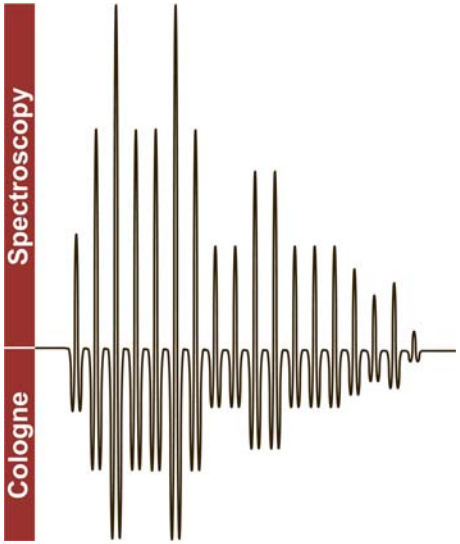


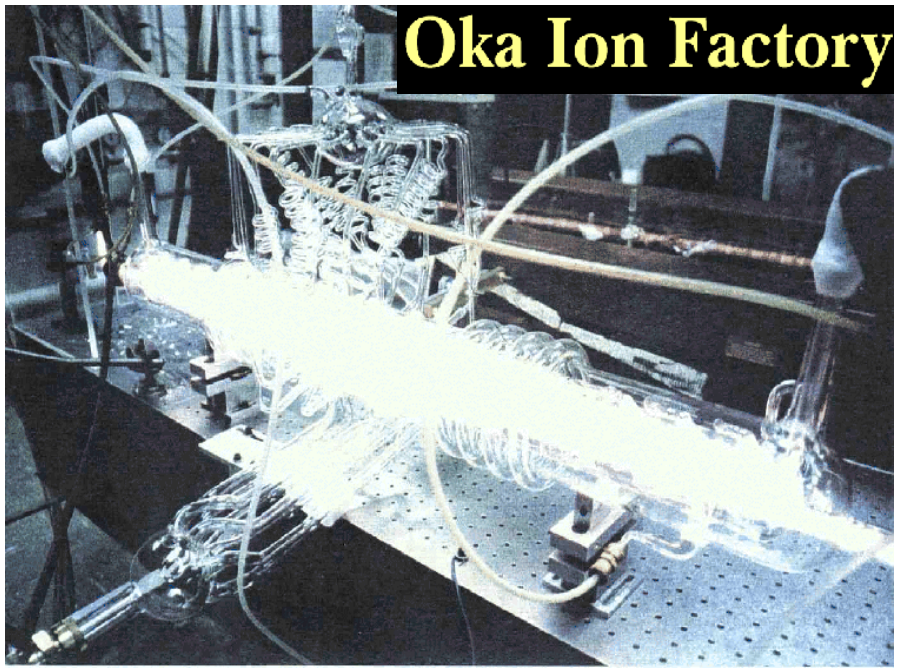
Physics, Chemistry, and Astronomy of H_3^+

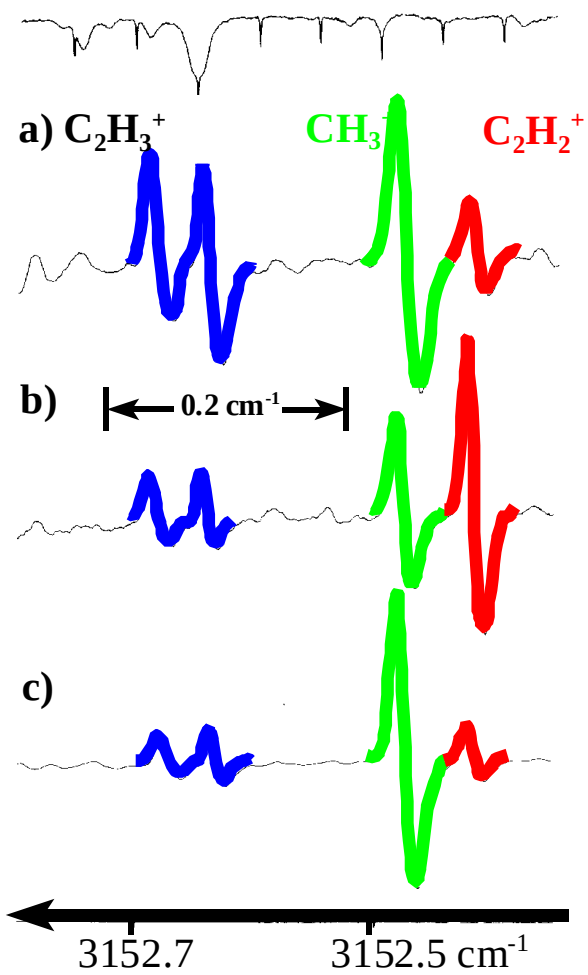
Probing H_2D^+ with FELIX and other Laser Sources

S. Schlemmer

- Laser Induced Reactions for Spectroscopy
- Methods
- Spectroscopy of H_2D^+
- Determination of Rotational Population

