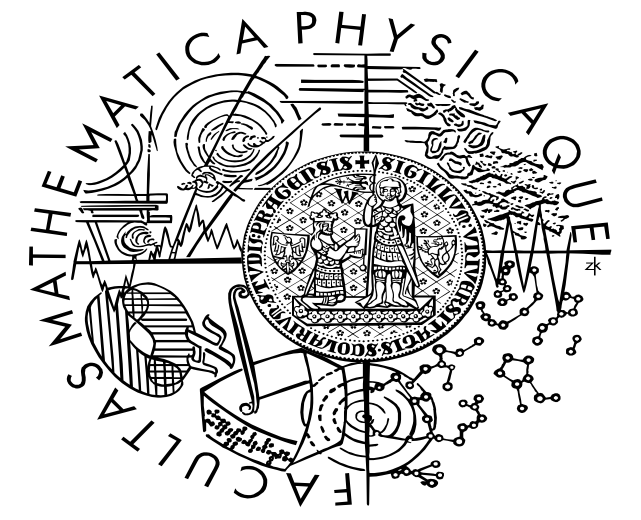




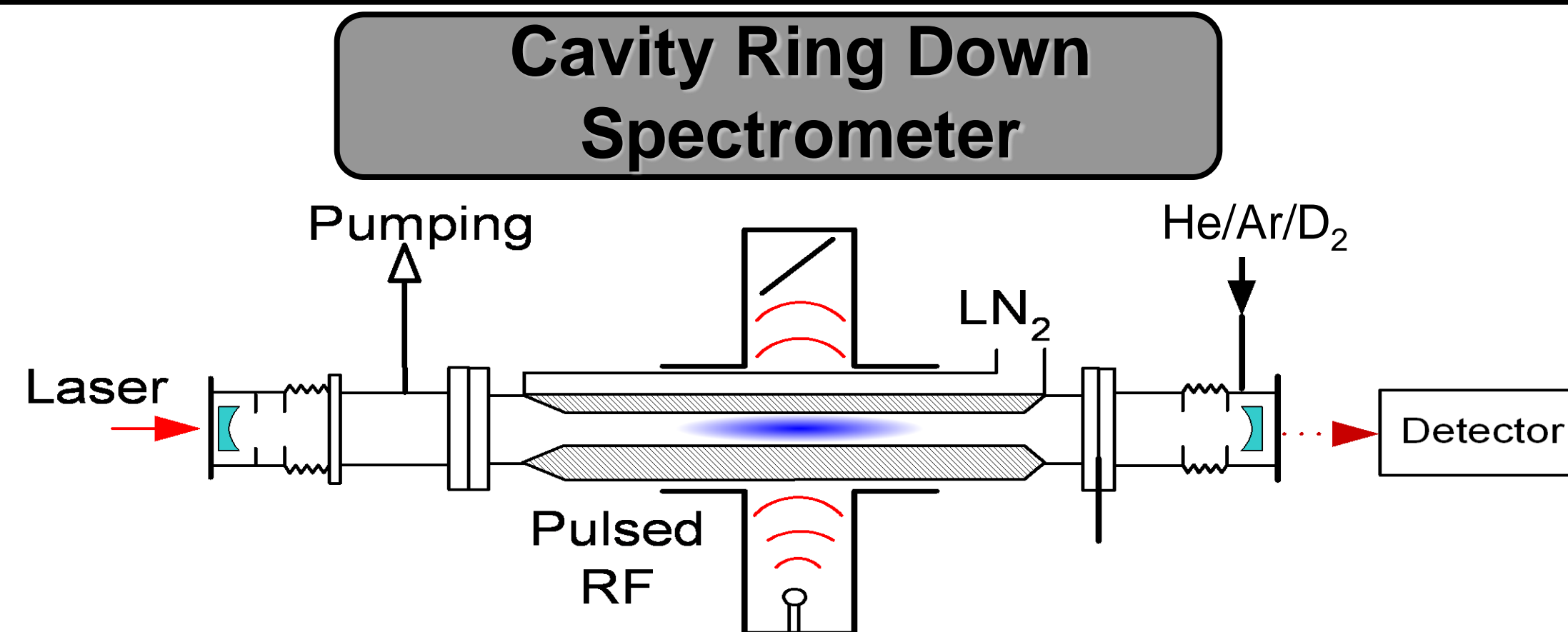
Recombination of D_3^+ ions with electrons, an application of absorption spectroscopy at 77–150 K

