



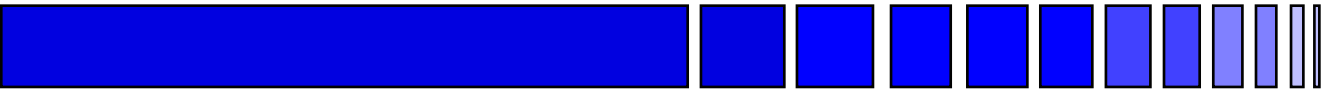
Overtone and Combination Band Spectroscopy of H_3^+

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University of Chicago

Therese R. Huet
Universite de Lille

James K. G. Watson
National Research Council of Canada

About H_3^+

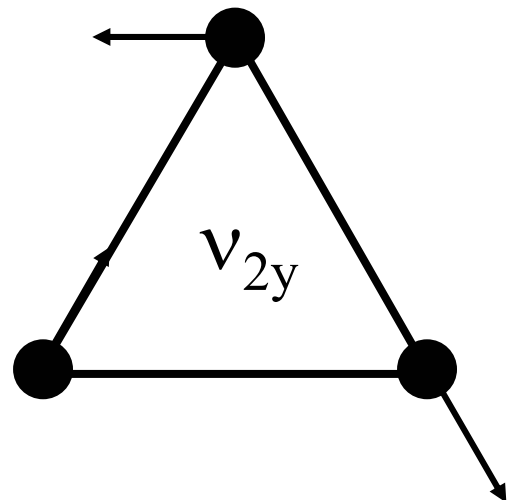
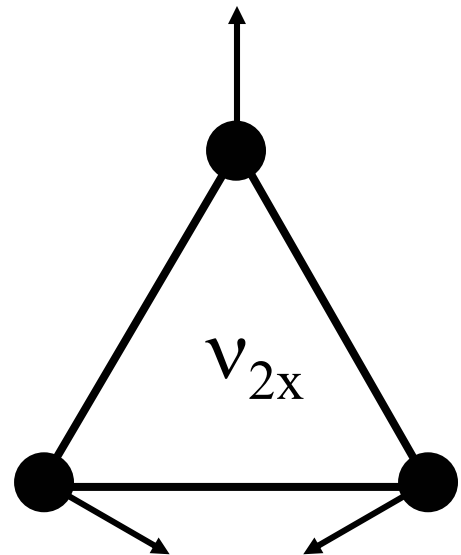
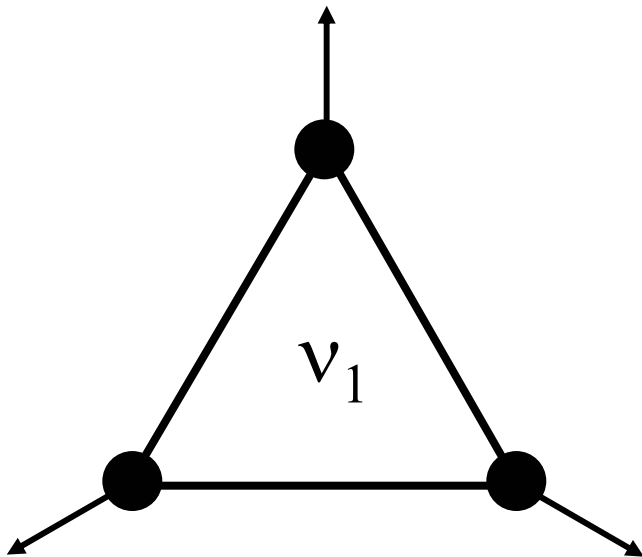


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No electronic spectrum

Equilateral triangle configuration

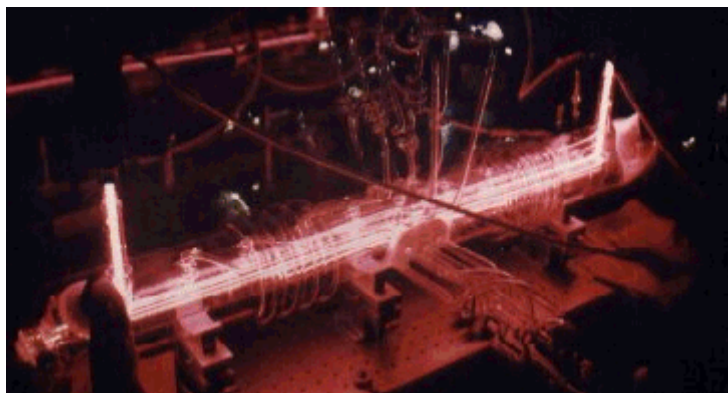
\Rightarrow no allowed rotational spectrum



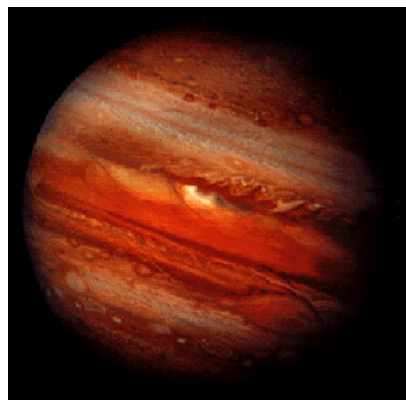
Importance of H_3^+

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- * Dominant ion in H_2 -dominated plasmas



- * ν_2 fundamental seen in emission on Jupiter



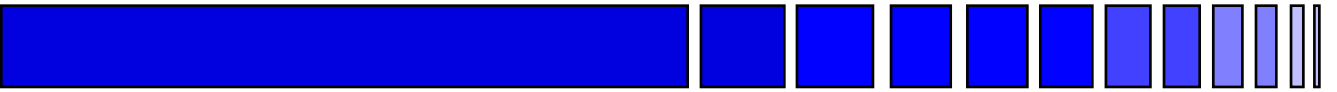
- * ν_2 seen in absorption in interstellar medium



- * As simplest polyatomic molecule, it is a benchmark for *ab initio* theory

Why Study High Energy H_3^+ ?