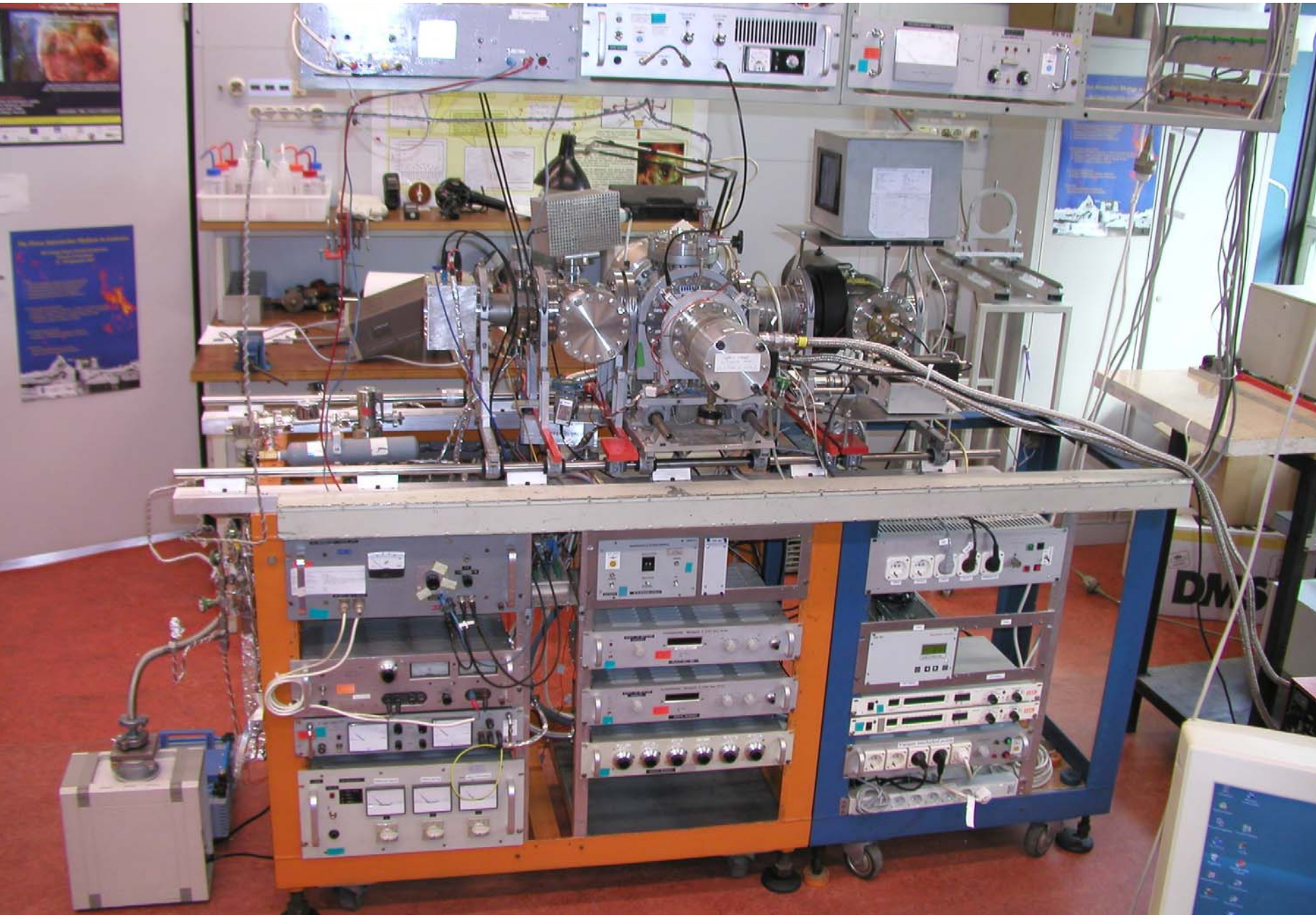
Molecular Ion Spectroscopy





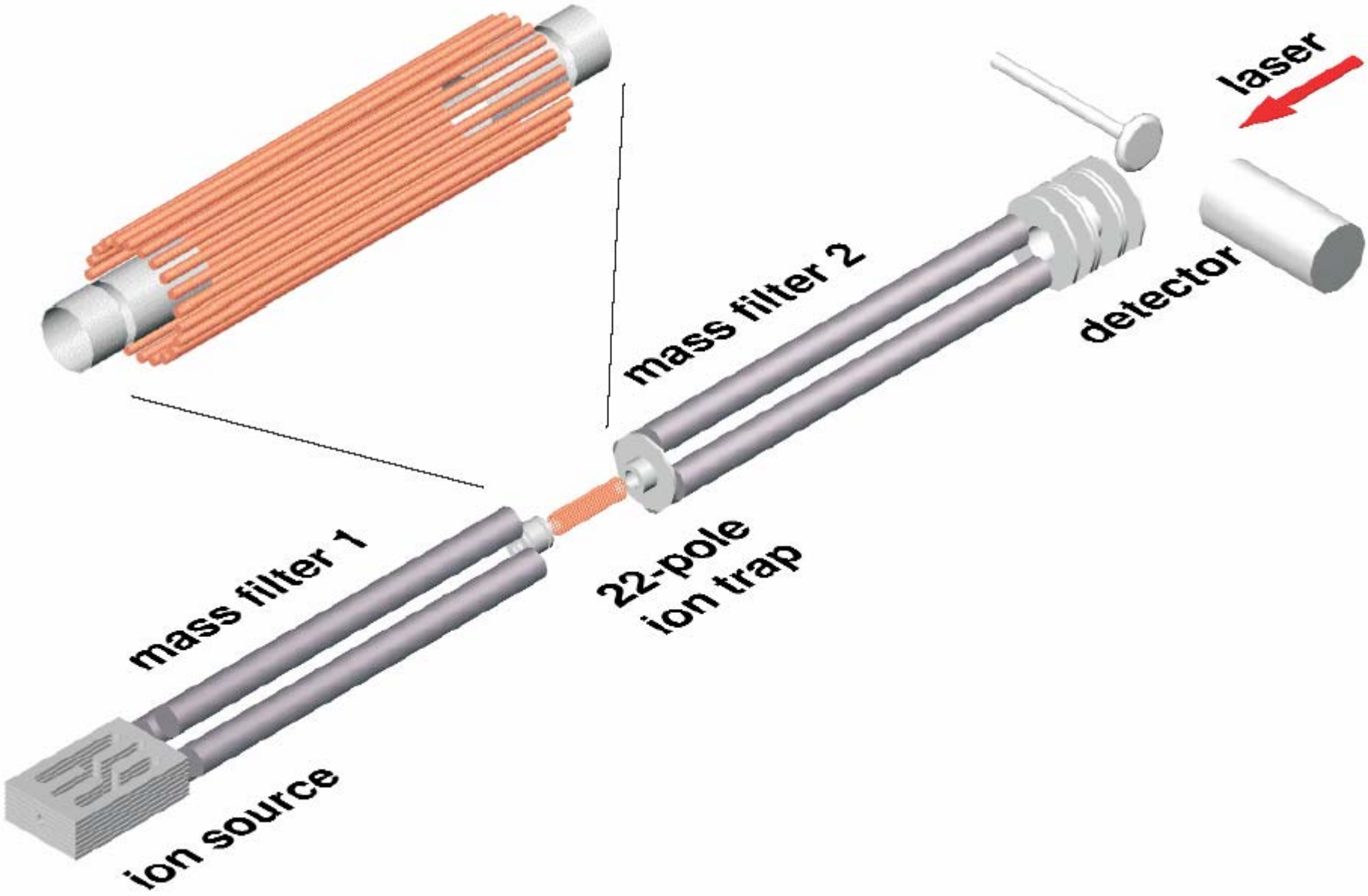
- [Cations] ≈ 10^{14} cm^{-2}
- Sensitivity
  [Ions] ≈ 10^{8} cm^{-3}
- Plasmachemistry
- Ion Temperature - Density of States

