



Fun with one: story of a spectral line

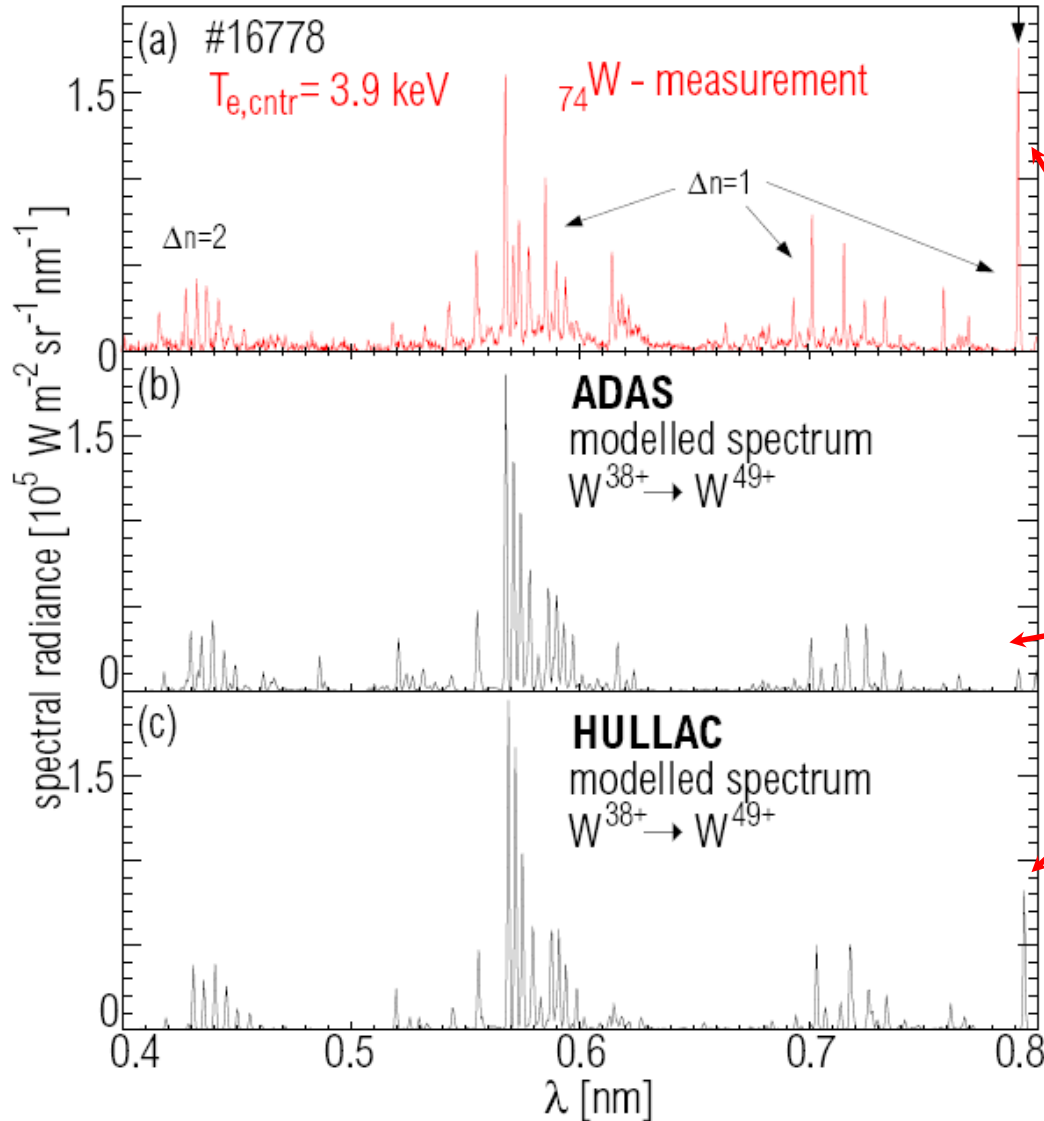
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W spectra from ASDEX Upgrade tokamak (4 keV)

