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Measurements of np - 2s transitions in the hydrogen atom

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Precision experiments in the hydrogen atom have a long tradition and extensive studies of transitions between low lying $n \leq 12$ states were carried out [1−6]. These measurements can be used to determine values of the Rydberg constant and the proton charge radius. We present a new experimental approach to perform measurements of transition frequencies between the metastable 2s $^2S_{1/2}(F = 0, 1)$ state of H and highly excited np-Rydberg states with principal quantum number $n \geq 23$.

We generate the hydrogen atoms by dissociating H_2 in a dielectric barrier discharge located at the orifice of a pulsed cryogenic valve [7]. The hydrogen atoms are entrained in the supersonic expansion of H_2. The atoms are photoexcited to a specific hyperfine level of the metastable 2s $^2S_{1/2}$ state by a home-built frequency-tripled Fourier-transform-limited pulsed titanium-sapphire laser (pulse length 40 ns). They enter a magnetically shielded region in which transitions to highly excited np or Rydberg Stark states are induced by a narrow-band frequency-doubled continuous-wave titanium-sapphire laser, which is phase locked to an optically stabilized frequency comb and referenced over a fiber network to a SI traceable primary frequency standard [8]. The highly excited Rydberg states are detected by pulsed-field ionization. We will report progress on our efforts to minimize uncertainties from stray electric fields and Doppler shifts and to obtain spectral lines with a FWHM below 10 MHz.

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