22-Pole Ion Trap

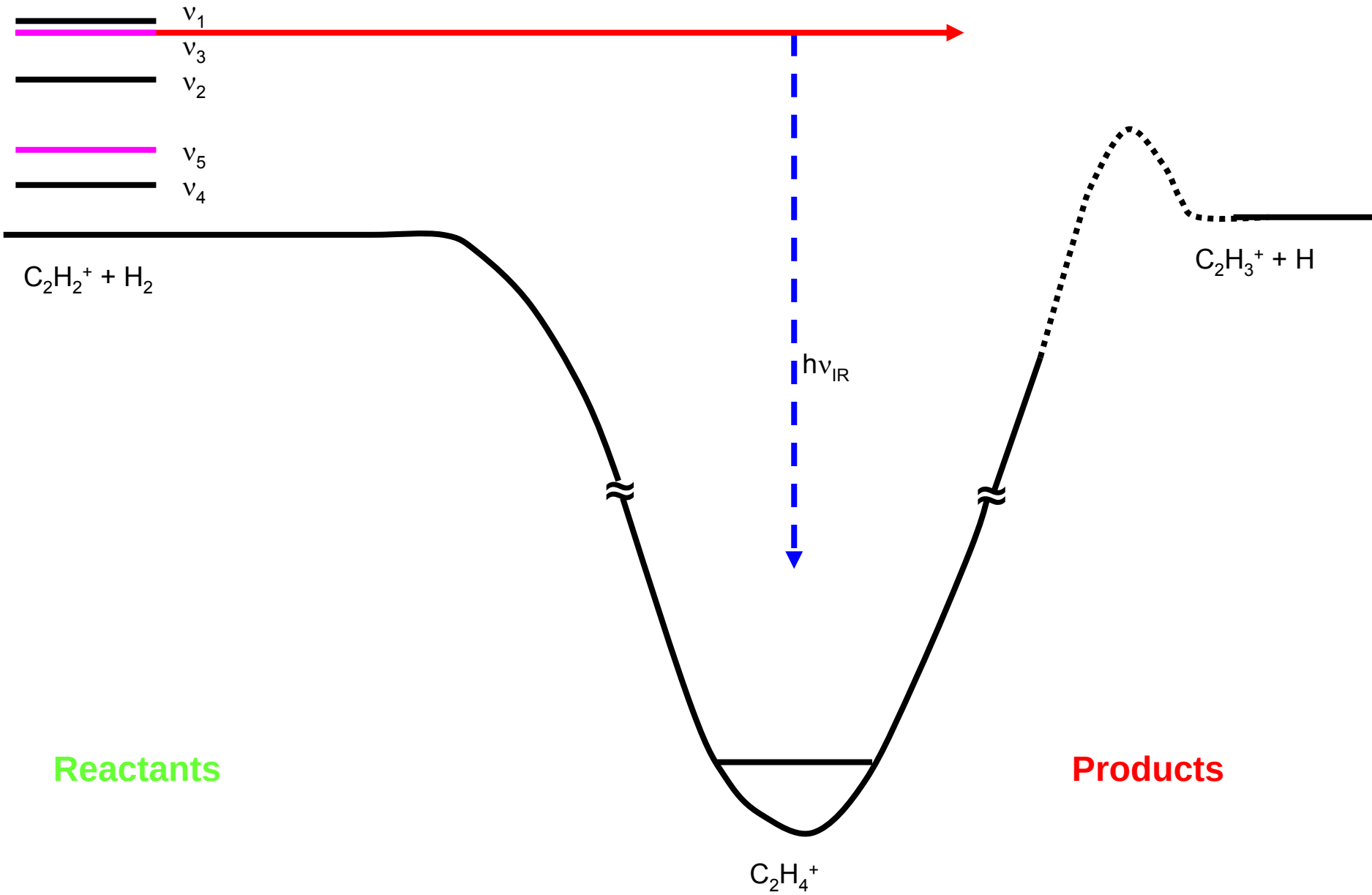


Laser Induced Reactions

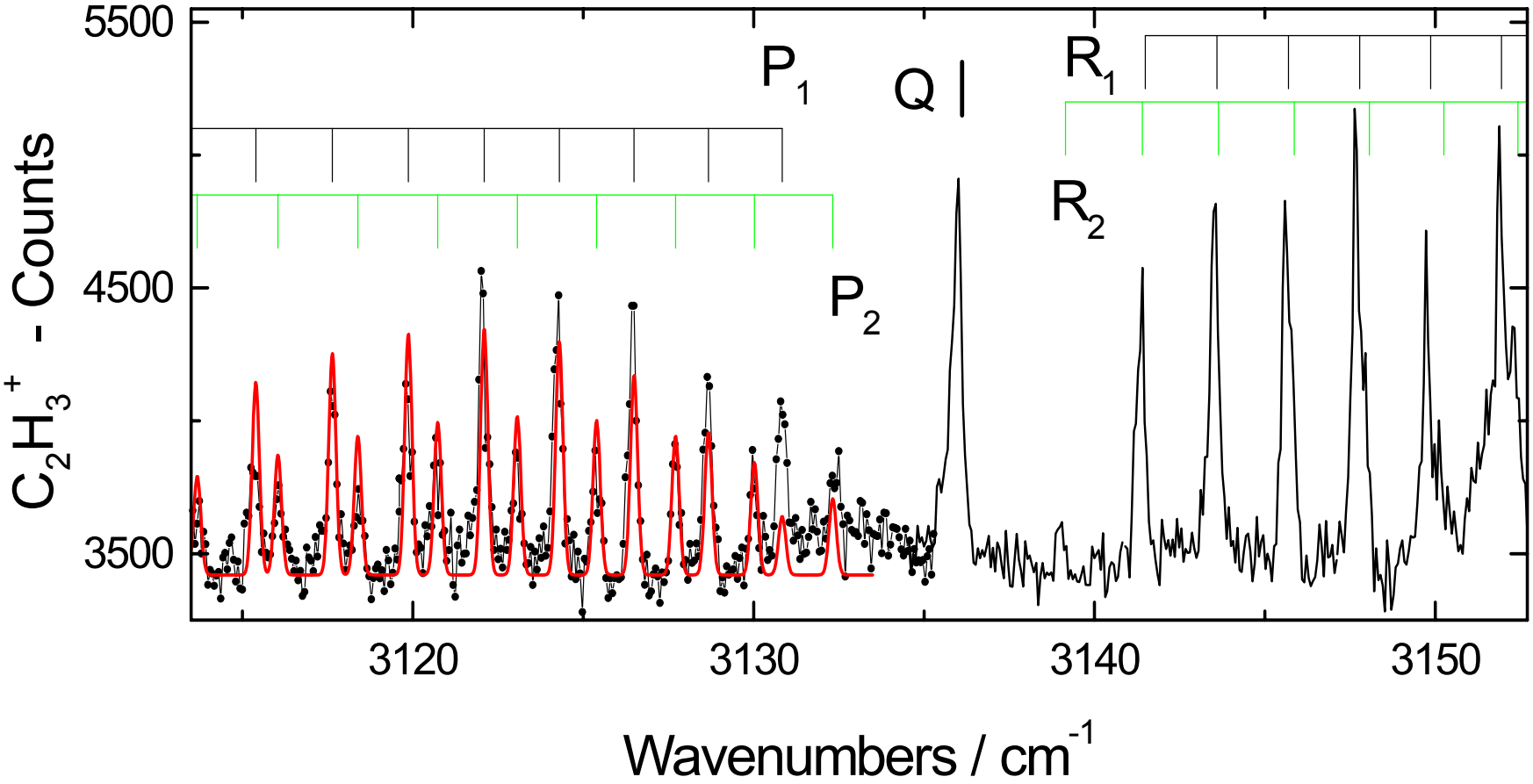
Spectroscopy with 1000 Ions



Laser induced Reactions

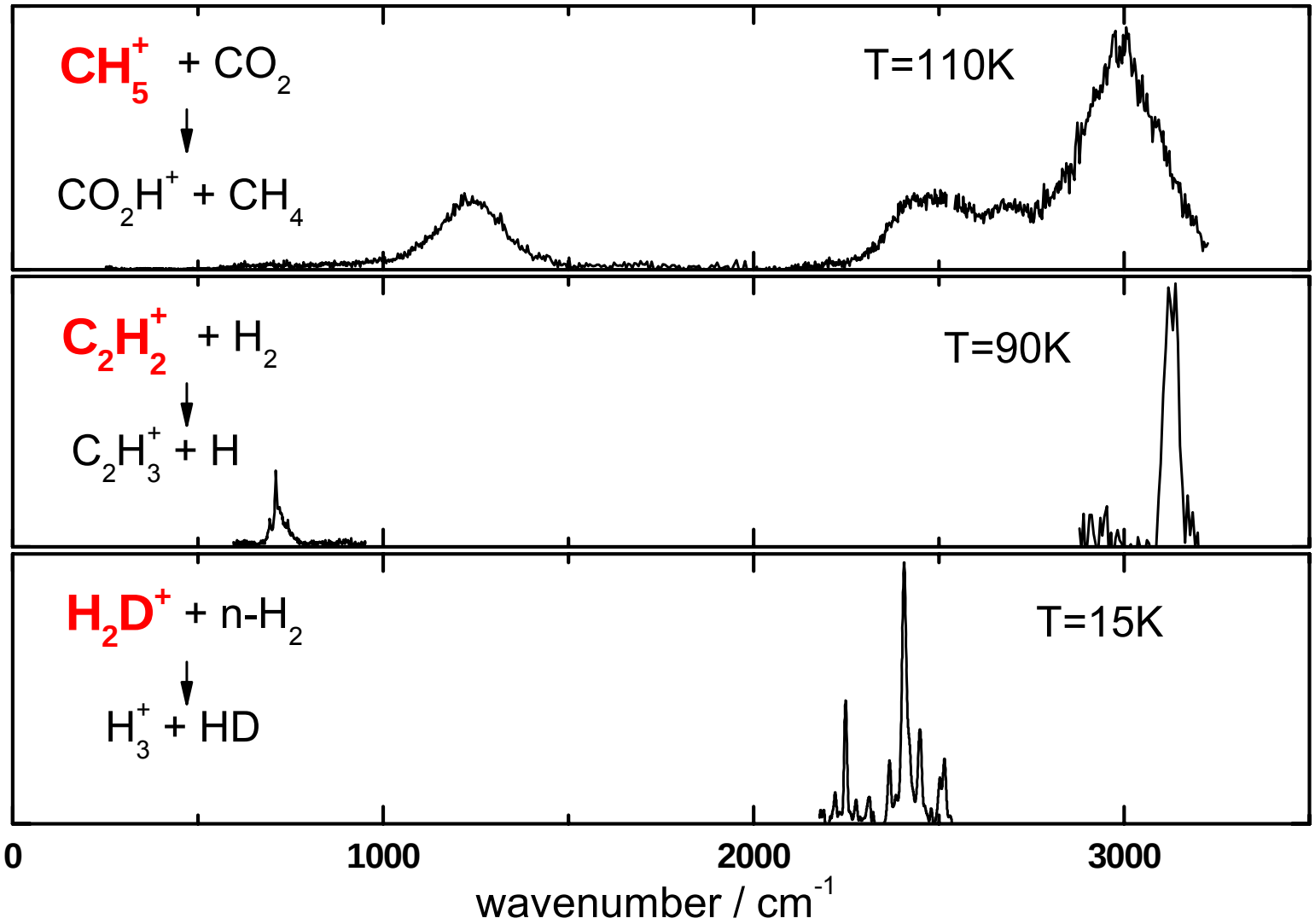


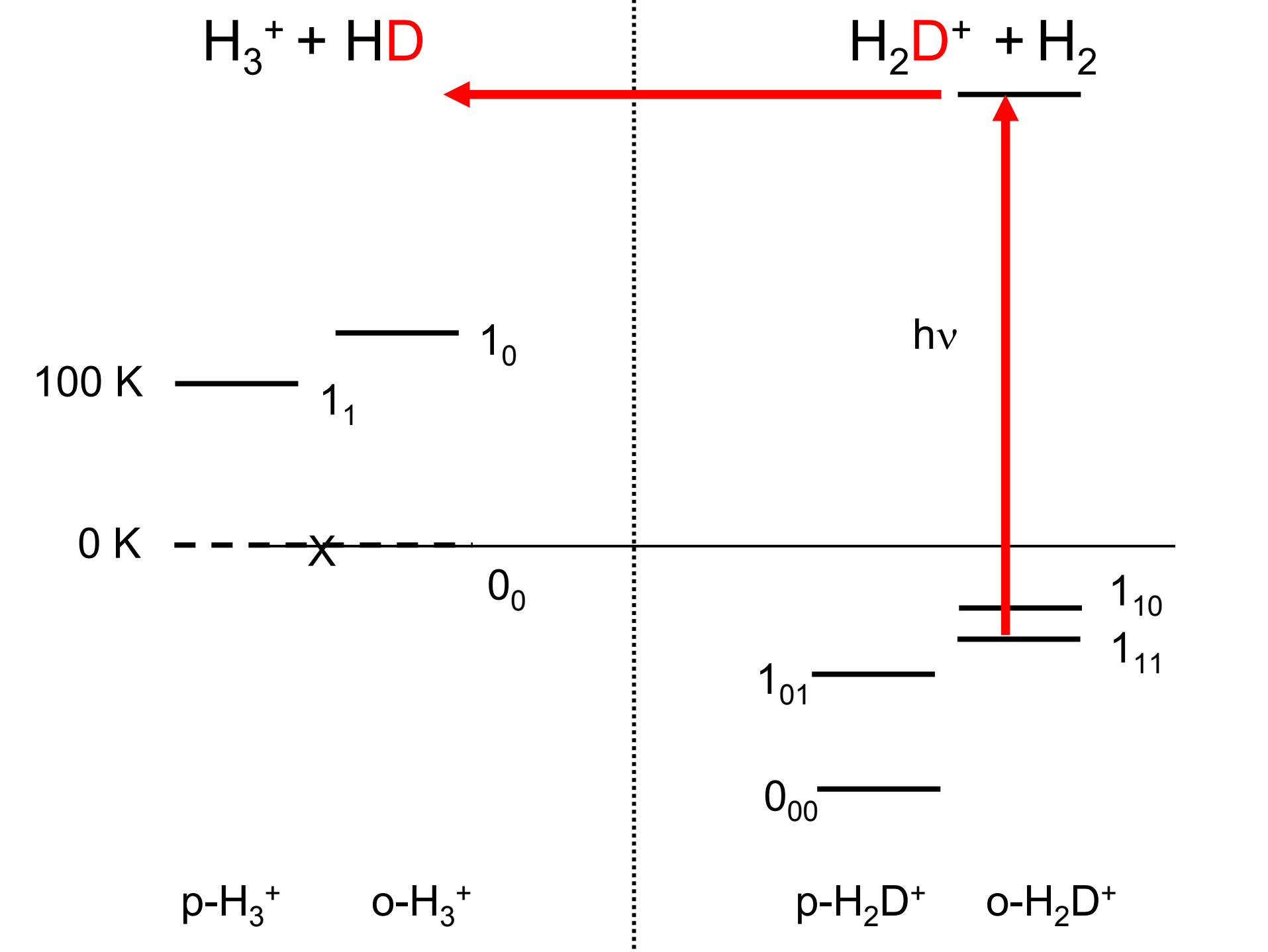
LIR: A Method for Spectroscopy



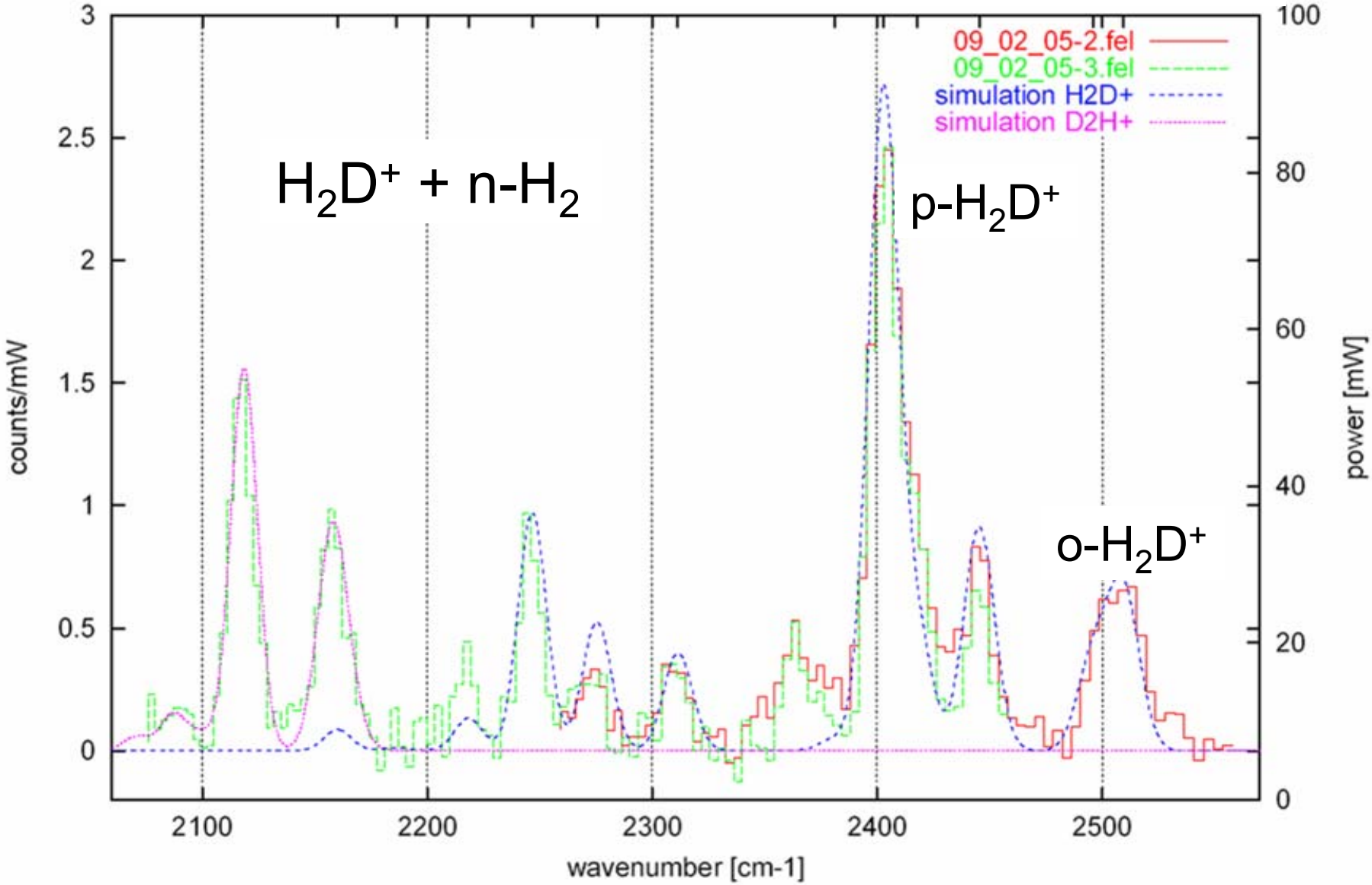
Schlemmer et al. J. Chem. Phys. **117**, 2068 (2002)

LIR spectra using FELIX



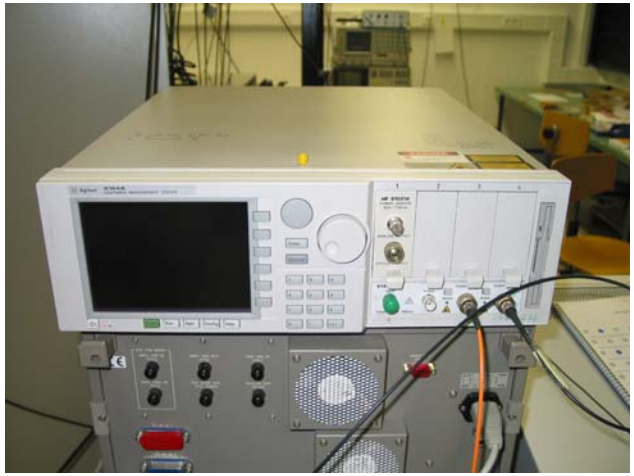

$H_3^+ + HD$
$H_2D^+ + H_2$
1_0
100 K
1_1
0 K
0_0
hν