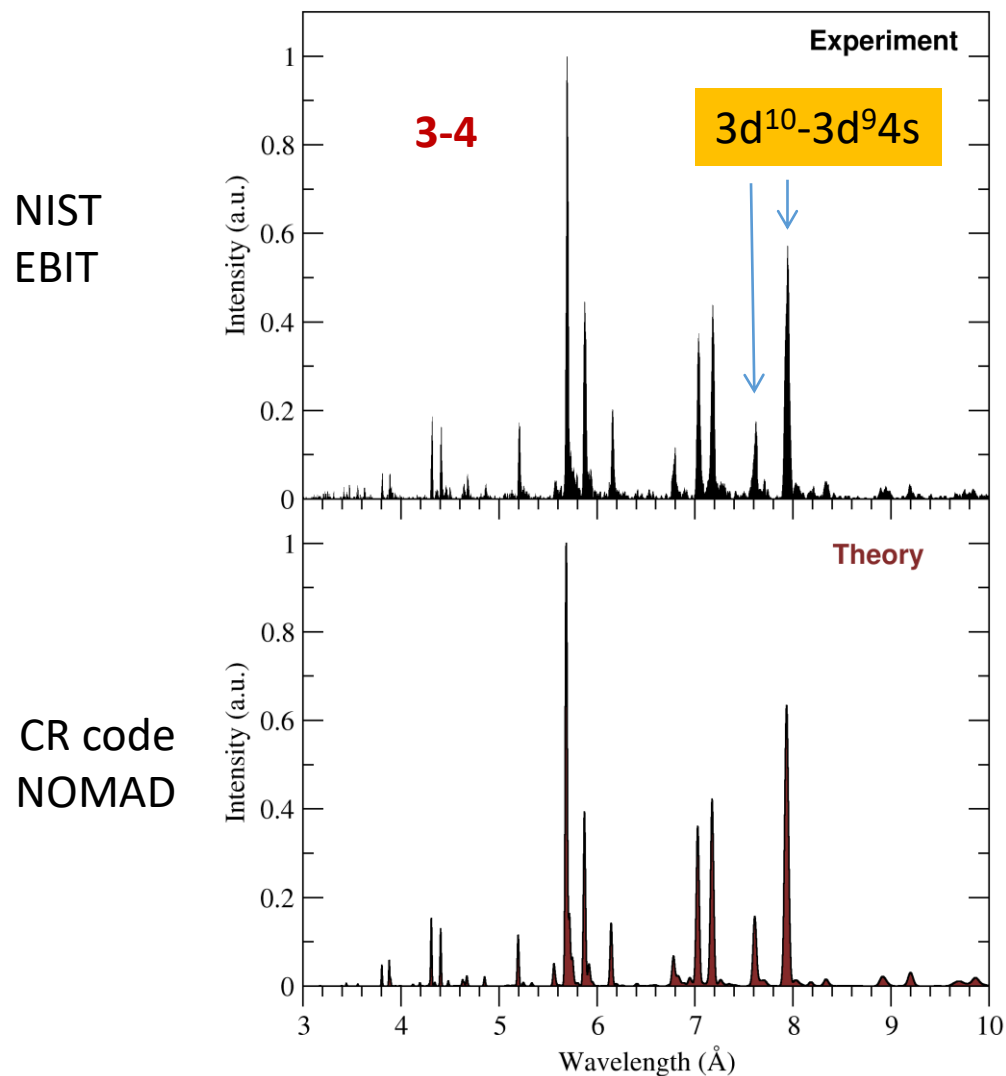


T. Pütterich,
 Ph.D. thesis (2005);
 R. Neu et al,
 Nuclear Fusion
45, 209 (2005)

7.93 Å in W^{46+}
 $3d^{10}-3d^94s$

E2 line?