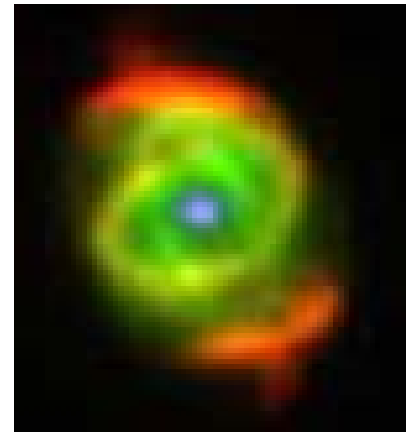
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- * $2\nu_2$ band discovered on Jupiter, higher bands may be observable



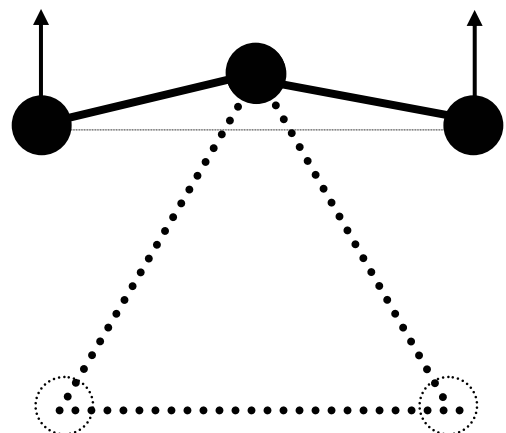
- * Emission from hot astronomical objects (planetary nebulae?)



- * Refinement of theoretical understanding

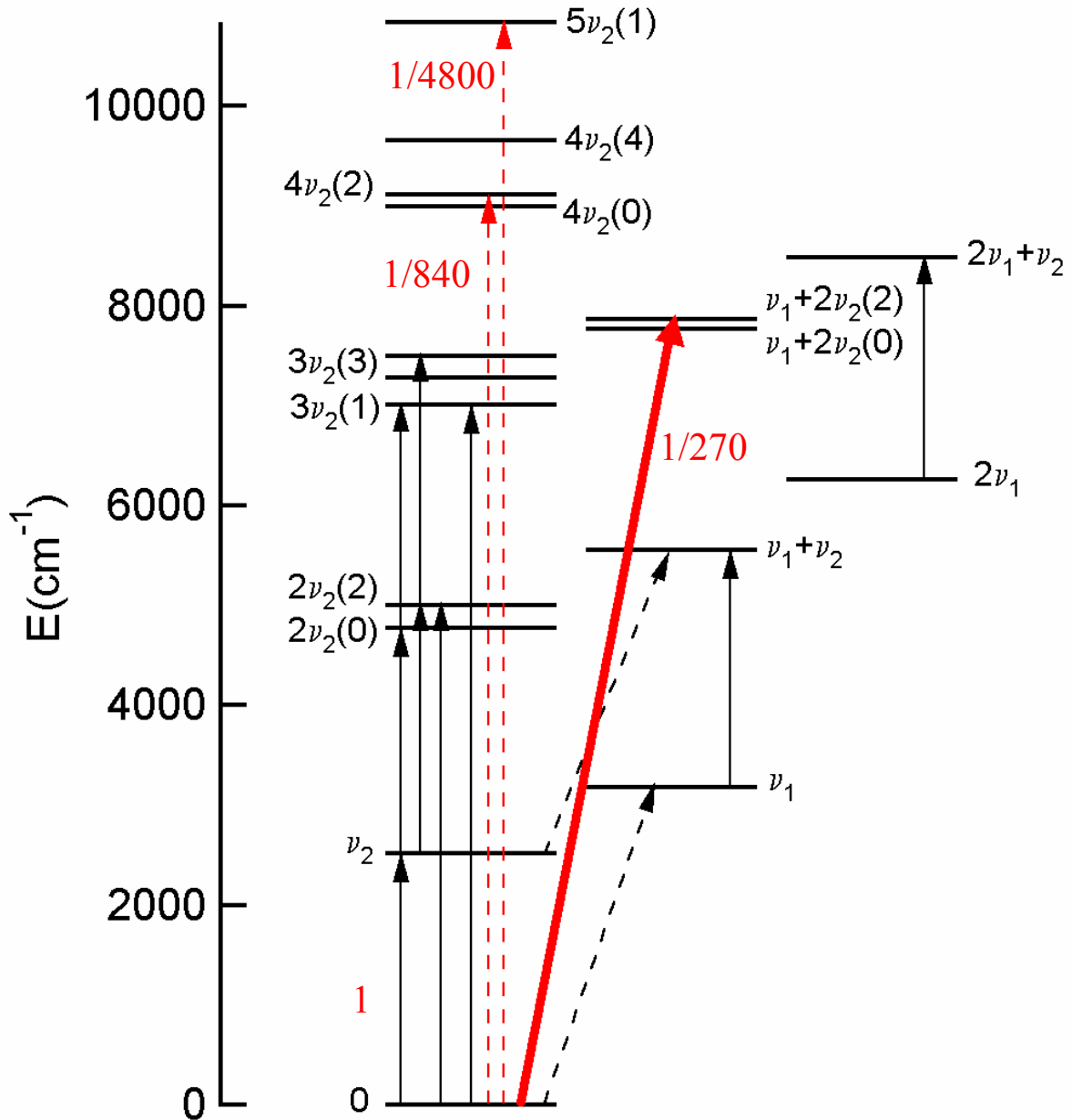
NGC 6543. Balick
AJ 94, 671 (1987)

- * Breaking the barrier to linearity



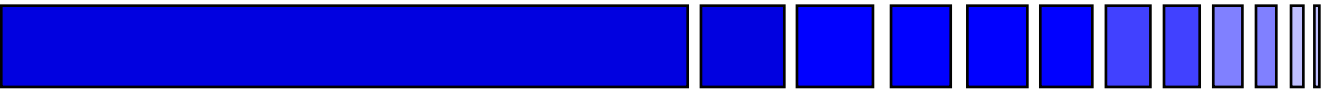
H₃⁺ Vibrational Bands

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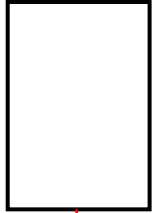


Experimental Technique

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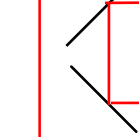
Diode Laser