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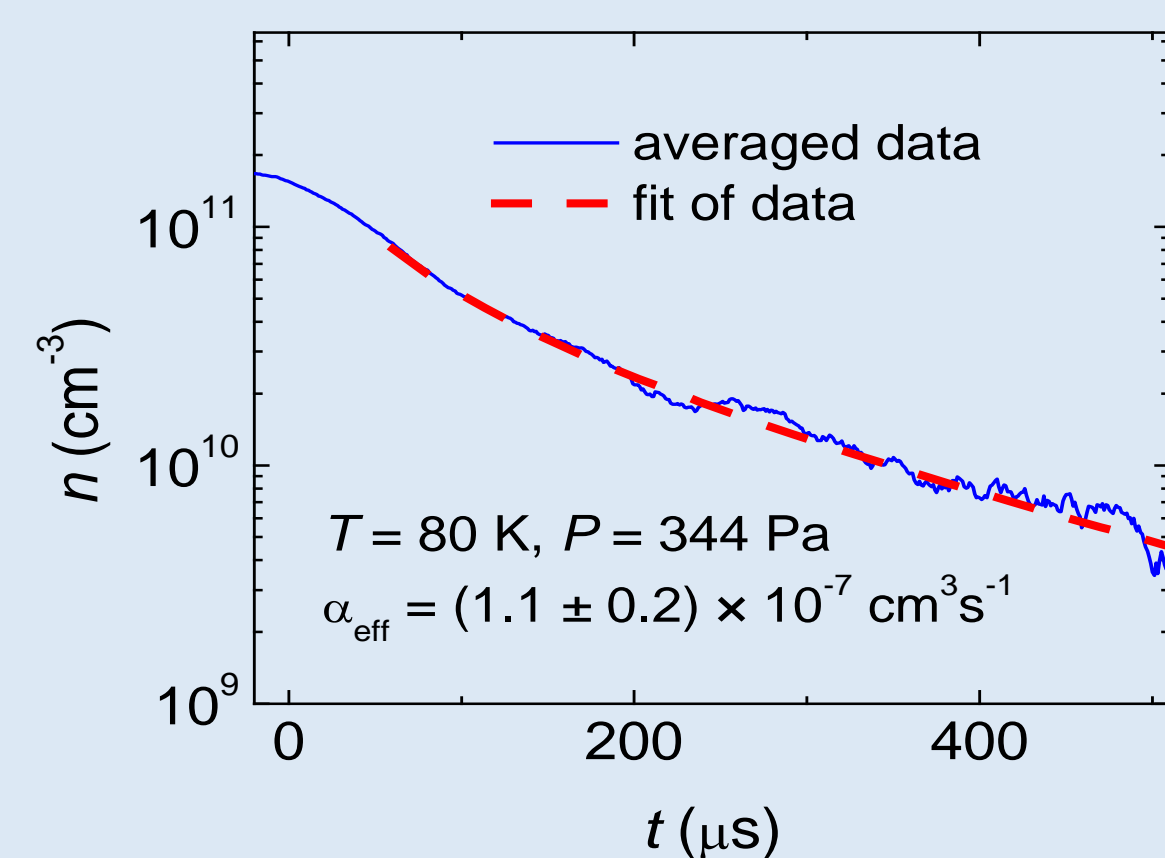
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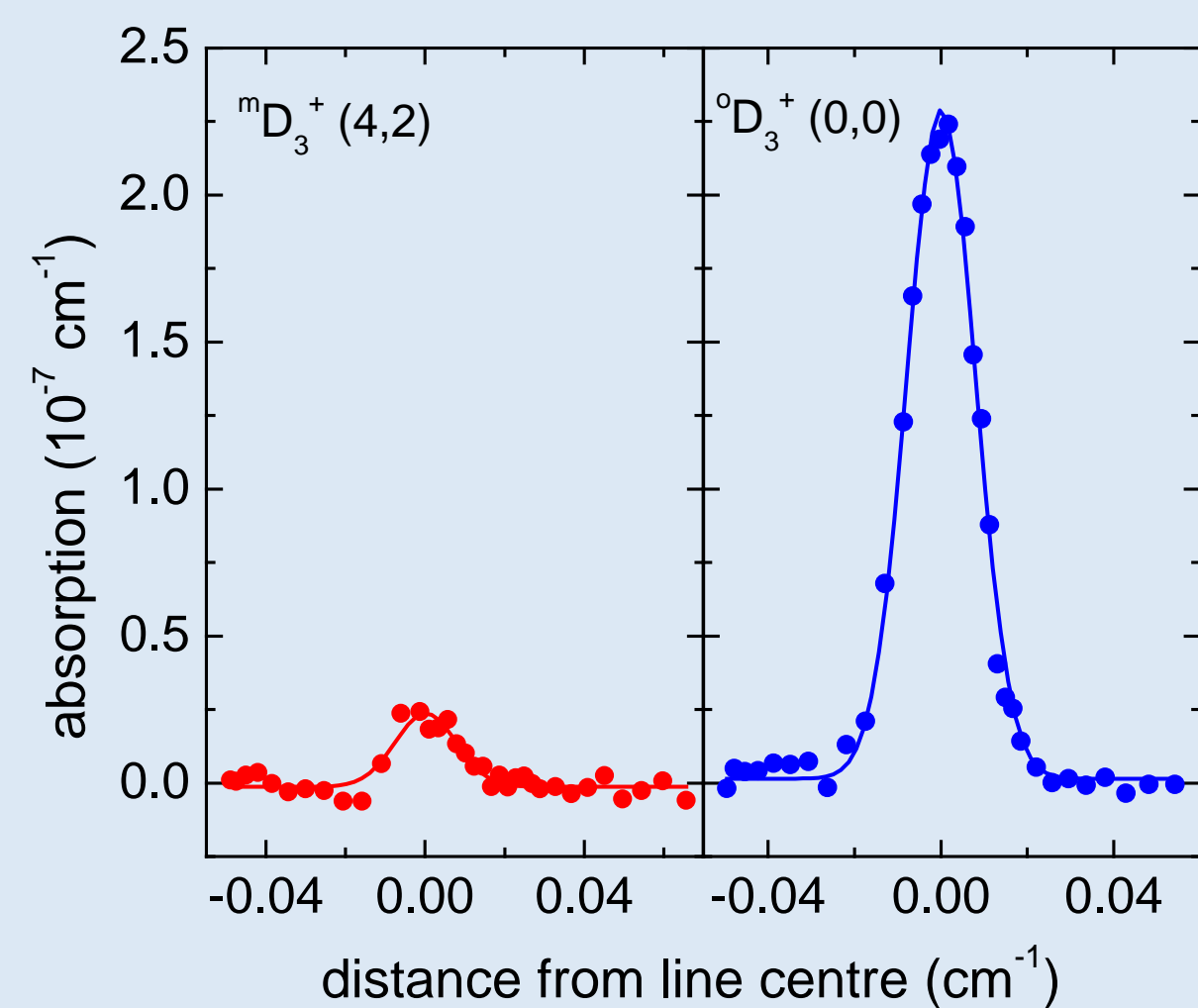
The CRDS apparatus. Mixture of He, Ar and D_2 is ionized in a pulsed discharge. The decay of ion density is measured using 1380 nm (H_3^+) or 1726 nm laser (D_3^+). Highly reflective mirrors (light blue in the picture) enable the laser to travel very large distance (~ 1000 m) in the cavity. Light exiting the cavity is collected by InGaAs avalanche photodiode.