EBIT X-ray measurements ($E_b \approx 4$ keV)



Mainly Ni-like W^{46+} :

$3d^{10}-3d^9 4s$

$3d^{10}-3d^9 4p$

$3d^{10}-3d^9 4d$

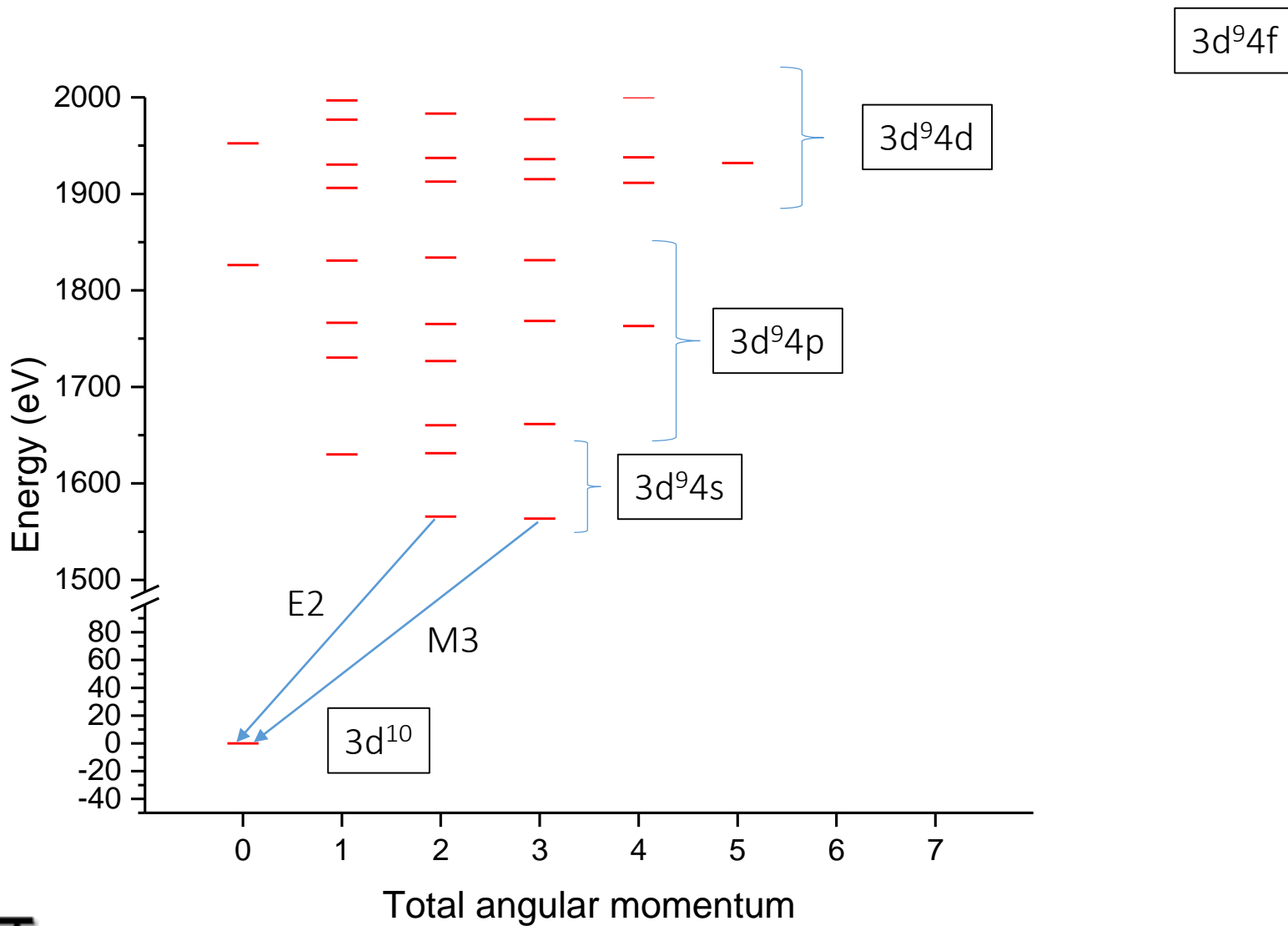