Spectrum Analyzer



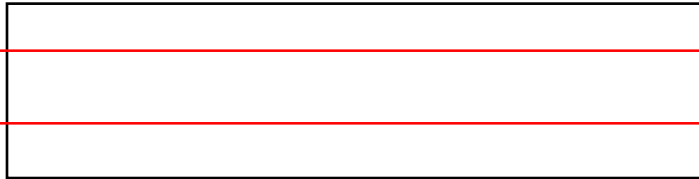
Reference Cell



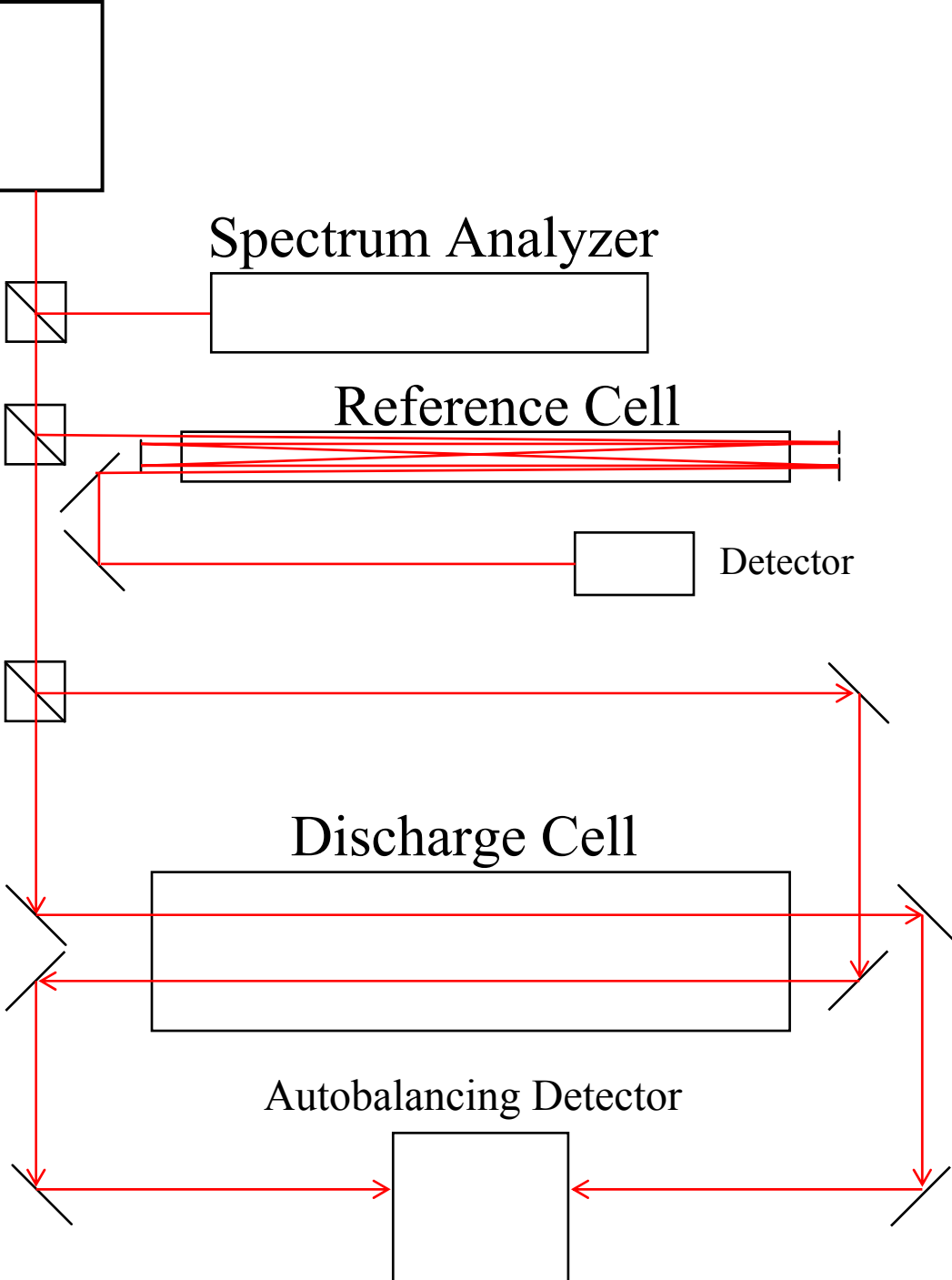
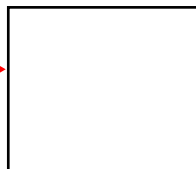
Detector



