EUV Spectra of Gadolinium Laser Produced Plasma

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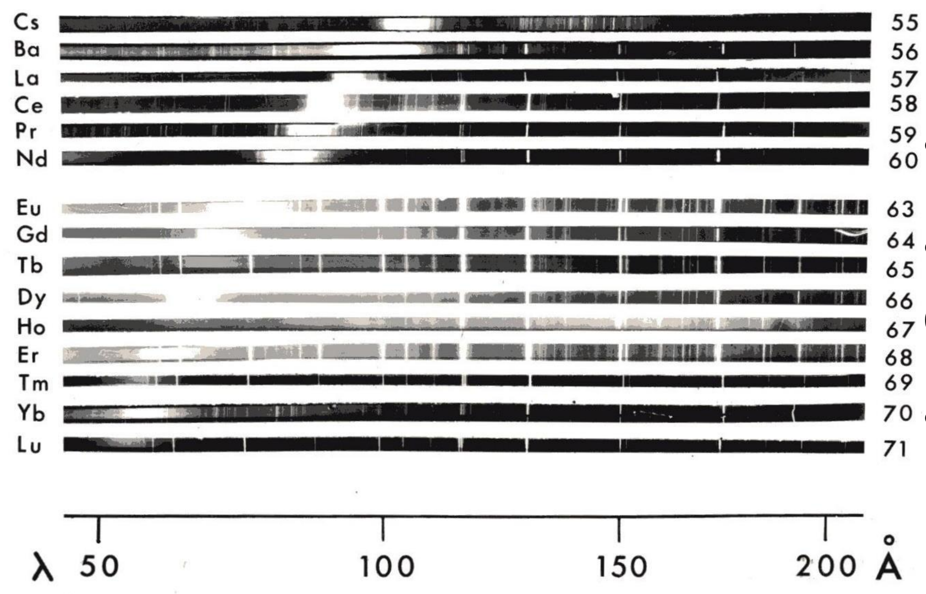

Figure 1: *UTA emission from the elements of Cesium to Lutetium [1]*

1.Introduction

•Development of sources below 13.5nm is a challenge for EUVL.

•EUV emission at 6.xnm could be coupled with a La/B_4C multi layer mirror to make a next generation light source.

•Gadolinium has been previously shown to have large UTA emission peaking at 6.75nm[1,2]

2.Experimental Setup

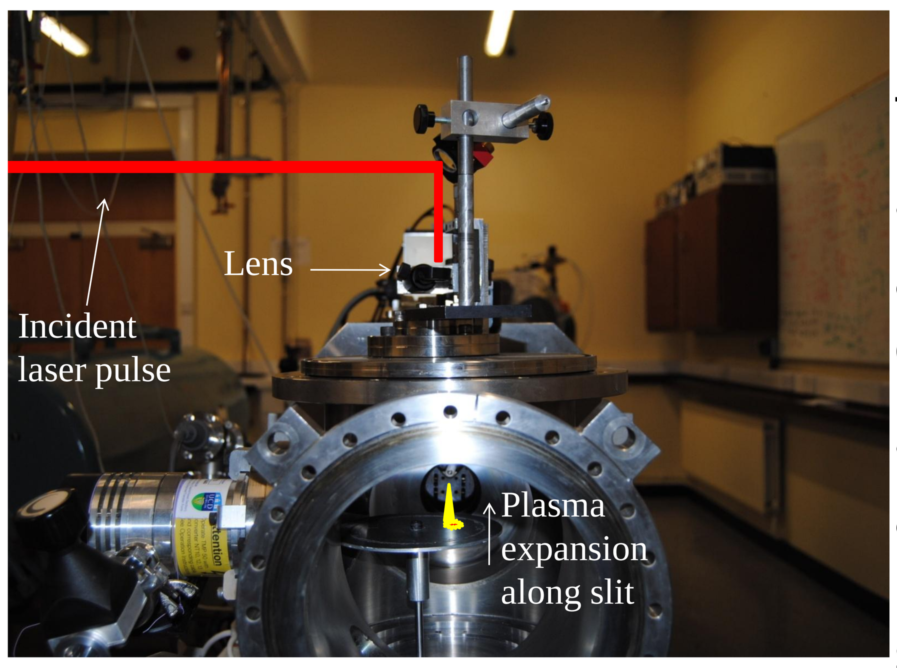

Figure 2: *Image of target chamber used*

•A 160ps, 1064nm, Nd:YAG laser pulse with energy of 450mJ irradiated the target.