$3d^{10}-3d^9 4f$

$3d^{10}-3d^9 5f$

$3d^{10}-3d^9 6f$

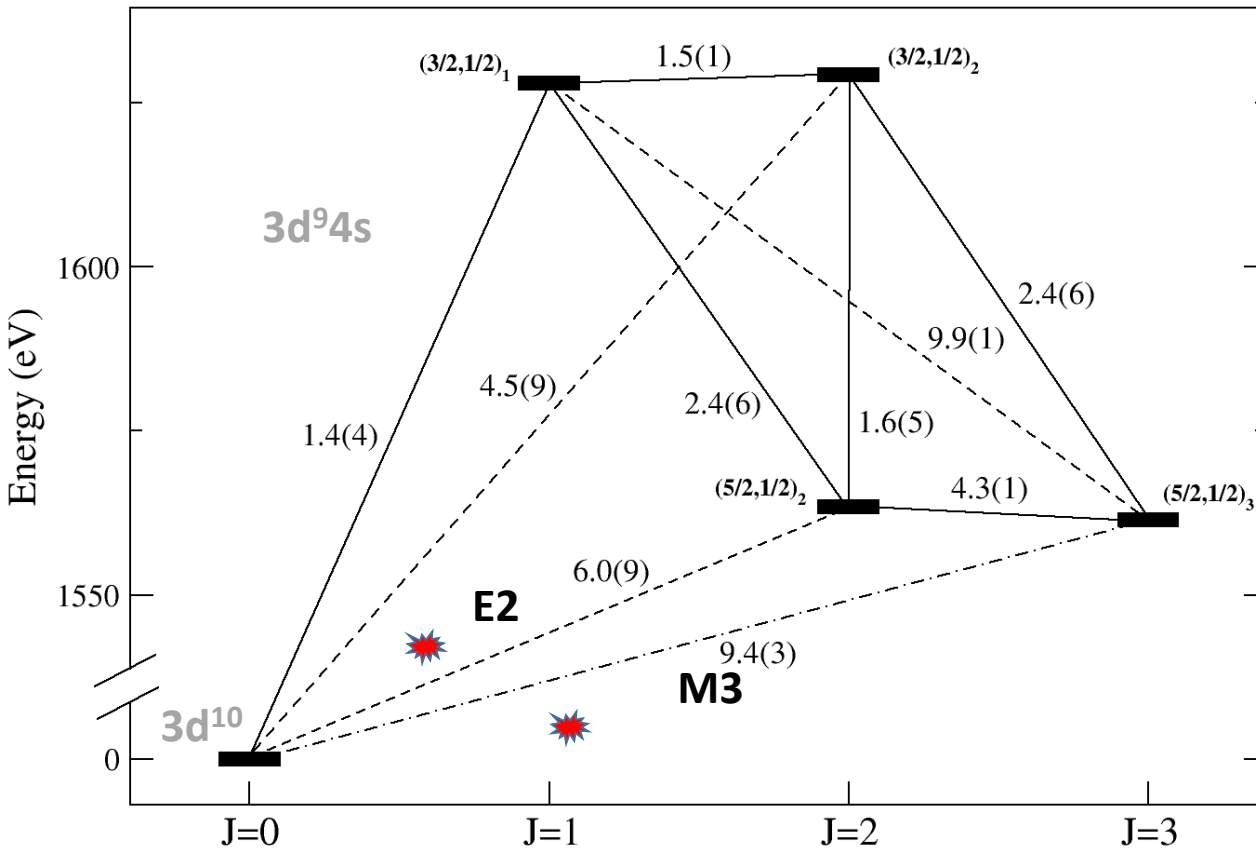
Phys. Rev. A **74**, 042514 (2006)

