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TOWARDS 1S-2S SPECTROSCOPY IN ATOMIC TRITIUM

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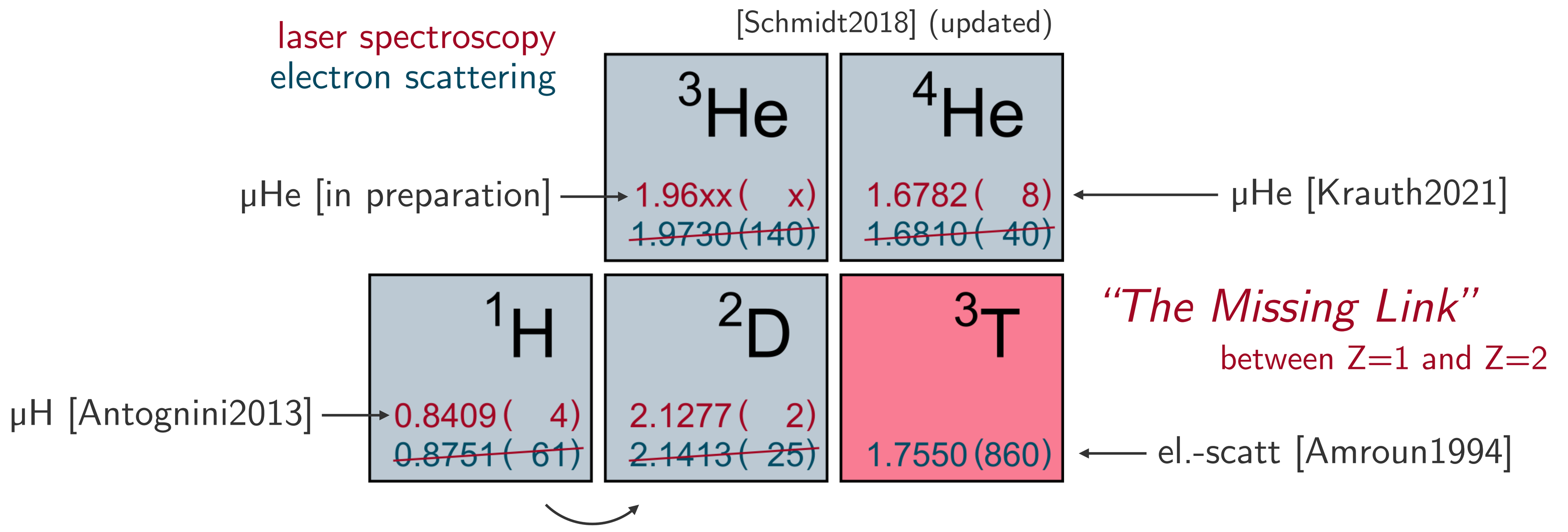
IMPROVING THE TRITON RMS CHARGE RADIUS

recent improvements on the precision of the rms charge radii (all values in fm) for the proton, deuteron, helion and alpha via laser spectroscopy:



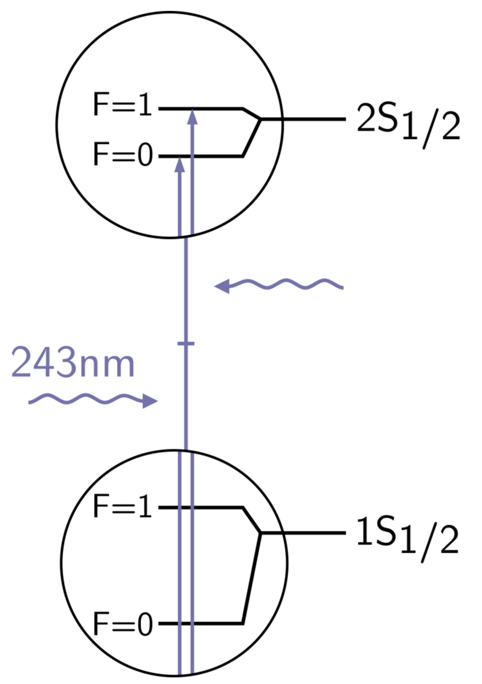
hydrogen-deuterium 1S-2S isotope shift

$$\langle r^2 \rangle_{^2\mathrm{D}} - \langle r^2 \rangle_{^1\mathrm{H}} = 3.82007(65)\ \mathrm{fm}^2$$ [Parthey2010, Jentschura2011]

...similar: combine high-precision proton charge radius from [Antognini2013] with hydrogen-tritium 1S-2S isotope shift → triton rms charge radius