• A range of power densities was achieved by varying the lens – target distance.

• Spectra from the plasma were analysed using a 2-meter grazing incidence soft x-ray spectrometer, shown in figure 3[3].

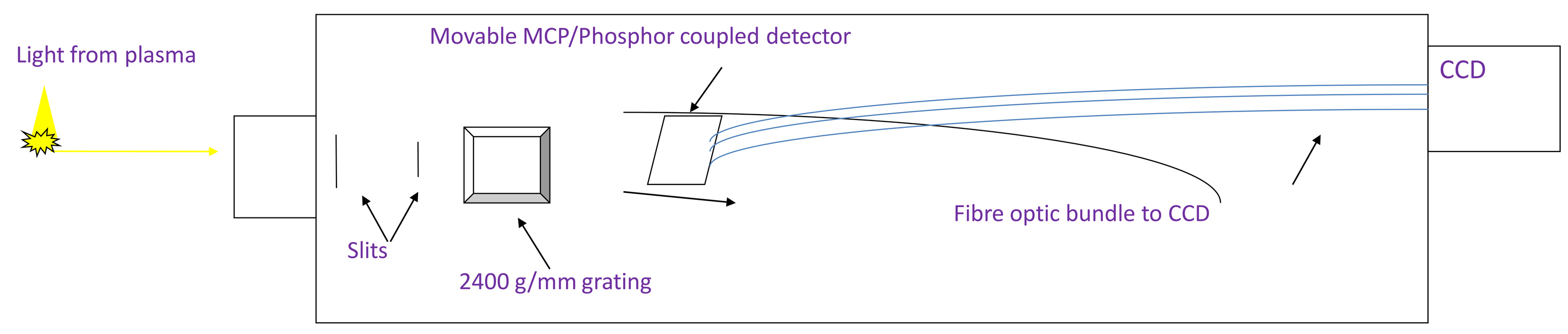

Figure 3: *Schematic of Schwob/Fraenkal soft x-ray spectrometer*

3. Atomic Calculations