$3d^9 4l$ configuration in W^{46+}

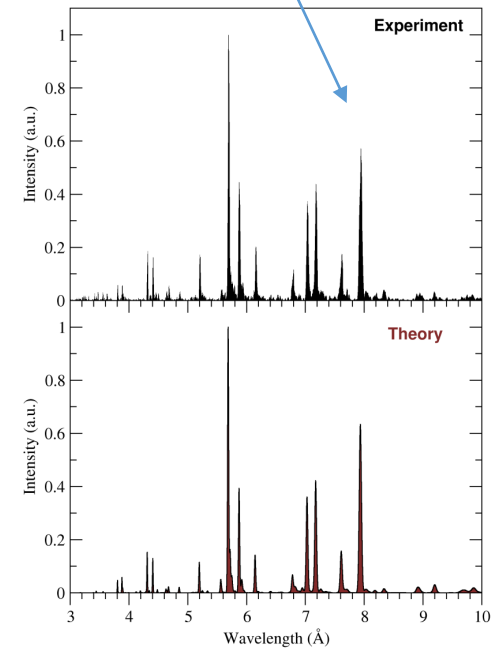


3d⁹4s configuration

Can M3 survive in fusion plasmas?..

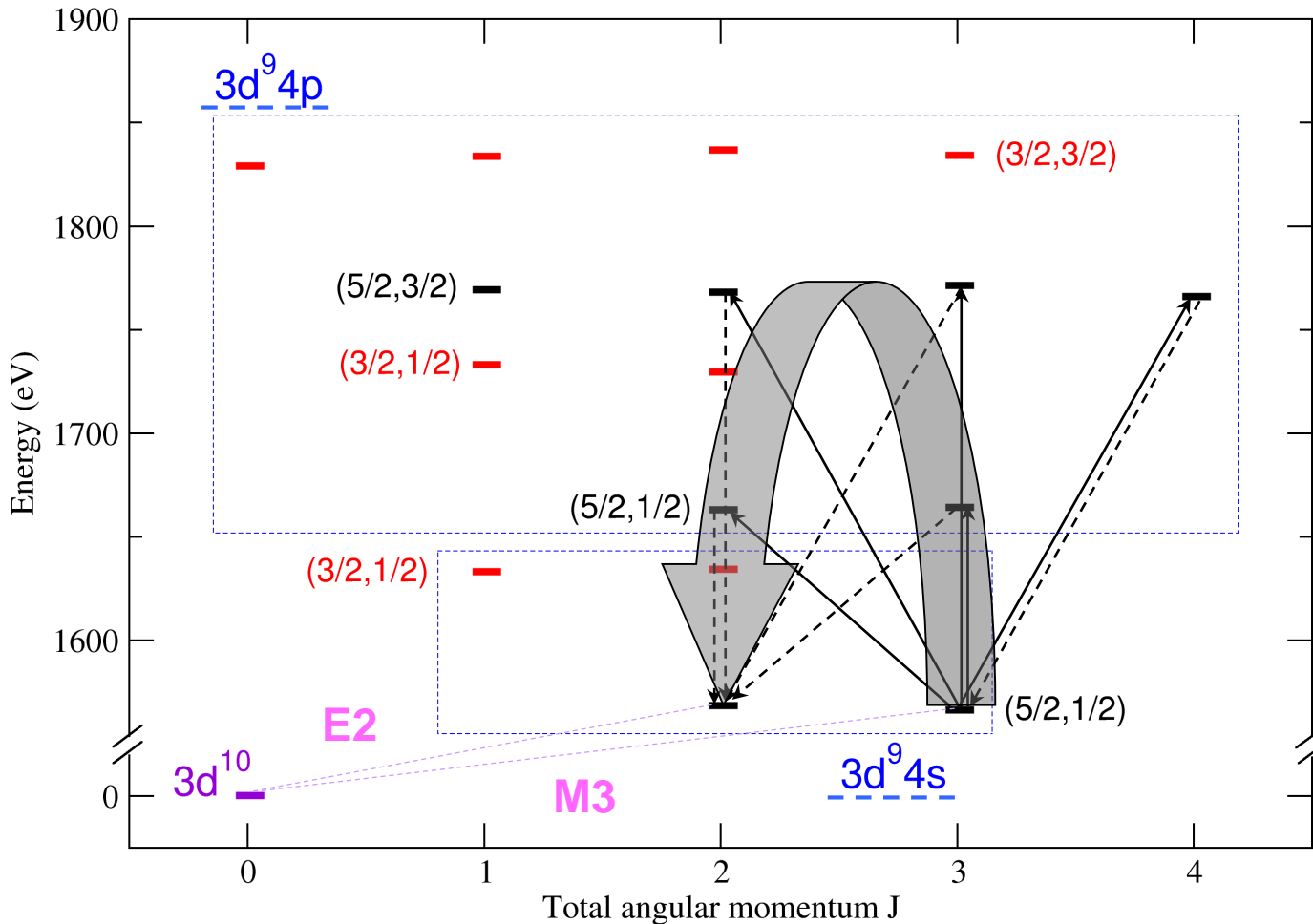


E2+M3



Line intensity: $I = N \cdot A \cdot E$
 $I(E2):I(M3) = 4:3$

CR population transfer M3 \Rightarrow E2



Ni-like W^{46+}

$3d^{10}$
 $3d^9 4s$
 $3d^9 4p$

Yu. Ralchenko,
 J Phys B **40**,
 F175 (2007)