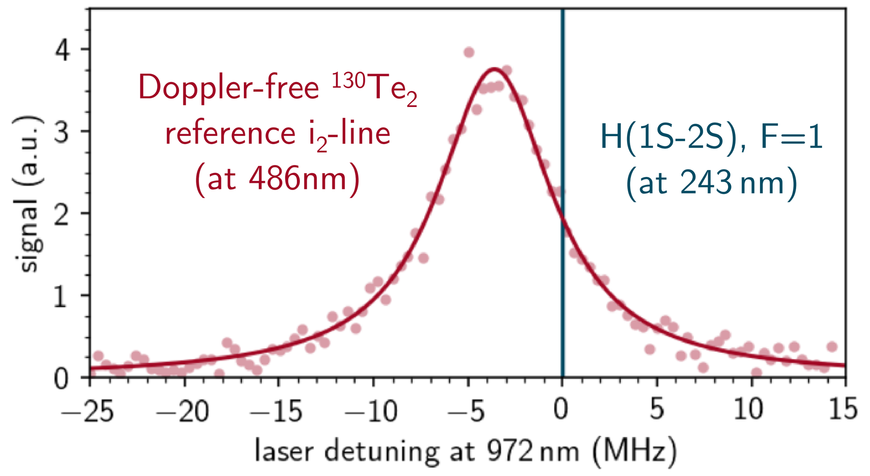
1S-2S SPECTROSCOPY IN HYDROGEN/TRITIUM

- intrinsically Doppler-free two-photon transitions; approx. 1.3 Hz natural linewidth
- high-precision atomic beam measurements at MPQ/Garching with H and D [Parthey2011]
  - not applicable to T, but very valuable to study systematic effects
  - detection via induced Lyman-α photons
- First results for T from measurements *inside* a running H/T discharge
- long-term goal: magnetic trapping of T
  ...please check our poster by Merten Heppener
  ("Towards Magnetic Trapping of Atomic Hydrogen"; 20.6)



LASER SYSTEM FOR 1S-2S SPECTROSCOPY

- commercial FHG diode laser system with approx. 100 mW at 243 nm
- laser system is stabilized to 972 nm optical reference cavity (FSR = 1.2 GHz, finesse = 250×10³) via Pound-Drever-Hall locking technique
- secondary $^{130}Te_2$ frequency reference at SHG output (486 nm)

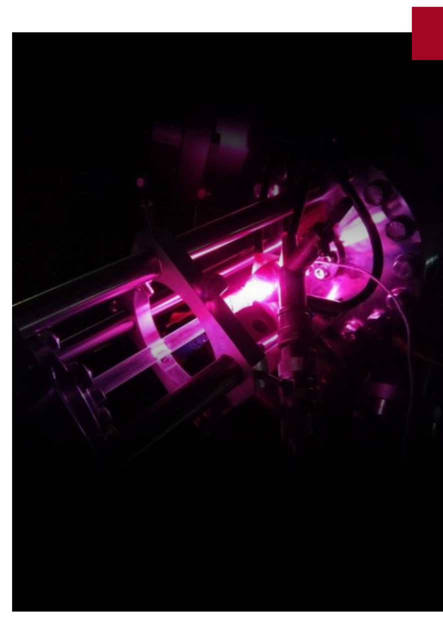


radiant heater assembly surrounding the $^{130}Te_2$ cell (operated at approx. 500°C)

...soon to be replaced by an optical frequency comb
- low two-photon transition probability → 243 nm enhancement cavity
- 243 nm resonant enhancement cavity improves effective laser power
  - length = 0.7 m, finesse = 70 (w/o cell) → power enhancement factor = 5
  - reflectivity and UV-induced degradation resistance expected to be improved with fluoride mirror coatings [Burkley2021]

OPTOGALVANIC SPECTROSCOPY IN A MICROWAVE DISCHARGE

- containment of radioactive tritium samples in a *sealed* discharge glass tube
- Evenson-type microwave cavity (currently running stable with constant flux of atomic hydrogen at 1 mbar with >15 W microwave power)
- in-cell miniature Pirani-type pressure sensors
- Brewster windows, glued with vacuum epoxy

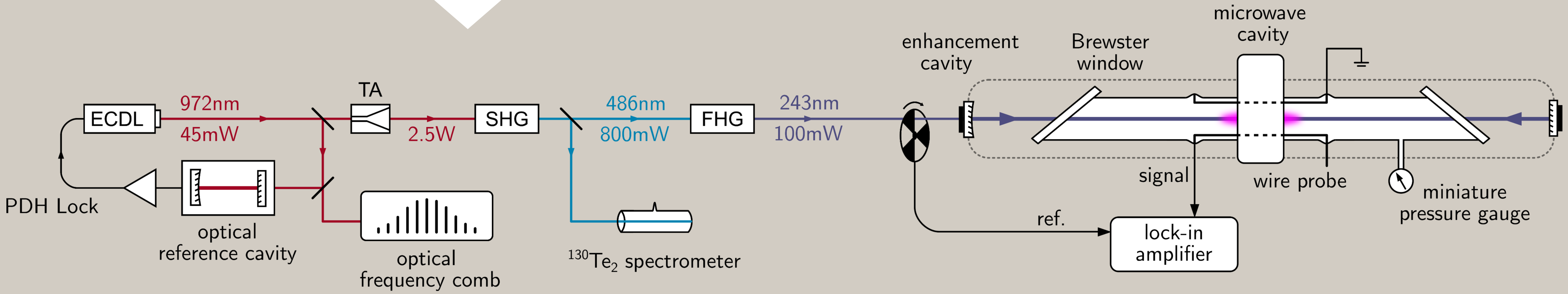


hydrogen microwave discharge

Idea: Laser-induced change of 2S state population can be monitored via optogalvanic detection due to change of the plasma's impedance!

- advantage: avoid optical detection within the intense fluorescence background in the plasma
- parallel tungsten wires probing the voltage induced by the inhomogenous microwave field [Suzuki1983] (He discharge)
- optical chopper allows for phase-sensitive detection

Currently, we are realizing a test setup with hydrogen.



OUTLOOK

- observation and optimization of optogalvanic signal for the H(1S-2S) transition
- study of systematic effects using the high-precision result for hydrogen from MPQ

References:

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