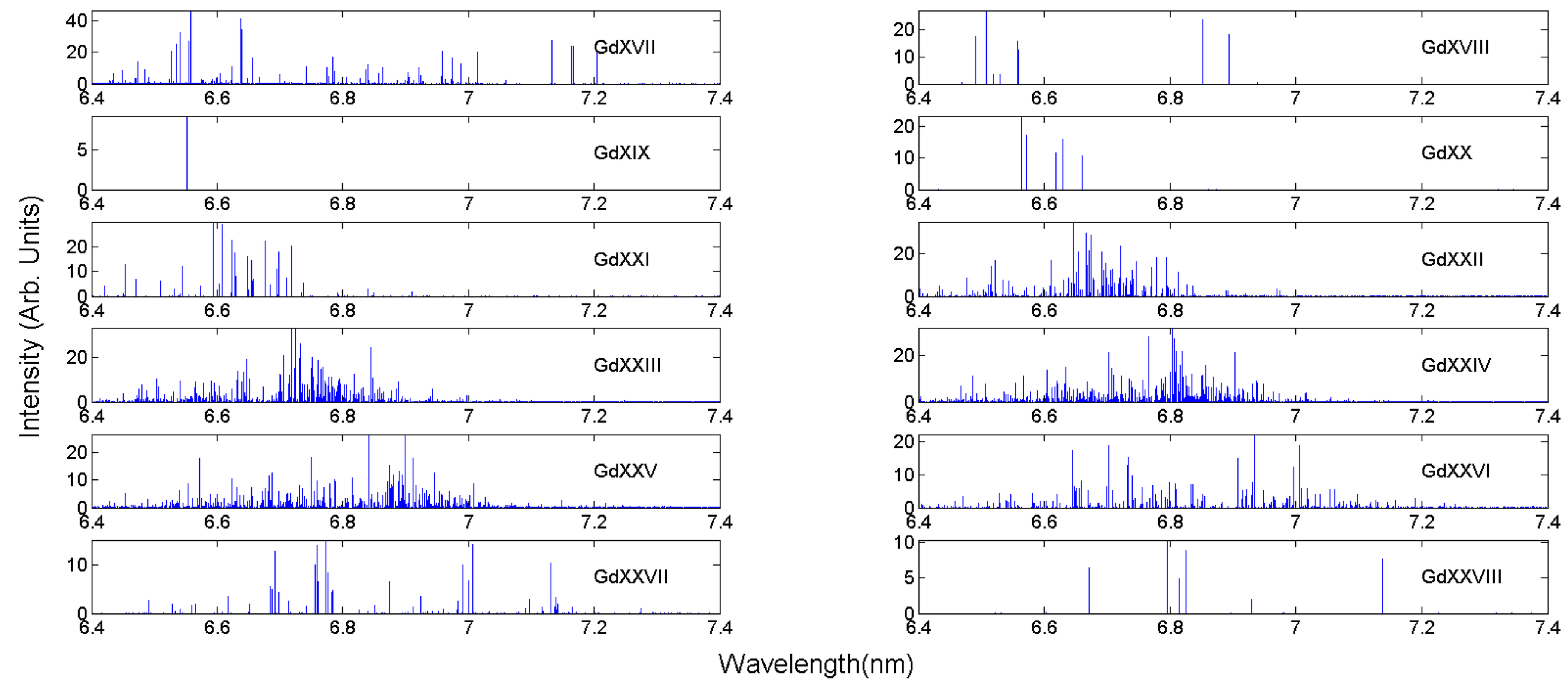

Figure 4: *Cowan code calculations of spectral output from Gd XVII - GdXXVII*

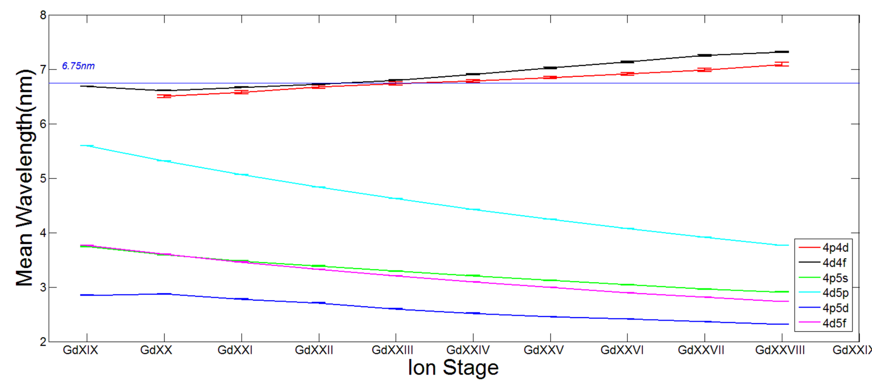

Figure 5: *Mean wavelength emission as a function of ion stage*

•UTA statistics of Cowan code calculations show that 4d - 4f, 4p – 4d are the main contributing transitions in the 6.x-nm region.