Discharge Cell

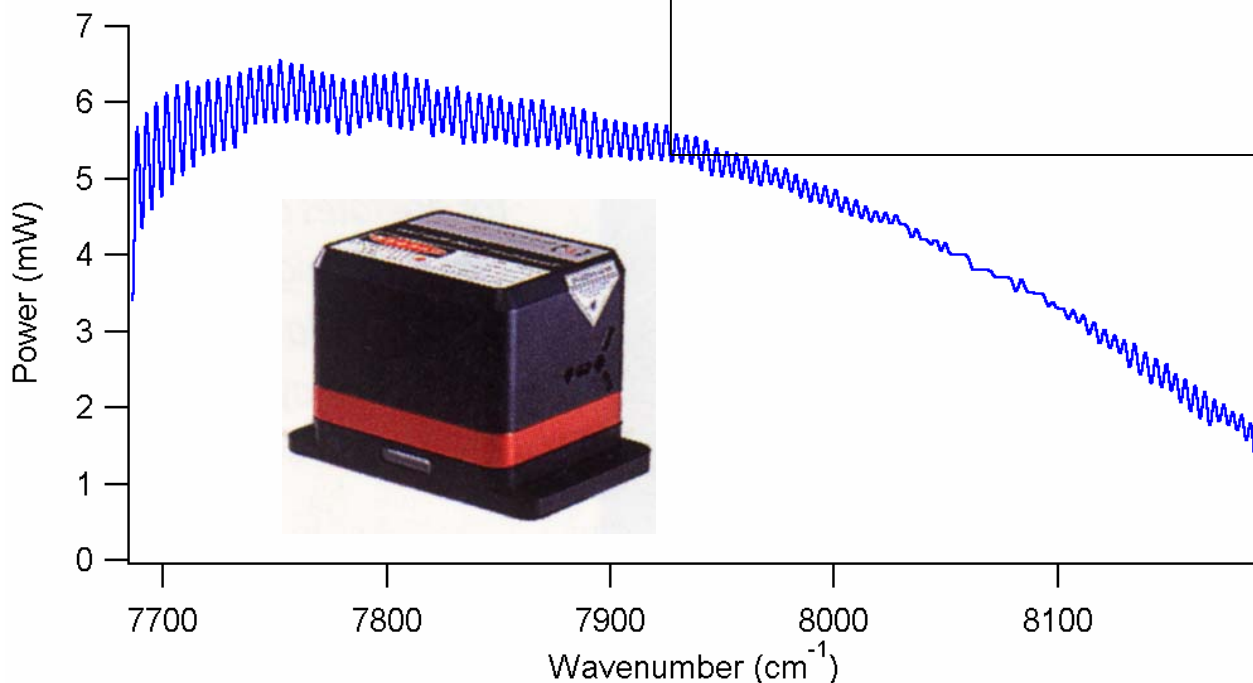
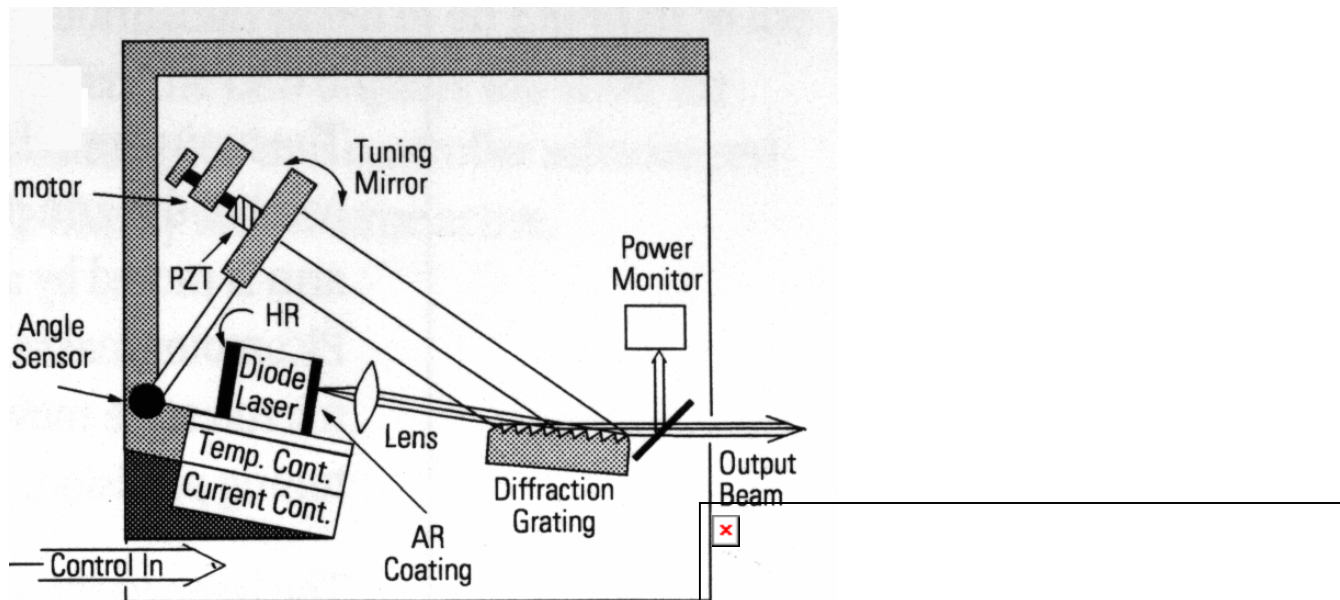


Autobalancing Detector



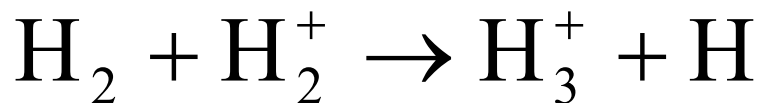
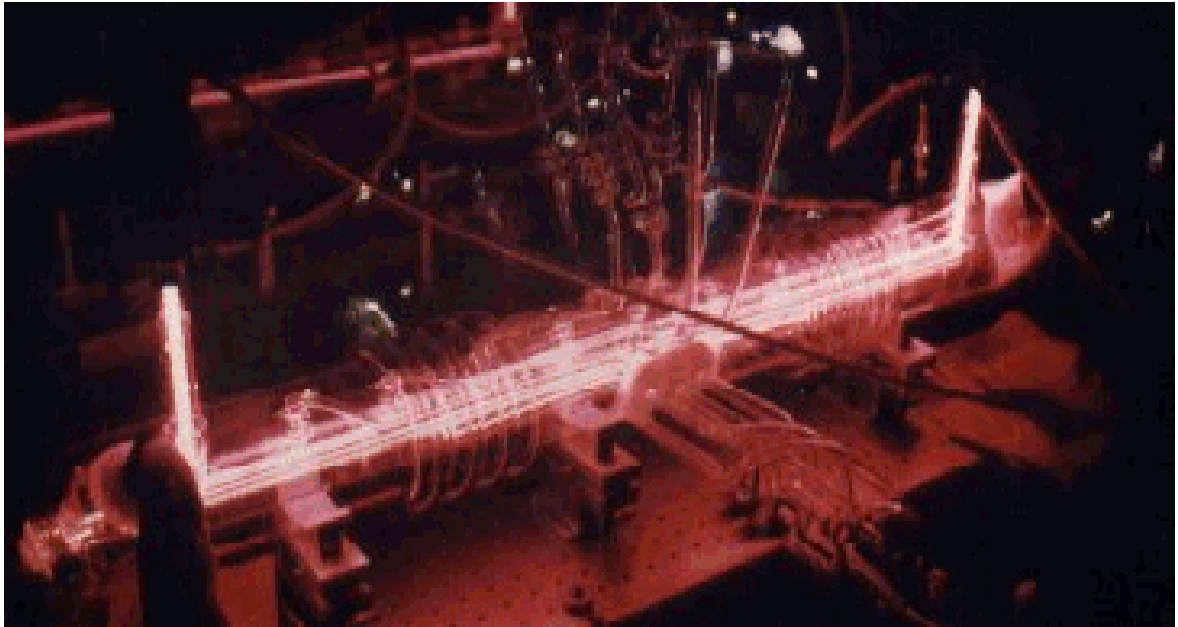
New Focus Diode Laser

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Plasma Conditions

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* $p(\text{H}_2) \sim 0.5$ Torr