- jj-coupling
- 4s-4p
- $\Delta l = 1, |\Delta J| \leq 1$

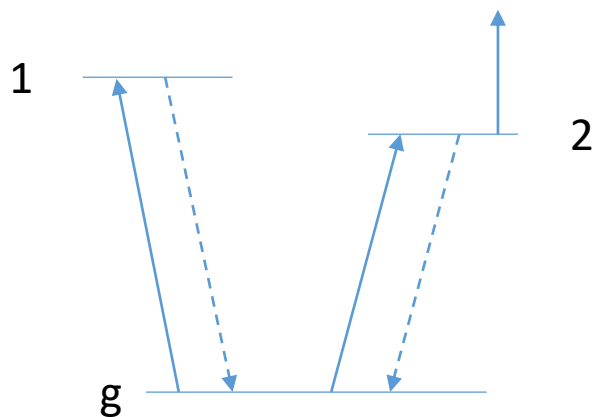
- $(5/2, J) \rightarrow (5/2, J')$
- $J=2..4$: no E1 into g.s
- $J=2,3$: E1 into $(5/2, 1/2)_2$

Density-sensitive ratio

Strong transition

$$N_g n_e \langle \sigma v \rangle_{g1} = N_1 A_1$$

$$N_g n_e \langle \sigma v \rangle_{g2} = N_2 A_2 + N_2 n_e \langle \sigma v \rangle_2$$