4. Theoretical Spectra

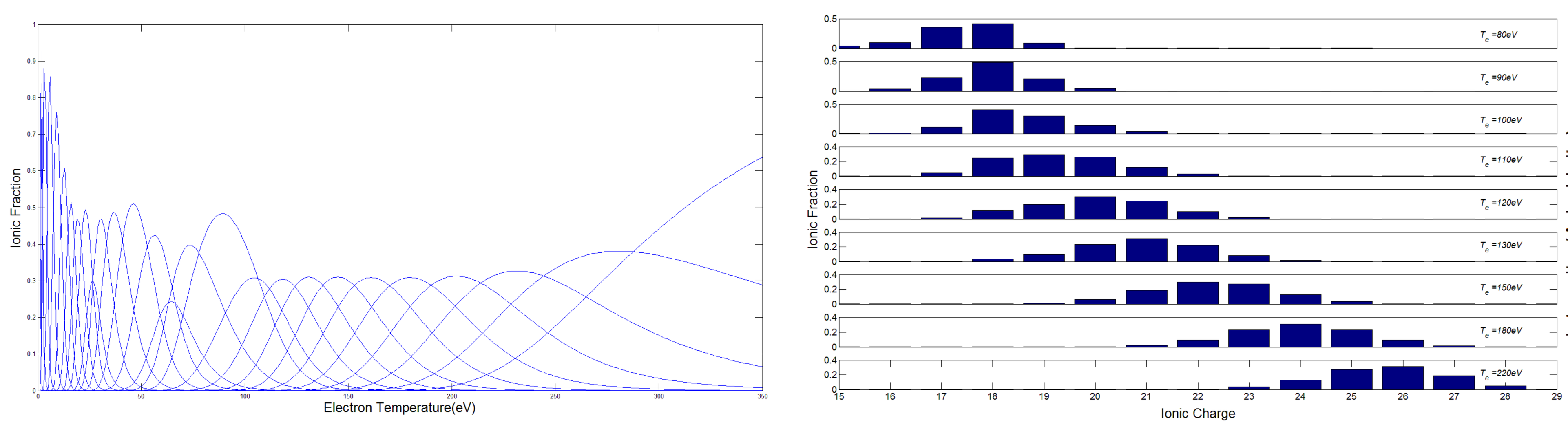

Figure 6: *Gd Ion fractions as function of electron temperature*

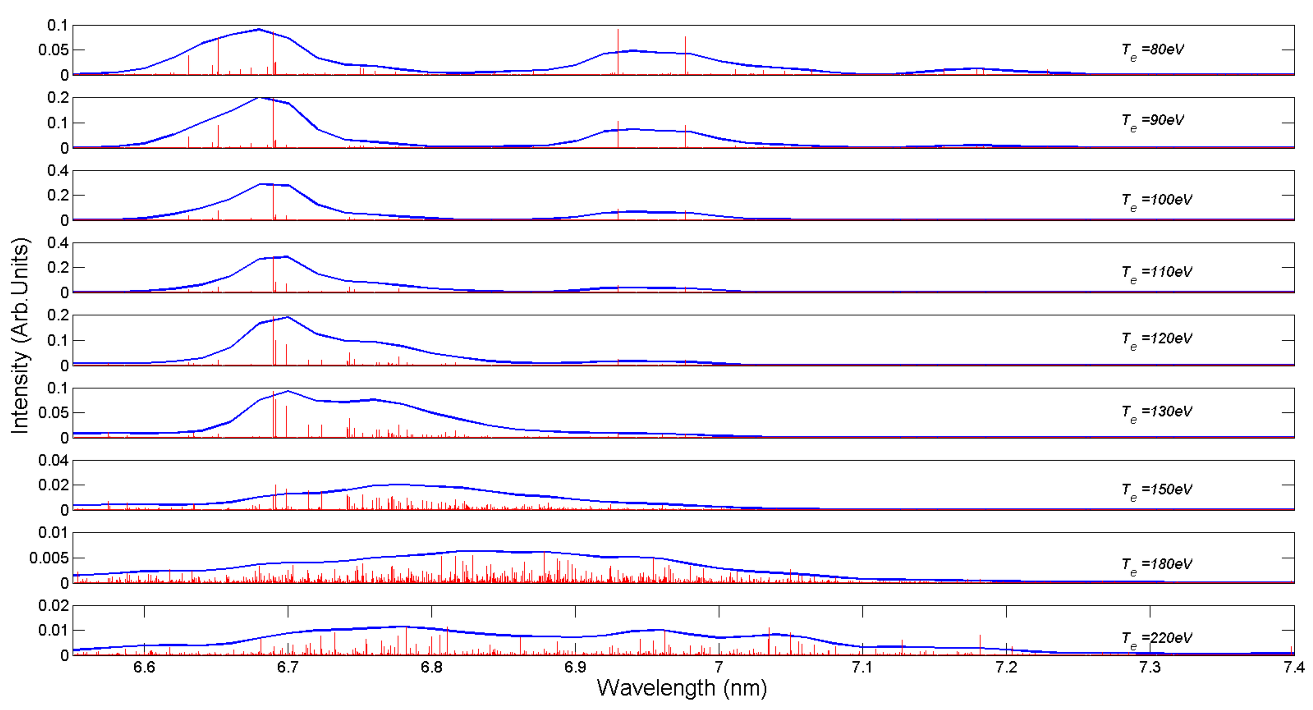

Figure 7: *Theoretical Gd spectra at different electron temperatures*

•Cowan code spectral output was weighted with CR model [4] ion fractions to give theoretical spectra at various n_e and T_e

•A range of power densities was achieved by varying the lens target distance.