1_{10}
1_{11}
1_{01}
0_{00}
p-H_3^+
o-H_3^+
p-H_2D^+
o-H_2D^+

LIR-Experimente mit FELIX

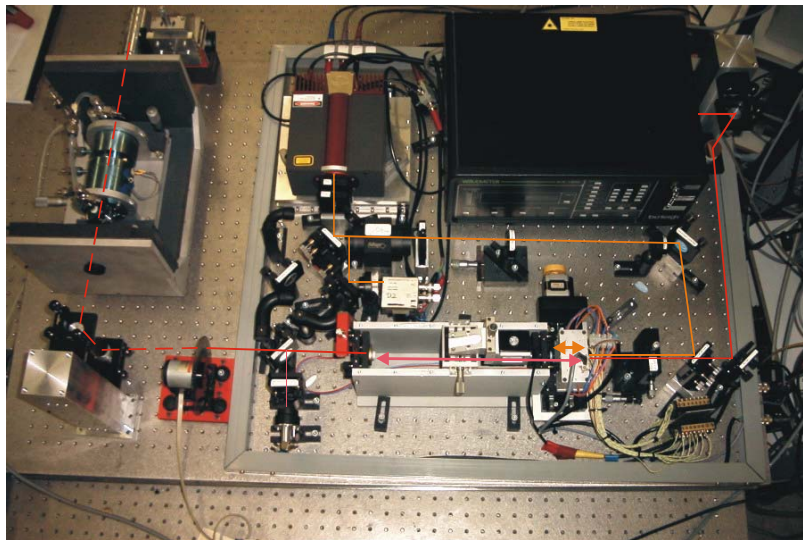


Laser for LIR of H_2D^+

FELIX:
Range: 50-3300 cm^{-1}
Power: 10Hz, ~200mW
Resolution: 0.5% FWHM



Agilent diode lasers:
6100-6600 and 6750-7300 cm^{-1} cw, ~5mW
narrow linewidth



Düsseldorf OPO (Prof. Schiller):
2600-3200 cm^{-1} cw, ~50mW
narrow linewidth

LIR of H_2D^+: ν_1

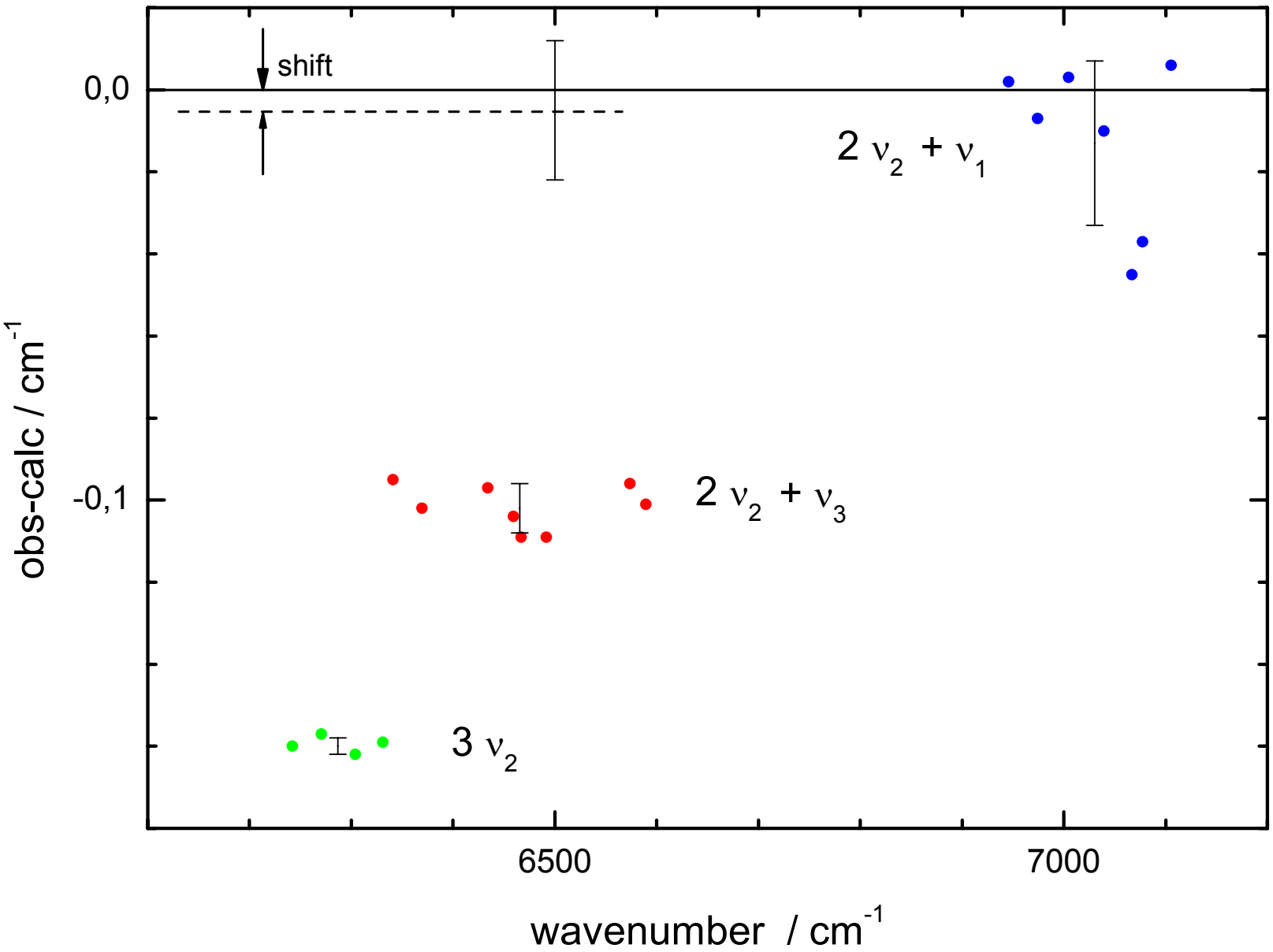
transition	this work	Ref. [14]	Ref. [11]	A_{if} [s^{-1}]	A_{tot} [s^{-1}]	g_u/g_l	B_{rel}
$1_{01} \rightarrow 0_{00}$	2946.3	2946.826	2946.802	53.167	53.4	1/3	0.318
$1_{11} \rightarrow 1_{10}$	3003.3	3003.304	3003.276	27.509	53.4	3/3	0.466
$0_{00} \rightarrow 1_{01}$	3038.1	3038.198	3038.177	20.353	53.9	3/1	1
$1_{11} \rightarrow 2_{12}$	3068.8	3068.860	3068.845	20.088	54.3	5/3	0.532
$1_{01} \rightarrow 2_{02}$		3077.626	3077.611	24.757	54.8	5/3	0.650
$1_{10} \rightarrow 2_{11}$		3094.690	3094.671	19.302	54.6	5/3	0.64
$1_{01} \rightarrow 2_{20}$	3164.1	3164.149		1.5976	53.1	5/3	0.04