Tube diameter 1.5 cm
Buffer gas flow ~ 350 – 1200 sccm
Pressure ~ 200 – 1000 Pa
Temperature ~ 77 – 300 K
Typical ion number densities (in discharge) ~ 10^{11} cm^{-3}
Reactants: He/Ar/ D_2 ~ $10^{17}/10^{14}/10^{14} \text{ cm}^{-3}$

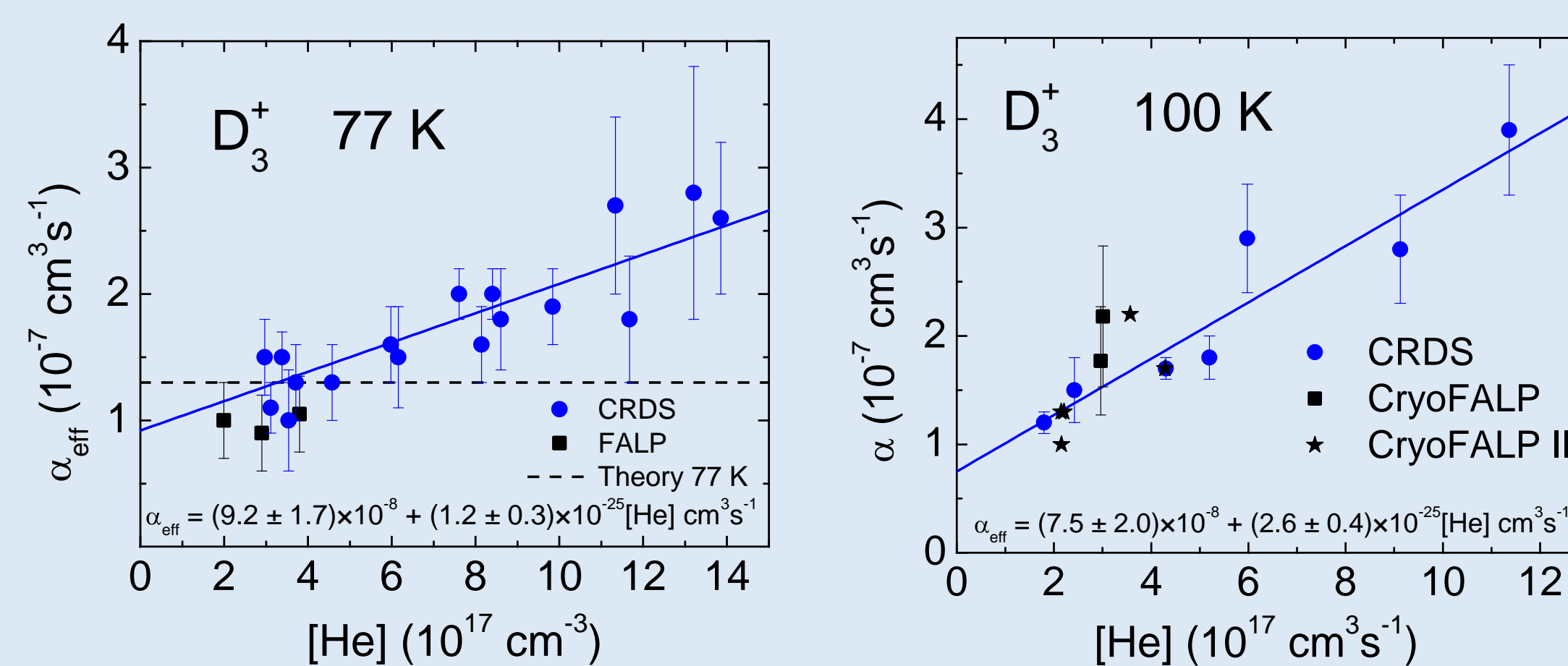


Example of measured ion number density decay in early afterglow.



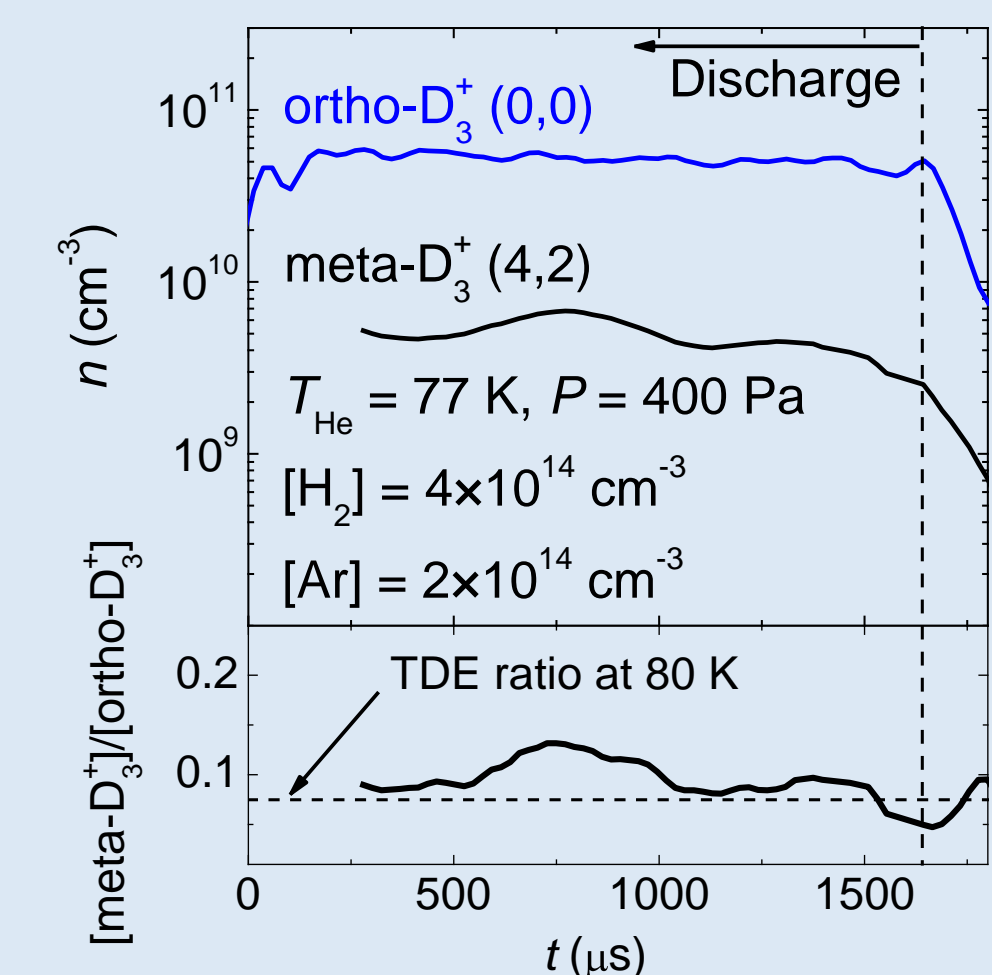
Example of measured absorption line profiles of D_3^+ ions at 112 K. Measured line centre positions are: $(5792.70 \pm 0.01) \text{ cm}^{-1}$ for ${}^mD_3^+$ and $(5793.90 \pm 0.01) \text{ cm}^{-1}$ for ${}^oD_3^+$.

