Determination of Hyperfine structure by using Laser

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- Hyperfine structure includes those atomic effects that are produced due to coupling between the electronic and nuclear momenta. It can be considered as the internal effect of the atoms. Usually we cannot switch off this effect but it can be modified. The change in the nuclear structure can be made by using some other isotope of the same element. Also by exciting the atom we can change the nature of the interaction between the electrons and nucleus.

- Before the use of laser as the light source, the effect was studied by observing small perturbations in the structure of the spectral lines. Modern techniques using laser has extended these measurements to unprecedented level of precision.

- Now, hyperfine structure includes all effects that originate with the coupling of nuclear spins and moments with their environment including the atomic electrons. The environment is usually under the control of a researcher, who can modify hyperfine structure, for example by changing an externally applied field.

- Atomic states are labeled using spectroscopic notation where L represents the normal designation S,P,D,... corresponding to L= 0,1, 2, 3,... Na , have ground state

$$3S_{\frac{1}{2}}$$

$E = \mu_s . B$

- spin-orbital interaction causes the fine structure of the electronic levels. The interaction energy between the magnetic field of the motion and spin magnetic moment is

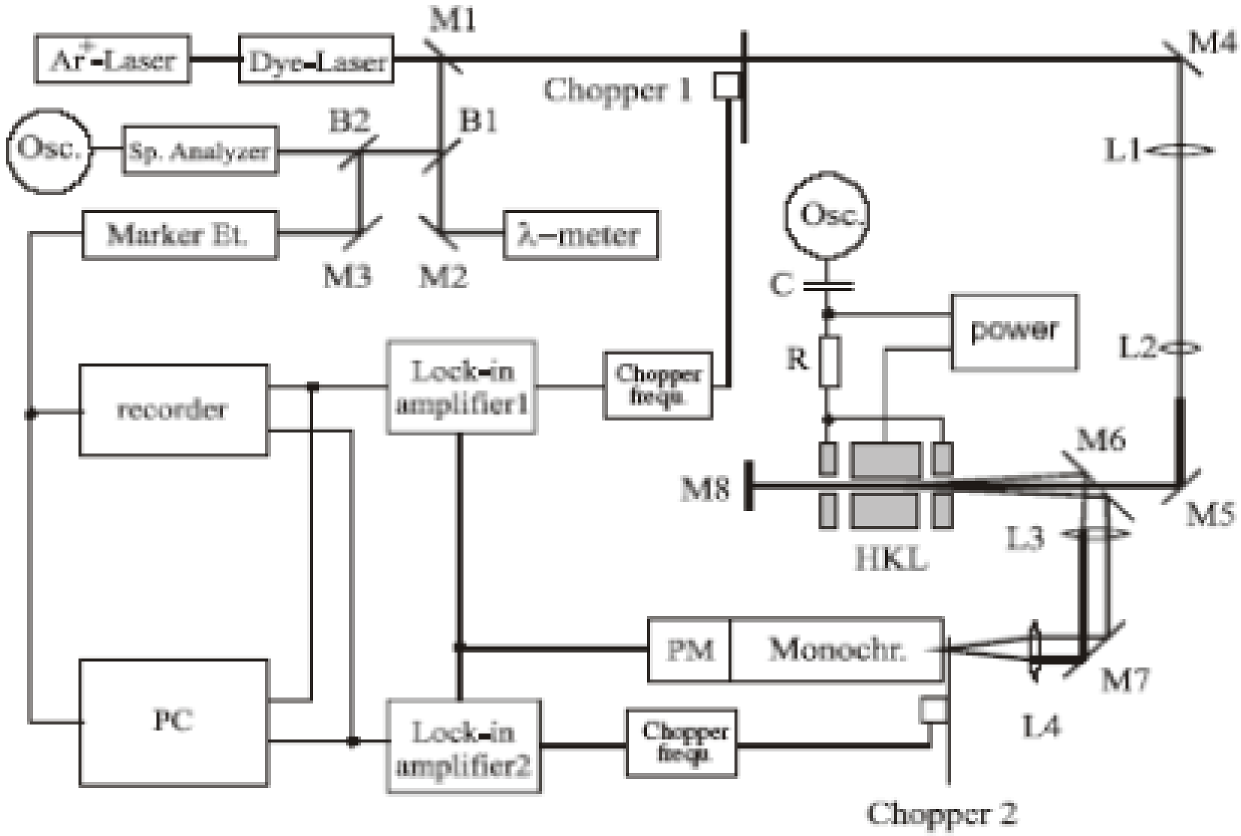
$$E = \mu_s . B$$

$$\langle L.S \rangle = \frac{1}{2}\hbar^2\left[J(J+1) - L(L+1) - S(S+1)\right]$$