< Obs-calc > = (-0.013 +/- 0.020) cm^{-1}

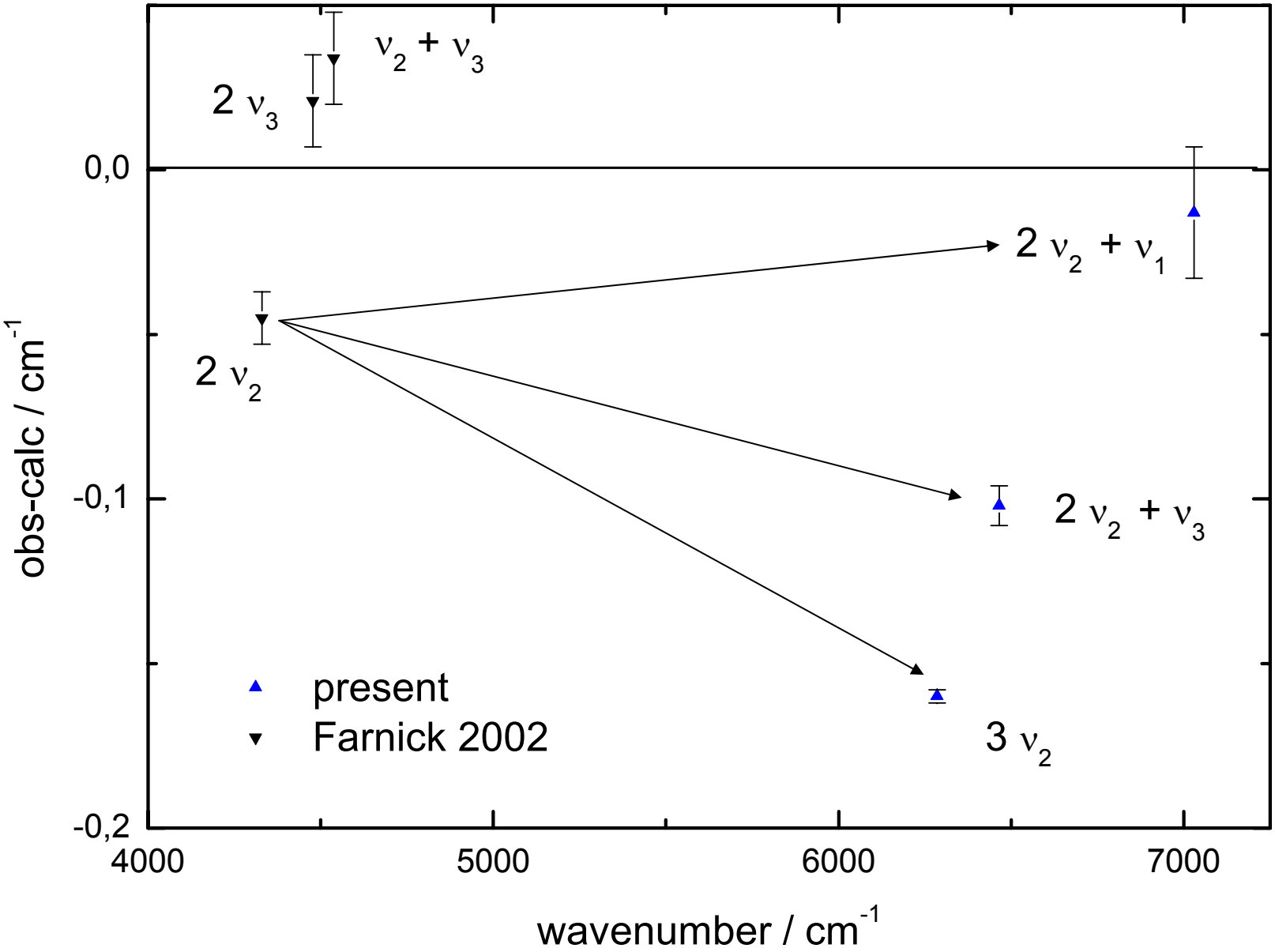
LIR of H_2D^+: Combination bands

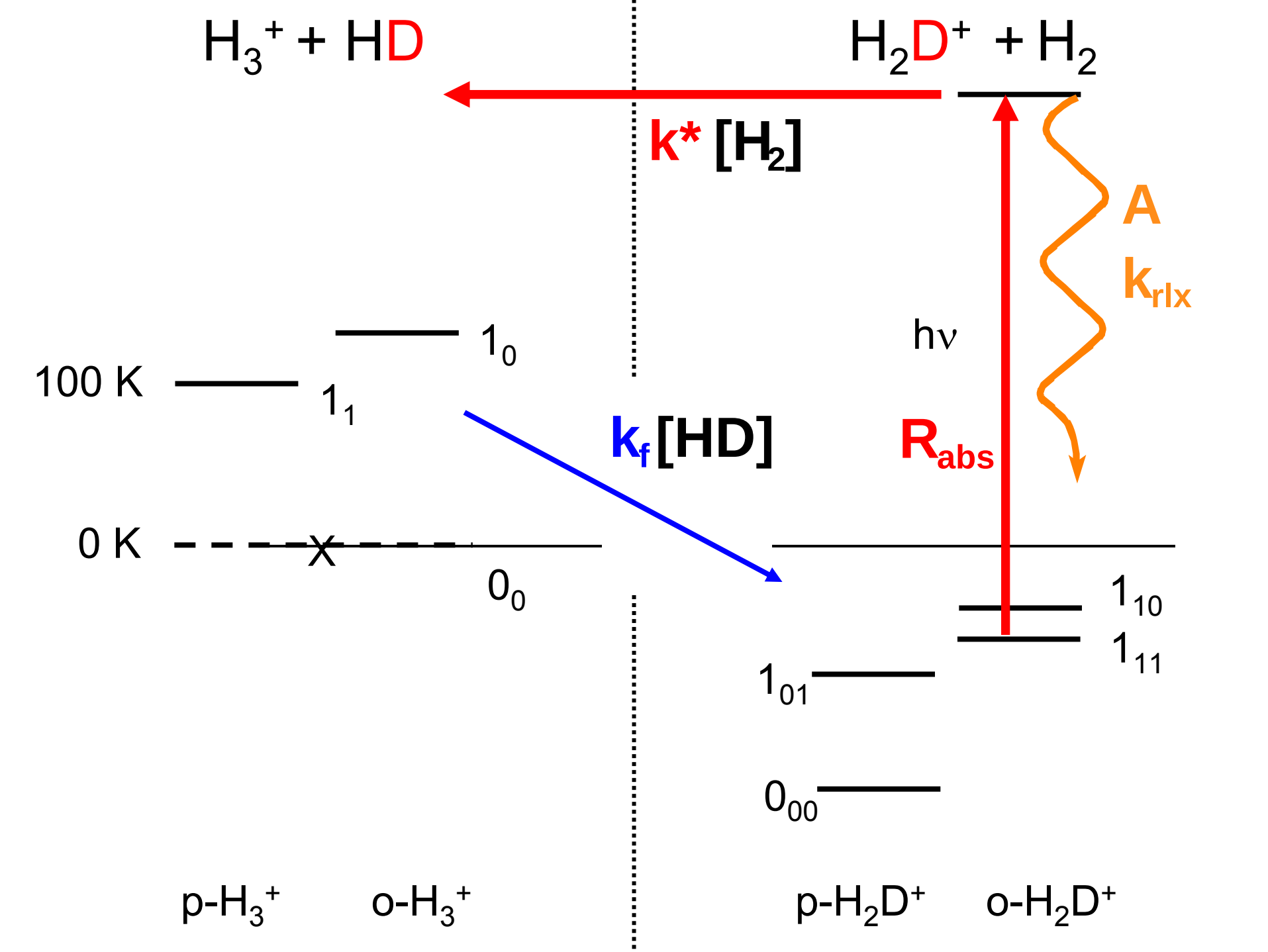
transition		this work	Ref.[19]	A_{ul}	A_{eff}	A_{tot}	g_u/g_l	B_{rel}	pow	Agilent [nm]
$3\nu_2$	$1_{01} \rightarrow 0_{00}$	6241.9	6242.121	7.08	74.3	154.7	1/3	0.21		1602.0
$3\nu_2$	$1_{10} \rightarrow 1_{11}$	6270.3	6270.544	2.13	75.4	156.9	3/3	0.19		1594.7
$3\nu_2$	$1_{11} \rightarrow 1_{10}$	6303.7	6303.941	3.36	82.2	154.5	3/3	0.29		1586.3
$3\nu_2$	$0_{00} \rightarrow 1_{01}$	6330.9	6331.127	1.21	81.8	158.7	3/1	0.31	5.397	1579.5
$2\nu_2+\nu_3$	$1_{11} \rightarrow 0_{00}$	6340.6	6340.778	9.36	78.1	268.1	1/3	0.27	5.318	1577.0
$2\nu_2+\nu_3$	$1_{10} \rightarrow 1_{01}$	6369.4	6369.557	6.04	83.0	267.4	3/3	0.51	5.06	1569.9
$2\nu_2+\nu_3$	$1_{01} \rightarrow 1_{10}$	6433.7	6433.833	4.64	81.3	270.3	3/3	0.38	4.37	1554.2
$2\nu_2+\nu_3$	$1_{11} \rightarrow 2_{02}$	6459.0	6459.133	2.47	90.7	269.8	5/3	0.34	4.077	1548.1
$2\nu_2+\nu_3$	$0_{00} \rightarrow 1_{11}$	6466.5	6466.635	4.10	96.4	271.6	3/1	1	3.994	1546.3
$2\nu_2+\nu_3$	$1_{01} \rightarrow 2_{12}$	6491.3	6491.451	4.49	90.6	266.8	5/3	0.60	3.668	1540.4
$2\nu_2+\nu_3$	$1_{10} \rightarrow 2_{21}$	6573.8	6573.925	3.64	88.6	280.7	5/3	0.47	2.23	1521.1
$2\nu_2+\nu_3$	$1_{11} \rightarrow 2_{20}$	6589.4	6589.505	2.49	96.4	280.9	5/3	0.32	?	1517.5
$\nu_1+2\nu_2$	$1_{01} \rightarrow 0_{00}$	6945.8	6945.868	10.25	80.3	105.2	1/3	0.22		1439.7
$\nu_1+2\nu_2$	$1_{10} \rightarrow 1_{11}$	6974.2	6974.253	5.54	92.3	117.0	3/3	0.36		1433.8
$\nu_1+2\nu_2$	$1_{11} \rightarrow 1_{10}$	7004.7	7004.794	5.10	82.4	105.5	3/3	0.33		1427.5
$\nu_1+2\nu_2$	$0_{00} \rightarrow 1_{01}$	7039.3	7039.366	3.72	96.5	121.4	3/1	0.70		1420.5
$\nu_1+2\nu_2$	$1_{11} \rightarrow 2_{12}$	7066.8	7066.878	3.60	137.9	191.0	5/3	0.37		1415.0
$\nu_1+2\nu_2$	$1_{01} \rightarrow 2_{02}$	7077.5	7077.560	4.05	120.0	170.9	5/3	0.42		1412.9
$\nu_1+2\nu_2$	$1_{10} \rightarrow 2_{11}$	7105.5	7105.505	3.38	77.2	129.9	5/3	0.35		1407.3