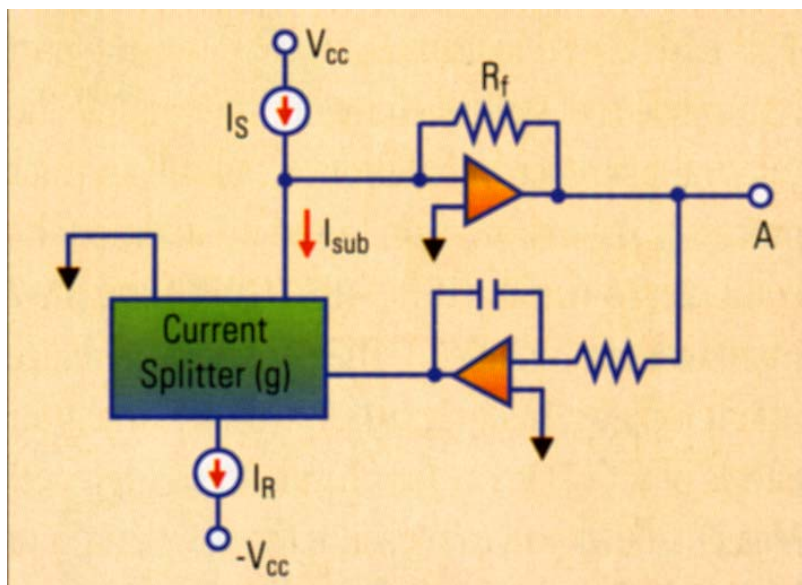
* ~ 5 kV @ 6 kHz, 150 mA

* liquid- N_2 cooling

New Focus “Nirvana” Detector

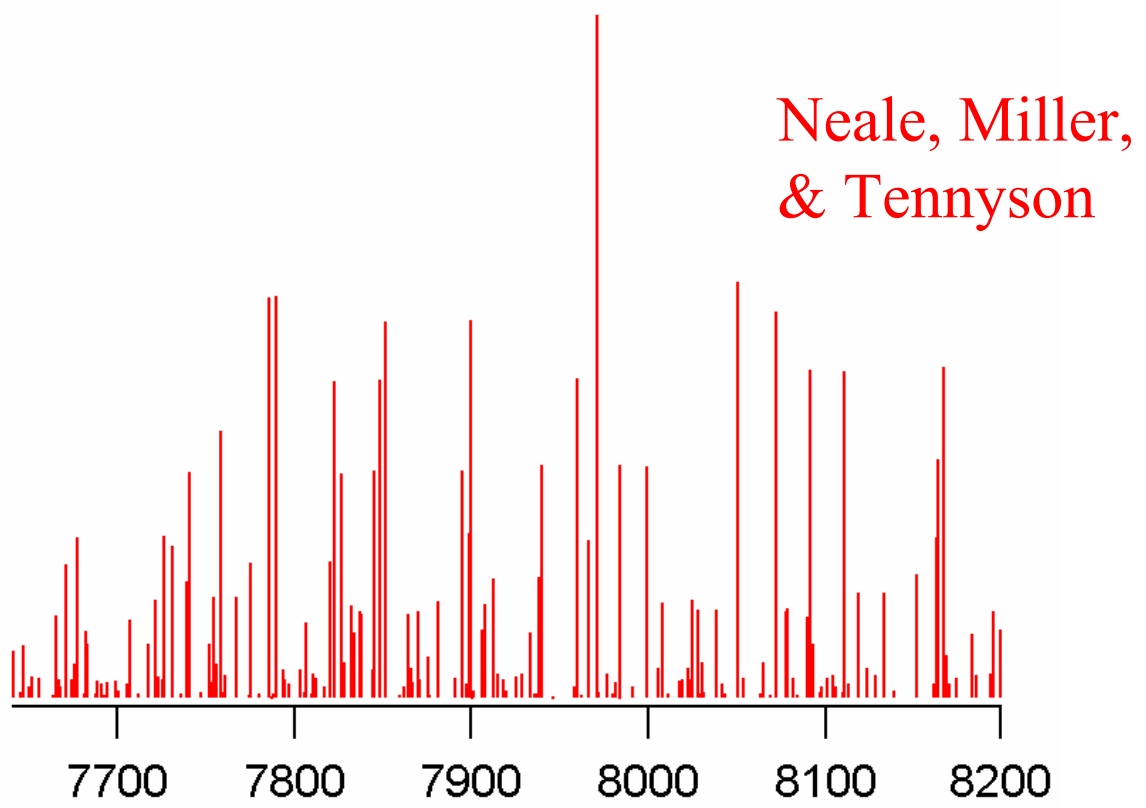
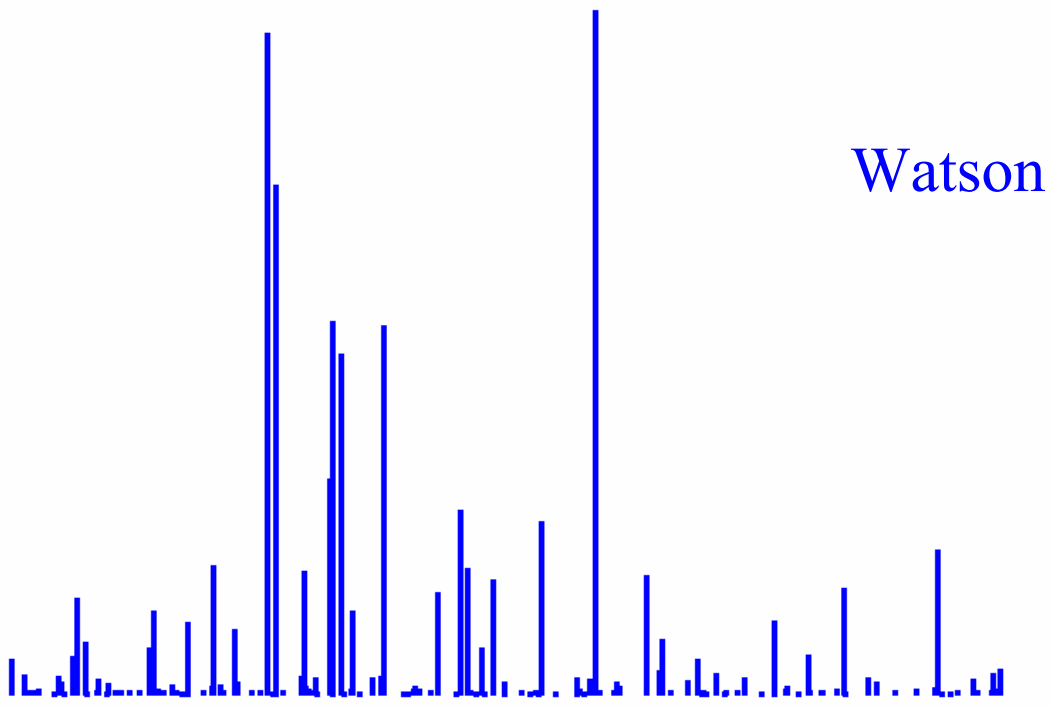
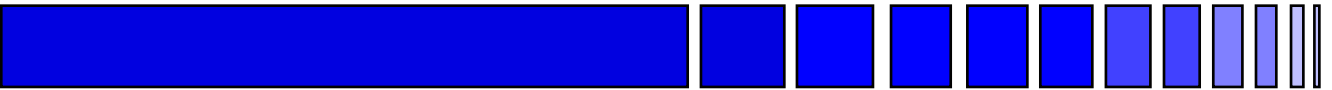
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“Autobalancing” detector outputs $(S - g \cdot R)$,
where the gain ‘g’ is such that $\langle (S - g \cdot R) \rangle = 0$
at a user-selectable bandwidth