$$\mu_J = g_J J_{\mu_B} / \hbar$$

$$\mu_S = g_S S_{\mu_B} / \hbar$$

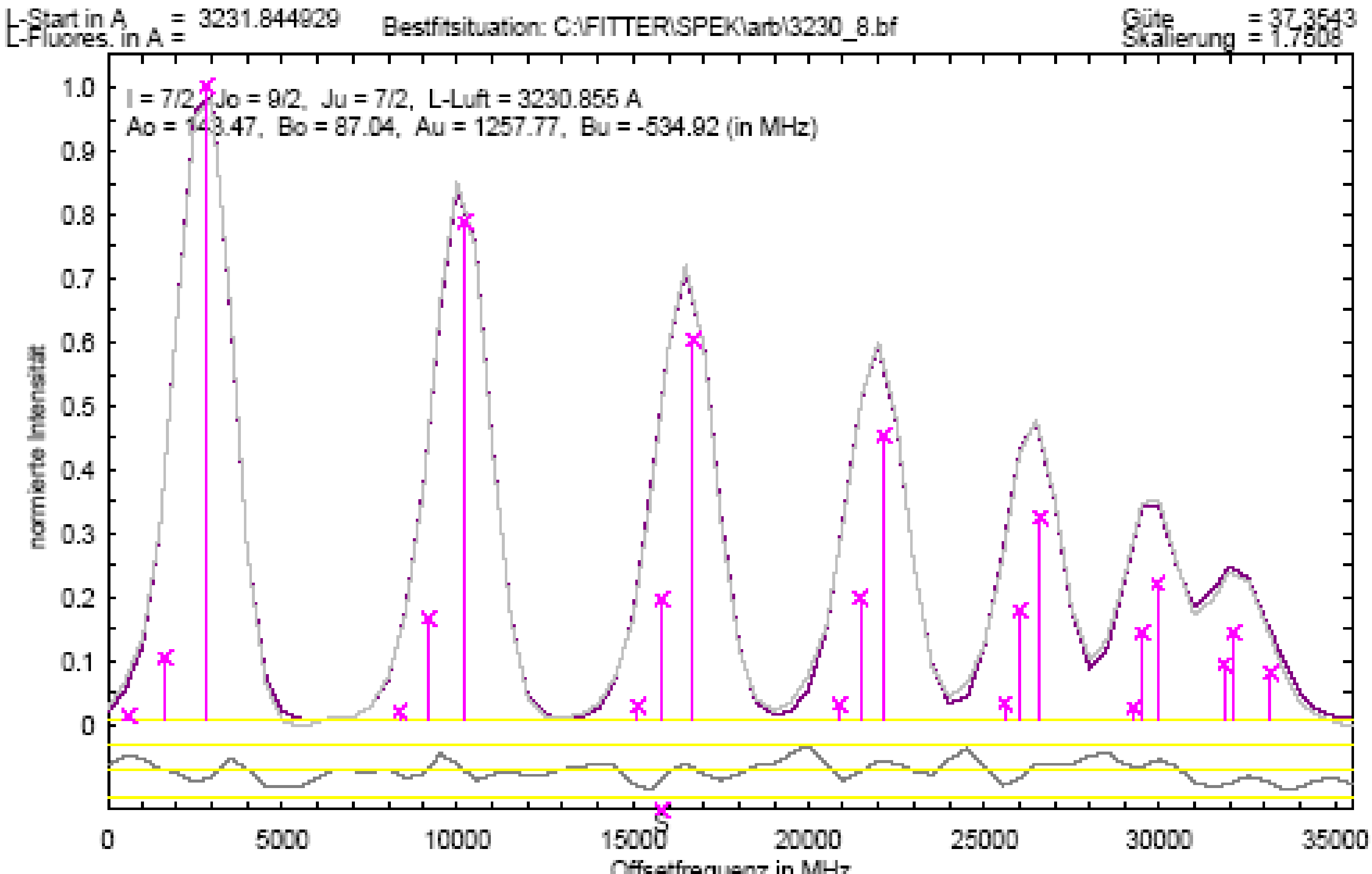
$$g_J = g_L \frac{J(J+1) + L(L+1) - S(S+1)}{2J(J+1)} + g_S \frac{J(J+1) - L(L+1) + S(S+1)}{2J(J+1)}$$