LIR of H_2D^+: Combination bands

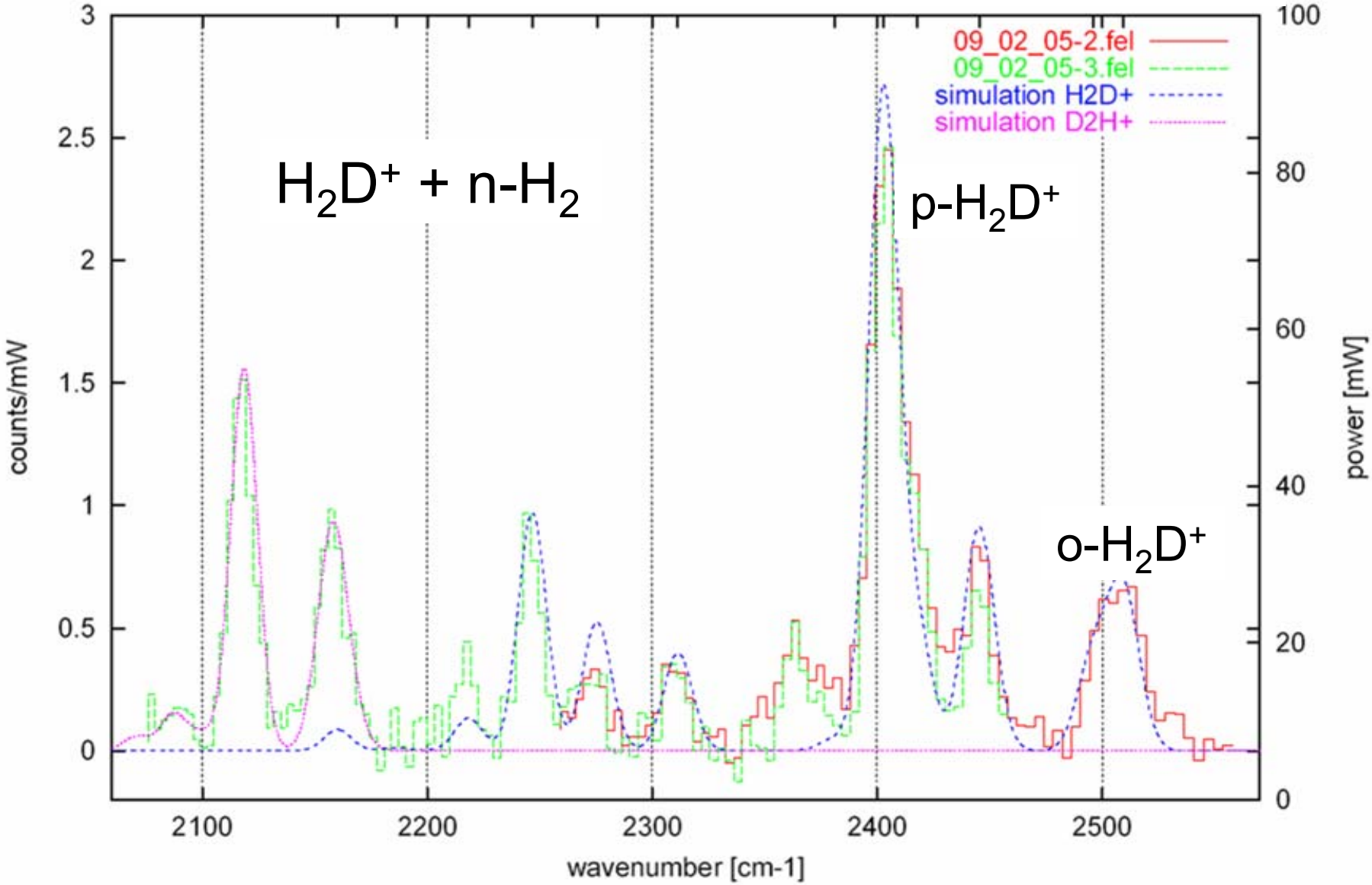


LIR of H_2D^+: Combination bands

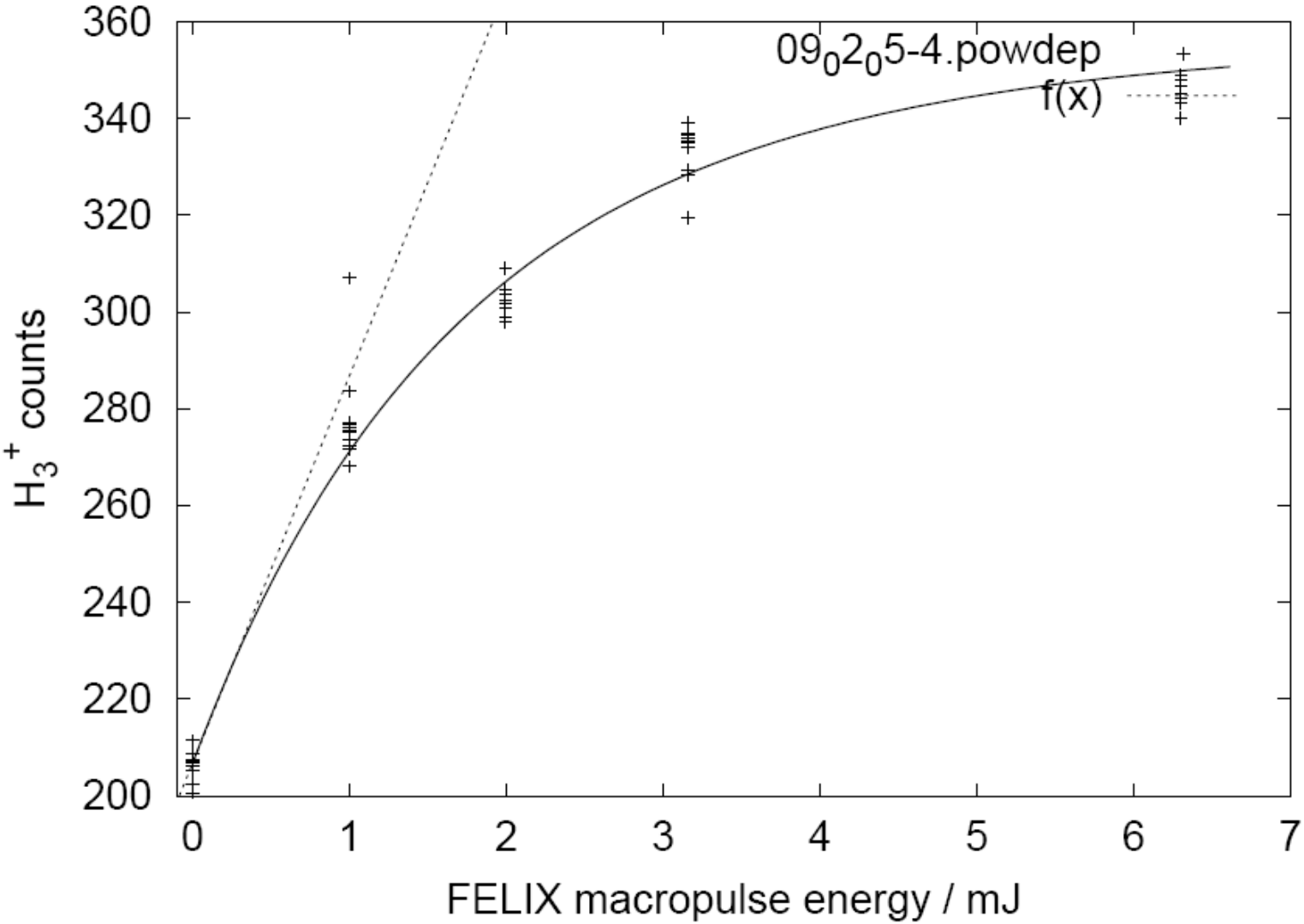



$H_3^+ + HD$
$H_2D^+ + H_2$
$k^*[H_2]$
A
k_{rlx}
hν
1_0
100 K
1_1
$k_f[HD]$
R_{abs}
0 K
0_0
1_{10}
1_{11}
1_{01}
0_{00}
p-H_3^+
o-H_3^+
p-H_2D^+
o-H_2D^+

LIR-Experimente mit FELIX



Power Dependence

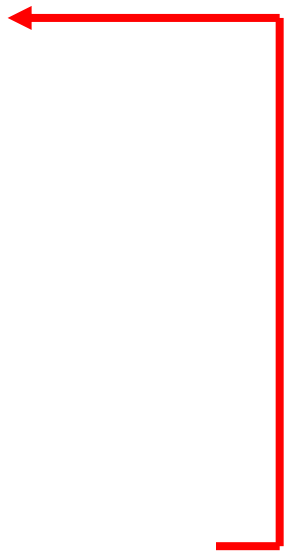


== > Saturation effects with pulsed, high power excitation

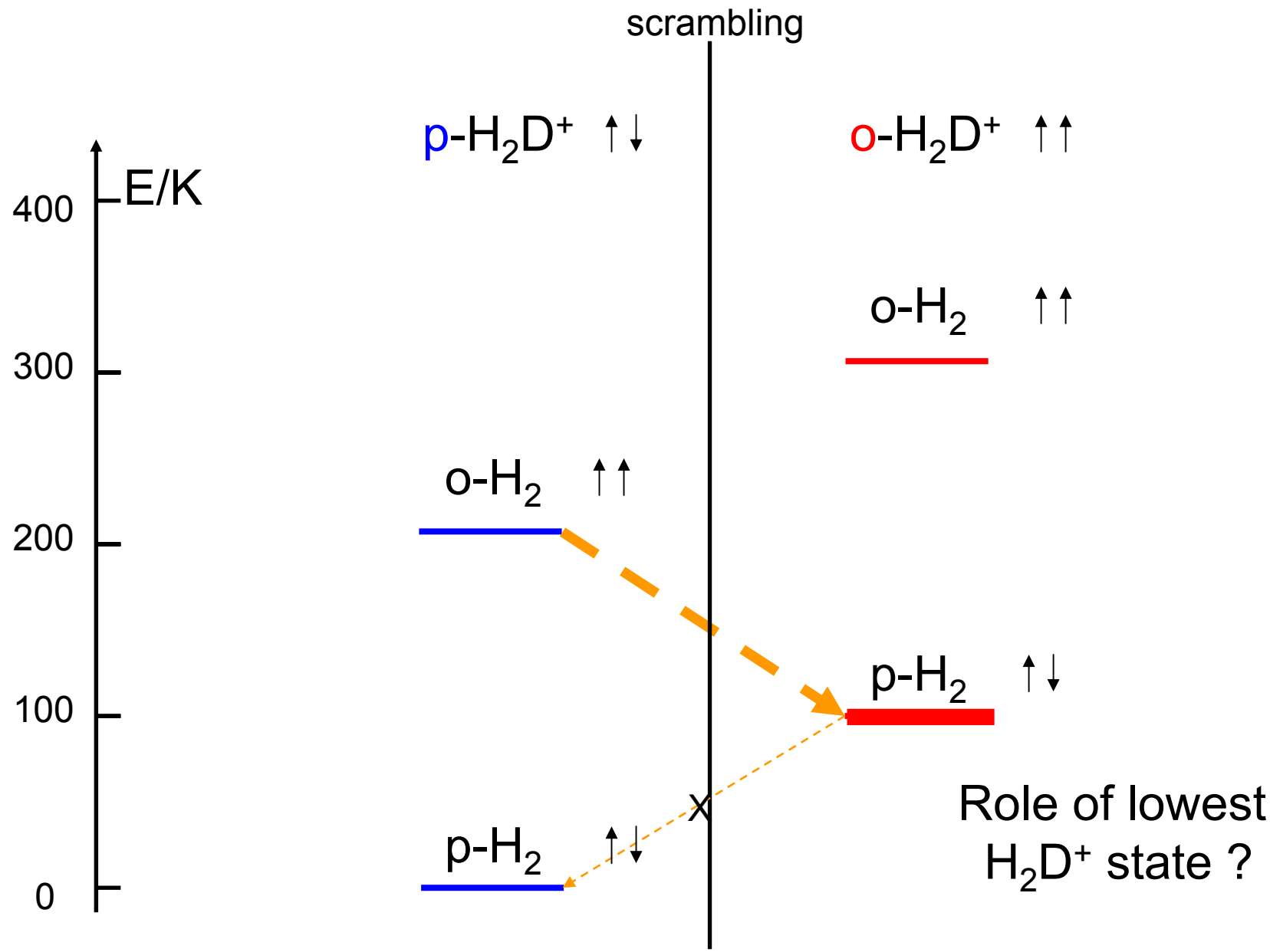
Competitive Molecular Processes

Conditions: T = 17 K (wall), 20-25 K (Doppler)
$[H_2] \sim 10^{11}$ cm^{-3} ,1 s storage

	k / 10^{-9} cm^3/s	k $[H_2]$ / s^{-1}
H_2, k_L	1	100
p-H_2 (1 %)	1	1
HD (0.03 %)	1	0.03