Experiment

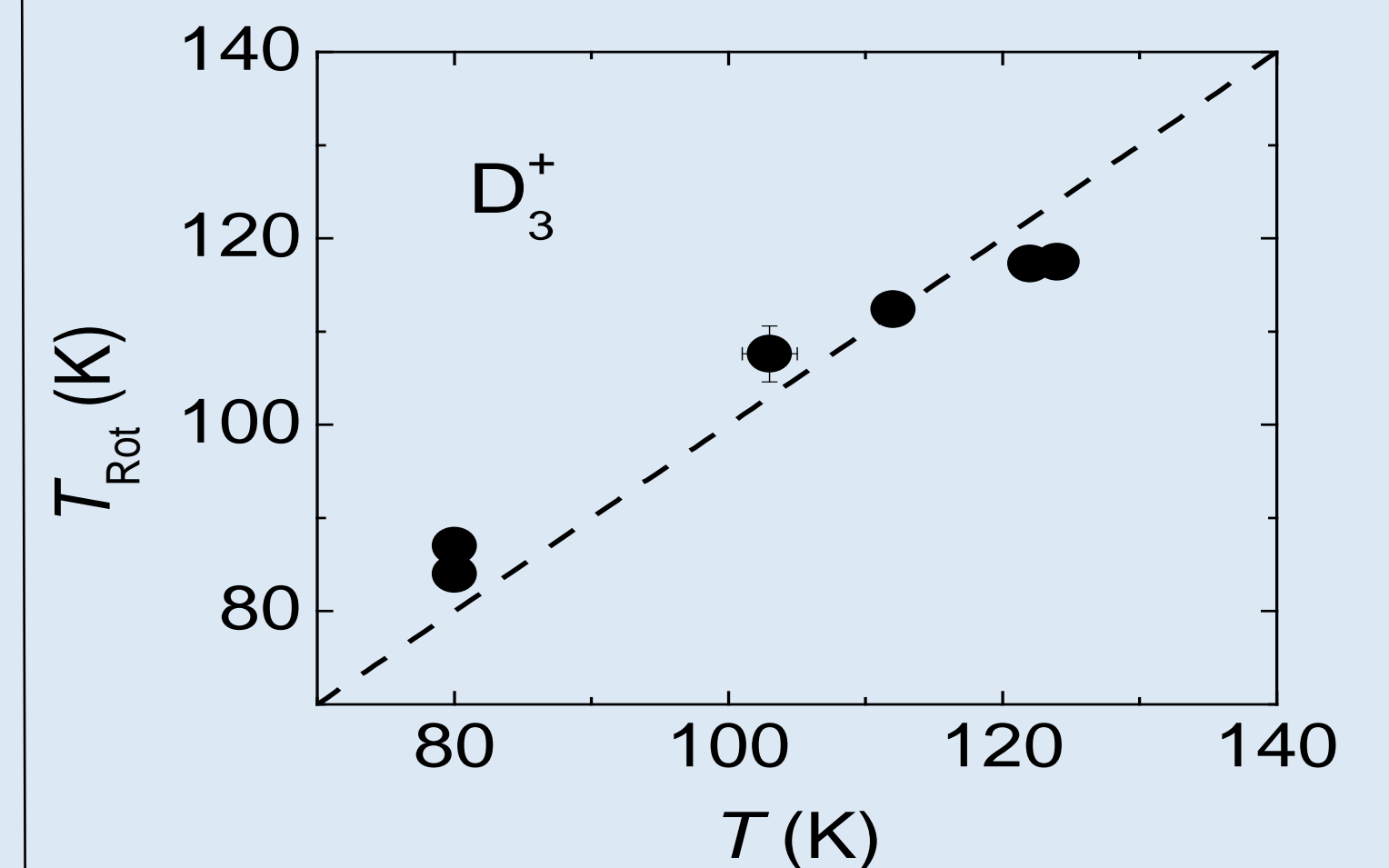


Dependence of measured effective recombination rate coefficient on helium number density at 77, 100 and 125 K. Data obtained in previous FALP experiments [1] are plotted squares. Unpublished FALP data are plotted as stars.