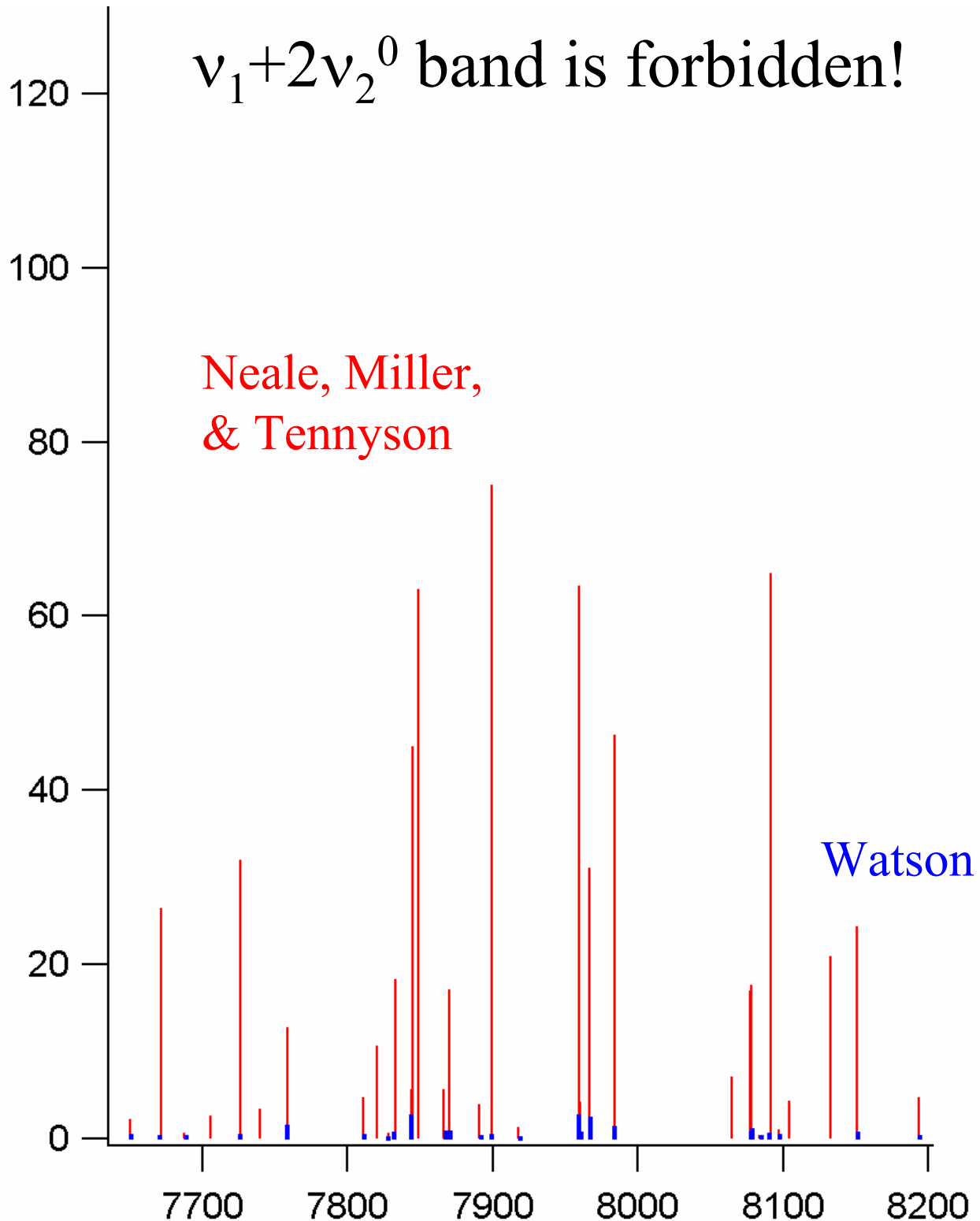
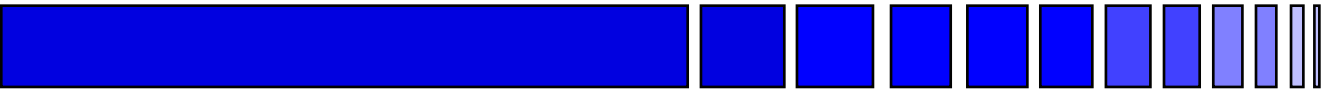
Theoretical Predictions