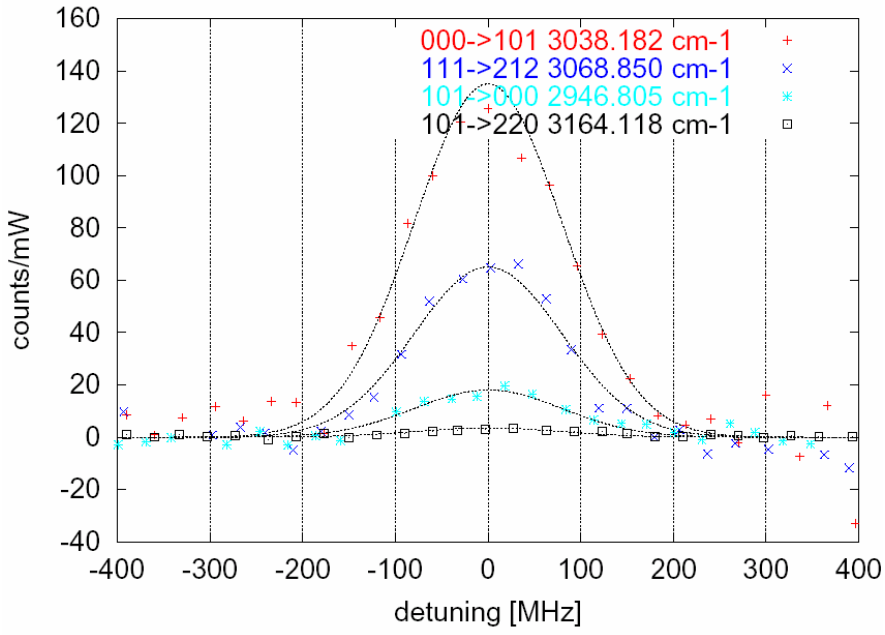


Para – Ortho Conversion in H_2D^+

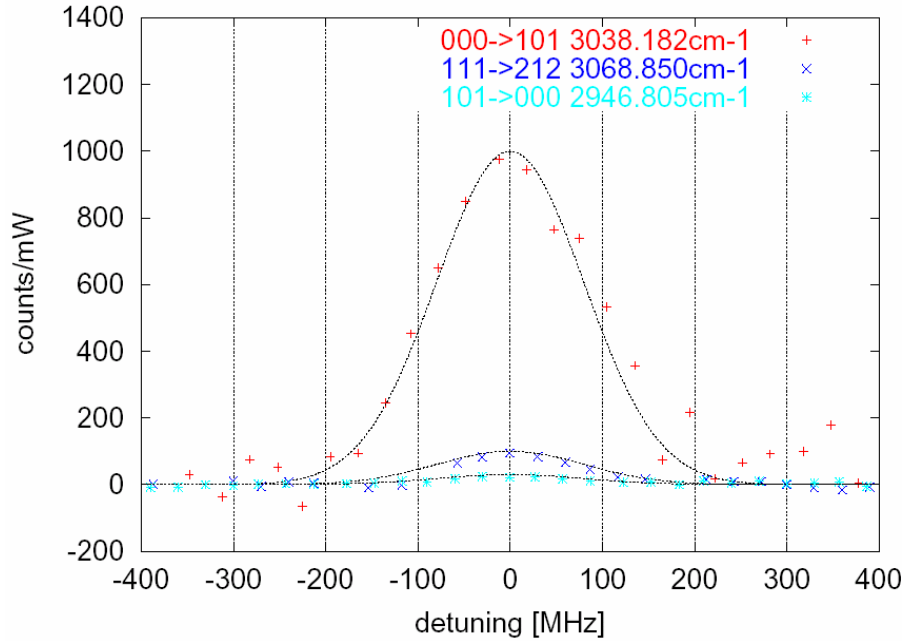


LIR-Experimente mit cw OPO

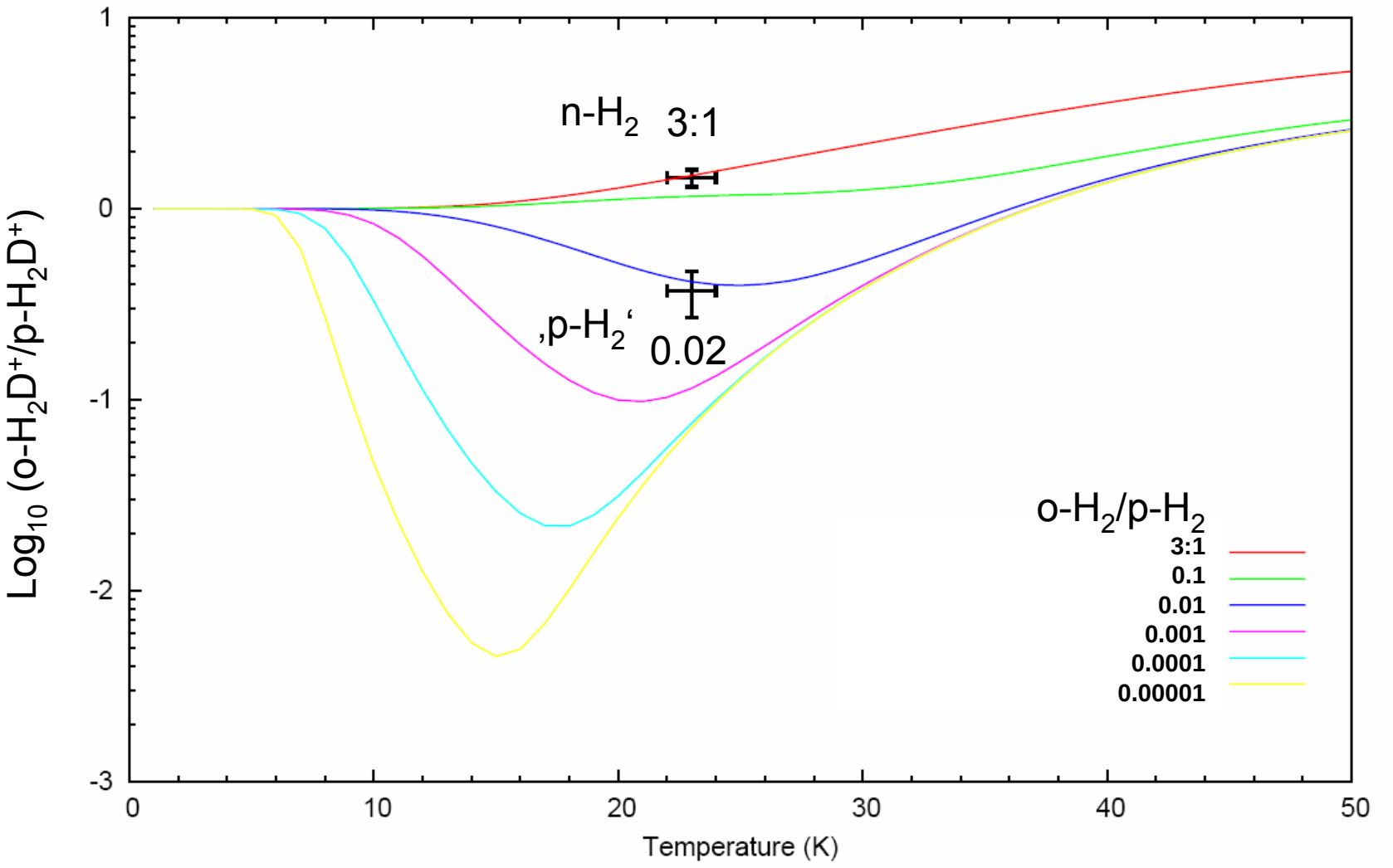
$H_2D^+ + n\text{-}H_2$



$H_2D^+ + p\text{-}H_2$

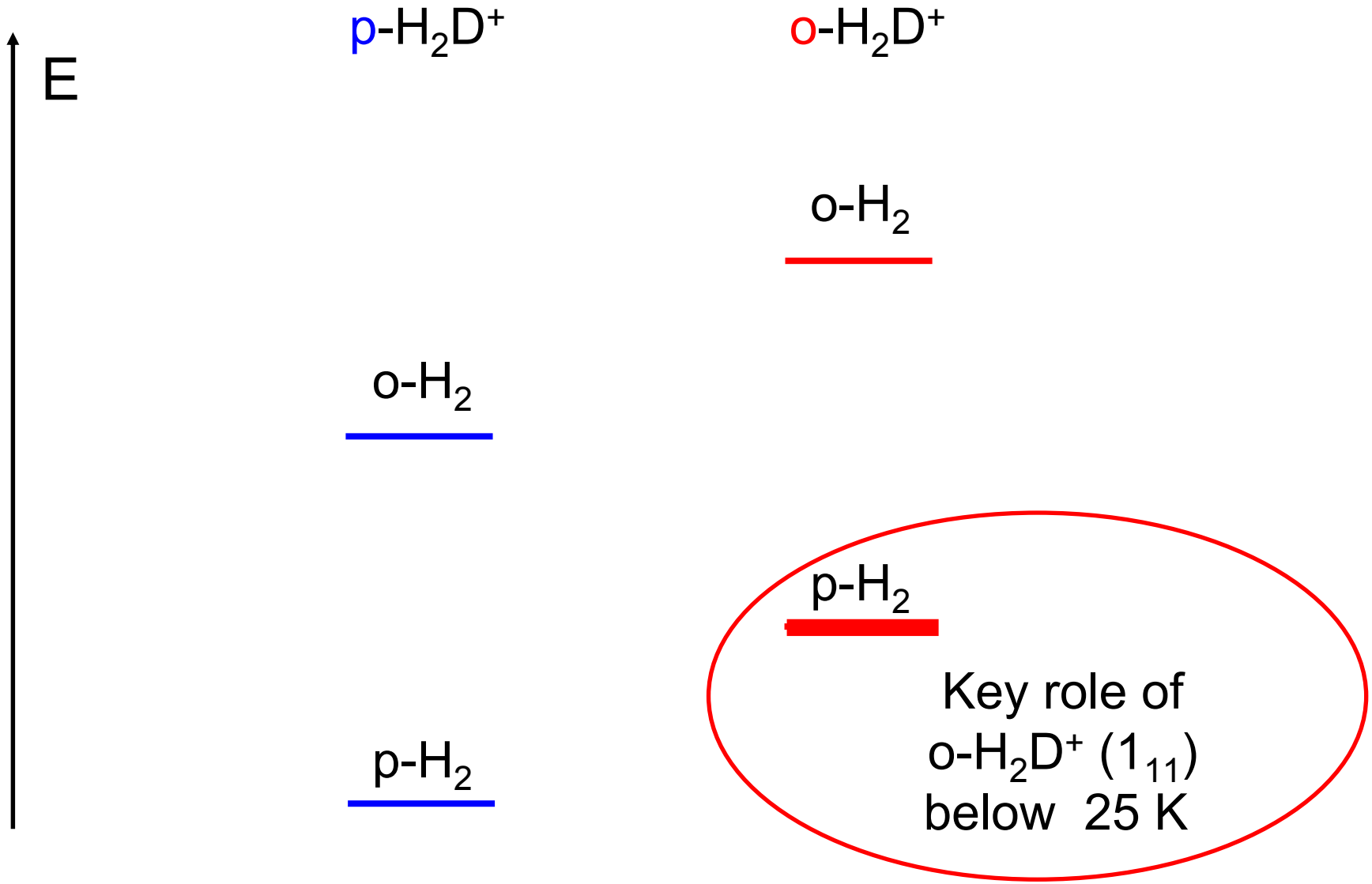


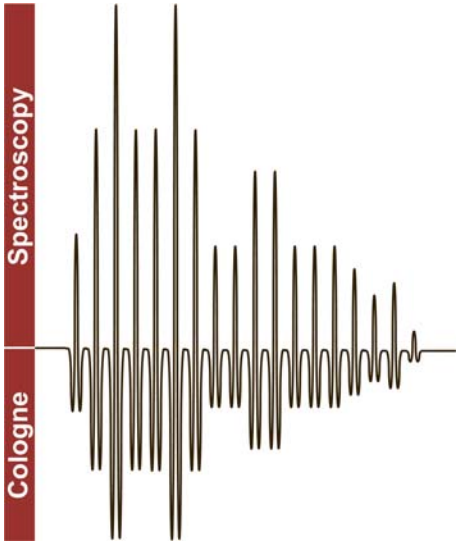
Comparison to simple Statistical Model



Para – Ortho Konversion

scrambling





Physics, Chemistry, and Astronomy of H_3^+

Probing H_2D^+ with FELIX and other Laser Sources

S. Schlemmer

- Acknowledgement

Dieter Gerlich
Oskar Asvany
Edouard Hugo

Britta Redlich / FELIX

Prof. Stefan Schiller
Frank Müller
Andreas Wicht