Gravitational quantum states (GQS) are traps for ultracold massive particles with gravity on top and a specularly reflecting mirror with a sharply changing surface potential on bottom. Energies of neutrons ($n$), hydrogen ($H$), and antihydrogen ($\bar{H}$) atoms in GQS are of the order of $\varepsilon_{0} \approx 0.6 \text{peV}$ and the characteristic size of wave functions is $l_{0} \approx 5.9 \mu\text{m}$. Ultralow energies make this system very sensitive to any tiny interactions and large sizes simplify the experimental techniques. GQS were discovered in experiments with ultracold neutrons (UCN) in 2002 and since then, they are actively used by several research groups (qBounce, Tokyo, GRANIT) at ILL, Grenoble.

While repulsive neutron-nuclei optical potential of many materials totally reflect UCN from surfaces, attractive van der Waals/Casimir-Polder potentials can also reflect ultracold atoms and molecules at surface due to quantum reflection. In contrast to the case of neutrons, nobody has ever observed GQS of atoms and antiatoms. Meantime, major motivations are growing up and prompting experimental efforts to observe GQS of $H$ and $\bar{H}$ and to improve to the maximum extend the precision of GQS studies with all these particles. Thus, GQS of $\bar{H}$ in the GBAR project at CERN is the most precise method identified so far for the direct measurement of the gravitational acceleration of antimatter. GQS and a related phenomenon of Centrifugal Quantum States (CQS) of these particles is a sensitive method for the searches for extra short-range forces arising due to yet undiscovered light bosons or other phenomena beyond the Standard Model, manifestations of extra dimensions or dark matter. The techniques developed within GQS studies promise to help achieving ultralow energies of $H$ thus providing unprecedented conditions for optical and hyperfine spectroscopy of $H$ with ultimate precision, which will be pursued within the GRASIAN project.