$$\alpha_{\text{eff}}(T) = \alpha_{\text{BIN}}(T) + K_{\text{He}}(T)[\text{He}]$$

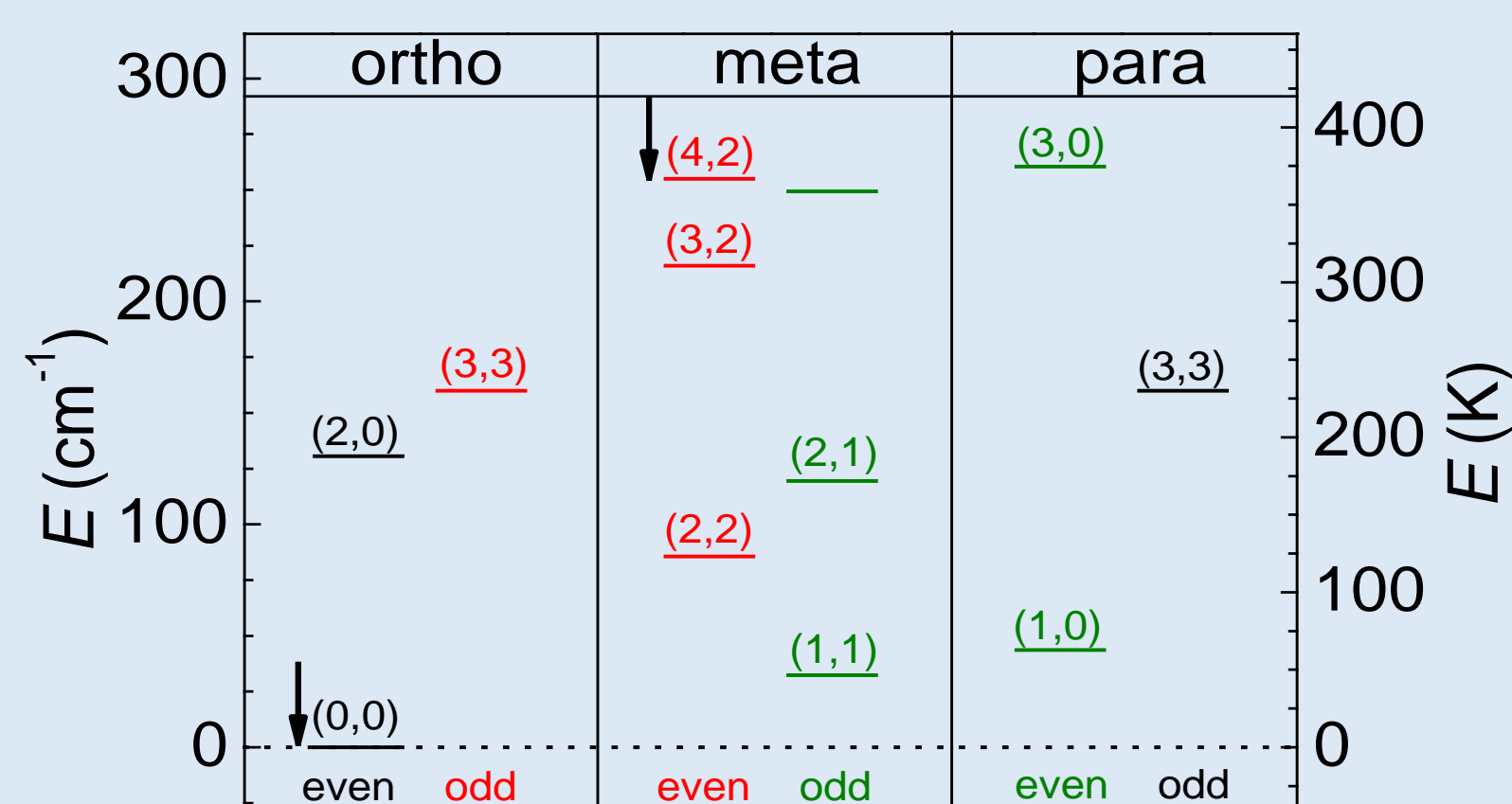


Upper panel: Measured number densities of the ions in ortho (0,0) and meta (4,2) states of D_3^+ in discharge and early afterglow. **Lower panel:** Ratio of the states shown in the upper panel. Dashed line indicates value of this ratio corresponding to the thermodynamic equilibrium (TDE) at 80 K.

