

Laser based investigation of spectroscopic parameters of cesium

By

Sami Ul Haq

*National Institute of Lasers and Optronics
(NILOP), Islamabad*

Studies of the highly excited states

Photoionization cross-section from excited states

Oscillator strength of the Rydberg transitions

Why Cesium:

- Cesium transitions are used in atomic clock
- Cesium transitions are used in MOT
- Theoretical predictions about cross section are available.
- NIST database has only few entries about excited state oscillator strengths.
 - ❖ Difficult to handle.
 - ❖ Lower transitions lie in IR region.
(852.3 nm and 894.6 nm)
 - ❖ Dye laser is extremely difficult in this region.

Experimental Set-up (Schematic)

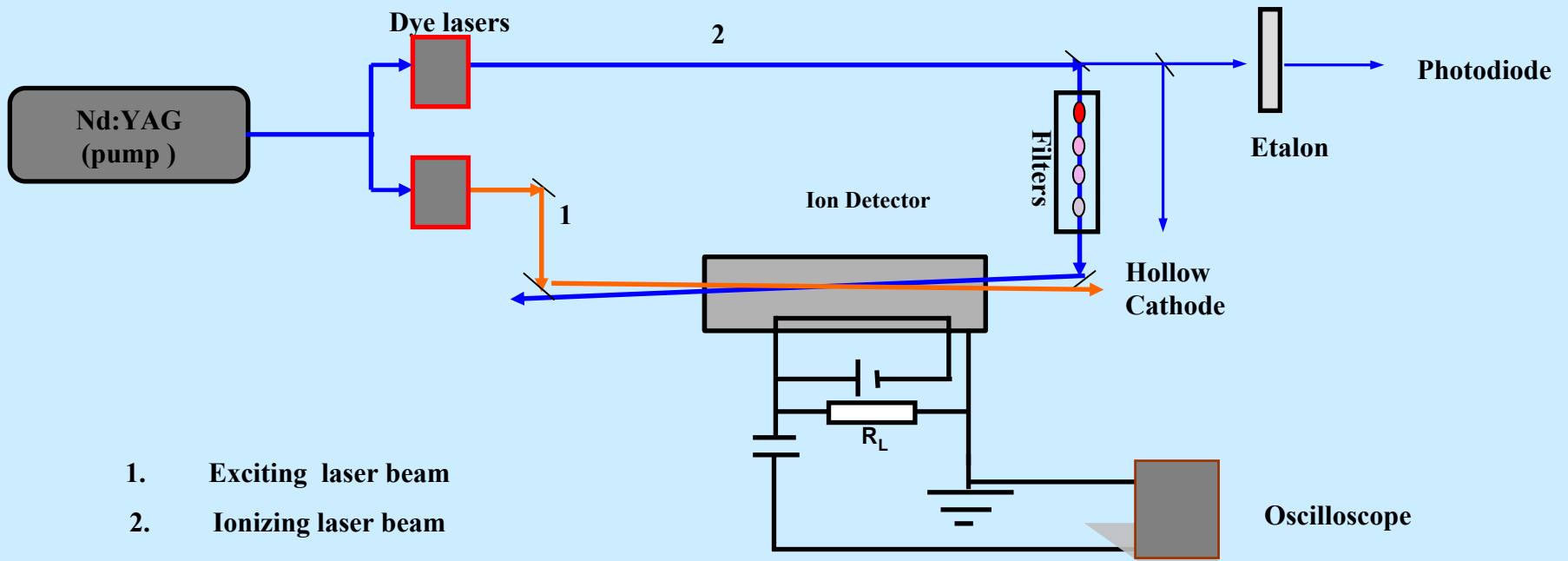
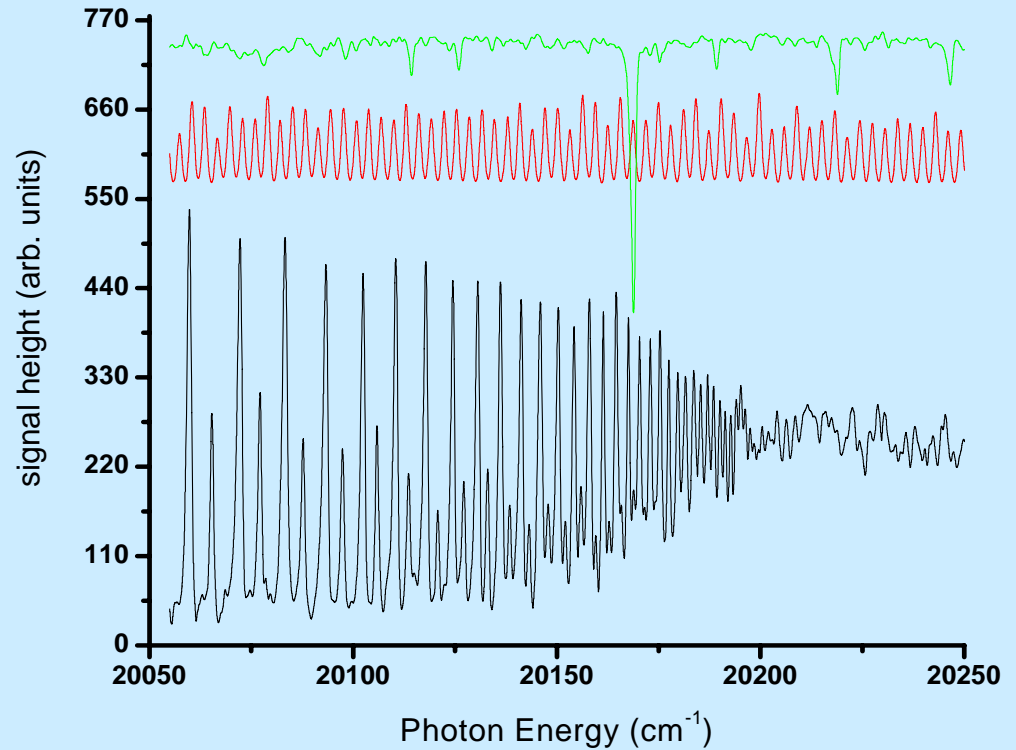
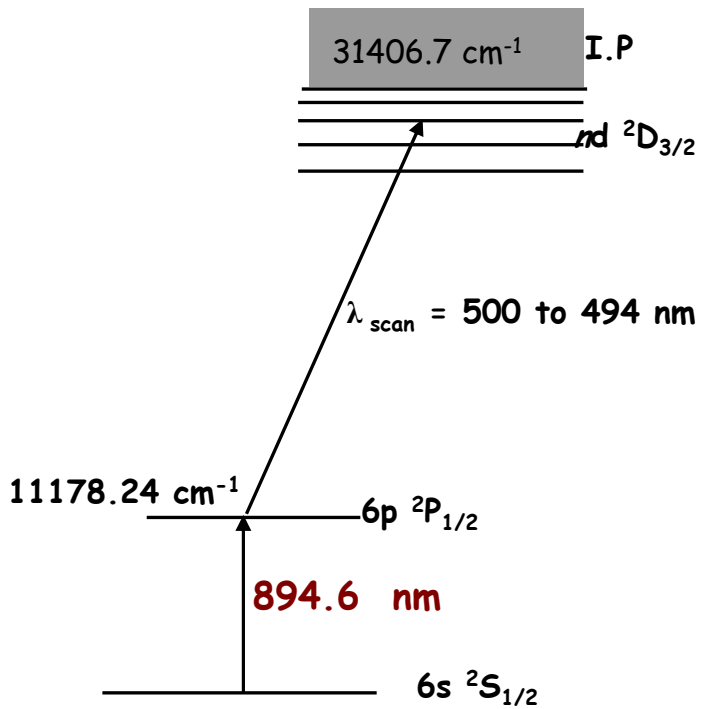
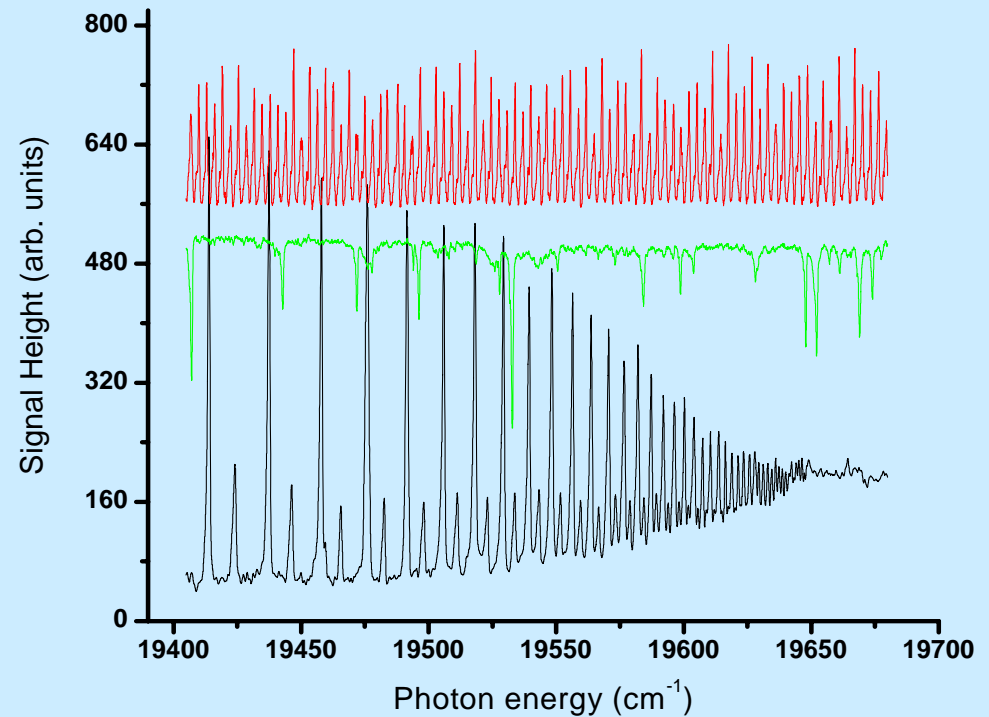
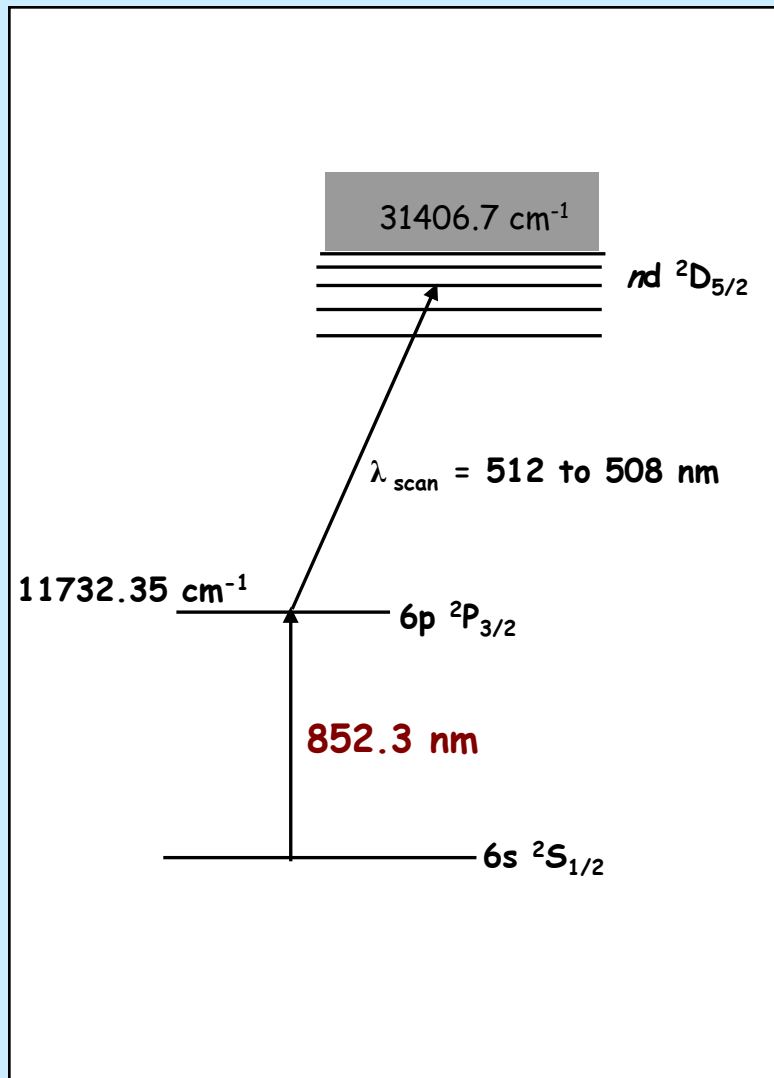