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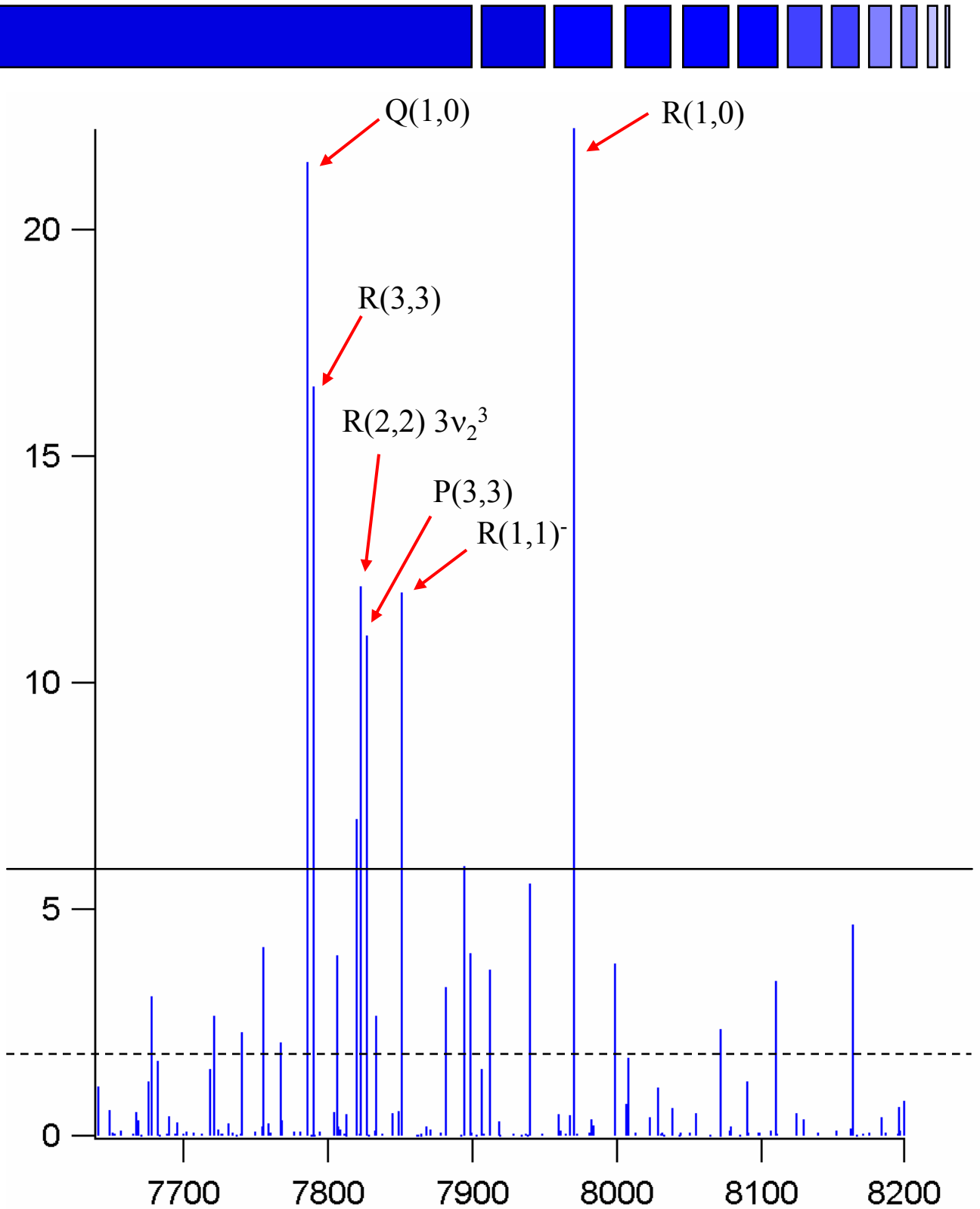
Predictions for $\nu_1+2\nu_2^0$

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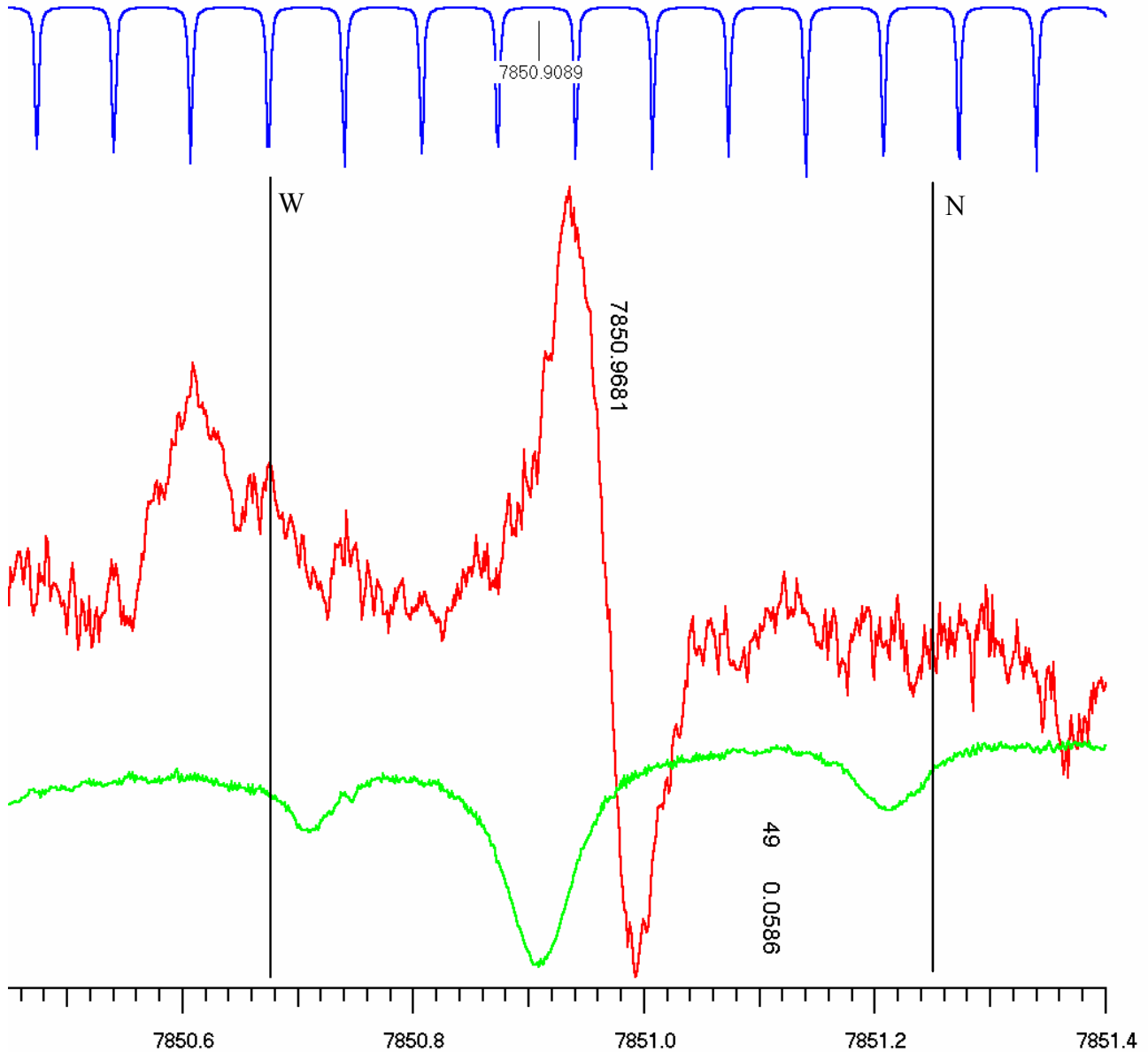
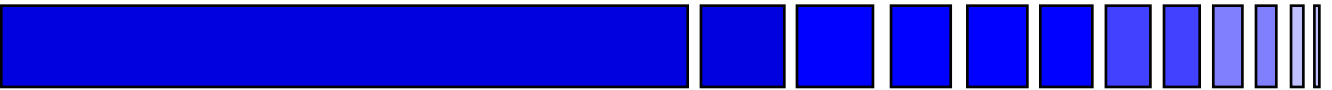
Lines Studied to Date

