emerge?*  
Objective: Expanding the parameter regime of controlled complex quantum systems in size, mass and complexity significantly beyond the current state of the art

STG 3 – *What is the role of quantum physics regarding the nature and arrow of time?*  
Objective: Defining the nature of time within the standard quantum framework and determine the degree to which one can measure and manipulate it

### New paradigms for quantum information science (QIS)

QIS 1 – *How can we surpass the capabilities of conventional quantum information processing approaches?*  
Objective: Using higher-dimensional and hybrid systems to develop new paradigms that use quantum and classical resources and other cost factors to their full potential

QIS 2 – *How can we efficiently describe and model multipartite quantum systems using a quantum information theoretical perspective?*  
Objective: Efficiently using novel quantum information theoretical tools to model large quantum systems and their underlying entanglement structure

QIS 3 – *How can we optimally harness the resources of hybrid and distributed quantum systems?*Objective: Combining the unique capabilities of different platforms to build hybrid quantum networks across Austria

### Physics of Engineered Quantum Many-Body Systems (MBS)

MBS 1 – *How can we create and exploit programmable quantum simulators?*Objective: Turning Rydberg atom arrays, ion crystals and superconducting circuits into simulators with new capabilities

MBS 2 – *What are the essential quantum many-body phenomena in and out of equilibrium?*Objective: Understanding the dynamics and thermalization of coherent many-body systems and finding universal signatures in their non-equilibrium behavior.

MBS 3 – *How can we efficiently learn information about quantum many-body systems?*Objective: Characterizing the structure and entanglement of large quantum systems and recovering the underlying laws governing the evolution of coherent and open quantum systems

The entire proposal and additional information can be found at <https://fileshare.uibk.ac.at/d/712135fd0c5745fa94af/> – please keep confidential!