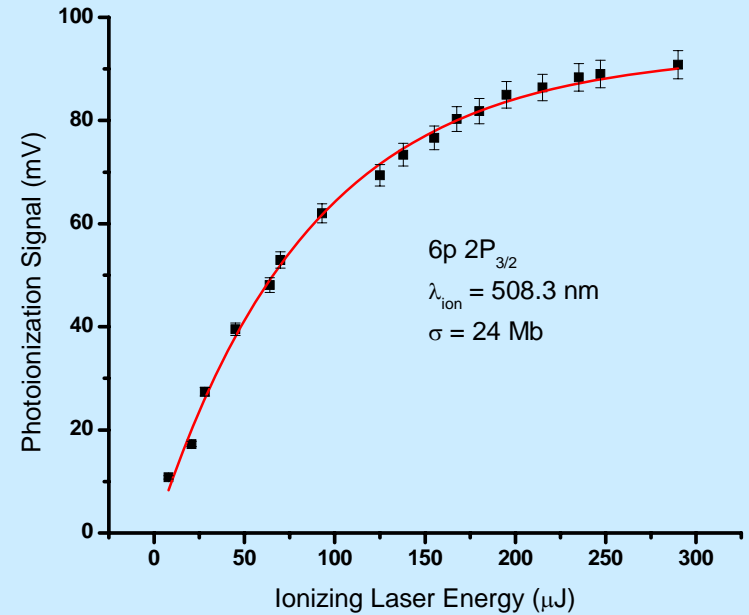
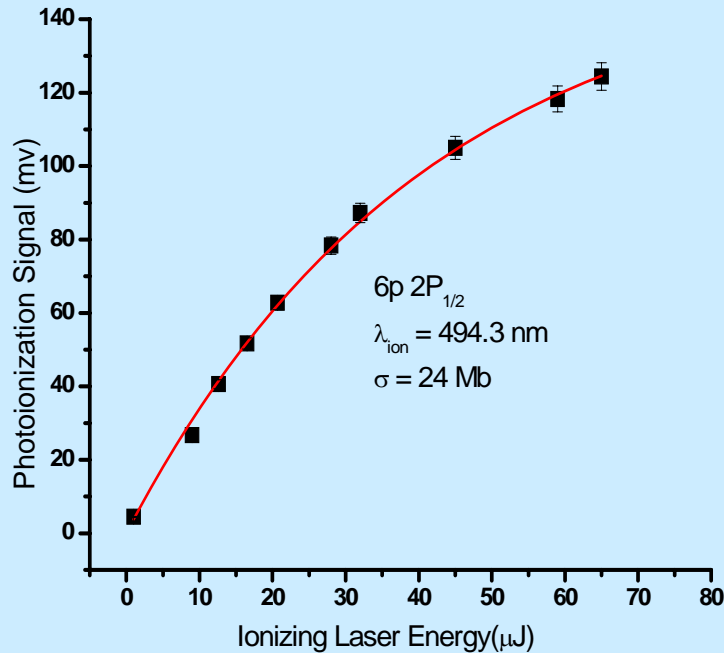
Photo excitation spectra of cesium