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Representative Spectrum

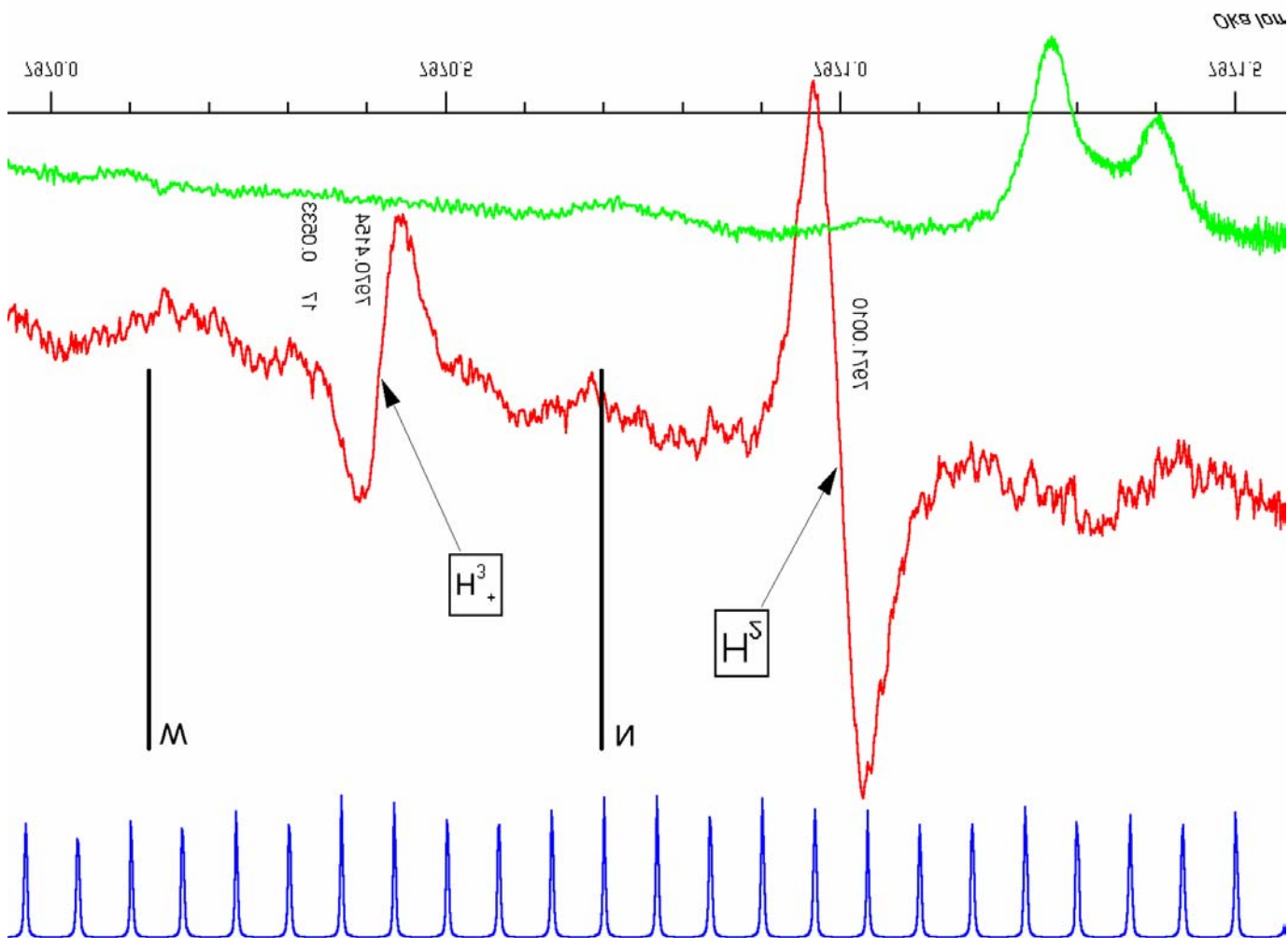
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Oka Ion Factory TM

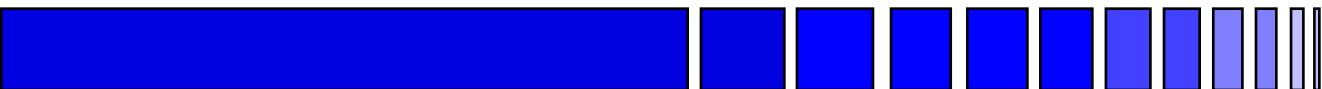
H₂ Rydberg Transitions

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Summary of Detections

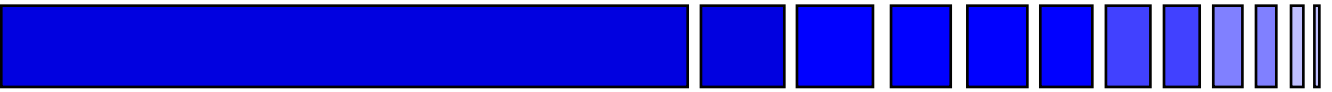
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Observed (cm ⁻¹)	Assignment (J'G'U')←(JK)	Watson [O-W]	Neale [O-N]
7785.76	(1,3,2)←(1,0)	7785.340 [0.420]	7786.009 [-0.249]
7789.88	(4,6,2)←(3,3)	7790.025 [-0.145]	7790.156 [-0.276]
7822.38	(3,2,3)←(2,2) [3v ₂ ³]	7822.250 [0.127]	7822.645 [-0.268]
7826.74	(2,0,2)←(3,3)	7826.679 [0.062]	7827.115 [-0.374]
7850.97	(2,4,2)←(1,1)	7850.677 [0.291]	7851.250 [-0.282]
7970.42	(2,3,2)←(1,0)	7970.124 [0.296]	7970.698 [-0.278]

Future Work

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- * Complete scan of $\nu_1 + 2\nu_2^2$ band
(expect ~ 30 lines)
- * Comparison of observed lines
and theoretical predictions
- * $4\nu_2$ band (Ti::Sapph laser)
- * $5\nu_2$ band? (Ti::Sapph)

$\nu_1 + 2\nu_2^2$ Band Intensities

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