

“Spectroscopy of the 1S–3S transition in hydrogen.”

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Abstract

The hydrogen atom occupies a central place in the history of the 20th- and 21st-century physics. As the simplest atom, it has served as a crucial testing ground for fundamental theories, and the precise measurement of its spectral lines has driven successive breakthroughs in our understanding of atomic structure.

This talk will present the application of two-photon Doppler-free spectroscopy to the hydrogen atom, with particular emphasis on the 1S–2S transition. We will discuss how the interpretation of these high-precision measurements is currently limited by the uncertainty in the proton charge radius, giving rise to the long-standing “proton radius puzzle.” This discrepancy motivated a series of experiments using muonic hydrogen—an exotic atom in which the electron is replaced by a negatively charged muon. Measurements in muonic hydrogen initially suggested a significantly smaller proton radius, intensifying the puzzle.

Finally, the most recent results on the 1S–3S transition in ordinary (electronic) hydrogen will be presented, together with their implications for the determination of the Rydberg constant and the proton charge radius.

Biography

François Biraben is a prominent French physicist and university-affiliated researcher who served as Research Director at the CNRS until becoming Emeritus. He spent the greater part of his career at the Laboratoire Kastler Brossel (LKB – ENS, Sorbonne Université, Collège de France, CNRS) in Paris, where he established himself as one of the leading experts in high-precision atomic spectroscopy, tests of quantum electrodynamics (QED), and the determination of fundamental constants.

During his PhD work under Bernard Cagnac, he performed pioneering observations of Doppler-free two-photon transitions and initiated the hydrogen spectroscopy program at LKB, which delivered, in the 1990s, the most precise measurements of the Rydberg constant of that period.

He subsequently founded and led two further experiments of major international impact. First, he launched the Paris branch of the muonic-hydrogen spectroscopy collaboration with the Paul Scherrer Institute; the proton radius value obtained by this collaboration showed a 7σ discrepancy with earlier electronic measurements, sparking the well-known “proton radius puzzle” that drove intensive research worldwide for over a decade. Second, he founded and directed the LKB cold-atom recoil experiment that used atom interferometry, optical lattices, and Bloch oscillations to measure the ratio $h/m(^{87}\text{Rb})$, yielding, at the time, the most accurate determination of the fine-structure constant α ever achieved in an atomic-physics experiment.

Through these projects and his long-term influence on precision measurements in atomic physics, François Biraben has been an important figure in the field of fundamental constants and high-precision metrology.