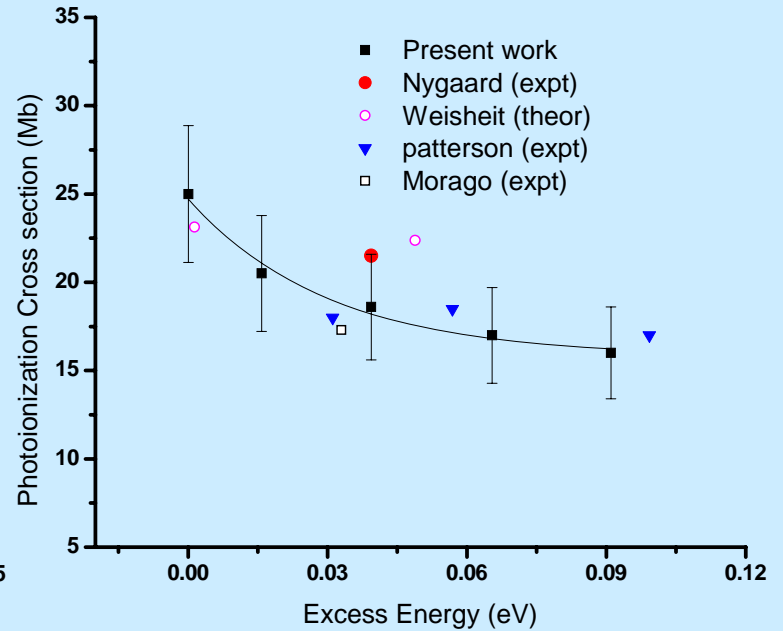
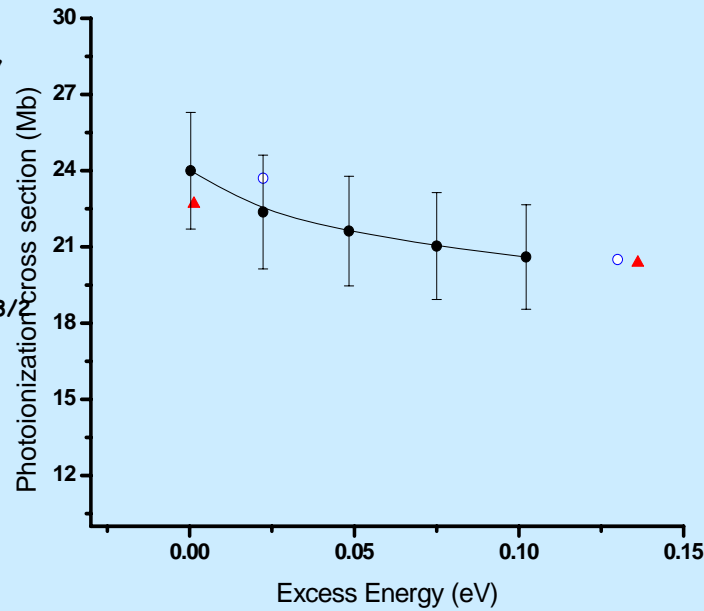
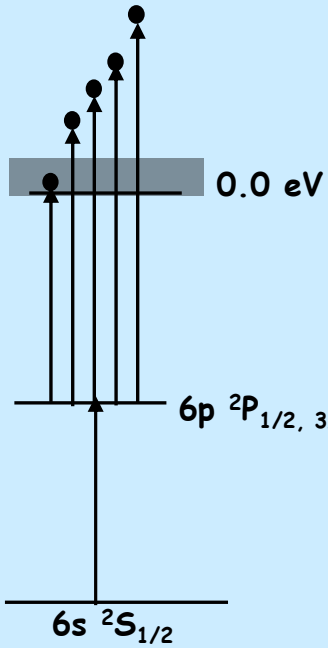
Photoexcitation spectrum of cesium