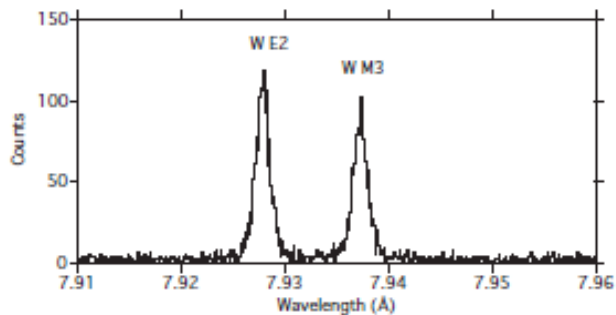
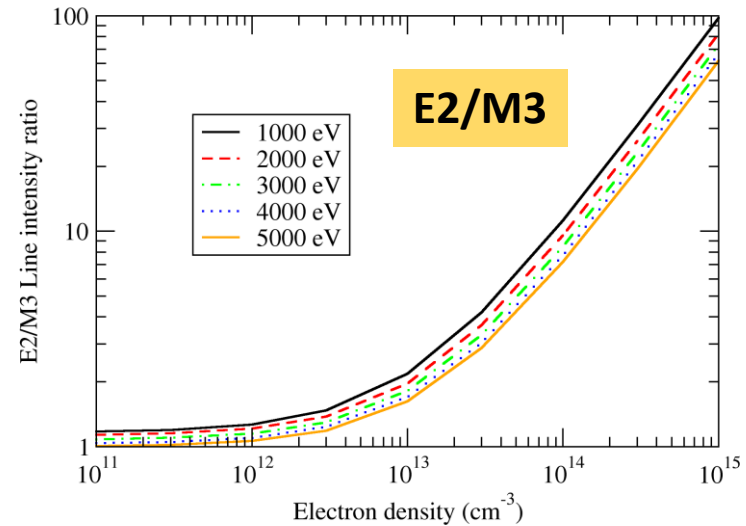
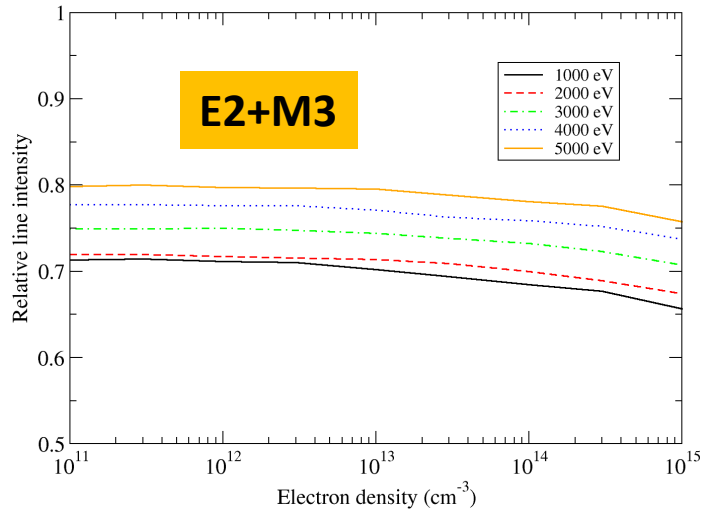
$$N_1 = \frac{N_g n_e \langle \sigma v \rangle_{g1}}{A_1}$$

$$N_2 = \frac{N_g n_e \langle \sigma v \rangle_{g2}}{A_2 + n_e \langle \sigma v \rangle_2}$$

$$\frac{N_1 A_1}{N_2 A_2} = \frac{\langle \sigma v \rangle_{g1}}{\langle \sigma v \rangle_{g2}} \cdot \frac{A_2 + n_e \langle \sigma v \rangle_2}{A_2}$$