Schematic diagram of experimental setup, where HKL is hollow cathode lamp, M1, M5, M7,M8 are mirrors, M6 is the mirror with hole, L1 to L4 are the lenses, B1 and B2 are beam splitters, Ar+Laser is pump laser, Dye laser is the dye ring laser, Osz. is the oscilloscope, Sp.Analyzer is the spectrum analyzer, E.M.Interfer. is internal marker etalon, λ− meter is the wavelength measuring instrument, R and C are the ohmic and capacitive resistances respectively

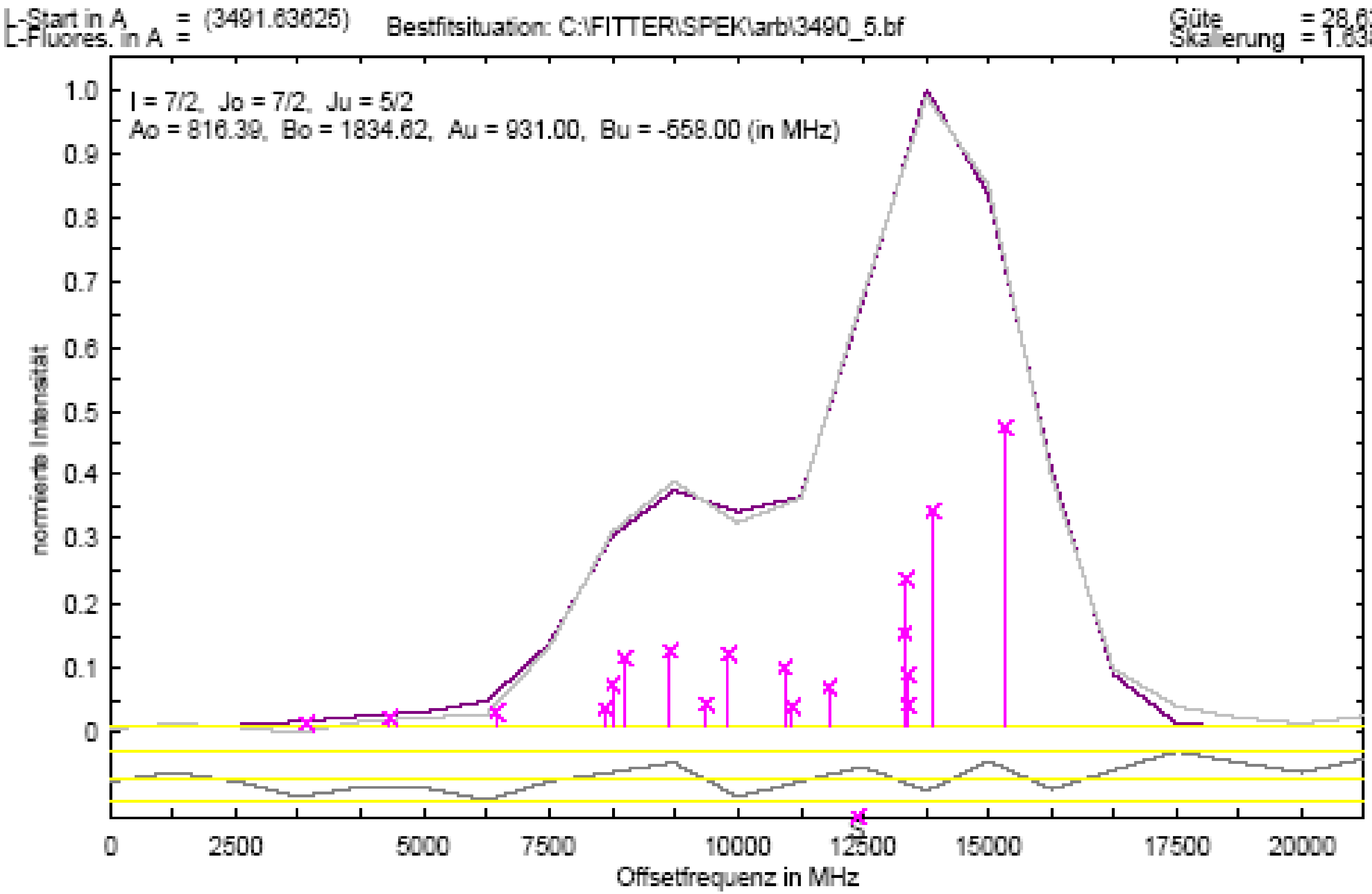
Determination of level 54792.614o5/2

- 3565.291Å was a known but an unclassified line



M

Best fit situation of line 3490.586Å



Simulation

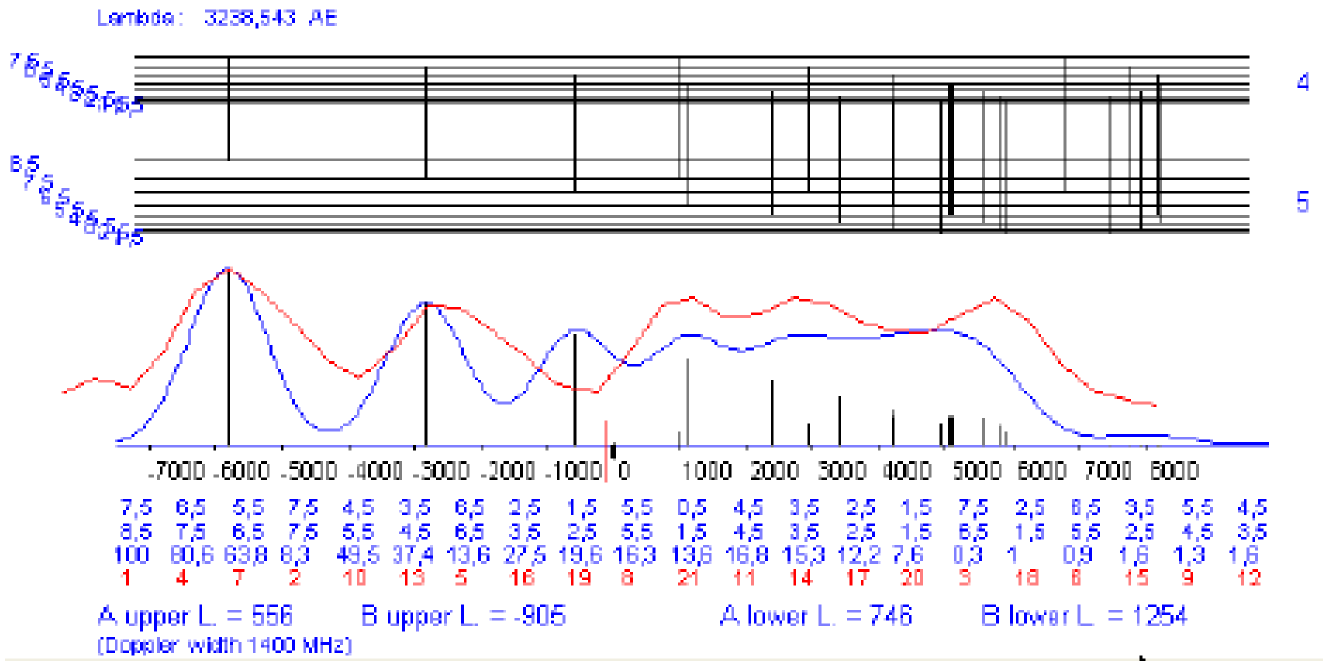


Figure 12: simulation of line 3238.543Å

Some observed lines

λ_F / Å	Even level		Odd level		λ_A/ Å
	Energy/cm^{-1}	J	Energy/cm^{-1}	J	
4066.660	50509.67	4.5	25926.38	4.5	6771.618
4081.481	21623.02	2.5	46116.94	2.5	5936.404
4089.016	49961.52	1.5	25512.66	0.5	4210.783
4094.052	23512.45	2.5	47931.23	3.5	5862.959
4118.064	46958.11	3.5	22681.70	4.5	5675.531
4120.491	24275.96	1.5	48537.97	2.5	6114.299
4123.595	51204.28	3.5	26960.48	3.5	6364.985
4125.650	24917.996	3.5	49149.53	4.5	6589.854
4130.771	50996.52	2.5	26794.81	2.5	4382.064
4137.77	54751.90	2.5	30590.99	3.5	6450.348
4148.716	43275.47	1.5	19178.43	2.5	5628.176
4149.839	22842.85	1.5	46933.36	2.5	4268.48, 4465.59
4150.413	54751.88	1.5	30664.68	1.5	6450.354
4182.364	51683.81	4.5	27780.65	3.5	6716.813
4183.968	47820.71	2.5	23926.72	3.5	6836.647

Thank you