Threshold photo ionization cross section ($6p\ 2P_{1/2,3/2}$ excited state)



Wave length dependence of Photoionization cross section



$(6p \ ^2P_{1/2, 3/2} \text{ excited state})$

Oscillator Strength of Rydberg transitions

Oscillator strength of a transition is a measure of the strength of the electronic transitions within atomic or molecular systems.

Experimentally, it can be measured using the following relation;

$$f_{ln} = \frac{4\pi\epsilon_0 mc}{\pi e^2} \left(\frac{S^{Ryd}}{S^+} \right) \left(\frac{\nu_{ln}}{\nu^+} \right) \sigma^+(\nu)$$

Here

f_{ln} is the oscillator strength of the Rydberg transition,

S^{Ryd} is the integrated signal intensity,

S^+ is the signal height at the series limit,

ν_{ln} is the wavelength of the transition,

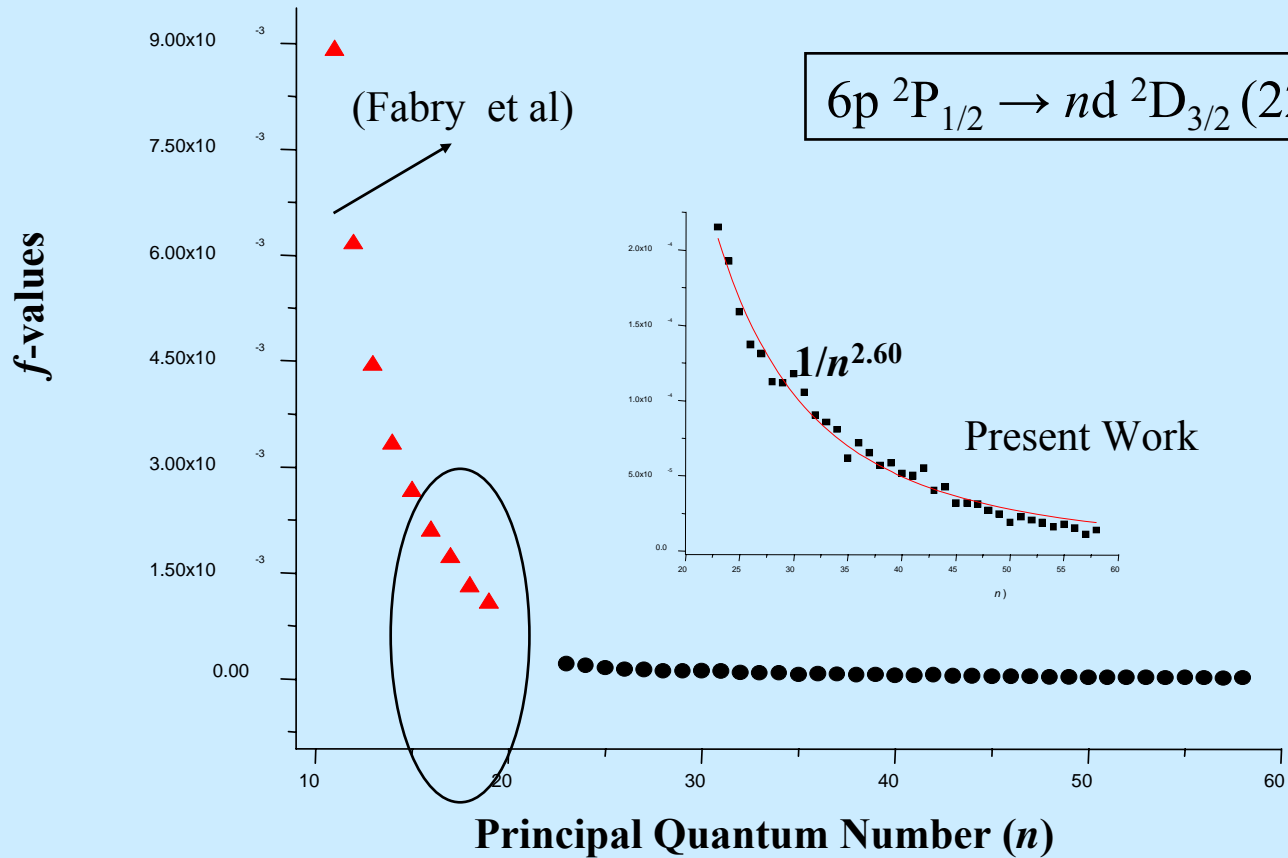
ν_+ is the wavelength of at the series limit and