E.g., resonance to intercombination lines in He-like ions

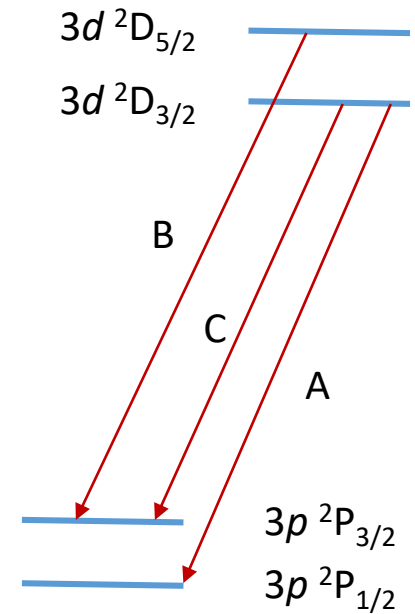
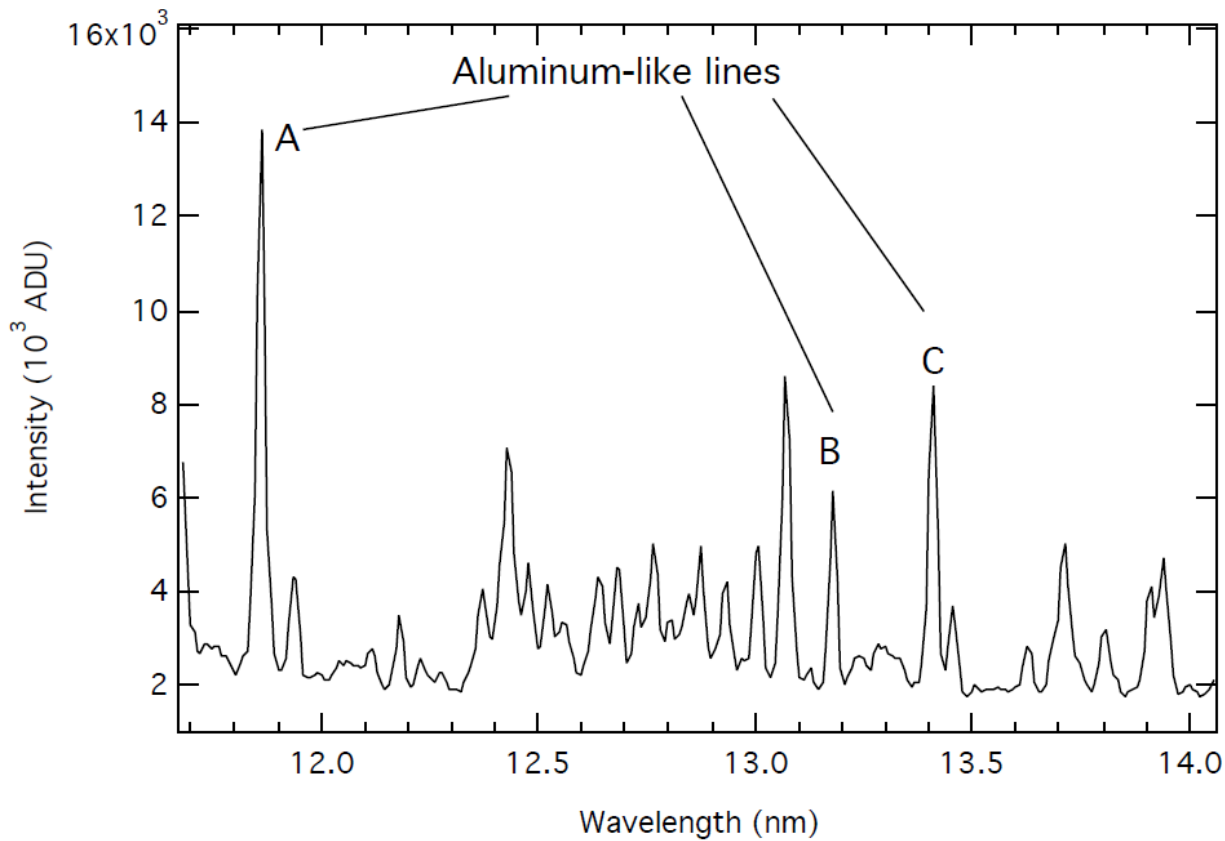
E2/M3 ratio is sensitive to density



E2 and M3 were resolved in
Clementson et al, PRA **81**, 012505 (2010)

Line intensity: $I = N \cdot A \cdot E$
 $I(E2):I(M3) = 4:3$

Al-like Kr: what's wrong with the E1 lines?



$$A_A = 6.2 \times 10^{10} \text{ s}^{-1}$$
$$A_B = 7.4 \times 10^{10} \text{ s}^{-1}$$
$$A_C = 3.2 \times 10^{10} \text{ s}^{-1}$$