Physics Colloquium - Colorado State University

Towards an improved measurement of the 2S-4P Transition in atomic hydrogen

4:00 PM, Monday; June 1, 2015
Refreshments at 3:45 PM
120 Engineering (Hammond Auditorium)

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ABSTRACT:
Precision measurements of atomic hydrogen have long been successfully used to extract fundamental constants and test bound-state QED. The extraction of the Rydberg constant $R_1$, one of the most precisely determined physical constants, from hydrogen spectroscopy is currently limited by the measurements of hydrogen lines other than the very precisely known 1S-2S transition [1]. We are currently working towards a new and improved measurement of the 2S-4P transition to address this limitation. This will also allow for a more precise extraction of the proton r.m.s. charge radius $r_p$ from electronic hydrogen, which currently disagrees by 4σ with the much more precise value extracted from muonic hydrogen spectroscopy [2].

To reach our accuracy goal for the transition frequency in the low kHz range, we implement for the first time a cryogenic beam of hydrogen atoms optically excited to the initial 2S state [3]. This strongly suppresses the first order Doppler shift of the one-photon 2S-4P transition, which is further suppressed by actively stabilized counter-propagating laser beams and time-of-flight resolved detection. Important, but often overlooked in high-precision experiments, quantum interference arising from spontaneous emission, or cross-damping [4, 5], is a leading systematic effect in our measurement. We have theoretically studied and experimentally characterized this effect and the resulting line distortions using a segmented detector to spatially resolve the emission pattern (Fig. 1). Finally, we show an experimental scheme to suppress the quantum interference shift and extract the unperturbed transition frequency.

BIO:
Lothar studied physics in Munich (LMU) and Cambridge (UK). In 2012 he worked with Peter Hommelhoff at MPQ, doing research on the field enhancement of nanotips interacting with ultrashort laser pulses. In 2013, he was in Holger Müller's group at Berkeley, working on atom interferometry in an optical cavity. He has been with the Hänsch group since 2014 where he has been working on precision spectroscopy of the hydrogen 2s-4p transition.