5. Experimental Spectra

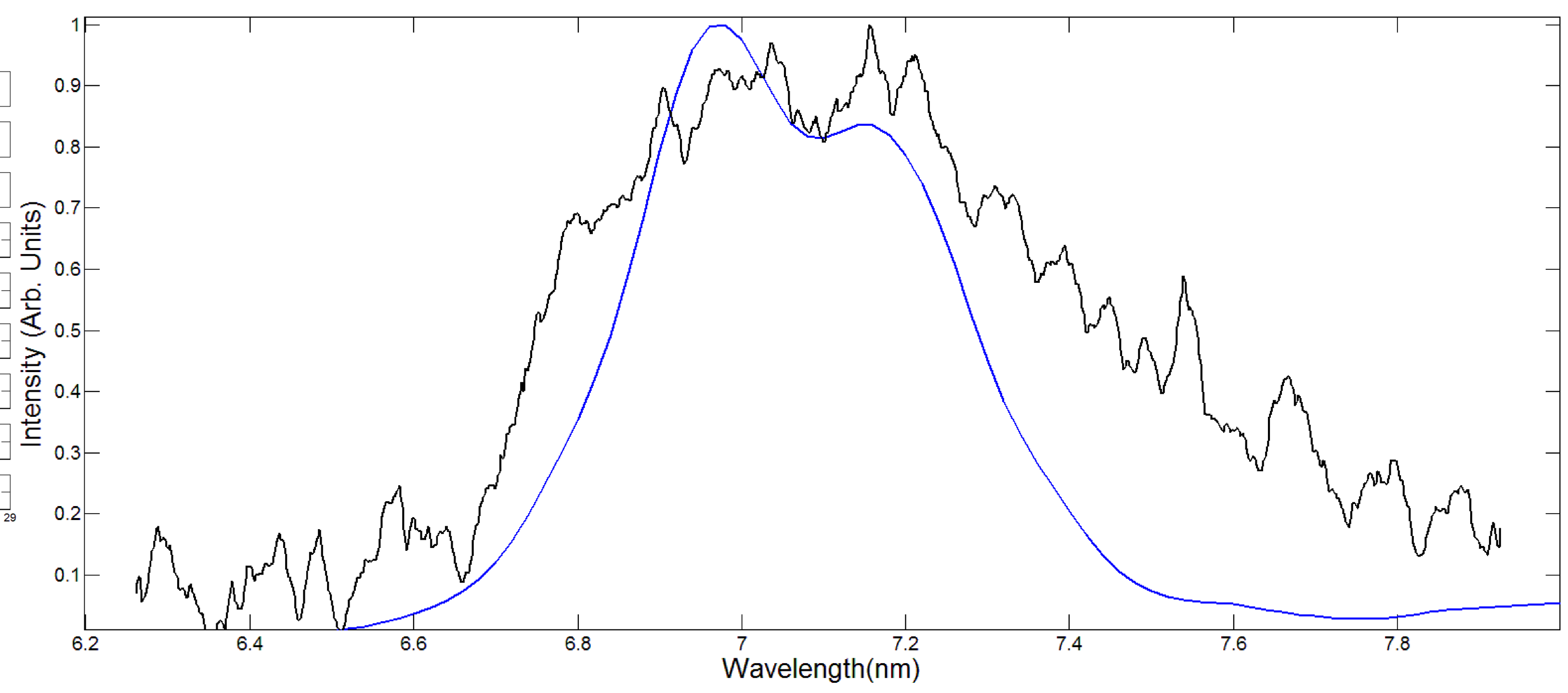

Figure 8: *Theoretical Gd spectra at different electron temperatures*

•Experimental spectra from Gd_2O_3 plasma along with theoretical calculations[3] are shown in figure 4