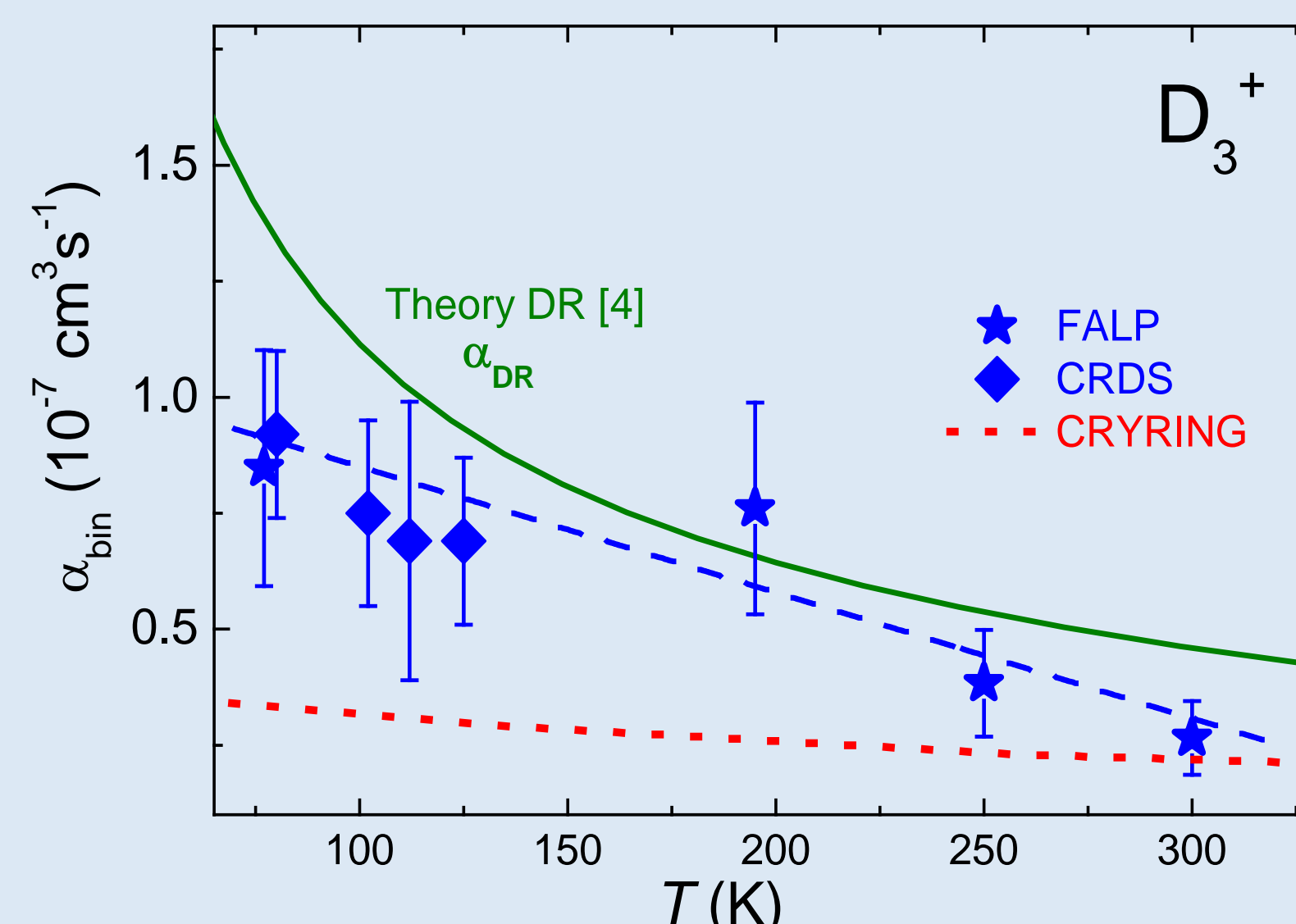


Measured dependence of rotational temperature of D_3^+ ions on kinetic temperature