σ^+ is the absolute cross section for photoionization.

Oscillator Strength of Rydberg transitions

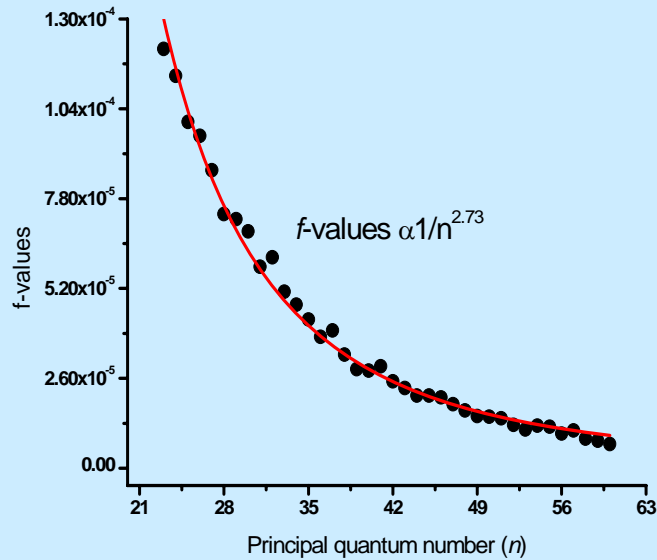
- Photo excitation spectra
- Absolute value of the photoionization cross section at threshold.
- Signal height at threshold
- FWHM and signal height of each transition
- Wavelength of each transition
- Threshold wavelength

Oscillator Strength of the Rydberg transitions



$KT = 0.043 \text{ eV}$

Oscillator Strength of Rydberg transitions



n	f -values		n	Present
	Present	Reported		
5		1.91E-1	33	5.11E-5
6		3.35E-1	34	4.73E-5
7		9.51E-2	35	4.30E-5
8		4.07E-2	36	3.80E-5
9		2.15E-2	37	3.99E-5
10		1.29E-2	38	3.29E-5
11		8.38E-3	39	2.87E-5
12			40	2.82E-5
13			41	2.95E-5
14			42	2.51E-5
15			43	2.32E-5
16			44	2.10E-5
17			45	2.10E-5
18			46	2.05E-5
19			47	1.85E-5
20			48	1.67E-5
21			49	1.51E-5
22			50	1.49E-5
23	1.21E-4		51	1.44E-5
24	1.14E-4		52	1.26E-5
25	1.00E-4		53	1.12E-5
26	9.62E-5		54	1.23E-5
27	8.62E-5		55	1.20E-5
28	7.36E-5		56	1.00E-5
29	7.21E-5		57	1.10E-5
30	6.85E-5		58	8.58E-6
31	5.83E-5		59	7.97E-6
32	6.10E-5		60	7.03E-6

Conclusion

- New energy levels have been acquired and extended the $nd\ ^2D_{3/2,5/2}$ up to $n = 65$.
- Photoionization cross-sections from the $6p\ ^2P_{1/2}$ state is higher than the $6p\ ^2P_{3/2}$ state of cesium.
- Smooth falling trend has been observed in the above threshold region, revealing that Cooper minima does not exist in near threshold region.
- The oscillator strength distribution for the $6p\ ^2P_{1/2} \rightarrow nd\ ^2D_{3/2}$ transitions is higher than the $6p\ ^2P_{1/2} \rightarrow nd\ ^2D_{5/2}$ transitions.

THANK YOU