•An electron temperature of 200 eV was found to give the best agreement with experiment

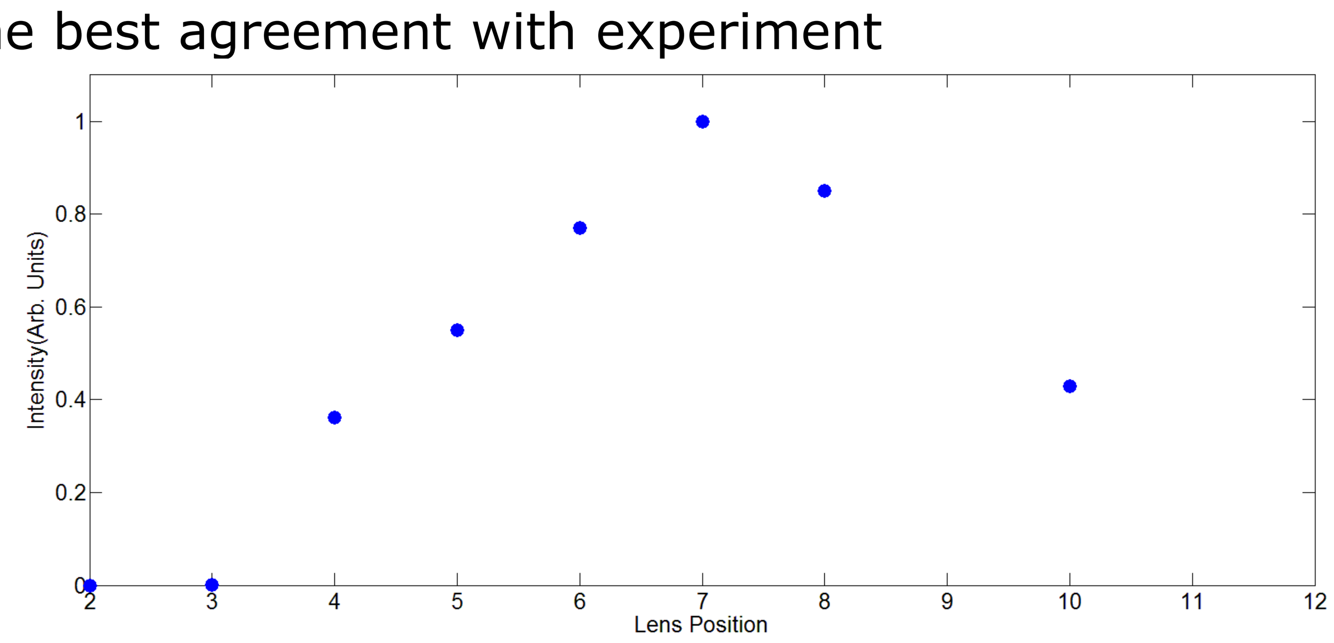

Figure 9: *In band intensity as a function of lens position*

6.Future Work

•Further spectral analysis

•Absolute intensity measurements will be made with a photodiode and Mo/B_4C coupled detector. This will allow the measurement of conversion efficiency.

•Ion emission will be characterised using an electrostatic spherical sector analyser.

7.References

[1] A Spectroscopic Study of Laser Produced Plasmas of the Rare Earth and Related Elements– G.O' Sullivan– Ph.D Thesis - 1980
[2] EUV spectra of Gd and Tb ions excited in laser-produced and vacuum spark plasmas – S.S. Churilov, R. R. Kildiyarova, A. N. Ryabtsev, and S. V. Sadovsky - Phys. Scr. **80** 045303 (2009)
[3]High Resolution duo-mulitchannel soft x-ray spectrometer for tokamak plasma diagnostics – J.L. Schwob – Rev. Sci. Instrum. **59** (9) (1987)
[4] X-ray emission in laser-produced plasmas - D. Colombant and G.F Tonon – J. Appl. Phys.., **44** (8) (1973)

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