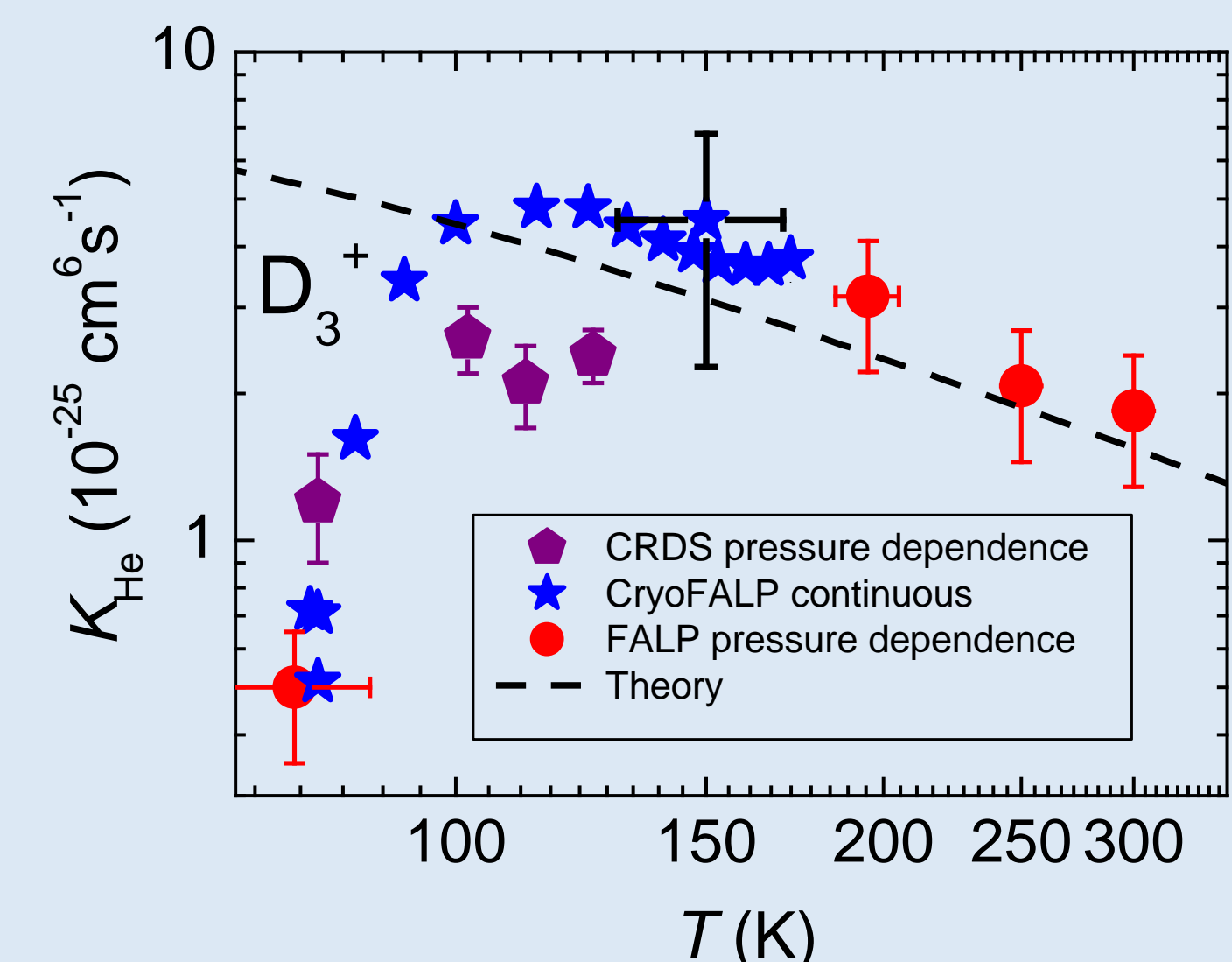
Comparison with theory



Lowest rotational levels of the ground vibrational state of D_3^+ ion [2]. Probed levels are noticed by arrows.



Measured binary recombination rate coefficient of D_3^+ with electrons. FALP [1] and storage ring data [3] are also shown.



Measured Ternary recombination rate coefficients of recombination of D_3^+ ions with electrons. Older data [1] and theory [4] are also shown.

References:

[1] T. Kotrik et al., J. Chem. Phys. **133**, 034305 (2010). [2] J. Tennyson, private communication. [3] A. Le Padellec et al., Physica Scripta **57**, 215 (1998). [4] V. Kokoouline, C. H. Greene, Phys. Rev. A **68**(1), 012703 (2003).

Acknowledgments:

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